CENTENNIAL COAL
Clarence Colliery
ANNUAL REVIEW

April 2023

Annual Review Title Block

Name of Operation	Clarence Colliery
Name of Operator	Clarence Colliery Pty Ltd
Development Consent/ Project Approval #	DA 504-00
Name of holder of Development Consent/ Project Approval	Centennial Coal Company Pty Limited
Mining Lease #	CCL705, ML1353, ML1354, ML1583, ML1721, (A307, A416, A451, EL5072)
Name of Holder of Mining Lease	Coalex Pty Ltd & Clarence Coal Investments Pty Ltd
Water License #	WAL 36479, WAL 41882
Name of Holder of Water License	Coalex Pty Ltd & Clarence Coal Investments Pty Ltd
RMP Start Date	1 August 2022 to perpetuity (RMP Version 1.0 dated 29 July 2022)
Annual Review Start Date	1 January 2022
Annual Review End Date	31 December 2022

I, certify that this audit report is a true and accurate record of the compliance status of Centennial for the period 1 January to 31 December 2022 and that I am authorised to make this statement on behalf of Centennial Clarence.

Note:

a) *The Annual Review is an 'environmental audit' for the purposes of s122B(2) of the Environmental Planning and Assessment Act 1979. Section 122E provides that a person must not include false or misleading information (or provide information for inclusion) in an audit report produced to the Minister in connection with an environmental audit if the person knows that the information is false or misleading in a material respect. The maximum penalty is, in the case of a corporation, $1 million and for an individual, $250,000.*

b) *The Crimes Act 1900 contains other offences relating to false and misleading information: section 192G (intention to defraud by false or misleading statement – maximum penalty 5 years imprisonment); sections 307A, 307B and 307C (False or misleading applications/information/documents –maximum penalty 2 years imprisonment or $22,000,or both).*

Name of Authorised Reporting Officer	Craig Gillard
Title of Authorised Reporting Officer	Managing Director & CEO
Signature of Authorised Reporting Officer	
Date	28 April 2023

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1 STATEMENT OF COMPLIANCE

The compliance status of Clarence Colliery in 2022 is provided in **Table 1-1**. There were six (6) non-compliances during the Reporting Period.

Table 1-2 presents a summary of the non-compliances.

Table 1-1: Statement of Compliance

Were all conditions of the relevant approval(s) complied with?	
Development Consent 504-00	**No**
Mining Lease (ML) 1353	Yes
ML 1354	Yes
ML 1583	Yes
ML 1721	Yes
CCL 705	Yes
Authorisation (A) 307	Yes
A 416	Yes
A 451	Yes
Exploration Lease (EL) 5072	Yes
Environmental Protection Licence (EPL) 726	**No**
Water Access Licence (WAL) 36479	Yes
WAL 41882	Yes
Subsidence Management Plan (SMP) Approvals	Yes
Statement of Commitments	Yes

Table 1-2: 2022 Non-Compliances

Relevant Approval	Condition #	Condition summary	Compliance Status	Comment	Where Addressed in Annual Review
EPL 726	L2.1	Exceedance of concentration limits specified in L2.4	**Low**	LDP002 did not comply with EPL water quality limits on several occasions during the Reporting Period in January, March, July, October, November and December	**Section 7.3.2** and **Section 11**
DA 504-00	Schedule 3 Condition 9(b)	Surface Water Impact Assessment Criteria			

Note: Compliance Status Key for Table 1-2

Risk Level	Colour Code	Description
High	Non-Compliant	Non-compliance with potential for significant environmental consequences, regardless of the likelihood of occurrence
Medium	Non-Compliant	Non-compliance with: • Potential for serious environmental consequences, but is unlikely to occur; or • Potential for moderate environmental consequences, but is likely to occur
Low	Non-Compliant	Non-compliance with: • Potential for moderate environmental consequences, but is unlikely to occur; or • Potential for low environmental consequences, but is likely to occur
Administrative	Non-Compliant	Only to be applied where the non-compliance does not result in any risk of environmental harm (e.g. submitting a report to government later than required under approval conditions)

2 INTRODUCTION

Clarence Colliery is an underground coal mining operation located within the NSW Western Coalfields (**Figure 2-1**). Up to 3 million tonnes per annum (Mtpa) of coal is extracted from the Katoomba Seam using the bord and pillar partial extraction method, supplying coal to both domestic and export markets. Up to 300,000 tonnes per annum (tpa) of coal products are transported by road in total. Operations at Clarence Colliery commenced in 1979.

Clarence operates under two Lithgow City Council (LCC) development consents and one State Government development consent. Development Consent IRM.GE.75 was granted in 1976 to allow the extraction of coal from the Katoomba Seam and was modified in 1993 to amend the reject emplacement areas (REAs) proposed in the original Environmental Impact Statement (EIS). Development Consent 174/93 was granted in 1994 to extend underground coal mining operations and upgrade REAs, water management facilities and ancillary structures within the Clarence Colliery Pit Top and was amended in 2019 to allow changes to REA III design. Development Consent DA 504-00 was granted in 2005 to expand operations and convert four explorations tenements into a new mining lease (ML 1583). There have been nine modification applications, the most recent modification 9 (MOD9) was granted in November 2022.

The Clarence Colliery holding includes Consolidated Coal Lease (CCL) CCL 705 and mining leases ML 1353, ML 1354, ML 1583 and ML 1721. Clarence Colliery undertake exploration activities in accordance with Exploration Licence (EL) 5072 and Authorisation (A) A307, A416 and A451. Underground mining at Clarence is undertaken in accordance with approved Subsidence Management Plans[1] (SMPs) which are prepared to satisfy the requirements of relevant mining authorities. Clarence operates under Environmental Protection Licence (EPL) 726, issued under the *Protection of the Environment Operations Act 1997* (POEO Act). The licence has an anniversary date of 1 January and allows four licenced discharge points (LDPs) and requires three dust monitoring points.

2.1 SCOPE

This Annual Review (AR) details the compliance and environmental management performance of Clarence over the Period 1 January 2022 to 31 December 2022. It has been prepared to demonstrate the sites performance and community engagement activities for Clarence. The AR has been prepared in accordance with the *Annual Review Guideline* (DPIE 2015), and satisfies:

- Schedule 5, Condition 5 of DA 504-00;
- Schedule A, General Terms of Approval of IRM. GE 76; and
- Reporting requirements of Extraction Plans / Subsidence Management Plans.

Subject to approval from the DPE, this AR will be available at the Clarence website https://www.centennialcoal.com.au/operations/clarence/

[1] MOD 7 approved the incorporation of Extraction Plan conditions to DA 504-00 to apply to areas that are not covered by an existing Subsidence Management Plan (refer to **Section 3.1.2**).

2.2 MINE CONTACTS

The contact details for the personnel responsible for environmental management and community relations at Clarence are provided in **Table 2-1**.

Table 2-1: Clarence Environmental Contact Details

Name	Position	Contact Details
Brian Nicholls	Mine Manager	T: 02 6353 8033
		E: brian.nicholls@centennialcoal.com.au
Matt Ribas	Environment & Community Coordinator	T: 02 6353 8039
		E: matt.ribas@centennialcoal.com.au
Community Information and Complaints Line		T: 02 6353 8010

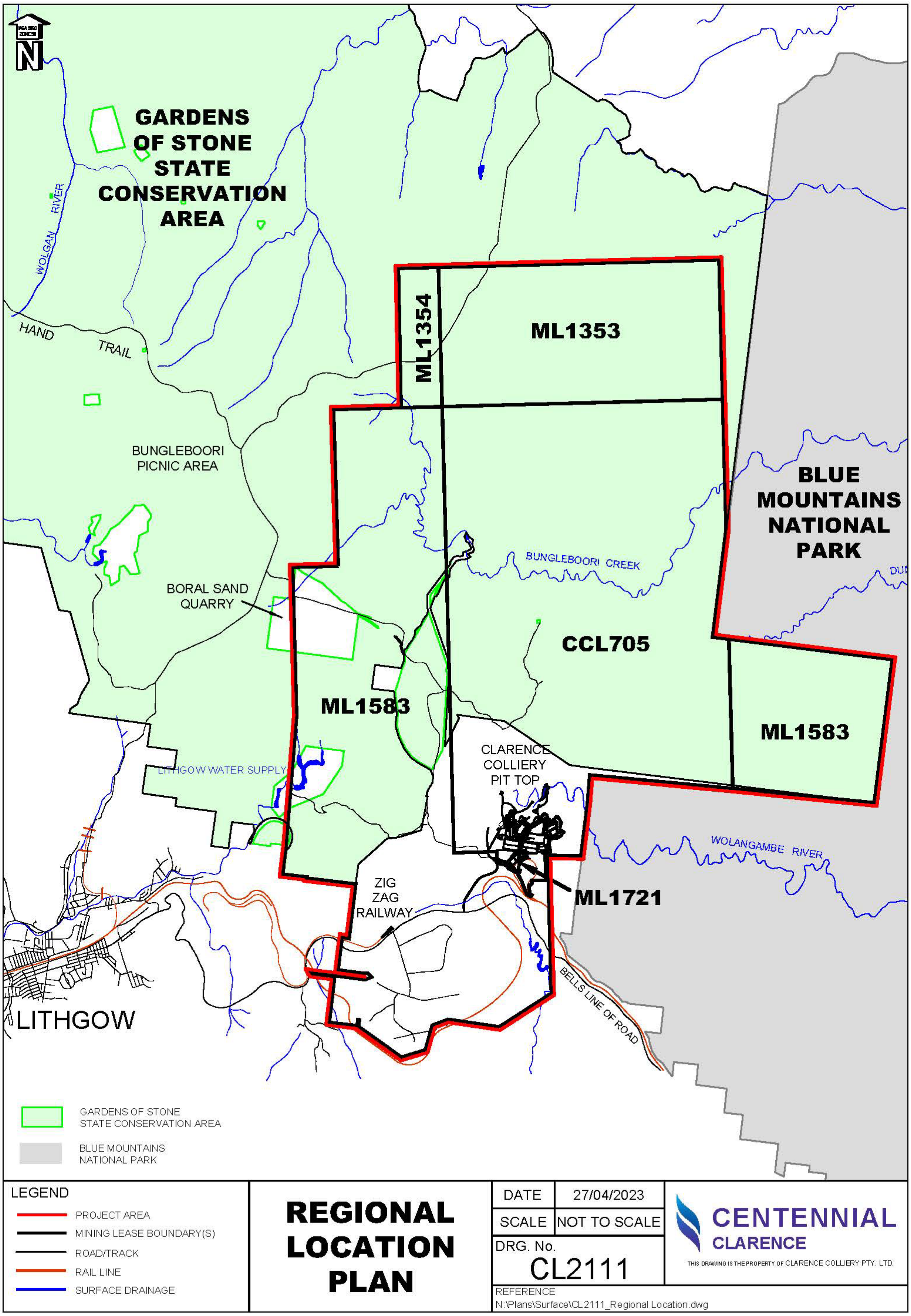


Figure 2-1: Regional Context & Site Layout

3 APPROVALS

3.1 PROJECT APPROVALS, MINING AUTHORISATIONS, AND OTHER LICENCES

A summary of Project Approvals, Mining Authorisations, and other Licences relevant to Clarence Colliery is provided in **Table 3-1**. Current Project Approvals, EPBC Approvals, Exploration Licences, and Mining Leases are available at the Clarence Colliery website.[1]

Table 3-1: Environmental Approvals held by Clarence Colliery

Approval	Description	Expiry Date	Change during Reporting Period (Y/N)
Development Consent - Lithgow City Council			
IRM.GE.76	Original development consent – construction of surface infrastructure and mining operation	Perpetuity	No
	MOD 1 – amend the REAs		
	MOD 2 – REA 3 decommissioning and rehabilitation		
Development Consent 174/93	Extension of underground coal mining and surface REAs.	Perpetuity	No
	MOD 1 - Relocation of REA 5 access and associated vegetation clearing		
Project Approval - NSW Department of Planning and Environment (DPE)			
Development Approval DA 504-00	Extension of the Clarence Underground Coal Mine	31/12/2026	Yes (refer to Section 3.1)
	MOD 1 – Increased road haulage (withdrawn)		
	MOD 2 – REA VI		
	MOD 3 – Road haulage to the west		
	MOD 4 – Road haulage to Mt Piper Power Station		
	MOD 5 – Manning increase		
	MOD 6 – CCR transfer to Chabon via rail		
	MOD 7 – Addition of Extraction Plan conditions		
	MOD 9 - Temporary Coal Transport Modification		
Subsidence Management Plans			
SMP	700 Area (Variation 6)	01/06/2025	No
SMP	900 Area (Variation 6)	24/12/2025	Yes (refer to Section 6.8)
SMP	800 Area (Variation 7)	24/12/2025	No

[1] https://www.centennialcoal.com.au/operations/clarence/

Approval	Description	Expiry Date	Change during Reporting Period (Y/N)
Mining Leases – NSW Resource Regulator (RR)			
ML 1353	Title to Northern Mining Area includes some surface land, some environmental conditions	21/07/2036	Yes (refer to **Section 3.1.1**)
ML 1354	Title to Mining Area adjacent to ML1353 includes some surface land, some environmental conditions	21/07/2036	Yes (refer to **Section 3.1.1**)
ML 1583	Title to 700 & 800 Area Workings include some surface land, some environmental conditions	9/07/2027	Yes (refer to **Section 3.1.1**)
ML 1721	Surface Lease to some of the Pit Top Area includes some environmental conditions	7/12/2036	Yes (refer to **Section 3.1.1**)
Consolidated Coal Leases (CCL) - RR			
CCL705	Title to Central Workings includes some surface land, some environmental conditions	20/12/2026	Yes (refer to **Section 3.1.1**)
Exploration Authorisations - RR			
Exploration Licence (EL) EL5072	Exploration License for 800 area	31/07/2022[1]	No
Authorisation 307	Exploration License for Southern areas of Workings	24/08/2019[1]	No
Authorisation 416	Exploration License for Western area of Workings	24/08/2025	No
Authorisation 451	Exploration License for Northern area of Workings	24/08/2019[1]	No
Rehabilitation Management Plan (RMP) – RR			
RMP	RMP as required by the Mining Amendment Regulation & DA 504-00	Perpetuity (Version Date 29/07/2022)	Yes (refer to **Section 3.1.1**)
Annual Rehabilitation Report & Forward Program (ARR&FP) – RR			
ARR&FP	ARR&FP as required by the Mining Amendment Regulation	1/07/2024	Yes (refer to **Section 3.1.1**)
Environmental Protection Licence - NSW Environment Protection Agency (EPA)			
EPL726	Environment Protection License	Renewed Annually 1st of January	No
Water Licences – DPE Water			
Bore Licences			
CLRP1	10BL161964	Perpetuity	No
CLRP2	10BL161965		No
CLRP3	10BL602213		No

Approval	Description	Expiry Date	Change during Reporting Period (Y/N)
CLRP4	10BL161962		No
CLRP5, CLRP7, CLRP10	10BL602211		No
CLRP6	10BL602212		No
CLRP 12	10BL604063		No
CLRP 11, 13, 14	10BL604099		No
CLRP 17, 20	10BL605316		No
CC114	10BL602819		No
HV1, HV2, HVU1, HVU2	10BL603337		No
Bore Licence	10BL605494		No
CLRP18,22	10BL605612		No
Bore Licence	10BL156676		No
Bore Licence	10BL161963		No
Water Supply Works			
Surface Licence Main Dam	10WA118714	30/06/2024	No
WAL 36479	10WA118758	11/12/2027	No
Water Supply Works	10WA10715	18/05/2026	No
Water Access Licence			
Water Access Licence	10AL122285	Perpetuity	No
Water Access Licence	WAL41882		No
Water Access Licence	WAL36479		No
Joint Water Supply Works			
Joint Water Supply Works	10WA103852	29/07/2027	No
Joint Water Supply Works	10UA103853	29/07/2027	No
Surface Authority			
Surface Authority	10SA001409	30/09/2017	No

Approval	Description	Expiry Date	Change during Reporting Period (Y/N)
Threatened Species Licenses – DPE Biodiversity, Conservation and Science Directorate (BCS)			
Section 95 Certificate C0002449	Installation and operation of two shallow piezometers within Paddys Swamp	31/12/2026	No
Threatened Species Licence C0003012	Installation and operation of one shallow piezometer within Oleria Swamp	22/09/2022	No
Threatened Species Licence C0004884	Installation of two shallow piezometers and two soil moisture probes within Pagoda Swamp	31/12/2026	No
Threatened Species Licence C0006510		31/12/2026	No
State Rail Authority			
Q648-100	Access Agreement	Life of Rail Loop	No
Forestry Corporation of NSW			
PB54303	Occupation Permit (Lv2)	Renewed Annually	No
WorkCover Authority NSW			
NDG020999	Dangerous Goods Permit	Perpetuity	No
NSW EPA			
RML 5078394	Radiation Management Licence	08/02/2023	No

Notes: [1] Expired ELs, renewals sought.

3.1.1 Changes During the Reporting Period

The following changes to Approvals, Mining Tenements, and other Licences occurred during the Reporting Period.

- On 2 July 2021, the Department of Regional NSW - RR commenced its Rehabilitation Reforms through an amendment to the Mining Regulations 2016 (Mining Regulations), via the NSW Mining Amendment (Standard Conditions of Mining Leases – Rehabilitation) Regulation 2021 (Mining Amendment Regulation).

  The Rehabilitation Reforms have effectively superseded the previous requirement under a Mining Lease to prepare a Mining Operations Plan (MOP) for any mining activity to be undertaken and to hold an appropriate security for the rehabilitation activities required to achieve the final landform.

To satisfy the Rehabilitation Reforms and Condition 29, Schedule 3 of DA 504-00, Clarence prepared a Rehabilitation Management Plan (RMP). The RMP also satisfies the requirements of its various mining leases.

The RMP was prepared in accordance with the NSW Resources Regulator (NSW RR) Form and Way-Rehabilitation Management Plan for Large Mines (NSW RR, July 2021) required under the Mining Regulation 2016 and submitted on the 29 July 2022 via the NSW RR Portal.

Annual reporting requirements in the RMP will be reported in the Annual Rehabilitation Report and Forward Program (ARR&FP) and submitted using the online form accessible via the NSW Resource Regulator's mine rehabilitation portal. The ARR&FP also sets out WCS the three-year forecast for mining and rehabilitation schedule.

- On 16 August 2022, Clarence received variations (which took effect on 17 October 2022) for all mining authorisations (including, ML 1353, ML 1354, ML 1583, ML 1721 and CCL705) to align with the prescribed standard conditions in the Mining Regulation 2016, Schedule 8A, Part 2.
- On the 17 November 2022, Modification 9 (MOD9) to DA 504-00 was granted by the DPE to re-instate its temporary ability to truck increased coal volumes (up from 100,000 tpa to 200,000 tpa) directly to Mount Piper Power Station from the Clarence Colliery until 31 December 2023.

3.1.2 Extraction Plan / Subsidence Management Plan Status

Subsidence Management Plans (SMP's) were a condition of the mining leases and approved under the Mining Act 1992. Underground mining at Clarence Colliery is undertaken in accordance with approved SMP's which are prepared to satisfy the requirements of relevant mining authorities (refer to **Table 3-1**).

DA 504-00 (MOD7) included the addition of conditions for future secondary extraction at Clarence to be undertaken in accordance with an approved Extraction Plan. At the time of preparing this 2022 Annual Review, a new Extraction Plan for 700 Shortwall Areas was under preparation and anticipated for submission into the DPE for approval in the next Reporting Period.

3.2 ANNUAL REPORTING REQUIREMENTS

Appendix 1 provides a checklist of statutory reporting requirements and performance conditions addresses within the Annual Review.

In accordance with Condition 11, Schedule 5 of DA 504-00 a copy of the 2022 Annual Review, once approved by the DPE, will be provided on the Clarence website: https://www.centennialcoal.com.au/operations/clarence/

4 OPERATIONS SUMMARY

4.1 PRODUCTION

Details of production and associated waste generated by the site for the report period and next reporting is provided in **Table 4-1**. A summary of the other operations and coal processing, handling and transport relevant to Clarence Colliery is provided in **Table 4-2**. There were no inconsistencies between the approved limit and actual production for the Reporting Period.

Table 4-1: Production Summary & Forecast

Material	Approved Limit	Previous Reporting Period (Actual)	This Reporting Period (Actual)	Next Reporting Period (Forecast)
Waste Rock / Overburden	N/A	N/A	N/A	N/A
ROM Coal	3,000,000 TPA	1,654,309 (T)	1,576,995 (T)	1,800,782 (T)
Coarse reject	250,000 TPA*	143,652 (T)	199,636 (T)	118,144 (T)
Fine reject (tailings)	N/A	0	0	0
Saleable Product	N/A	1,532,536 (T)	1,421,793 (T)	1,800,782 (T)

TPA = Tonnes Per Annum.
*Approval limit of 250,000T Coarse Coal Rejects (CCR) applies to emplacement within REA IV only.

Table 4-2: Other Operations

Approved Operation	Approved Limit	Previous Reporting Period (Actual)	This Reporting Period (Actual)
Hours of Operation	24/7	24/7	24/7
Transport (rail)	N/A	1,936,232 (T)	1,216,293 (T)
Transport (road)	300,000 TPA*	148,435 (T)	163,970 (T)

24/7 = 24hrs a day/7 days a week.
TPA = Tonnes Per Annum.
* in accordance with Condition 7AA in Schedule 2 of DA 504-00, until 31 December 2023, Clarence may transport up to 300,000 tonnes of coal by road per calendar year in total, including up to 200,000 tonnes of coal by road per calendar year to the Mount Piper Power Station or to the Lidsdale Siding, and up to 200,000 tonnes of coal by road per calendar year to locations north of Sydney or Eastern NSW

Table 4-3: Coal Processing, Handling and Transport Summary

Month	Product Transported via Rail	Product Transported via Road
January 2022	30,806	12,692
February 2022	101,737	15,884
March 2022	88,648	16,188
April 2022	183,519	11,514
May 2022	108,863	15,770
June 2022	81,780	16,378
July 2022	22,184	14,858
August 2022	91,278	23,028
September 2022	128,354	10,868
October 2022	97,970	9,576
November 2022	149,372	9,652
December 2022	131,782	7,562
Total 2022	**1,216,293**	**163,970**

4.2 MINING OPERATIONS

During 2022, the following mining activities included:

- 800 Area:
  - Development of the 805 panel continued;
  - Development of the 804 panel re-commenced;
  - Extraction of the 822 panel was commenced and completed;
  - Extraction of the 821 panel was commenced;
- 900 Area:
  - Development of the 906 panel was completed;
  - Extraction of the 906 panel was commenced;
  - Development of the 919 panel was commenced;
  - Development of the 915 panel was completed; and
  - Extraction of the 915 panel was completed

The mining activities completed during the Reporting Period are displayed in **Plan 1**.

REA V stage 1 remained in operational use during the 2022 reporting period with all the activities undertaken being within the HRA consent conditions as submitted Aug 2016.

4.3 EXPLORATION

The Clarence Colliery 900 West Exploration Program was commenced with two exploration boreholes completed during the 2022 reporting period.

The program consists of four (4) boreholes, titled CLRP40 – CLRP43, planned across the north-west of the Clarence title area, within ML 1583. Each borehole within the program will intersect and recover the Katoomba seam as a minimum. All recovered coal core will be analysed for coal quality. Select core samples will be taken for geotechnical analysis and each borehole will be geophysically logged.

All drill sites will be rehabilitated following drilling and boreholes sealed appropriately.

4.4 LAND DISTURBANCE

There was no land disturbance outside of the REA V stage 1 design boundary and construction was completed as per the HRA consent conditions.

4.5 CONSTRUCTION

There were no construction activities at the site during the Reporting Period.

4.6 NEXT REPORTING PERIOD

During 2023, the following mining activities plan to be undertaken:

- Development of the 804 panel;
- Development of the 805 panel;
- Extraction of the 801 South panel;
- Extraction of the 906 panel;
- Development of the 919 panel.

5 ACTIONS REQUIRED FROM PREVIOUS ANNUAL REVIEW

Table 5-1 summarises the outcomes of the 2021 Annual Review, including actions issued by the relevant government departments and actions taken by Clarence.

The DPE provided feedback of the 2021 Annual Review regarding additional reporting requirements for future Annual Reviews to address community concern in relation to the status and management of biodiversity areas and the reporting of greenhouse gas management measures.

Table 5-1: Actions from Previous Annual Review

Action Required	Requested By	Action Taken	Annual Review Section
Regulator Requirements			
Report on the status of the long-term security arrangement for biodiversity offsets required by the development consent for the mine. Please include information on the type(s) of long-term security arrangements that have been implemented and/or are to be implemented for the mine.	DPE	Western Region Biodiversity Offsets Strategy (WR-BOS) approved by DPE.	**Section 6.6.6**
Report on greenhouse gas emissions for the Reporting Period and include a comparison of actual greenhouse gas emissions against the predictions in the environmental assessment(s) for the mine. Please ensure that the method used to calculate the environmental assessment prediction(s) and annual emissions are calculated the same.	DPE	Dedicated section included within 2022 AR.	**Section 6.5**
Report all reasonable and feasible steps undertaken during the Reporting Period to improve energy efficiency and reduce greenhouse gas emissions generated by the mine.	DPE	Dedicated section included within 2022 AR.	**Section 6.5**

6 ENVIRONMENTAL PERFORMANCE

Clarence implements an Environmental Management Strategy, including management plans, procedures and monitoring programs that provide a framework for managing environment and community risks and impacts.

To measure compliance with site approvals and licences, Clarence undertakes a comprehensive monitoring program. The environmental monitoring program is shown in **Figure 6-1**.

This section provides a summary of environmental performance in the Reporting Period, including:

- Section 6.1 – Meteorological Summary
- Section 6.2 – Noise
- Section 6.3 – Blasting
- Section 6.4 – Air Quality
- Section 6.5 – Greenhouse Gas Monitoring
- Section 6.6 – Biodiversity
- Section 6.7 – Heritage
- Section 6.8 – Subsidence
- Section 6.9 – Other Matters; including:
    - Section 6.9.1 – Waste

Note, there are separate sections for reporting the environmental performance for water (**Section 7**), rehabilitation (**Section 8**), and community aspects (**Section 9**).

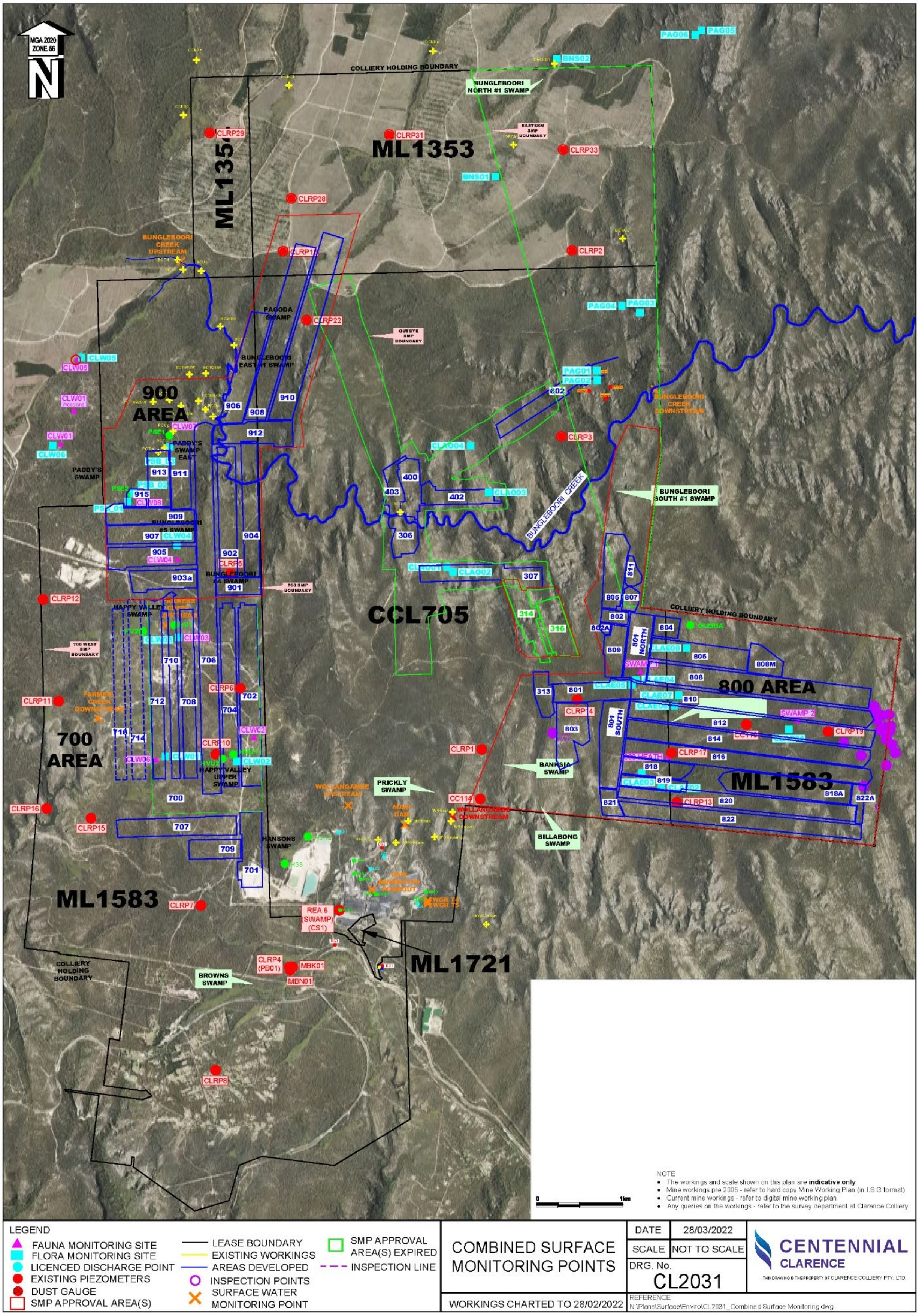


Figure 6-1: Clarence Environmental Monitoring Program

6.1 METEOROLOGICAL SUMMARY

Meteorological monitoring is undertaken at the Clarence Automated Weather Station (AWS). The weather station is required under M5.1 of EPL726 and Schedule 3, Condition 17 of DA 504-00.

A meteorological summary is presented below in **Table 6-1** and graphically in **Figure 6-2.** Clarence recorded a total rainfall of 1556.4mm during the Reporting Period. July had the highest rainfall of 247.2mm, with the lowest rainfall recorded, 65.6mm during December. The minimum temperature at Clarence Colliery was during July at -2.5°C. The maximum recorded temperature was 30.03°C during January.

Wind direction and speed is continuously measured at the Clarence AWS. The wind direction was predominantly from the west-south-westerly direction throughout the Reporting Period. These trends are displayed in **Figure 6-3.**

Table 6-1: Meteorological Summary at Clarence Colliery

Month (2022)	Rainfall (mm)	Cumulative Rainfall (mm)	Min Temperature (Deg C)	Max Temperature (Deg C)
January	181.4	181.4	10.5	30.0
February	103.6	285	7.4	28.5
March	317.4	602.4	8.5	26.1
April	105.8	708.2	6.3	22.7
May	97	805.2	8.1	20.8
June	12.6	817.8	-1.1	13.7
July	247.2	1065	-2.6	15.4
August	68	1133	-1.1	16.8
September	114.4	1247.4	0.6	17.7
October	151	1398.4	4.1	13.9
November	92.4	1490.8	2.8	16.1
December	65.6	1556.4	5.7	21.5

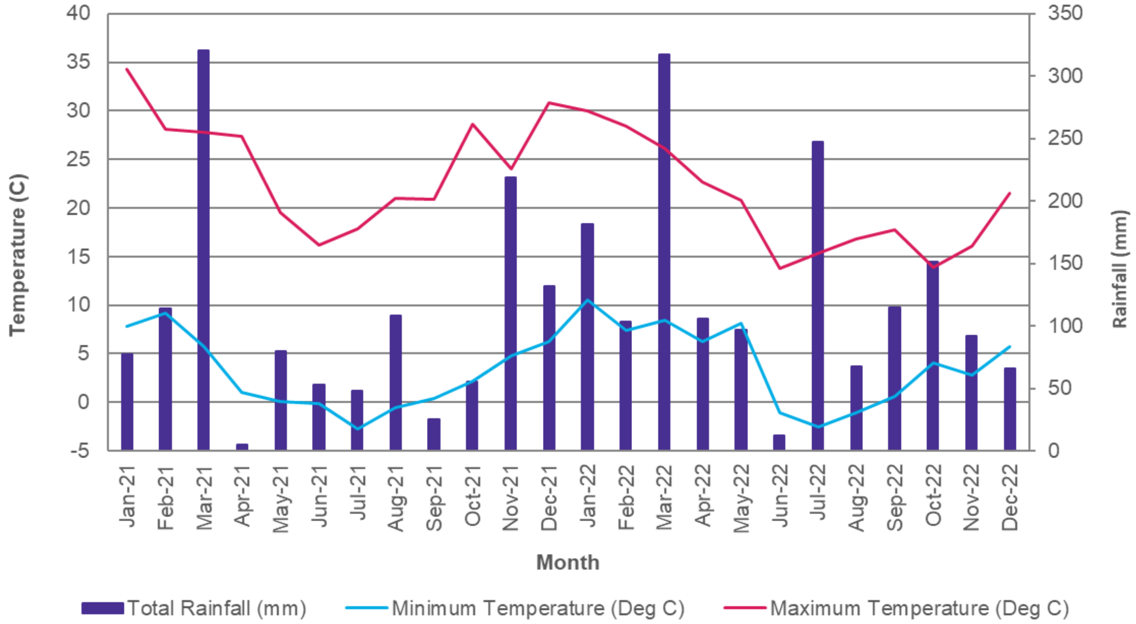


Figure 6-2: 2022 Rainfall and Temperature Summary

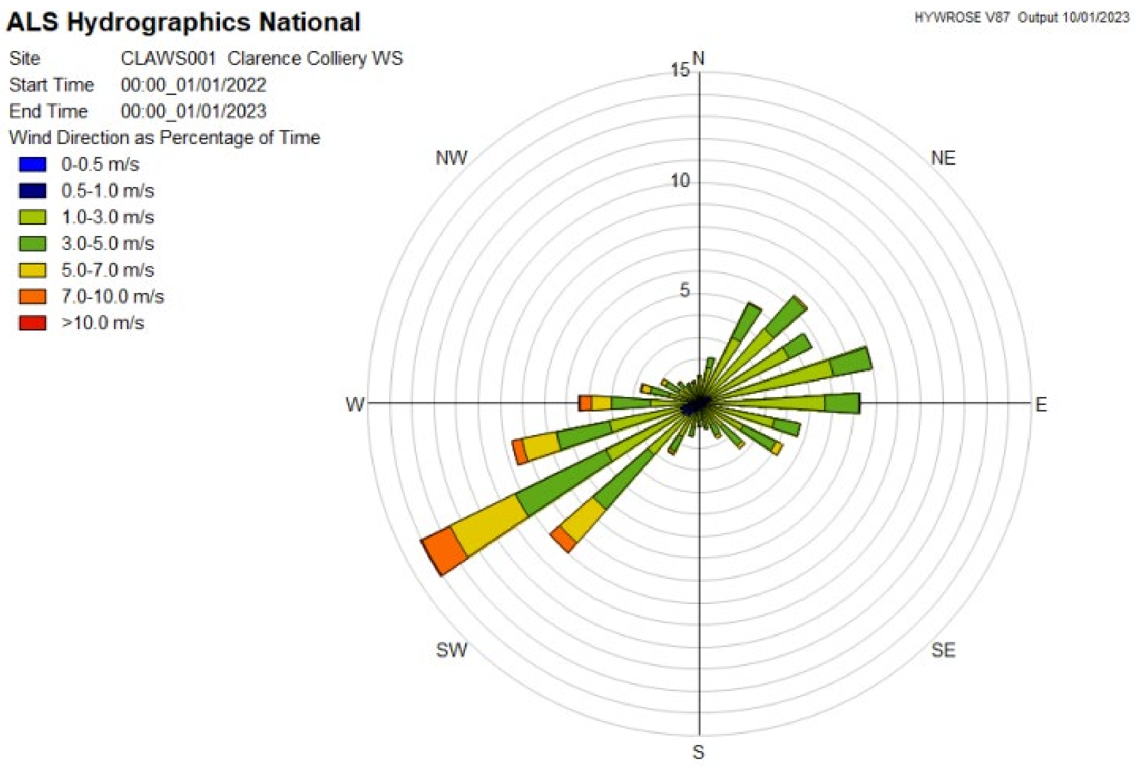


Figure 6-3: Wind Rose Plot for Clarence AWS 2022

6.2 NOISE

6.2.1 Environmental Management

Clarence Colliery manages noise in accordance with the Western Region Noise Management Plan (WRNMP) dated February 2021. This plan was approved by DPIE 15 Feb 2021. The following sources of noise identified in the WRNMP are relevant for Clarence Colliery operations:

- Operation of mobile equipment – e.g. trucks, dozers, loaders;
- Coal handling and preparation plant (CHPP);
- Train loading operations and rail loop;
- Coal transporting activities – e.g. overland conveyors, haul trucks, rail; and
- Ventilation fans.

Key noise mitigation measures for Clarence Colliery include:

- Maintaining all plant and equipment to manufactures specifications.
- Operate mobile plant in a quiet, efficient manner and regular training of operators.
- Installation of frequency modulated reversing alarms or “quakers” on mobile plant to replace reversing alarms.
- Installing acoustic enclosures around processing plants.
- Switching off vehicles and plant when not in use.

6.2.2 Environmental Performance

In accordance with DA 504-00 and EPL 726 noise monitoring is undertaken annually at CNM1 as required by the WRNMP. Clarence annual monitoring (attended) commenced on Tuesday 29 November 2022 and concluded on Wednesday 30 November 2022. Supplementary attended noise monitoring was also conducted at C3.

The noise assessment and analysis of the measured data has shown that Clarence Colliery noise emission levels followed the noise limits at all monitoring locations during the day, evening and night-time noise monitoring periods during the survey.

Table 6-2: 2022 Attended Noise Monitoring Results

Receiver ID	Time of Day	Performance criteria dB(A) Laeq (15 min)	Performance during the Reporting Period (actual) dB(A)L
CNM1	Day	38	38
	Evening	36	<33
	Night	35	<35**

Notes: (a) The noise criteria do not apply where the Applicant and the affected landowner have reached a negotiated agreement in regard to noise, and a copy of the agreement has been forwarded to the Planning Secretary and EPA. (b) Noise generated by the development must be monitored and measured in accordance with the relevant procedures and exemptions (including certain meteorological conditions) of the NSW Noise Policy for Industry (EPA, 2017) ** Based on the measured estimated contribution at C3 at Clarence operations were not audible during the measurement.

6.2.3 Comparison Against Predictions

Noise modelling emissions were completed for MOD2 Environmental Assessment for REA 6 (2013). MOD2 EA predicted noise emissions will not significantly increase or decrease during construction of REA VI and will be similar to the typical emissions during mine operations. Noise emissions from construction activities are predicted to fall considerably within the relevant construction noise criteria (GHD 2013).

The Clarence Colliery Modification 5 Statement of Environmental Effects (SEE) (EMM 2019) was prepared to modify DA 504-00 to increase the number of full-time equivalent personnel at Clarence Colliery from 300 to 400. This SEE is being used as the two subsequent modification reports are to implement transfer of Coarse Coal Reject (CCR) to Charbon Colliery (MOD 6) and to provide extraction plan conditions for the site moving forward (MOD 7). These two projects have not yet been implemented at Clarence and therefore the predictions are not yet applicable.

Section 7.4 of the SEE states that the modification does not include any demolition of surface activities which may general additional noise or vibration impacts. Therefore, the noise environment should remain unchanged from previous years (EMM 2019).

For MOD9, a modification report prepared by James Bailey & Associates Pty Ltd (JBA). Previous modifications have assessed the noise impacts of truck haulage from Clarence, including up to 40 truck movements per day as proposed by this Modification. Consistent with the findings of previous assessments, the proposed additional truck movements from Clarence would not increase the approved noise levels in a 15 minute assessment period. Rather, the trucks movements will be experienced over a greater number of days per year. Accordingly, the predicted noise levels from Clarence to receptors, expressed as LAeq, 15min level for direct comparison with the DA 504-00 noise criteria, would therefore remain unchanged (JBA 2022).

There were no exceedance of the noise criteria during the Reporting Period. The noise predictions in MOD2, MOD5 and MOD9 were upheld during the Reporting Period.

6.2.4 Long Terms Analysis

A summary of exceedances recorded at Clarence Colliery over the last 5 years is presented below in **Table 6-3**. There have been no exceedances at Clarence Colliery during this time period.

As displayed in **Figure 6-4** to **Figure 6-6** , the attended noise monitoring results have not exceeded the relevant noise criteria since 2017.

Table 6-3: Summary of Exceedances from CNM1 2018 – 2022

	2018	2019	2020	2021	2022	Total
Day	0	0	0	0	0	0
Evening	0	0	0	0	0	0
Night	0	0	0	0	0	0

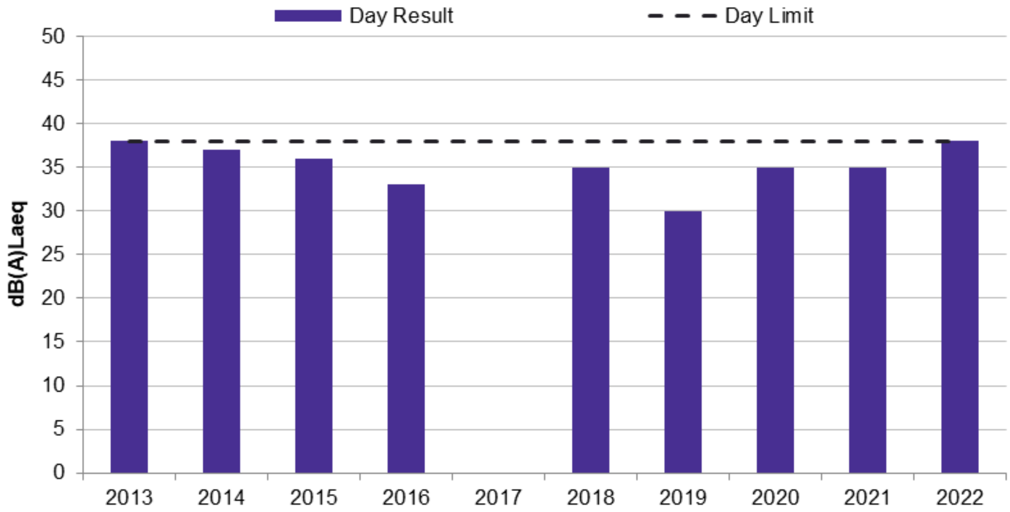


Figure 6-4: Day Noise Monitoring Summary (2013 to 2022)

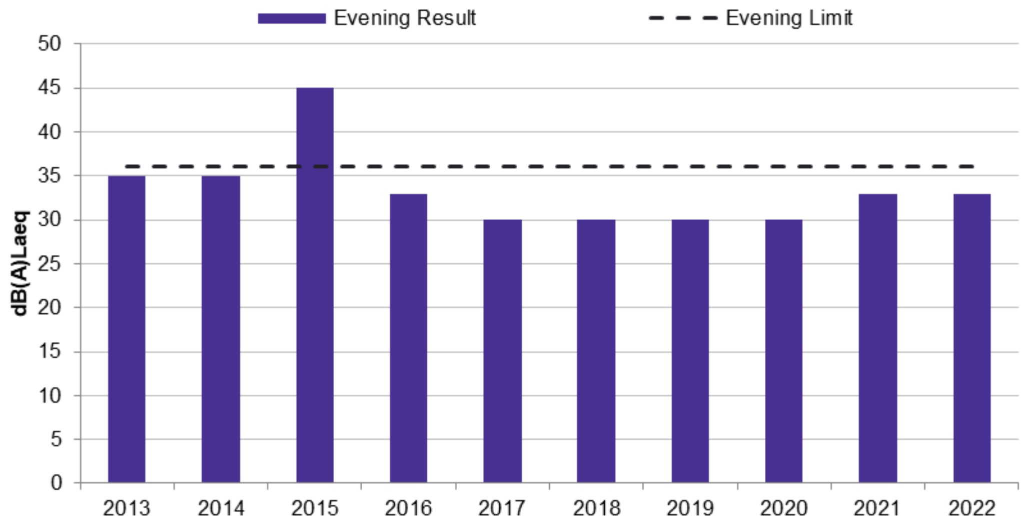


Figure 6-5: Evening Noise Monitoring Summary (2013 to 2022)

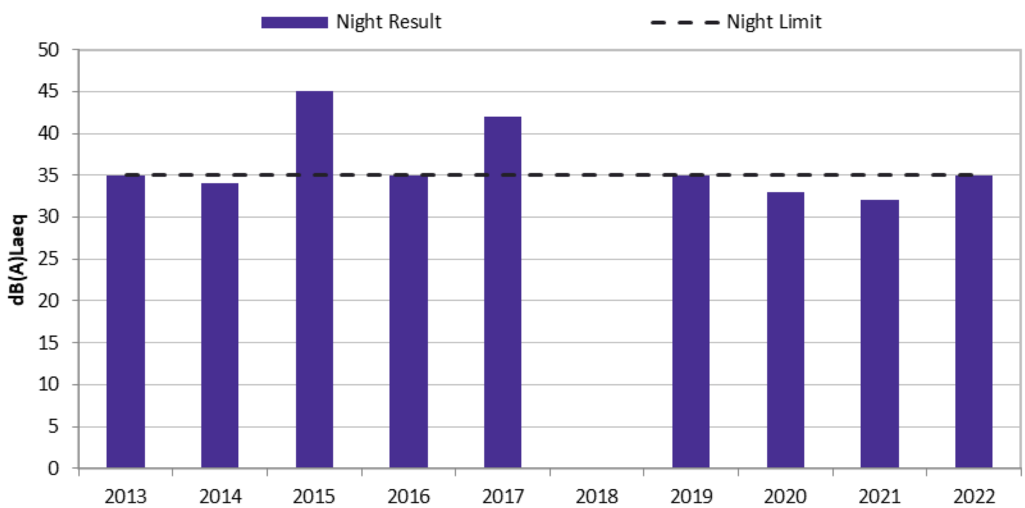


Figure 6-6: Night Noise Monitoring Summary (2012 to 2022)

6.2.5 Implemented / Proposed Improvements

Clarence Colliery has previously installed a reinforced noise barrier at the rotary breaker to shield the hopper to mitigate any potential noise from this source.

Noise management controls are considered effective based upon compliance with the noise criteria. Clarence will continue to implement the WRNMP.

A sound power level assessment was proposed to be conducted during the 2022 reporting period to determine possible areas of improvement associated with the equipment currently in service at Clarence. This monitoring assessment was postponed during the reporting period and will now be undertaken in 2023.

6.3 BLASTING

There was no blasting carried out at Clarence Colliery in the 2022 Reporting Period.

6.4 AIR QUALITY

6.4.1 Environmental Management

Clarence Colliery monitors air quality aspects in accordance with the *Western Region Air Quality and Greenhouse Gas Management Plan, 2021* (AQGHGMP), as required by Condition 14 Schedule 3 of DA 504-00. Impact assessment criteria for air quality aspects is outlined in Condition 13, Schedule 3 of DA 504-00. Monitoring requirements are also specified in Condition M2.2 of EPL 726.

Key dust mitigation measures for Clarence Colliery operations include:

- Signage to display speed limits on all unsealed roads in the surface facilities area;
- A water truck on unsealed areas during use or windy conditions; and
- Water sprays (sprinkler system) on main roads and the coal product stockpile during dry and windy conditions.

All mitigation measures identified in the AQGHGMP are utilised as required and implementation of appropriate dust controls are triggered by a range of methods, including:

- Dust monitoring results, indicating an elevated level of dust beyond the site boundary;
- Site inspections and observation of visible dust plumes; and
- Meteorological data from the Pit Top weather station.

Clarence Colliery operates in accordance with the Trigger Action Response Plan (TARP) provided in Section 5.2 of the AQGHGMP.

As required by the AQGHGMP, current dust monitoring consists of:

- Three dust deposition gauges, collected monthly; and
- High Volume Air Sampler (HVAS) which measures PM_{10} and total suspended particulate (TSP), operating over two months of a calendar year.

The Air Quality Monitoring Locations at Clarence Colliery are displayed in **Figure 6-7** and outlined in **Table 6-4**.

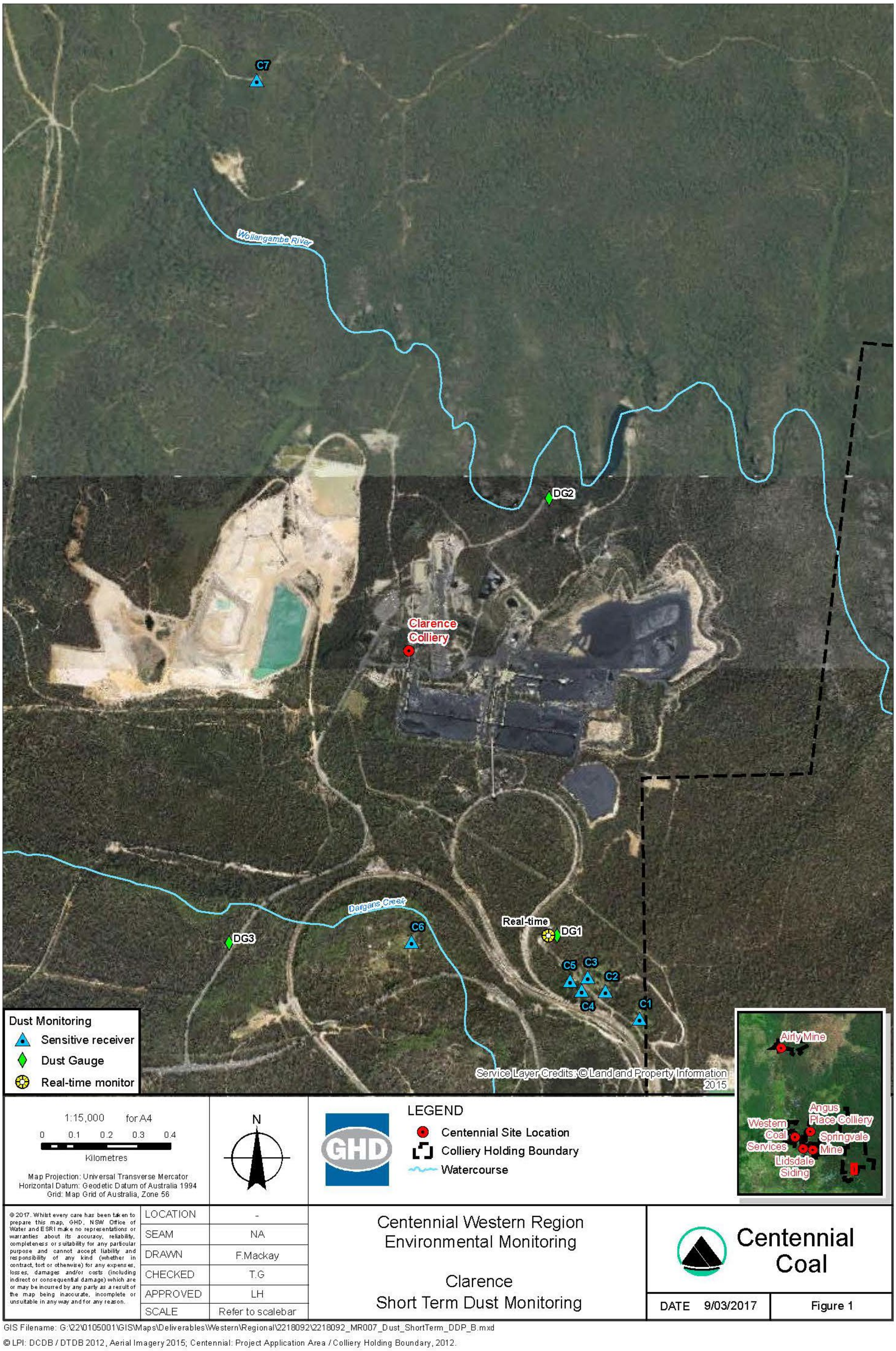


Figure 6-7: Clarence Air Quality Monitoring Locations

Table 6-4: Clarence Colliery Air Quality Monitoring Locations

Monitoring Point Reference	Description / Location
DG1	Located south-east of Clarence Operations
DG2	Located on the northern side of Clarence Operations
DG3	Located south-west of Clarence
TEOM	Located south-east of Clarence Operations

6.4.2 Environmental Performance

Schedule 3, Condition 13 of DA 504-00 provides the air quality criteria at any residence on privately owned land in **Table 6-5**, **Table 6-6** and **Table 6-7**.

Table 6-5: Long Term Criteria for Deposited Dust

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited Dust	Annual	2 g/m^2/month	4 g/m^2/month

Table 6-6: Short Term Criteria for Particulate Matter

Pollutant	Averaging Period	Criterion
Particulate matter < 10 µm (PM_{10})	24-hour	50µg/m^3

Table 6-7: Long Term Criteria for Particulate Matter

Pollutant	Averaging Period	Criterion
Total suspended particulate matter (TSP)	Annual	90µg/m^3
Particulate matter < 10 µm (PM_{10})	Annual	25µg/m^3

Notes: (a) Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method. (b) The air quality criteria in Tables above do not apply where the Applicant and the affected landowner have reached a negotiated agreement in regard to air quality, and a copy of the agreement has been forwarded to the Planning Secretary and EPA.

Depositional Dust

A summary of monthly data for insoluble solids at DG1, DG2 and DG3 is shown in **Table 6-8**. The deposition dust results for 2022 ranged from between <0.1 g/m^2/month and 2.3 g/m^2/month, with the lowest being at DG2 during the month of January and the highest being at DG3 during the month of September. **Figure 6-8** displays the rolling annual average of dust deposition for 2022.

The annual averages for deposited dust are below the annual criterion of 4g/m^2/month (**Table 6-8** and **Figure 6-8**) and remain complaint with the limits in the DA 504-00 and the AQGHGMP.

DG2 is the background dust gauge while DG1 and DG3 are the compliance monitoring points. The AQGHGMP stipulates air quality criteria of no more than a 2 g/m^2/month increase above the background dust gauge. The maximum increase against the background was 2.0g/m^2/month recorded by DG3 in September, which is below the air quality criteria (i.e. no more than 2g/m^2/month increase).

Table 6-8: Monthly Summary of Insoluble Solids g/m²/month during 2022

Month	DG1	DG2	DG3	Criteria
January	0.2	<0.1	0.6	maximum 2g/m²/month increase against the background (DG2)
February	0.2	0.1	0.4	
March	0.2	0.2	0.2	
April	0.2	0.1	0.4	
May	0.2	0.3	0.3	
June	0.2	0.3	0.5	
July	0.3	*	0.5	
August	0.3	0.3	1.5	
September	0.5	0.3	2.3	
October	0.6	0.6	1.0	
November	0.5	0.1	0.7	
December	1.7	0.5	1.2	
Annual Average	**0.4**	**0.3**	**0.8**	4 g/m²/month

Notes: *Depositional Dust Gauge D2 damaged during the month of July, no sample available results for the July

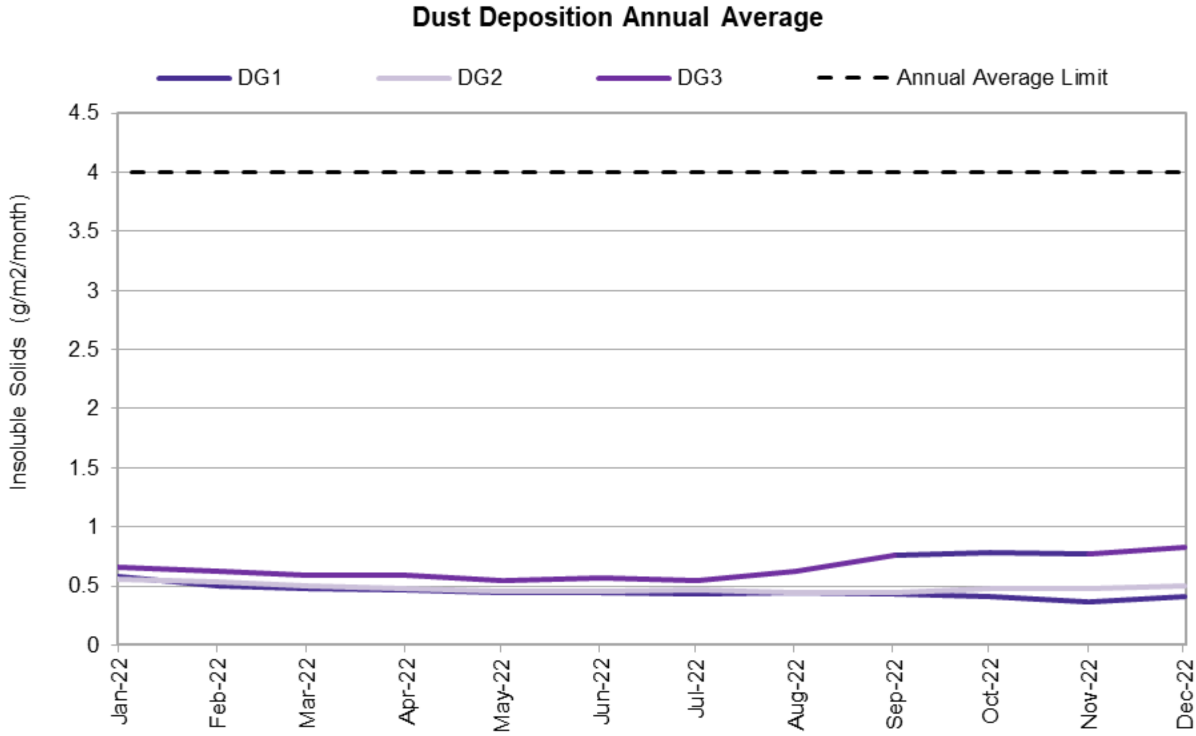


Figure 6-8: 2022 Depositional Dust Annual Results

PM_{10} and TSP

Real time air quality monitoring for PM_{10} utilises a TEOM unit (as shown on **Figure 6-7**).

Table 6-9 presents the PM_{10} and TSP monitoring results obtained during the Reporting Period. **Figure 6-9** and **Figure 6-10** displays the monitoring results for 2022, including the rolling annual average, of PM_{10} and TSP respectively.

The 24hr average and annual average results for PM_{10} are below the criterion of 50µg/m³ and 25µg/m³ respectively (**Table 6-9** and **Figure 6-9**) and remain complaint with the limits in DA 504-00 and the AQGHGMP.

The annual average results for TSP are below the criterion of 90µg/m³ (**Table 6-9 and Figure 6-10**) and remain complaint with the limits in DA 504-00 and the AQGHGMP. The TEOM unit PM_{10} data capture rate was 83% during the Reporting Period, primarily due to power outages, damaged filters and equipment tampering by unknown persons.

Table 6-9: 2022 Results Particulate Matter

	Criteria (µg/m³)	Maximum (µg/m³)	Mean (µg/m³)
24hr PM_{10} (short term)	50	36.6	N/A
PM_{10} (long term)	25	N/A	4.4
Estimated TSP[1]	90	N/A	13.6

[1] A ratio of PM_{10} and TSP is used to estimate TSP contributions. For Clarence a ratio of 0.40 is used to calculate compliance with the TSP criteria from the PM_{10} data.

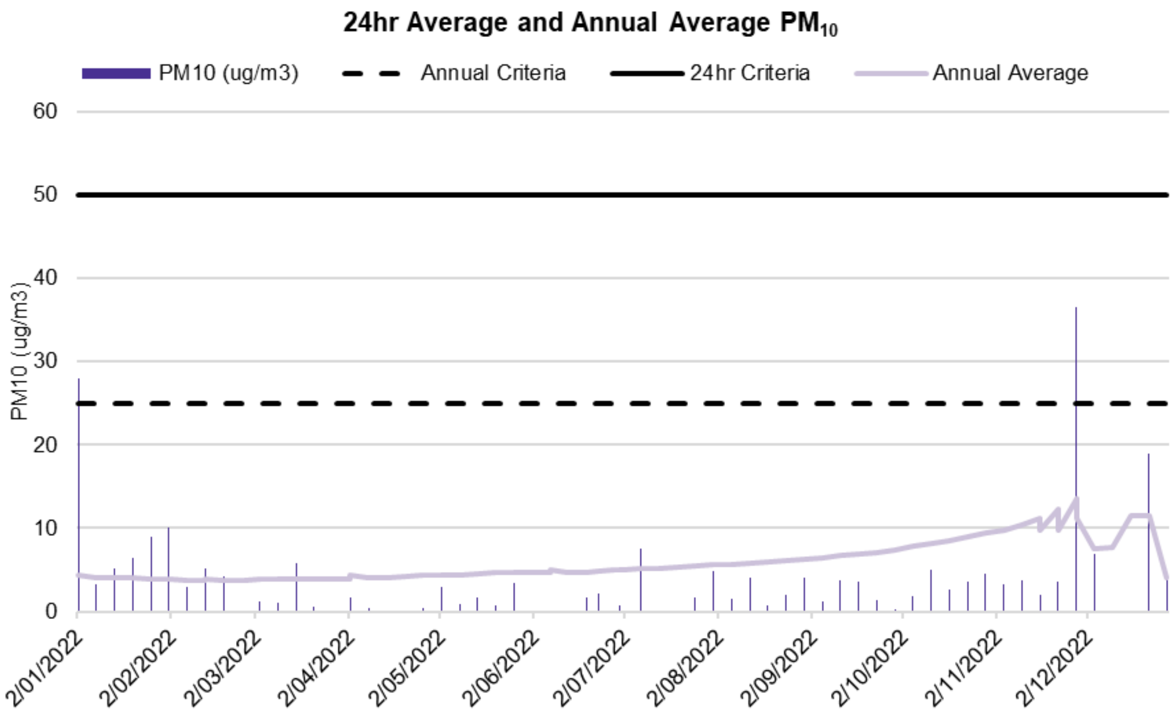


Figure 6-9: 24hr and Annual Average PM_{10}

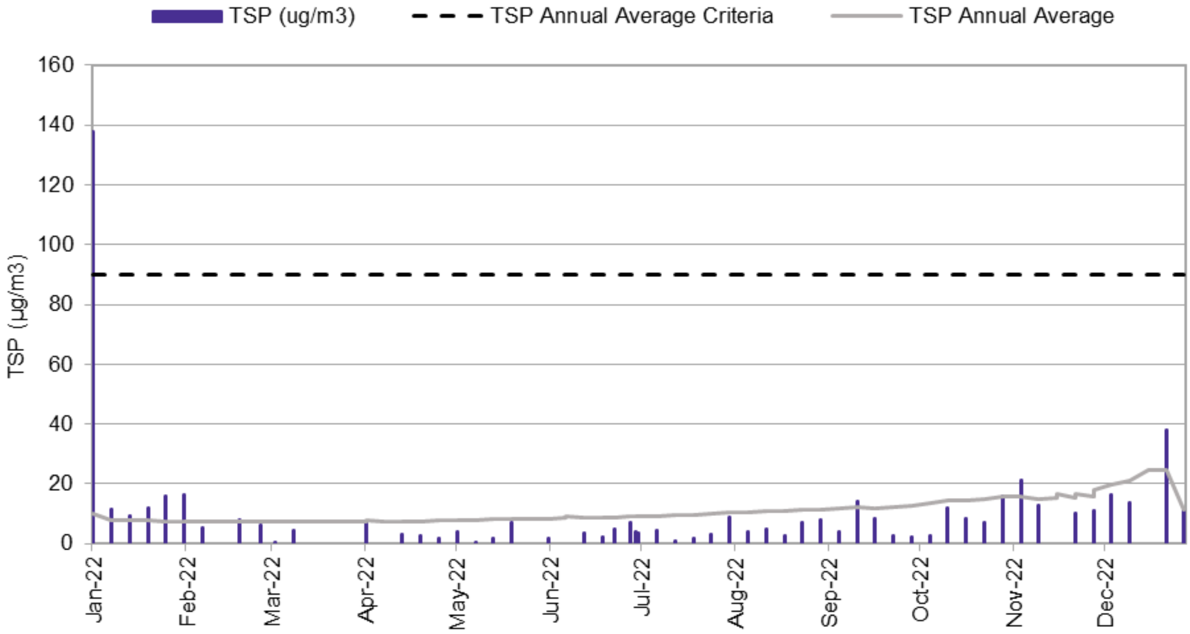


Figure 6-10: Annual TSP Summary Results at HVAS

6.4.3 Comparison Against Predictions

Dispersion modelling predictions of dust deposition rates and TSP and PM_{10} were completed for the MOD2 Environmental Assessment for Reject Emplacement Area (REA) VI by SLR (2013) and are shown in **Table 6-10**.

The results of the air quality modelling (SLR, 2013) show that the predicted concentrations and deposition rates for incremental particulate matter (TSP, PM10, PM2.5 and dust deposition) were below the applicable impact assessment criteria at all assessment locations for all modelled scenarios (GHD 2013).

The modification report for MOD9, identified there will be a small increment in particulate emissions from the additional trucks being loaded and unloaded, however this is unlikely to result in an exceedance of air quality criteria (JBA 2022).

All air quality monitoring results are well below annual criteria and consistent with predicted results.

Table 6-10: Predicted Air Quality Concentrations

Parameter	Averaging Period	Assumed Background Ambient Level	Predicted Air Quality Concentrations (Background + Project)[1]
Deposited Dust[2]	Annual	2 g/m²/month	2.1 g/m²/month
TSP[3]	Annual	18.5 µg/m³	20.9 µg/m³
PM_{10}[4]	24-hour	43.3 µg/m³	44.2 µg/m³
	Annual	9.4 µg/m³	10.5 µg/m³

[1] Maximum increment due to Clarence Colliery operations at identified sensitive receiver locations (GHD, 2013)
[2] Project criterion – 2 g/m²/month (incremental), 4 g/m²/month (cumulative)
[3] Project criterion – 90 µg/m³
[4] Project criterion – 50 µg/m³ (24-hour averaging period), 25 µg/m³ (annual averaging period)

6.4.4 Long Terms Analysis

Table 6-11 provides a summary of air quality monitoring results for the previous 5 years from 2018 to 2022, including the annual averages for deposition dust (insoluble solids), PM_{10} and TSP. Note, 2019 was affected by regional drought and bushfire events.

A summary of air quality exceedances recorded at Clarence Colliery over the last five (5) years is displayed in **Table 6-12**.

Air quality monitoring during the Reporting Period confirmed dust deposition, TSP and PM_{10} results were below their respective 24hr and annual average criteria and are consistent with long term data trends and predications.

Table 6-11: Long Term Air Quality Monitoring Summary (2018 - 2022)

Monitoring Location	Annual Averages					Development Consent Criteria (Annual Average)
	2018	2019	2020	2021	2022	
Insoluble Solids (g/m²/month)						
DG1	1.2	1.5	1.1	0.6	0.4	4 g/m²/month
DG2	1.6	1.2	1.2	0.6	0.3	
DG3	2.1	1.1	0.6	0.7	0.8	
PM_{10} (µg/m³)						
Real-time	7.04	14.95	5.76	9.35	4.4	25 µg/m³
TSP (µg/m³)						
Real-time	9.61	17.76	7.92	17.98	10	90 µg/m³

Table 6-12: Exceedances for Particulate Matter

	2018	2019	2020	2021	2022
24hr PM_{10} (short term)	0	1[1]	0	0	0
PM_{10} (long term)	0	0	0	0	0
TSP	0	0	0	0	0

[1] Exceedance due to extraordinary events i.e. bushfires

6.4.5 Implemented / Proposed Improvements

Dust emission controls are considered effective based upon compliance with the air quality criteria during the Reporting Period.

Clarence Colliery will continue to implement the AQGHGMP.

6.5 GREENHOUSE GAS MONITORING

6.5.1 Environmental Management

Condition 23, Schedule 3 of DA 504-00 requires Clarence Colliery to monitor greenhouse gas emissions generated by the development, as well as investigate ways to reduce greenhouse gas emissions on site and report on these investigations in the Annual Review.

Greenhouse gas (GHG) reporting and management measures are provided in the AQGHGMP. GHG emissions from Clarence Colliery will continue to be monitored and reported annually in accordance with the *Commonwealth Government National Greenhouse and Energy Reporting Scheme* (NGERS) established by the *National Greenhouse and Energy Reporting Act 2007* (NGER Act).

In accordance with the AQGHGMP (2021), in addition to tracking energy demand and GHG emissions per tonne of ROM coal produced, measures to minimise GHG emissions, to the greatest extent practicable, are implemented. These include:

- Cost effective measures to improve energy efficiency;
- Regular maintenance of plant and equipment to minimize fuel consumption; and
- Consideration of energy efficiency in plant and equipment selection

6.5.2 Environmental Performance

Table 6-13 reports the Scope 1 Emissions (Direct) and Scope 2 Emissions (Indirect) in tonnes CO2-e produced for the current period and compares these against EIS predictions.

Table 6-13: Summary of GHG Emissions Reporting for 2018 to 2022

Emission Source	Estimated Emissions (tonnes CO_2-e)					Predicted Emissions
	FY18	FY19	FY20	FY21	FY22	
Scope 1 Emissions						
Fuel combustion	2,448	2,512	2,602	2,516	2,501.2	*1,419*
Oil/Grease consumption	114	135	123	79	58.9	*124*
SF_6	0	0	0	0	0.2	*0.2*
Fugitives - CH_4	0	0	0	0	0	*13,689*
Fugitives - CO_2	9,977	11,797	9,573	9,303	8,059	
Total Scope 1	**2,473**	**3,403**	**5,306**	**7,572**	**8,701**	***15,233***
Scope 2 Emissions						
Electricity consumption	41,050	39,488	40,911	39,456	39,555	*40,911*
Total Scope 2	**41,050**	**39,488**	**40,911**	**39,456**	**39,555**	***40,911***
Total Greenhouse Gas Emissions						
Scope 1 and 2 Emissions	**53,589**	**53,932**	**53,209**	**51,354**	**50,174**	***56,144***

6.5.3 Comparison Against Predictions

Table 6-13 summarises greenhouse gas emissions predicted for the project in the Clarence Colliery - Modification 6 Greenhouse gas assessment (EMM, 2020), with comparison to actual emissions during the current and previous reporting periods.

During the 2022 Reporting Period the calculated Scope 1 and Scope 2 GHG emissions for Clarence were 8,701 (t CO_2-e) and 39,555 (t CO_2-e) respectively and the combined total GHG emissions 50,174 (t CO_2-e) were approximately -11% less than the 56,144 (t CO_2-e) as predicted in the EIS (EMM, 2020).

It is noted there have been subsequent project modifications, however MOD 7 involved administrative condition changes to provide extraction plan conditions for the site moving forward and therefore no change to predicted emissions.

For MOD9, a modification report was prepared by James Bailey & Associates Pty Ltd (JBA) which identified there would be an incremental increase in (scope 3) GHG emissions resulting from the additional truck movements required (as opposed to this coal being transported by rail), however this increase will be immaterial in relation to NSW's or Australia's total GHG emissions (JBA, 2022). There was no associated change to the predicted scope 1 or scope 2 emissions for the project (as presented in **Table 6-13)**.

6.5.4 Long Term Analysis

Table 6-13 presents a summary of GHG emissions reported over the last five (5) years. Based on the information reported, GHG emissions have been below EIS estimates for the project and have generally been decreasing year on year.

6.5.5 Implemented / Proposed Improvements

Mitigation measures to minimise to the greatest extent practicable GHG emissions from Clarence included regular maintenance of plant and equipment to minimise fuel consumption and consideration of energy efficiency in plant and equipment selection/phase.

6.6 BIODIVERSITY

6.6.1 Environmental Management

Ecology monitoring, assessment and reporting are currently managed through the Western Region Biodiversity Management Plan (WRBMP). At the time of preparing this 2022 Annual Review, the WRBMP was still under consideration with DPE. Management measures within the WRBMP specific to Clarence include, but not limited to access management, bushfire management, erosion control, salinity management, preclearance surveys and waste management.

Eight native vegetation communities have been mapped as occurring within the Clarence Colliery holding. Two of these communities include the Temperate Highland Peat Swamps on Sandstone community which is listed under the EPBC Act.

This community is commensurate with the Newnes Plateau Shrub Swamps and Newnes Plateau Hanging Swamps, with Newnes Plateau Shrub Swamps listed as an Endangered Ecological Community (EECs) under the Biodiversity Conservation Act 2016 (BC Act). Within the mining area, the partial extraction technique ensures minimal subsidence of less than 100 mm. It is therefore extremely unlikely that mining at Clarence Colliery will have an impact on the local flora and ecological communities.

A flora monitoring program was setup as part of the Subsidence Management Plan (SMP) process to verify that this is the case and to identify any natural variations. Risk and potential impacts to threatened flora over the mining area is managed through the SMPs, Extraction Plans and the WRBMP.

6.6.2 Environmental Performance

Clarence has obligations for the management and monitoring of offset sites and undertakes monitoring in accordance with the Subsidence Management Plans for Flora and Fauna. The results of this monitoring are detailed in the following sections.

Flora Monitoring

During the Reporting Period, Gingra Ecological Surveys (GES) completed flora monitoring across six broad areas; Clarence East (Eastern SMP area), Clarence West (also known as the '700 area'), Outbye, 800 Area, 900 Area and Pagoda Swamp. Flora monitoring occurred in Summer, Autumn and Spring in 2022. The results of the Spring flora monitoring are summarised below with the complete reports provided in **Appendix 3**.

A new site was established in February 2021. This is in Pagoda Swamp, which is located to the south of Waratah Ridge, south-west of Mount Horne. Locations of the sites and their sampling dates are provided in **Table 6-14.**

Table 6-14: 2022 Flora Survey Sites

Site	Location	Type	Easting (GDA)	Northing (GDA)
Clarence East				
PAG_01	Gorilla Rock	Impact	246753	6300035
PAG_02	Gorilla Rock	Impact	246755	6299924
PAG_03	Waratah East	Impact	247251	6300707
PAG_04	Waratah East	Impact	246938	6300784
PAG_05	Waratah North	Control	247962	6303960
PAG_06	Waratah North	Control	247888	6303910
BNS_01	Bungleboori North Swamp	Impact	245582	6302273
BNS_02	Bungleboori North Swamp	Impact	246290	6303633
Clarence West				
CLW_01	Heath	Impact	241774	6295584
CLW_02	Swamp	Impact	242596	6295527
CLW_03	Happy Valley Swamp	Impact	241923	6296954
CLW_04	Hanging swamp	Impact	241904	6298016
CLW_05	Pine Swamp	Control	240804	6300186
CLW_06	Heath—Paddys Creek Ridge	Control	240472	6299171
Outbye				
CLAO_01	S of Bungleboori Creek	Impact	245023	6297763
CLAO_02	S of Bungleboori Creek	Impact	245092	6297707

Site	Location	Type	Easting (GDA)	Northing (GDA)
CLAO_03	N of Bungleboori Creek	Impact	245504	6298627
CLAO_04	N of Bungleboori Creek	Impact	245294	6299168
800 Area				
CLAE_01	Gully N of Dumbano Fire Trail dam	Impact	248971	6295894
CLAE_02	Heath ridge	Impact	247495	6295216
CLAE_03	Heath ridge	Impact	247271	6295388
CLAE_04	Secret Swamp	Impact	247203	6296462
CLAE_05	Secret Swamp	Impact	247159	6296404
CLAE_06	Olearia Swamp	Impact	247648	6296165
CLAE_07	Olearia Swamp	Impact	247701	6296288
CLAE_08	Olearia Swamp	Impact	247789	6296830
900 Area				
PSB_01	Paddys Swamp Branch	Impact	241338	6298523
PSB_02	Paddys Swamp Branch	Impact	241404	6298617
PS_03	Paddys Swamp (lower)	Impact	241822	6299156
Pagoda Swamp				
PAS_01	Pagoda Swamp	Impact	242878	6300496

The entire study area was subject to the Gospers Mountain bushfire, which burnt through the area from November to December 2019. Most sites were affected by very high intensity fire, but fire intensity at a small number of plots was patchier with small areas of shrubs and ground cover plants remaining unburnt. Plots with some unburnt patches included PAG_01, PAG_03, PAG_05, CLAO_01, CLAO_03 and CLAO_04. At the swamp sites the bushfire had burnt above ground vegetation with only very localised patches of surface peat consumption. No deep consumption of peat deposits was observed in the study area (GES 2022).

Clarence East & Clarence West Heath & Pagoda Sites

- At PAG_01 and PAG_03 some *Actinotus helianthi* plants had died and *Stylidium graminifolium* plants had leaf discoloration due to waterlogging.
- At PAG_02 Acacia asparagoides plants were affected by leaf predation.
- At PAG_03 leaf damage was observed on *Phyllota squarrosa* plants due to browsing. Senescent *Actinotus helianthi* plants were also observed at PAG_04.
- at PAG_04 *Caustis pentandra* plants had branch dieback.
- At PAG_05 *Banksia ericifolia* and *Banksia penicillata* plants were suffering leaf predation due to insect attack. Severe dieback of *Stylidium lineare* plants was also observed, due to waterlogging.
- At PAG_06 *Banksia penicillata* plants were suffering leaf predation due to insect attack.
- At CLW_01 *Phyllota squarrosa* plants showed signs of leaf predation. Several other plant species at this site had dieback associated with waterlogging.

- At CLW_06 *Leptospermum trinervium* plants had leaf dieback due to waterlogging. Leaves of *Mirbelia rubiifolia* and *Xanthorrhoea media* were suffering leaf discoloration due to waterlogging.
- Species richness at the two plots surveyed in spring 2022 were similar to previous records, apart from at PAG_01 where species richness was slightly higher than previous records.

Clarence East and West Swamp Sites

- At CLW_02 *Poa sieberiana* subsp. *cyanophylla*, *Grevillea acanthifolia*, *Patersonia fragilis* and *Lomandra filiformis* subsp. *coriacea* plants had dieback due to waterlogging.
- No signs of disease were recorded at CLW_03.
- At CLW_04 *Olearia quercifolia* plants were affected by severe dieback due to a fungal pathogen.
- At CLW_05 one *Leptospermum grandifolium* plant had leaf discoloration due to waterlogging, *Juncus continuus* plants had dead stems, a *Eucalyptus pauciflora* sapling had leaf dieback and *Celmisia longifolia* plants had been browsed.
- No signs of plant disease were observed at either of the BNS_01 or BNS_02 plots.
- Whilst there was a decline in species richness in autumn 2022 compared to summer counts, the levels are within the previously recorded range and consistent with normal post-fire trends.
- In spring 2022 species richness was lower. The very wet conditions meant that small ground layer plants had either died or were difficult to detect due to the saturated conditions.

Clarence Outbye

- There was a single instance of plant disease at the Outbye plots CLAO_01 in autumn 2022 where several *Isopogon anemonifolius* plants had died due to waterlogging.
- The species richness counts for CLAO_01 and CLAO_02 recorded in autumn and spring 2022 were similar to levels recorded in spring 2021.

Clarence 800 Area

- At CLAE_01 *Banksia spinulosa* plants had leaf yellowing due to waterlogging.
- Two plant species at CLAE_02 were showing signs of leaf dieback and yellowing associated with waterlogging, *Conospermum taxifolium* and *Banksia spinulosa*. At the other heath site CLAE_03, *Isopogon anemonifolius* plants had dark discoloration due to waterlogging.
- At CLAE_04 *Banksia spinulosa* plants had leaf yellowing due to waterlogging.
- At CLAE_06 and CLAE_08, *Olearia quercifolia* plants were in good condition, with no signs of dieback or leaf damage.
- Apart from the few identified impacts of the prolonged wet weather conditions, plant health was good.
- Table 3 shows some species richness figures following the 2013 and 2019 bushfires. The levels in spring 2022 were similar to 2021 levels with the exception of CLAE_04 and CLAE_08 where species richness was lower in spring 2022.

Clarence 900 Area

- Sites were established along different sections of Paddys Swamp in the Clarence 900 area in November 2014. This area was affected by the October 2013 bushfire. The sites burnt again in December 2019.
- There are a range of human disturbance factors already operating in the vicinity of the two sites in the upper catchment (PSB_01 and PSB_02) of Paddys Swamp. This includes drainage works associated with earlier operation of the sand quarry 600 meters to the south, extensive new clearing of the quarry and a trail bike track to the north of PSB_01.
- Site PS_03 is located in the main section of Paddys Swamp, in an area substantially free of past human disturbance, although an old, defunct pipeline passes by the eastern edge of the swamp.
- Species richness at the Paddys Swamp sites in spring 2022 was within the previously recorded range and similar to levels recorded in autumn 2022.
- Plant health less satisfactory than previous records with several instances of waterlogging associated plant disease. At PSB_01 *Banksia marginata* plants were suffering from leaf predation. Eucalypt saplings which had emerged following the 2019 bushfire were severely impacted with several dead *Eucalyptus radiata* plants.
- At PS_03 *Baumea rubiginosa* plants had leaf yellowing.

Pagoda Swamp

- A new monitoring survey plot was established at Pagoda Swamp in February 2021. During 2021 mining operations approached the southern end of this Swamp.
- Nineteen plant species were recorded within the plot in summer 2021, 26 species were recorded in autumn 2021 and 20 species were recorded in spring 2021 when the Swamp was exceptionally wet. In summer 2022, 26 species were again recorded. There was some vegetation damage with shrubs being pushed over by water during a November storm. In June 2022 sixteen species were recorded, followed by 21 species in spring 2022.

Plant condition in spring 2022 was affected by record high rainfall with many instances of leaf yellowing and death due to waterlogging with the period of above average rainfall now reaching 33 months in duration and very wet months in January, March and July. Plant disease associated with pathogens was limited to very few observations.

The occurrences of exotic plant species in 2022 were consistent with a post-fire decline with limited new germination in response to the high rainfall. Occurrences of weeds continue to be at plots with a disturbance history involving proximity to clearing and pine plantation, logging, feral animals and recreational use.

As the plots were all bush fire affected, with most sites suffering a very high intensity fire in December 2019, future surveys will be necessary to determine whether the recovery trajectory continues to be consistent with past events, or whether particular plots have a different trajectory due to factors other than fire intensity. The trajectory following the October 2013 had indicated that ecosystem function across the study area was normal. On the current trajectory following the December 2019 bushfire it is indicated that ecosystem functioning at recent and historic undermined plots being no different to control plots.

There have been no indications of residual effects of subsidence in areas undermined previously, particularly in the Clarence East area where mining occurred in 2019-20. The patterns of species richness, species composition and plant disease relate strongly to bush fire impacts and recovery and the persistent wet conditions with almost three years above average rainfall. There is no indication of a mining effect (GES, 2022).

Fauna Monitoring

Fauna monitoring during the Reporting Period at Clarence Colliery was undertaken by Biodiversity Monitoring Services (BMS) (**Table 6-15**). Fieldwork for the 700 Area (Eastern, Western and Outbye), 800 Area (Eastern Portion) and 900 Area were partially completed in the Reporting Period due to access constraints. The complete fauna monitoring reports are included in **Appendix 4**.

Table 6-15: 2022 Fauna Survey Sites

Site Name	Easting	Northing	Landscape	Establishment date	Undermining date
Clarence East Area					
Heath 1	245245	6299216	Pagoda heath above steep-sided valley	Autumn 2008	1998 (development)
Heath 2	245294	6297667	Woodland below Pagoda heath in steep-sided valley	Autumn 2008	1998 (development)
Gully	245497	6298910	Woodland above steep-sided valley	Autumn 2008	1999 (development)
Clarence 800 Area					
800 Swamp 1	247193	6296433	Heath Swamp within steep-sided valley	Autumn 2009	Dec 2013 (development)
800 Swamp 2	248940	6295833	Woodland with small patches of hanging swamp within steep-sided valley	Autumn 2009	June 2015 (development), June 2016 (extraction)
800 Heath	247448	6295310	Ridgetop heathland	Autumn 2009	April 2018 (extraction), development unknown
Clarence 900 Area					
A North	241839	6299342	Heath Swamp within steep-sided valley	Spring 2014	October 2022
B South	241374	6298571	Woodland moving into heath swamp within shallow-sided valley	Spring 2014	August 2022 (extraction)
CLW01	240634	6299166	Pagoda heath above steep-sided valley	Spring 2006	Spring 2018 (extraction)
CLW04	241899	6297998	Heath swamp within steep-sided valley	Spring 2006	April 2015 (development) Nov 2015 (extraction)
CLW05	240772	6300158	Heath swamp within steep-sided valley	Spring 2006	December 2018

Site Name	Easting	Northing	Landscape	Establishment date	Undermining date
Nine Mile	242000	6301270	Heath Swamp within steep-sided valley	Autumn 2018	NA
Paddy's Swamp	241375	6299055	Heath Swamp within steep-sided valley	Autumn 2018	July 2022
Clarence West Area					
CLW01	240634	6299166	Pagoda heath above steep-sided valley	Spring 2006	Mid 2018 (extraction)
CLW02	242610	6295587	Heath swamp within shallow-sided valley	Spring 2006	March 2010 (extraction)
CLW03	241840	6297085	Heath swamp within steep-sided valley	Spring 2006	Sept 2010 (development), Dec 2010 (extraction)
CLW04	241899	6297998	Heath swamp within steep-sided valley	Spring 2006	April 2015 (development), November 2015 (extraction)
CLW05	240772	6300158	Heath swamp within steep-sided valley	spring 2006	December 2018
CLW06	241657	6295513	Pagoda heath above steep-sided valley	spring 2006	March 2011 (development), December 2011 (extraction)
Nine Mile Swamp	242000	6301270	Heath Swamp within steep-sided valley	autumn 2018	NA
Paddy's Swamp	241375	6299055	Heath Swamp within steep-sided valley	autumn 2018	NA

Clarence 800 Area

Terrestrial Fauna Monitoring at the three Clarence 800 (ML 1583) Area sites was unable to be conducted in autumn, spring and summer 2022. The only access to the 800 Area is via the Wollangambe/Dumbano Fire Trail. The condition of the trail has degraded due to the adverse weather throughout 2022. Large stretches of bog hole and saturated ground meant the road in was unable to be traversed for survey work in throughout 2022. As such, there is no data to update that of the 2021 report (BMS 2022).

Clarence Outbye Area

Terrestrial Fauna Monitoring at the three sites (in the Clarence Outbye Area were unable to be conducted in autumn, spring and summer 2022. The only access to the Heath 1 and Gully is via Waratah Ridge Road. Waratah Ridge Road has been closed since February due to the Wartime Remnants Clean up Project. This hazardous materials clean-up is being undertaken across the entrance to the fire trail that leads out to two of the Outbye sites. Alternative access via Glow Worm Tunnel Road would still not facilitate access, though access along this road was also restricted by wet weather in autumn. The only access to Heath 2 site is via the Wollangambe/Dumbano Fire Trail.

The condition of the Wollangambe/Dumbano Trail has degraded due to the adverse weather throughout 2022. Large stretches of bog hole and saturated ground meant the road in was unable to be traversed for survey work in throughout 2022. As such, there is no data to update that of the 2021 report (BMS 2022).

Clarence 900 Area (Panels 913 and 917)

The 900 Area sites were surveyed between the 16th and 20th May, the 31st October and 4th November, and 28th November and 9th December 2022.

The results from the survey of the Clarence Colliery 900 Area in 2022 show that the assemblages found are more typical of that found throughout Newnes Plateau than we would expect after extensive fires swept through the area in December 2019. The timing of the survey was successful, in terms of the number of individuals and diversity of species within the main fauna groups surveyed, though reduced survey efforts of some sites used in analyses were experienced in 2022 due to access issues.

Species richness was on average for reptiles and amphibians, and on the lower side of average for birds and mammals. Richness for all four groups declined since last year. Bird and mammal Simpson's were stable, possibly showing the slightest decline over time. Mammal Simpson's and richness are relatively stable over the long term, but trapping rates declined sharply post fire. They had been tracking up since the State Mine fire, but the Gospers Mountain fire reset the system.

Recovery of small mammal captures was tracking in advance of the previous fire, but stalled in 2022. Reptile Simpson's and richness were average, noting that wet survey conditions in 2021-22 did not favour this group. Low numbers in 2014 are due to the fact surveys only began in spring 2014, so survey effort was greatly reduced. Despite the wet conditions, amphibian diversity indices showed no growth in 2022. Reduced access/survey effort and cool conditions may explain this (BMS 2022).

Swamps in this area had peat mostly consumed and canopy layers were fully burnt, so finding Blue Mountains Water Skink in 2021 was surprising. This species was found again in 2022, with three records across the two 900 Area swamps. The availability of rock outcropping near 900 North means refugia for small mammals allowed some to survive the fire, particularly Antechinus.

Bat species richness and activity were very low in 2022, but this is expected with cold wet conditions. As is often the case with fire, once the vegetation and associated food source is wiped out, there is a delay in seeing return of species to the landscape. There were sufficient numbers and diversities of these fauna groups to be able to calculate a set of diversity indices that form part of the baseline monitoring database. Above average rainfall in most months since fire appears to have helped start the regeneration process on the Plateau. Fauna results have followed with overall abundance down, but most functional groups represented (BMS 2022).

Given the low levels of subsidence from previous mining at Clarence Colliery, and the predicted low levels (30mm) of subsidence for 900 Area, the risk of adverse impacts on fauna within this area is considered to be low. The monitoring of recovery from fire within those sites mined and un-mined will be an important tool in the on-going assessment of mining activities (BMS 2022).

Clarence West Area

The CLW sites were surveyed between the 9th May and 3rd June 2022, 10th October and 11th November 2022, and 28th November and 9th December 2022.

The results from the survey of the Clarence Colliery Western SMP Area in 2022 show that the assemblages found are more typical of that found throughout Newnes Plateau than we would expect after extensive fires swept through the area in December 2019. The timing of the survey was successful, in terms of the number of individuals and diversity of species within the main fauna groups surveyed, though park closure and weather conditions caused access issues for 5 sites across autumn and spring this year.

Most diversity parameters have remained stable over the long term, except bird and amphibian species richness which have increased. Most diversity parameters that have remained within levels of expected variation still declined sometime in 2017-2019, with native non-bat mammal species richness the only measure to show an all time low in the drought/fire period (2020). Small mammal capture rates almost returned to pre fire levels in 2019, six years post fire, but crashed in 2020 to an all time low. This is likely due to the lack of rocky refugia proximal to the CLW sites, combined with the severity of the peat burning in many of the swamps and the frequency of fire.

Bat activity was down in 2022, though species richness was still within the normal level of variation, suggesting the invertebrate food source that this group relies on may have experienced low activity due to cold/wet conditions. As is often the case with fire, once the vegetation and associated food source is wiped out, there is a delay in seeing return of species to the landscape.

There were sufficient numbers and diversities of these fauna groups to be able to calculate a set of diversity indices that form part of the baseline monitoring database. Above average rainfall in most months since fire appears to have helped start the regeneration process on the Plateau. Fauna results have followed with overall abundance down, but most functional groups represented.

Given the low levels of subsidence from previous mining at Clarence Colliery, the risk of adverse impacts on fauna within this area is considered to be low. Statistical analysis of fauna populations in the CLW areas suggest changes in diversities are primarily due to climatic changes, though some evidence of lower diversity measures in undermined sites is shown.

The differences seen this year were similar to last year, but different to previous years (except bird Simpson's), so continued monitoring of these indices will tell whether we have evidence of ongoing change due to mining, or simply a temporal anomaly. At present, there appears to be little conclusive evidence of subsidence impacts upon the fauna diversity at CLW Area (BMS 2022).

Aquatic Ecology Monitoring

As required by the Clarence Colliery Water Management Plan (May 2017), Marine Pollution Research Pty Ltd (MPR) were commissioned to undertake the biannual (Autumn and Spring) stream health monitoring in 2022, to assess the possible effects on aquatic ecology of:

- Wollangambe River below the Clarence Colliery Licensed Discharge Point 2 (LDP2).
- The upper Bungleboori Creek catchment; and
- The upper Carne and Dingo Creek catchments.

The stream health surveys are being conducted using standardised methods applied to other Centennial Coal stream health studies in the Coxs and Wolgan River upper catchments. A summary of the stream health results for Wollangambe River are provided below. For the complete report and all of the aquatic ecological monitoring completed during the 2022 Reporting Period refer to **Appendix 5**.

Wollangambe River

Leading up to both the autumn and spring 2022 aquatic ecology surveys, Clarence Colliery and the Wollangambe area was subject to above average rainfall with some major wet weather events causing large amounts of runoff and associated increases in LDP discharge. Discharge rates generally increased in times of greater rainfall and maintained more consistent rates of between 10-20 ML/day for most of 2022 (MPR 2023).

For five of the seven Clarence aquatic ecology monitoring sites, water quality in the Wollangambe River is influenced by the contribution of LDP002 discharges. For the most part, the 2022 seasonal survey water quality results were mostly within the ANZG (2018) default guideline values (DGVs) for slightly disturbed upland rivers and followed a similar pattern to that noted for previous years, however the upstream and reference sites produced values outside the DGV range owing to the naturally acidic, very low conductivity runoff from catchments containing swamps (MPR 2023).

The 2022 macroinvertebrate indices results varied between sites; while the autumn 2022 macroinvertebrate diversity, Signal and EPT index values were mostly consistent with, or improved compared to recent surveys (and within or above their respective LTM ranges), the spring 2022 survey results returned relatively low diversity values at all sites except WGRswamp, WGRdown and WGRXdown-edge, and low EPT values at WGRup, WGRtrib1 and WGRXdown-riffle sample (MPR 2023).

6.6.3 Comparison Against Predictions

Sections 5.6 and 5.7 of the 1993 EIS (R. W. Corkery & Co. 1993) for the Clarence Colliery Northern Extension discuss the predicted effects on flora and fauna to be caused by the development. The EIS concludes that the impacts on flora and fauna by underground mining would be minor, if any occurs at all. Section 6.6.2 concludes that there have not been any measurable impacts at those sites monitored, caused by mining activities within the lease area during the Reporting Period.

6.6.4 Long Terms Analysis

Long-term analysis of the threatened species is presented below for the Clarence 900 Area (Panels 913 and 917) (see **Table 6-16** and **Figure 6-11**) and the Clarence West (CLW) Area (see **Table 6-17** and **Figure 6-12**).

It is observed that the number of threatened species in the Clarence 900 Area has varied over the years, but remains fairly stable over the long term. Whilst in the CLW Area the number of threatened species has been increasing over time, peaking in spring 2018.

For the complete fauna monitoring reports and long term analysis refer to **Appendix 4**.

Table 6-16: Threatened species in 900 Area in autumn (A) and spring (S) over time

Category	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Woodland-dependent bird species (%)	-	-	-	-	-	-	64.5	65.4	64.9	74.5	65.6	72.7	75.0	71.1	82.8	77.4	73.1	75.8
Declining bird species (%)	-	-	-	-	-	-	6.5	7.7	2.7	8.5	9.4	6.8	4.2	7.9	10.3	9.7	3.8	6.1
Threatened species	-	4	3	7	4	4	5	8	5	7	5	5	6	4	6	3	4	3

Table 6-17: Threatened species in CLW Area in autumn (A) and spring (S) over time

Category	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Woodland-dependent bird species (%)	-	-	-	-	-	-	65	59	59	63	63	64	61	60	70	66	64	62
Declining bird species (%)	-	-	-	-	-	-	5	7	7	9	8	8	3	7	10	8	8	6
Threatened species	4	5	3	6	3	6	7	7	9	11	6	6	8	7	7	9	7	10

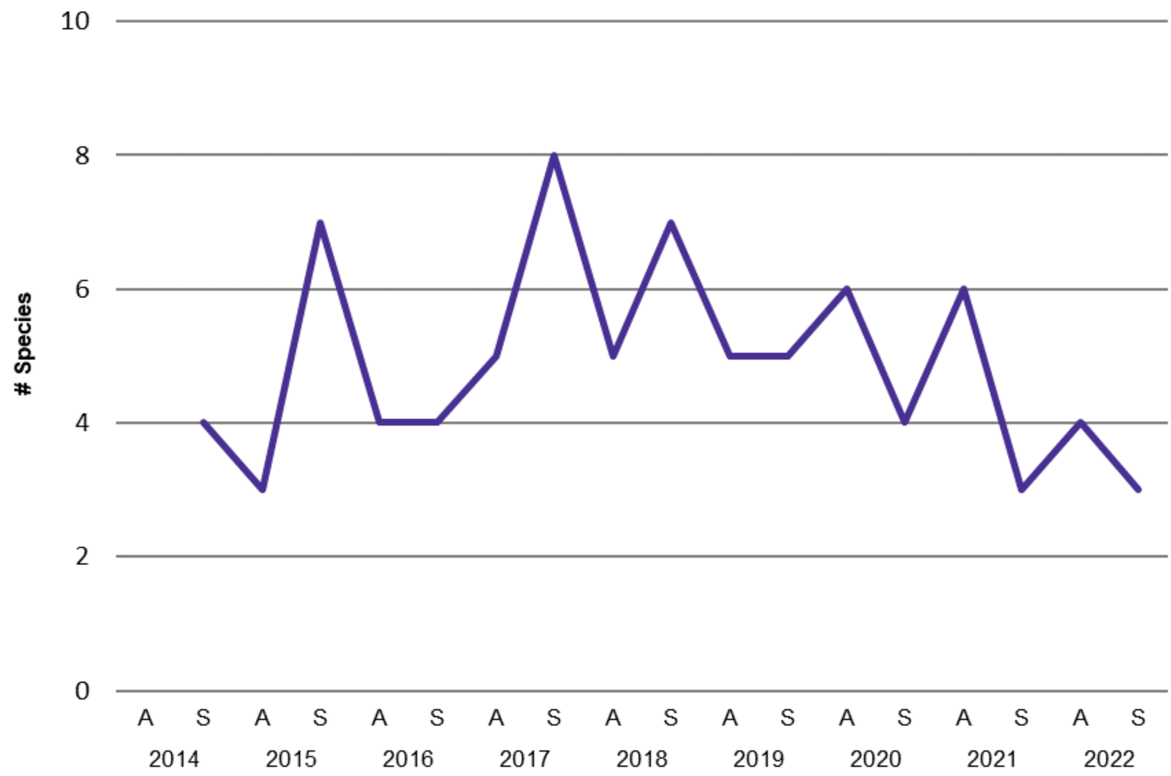


Figure 6-11: Number of threatened species in the 900 Area over time

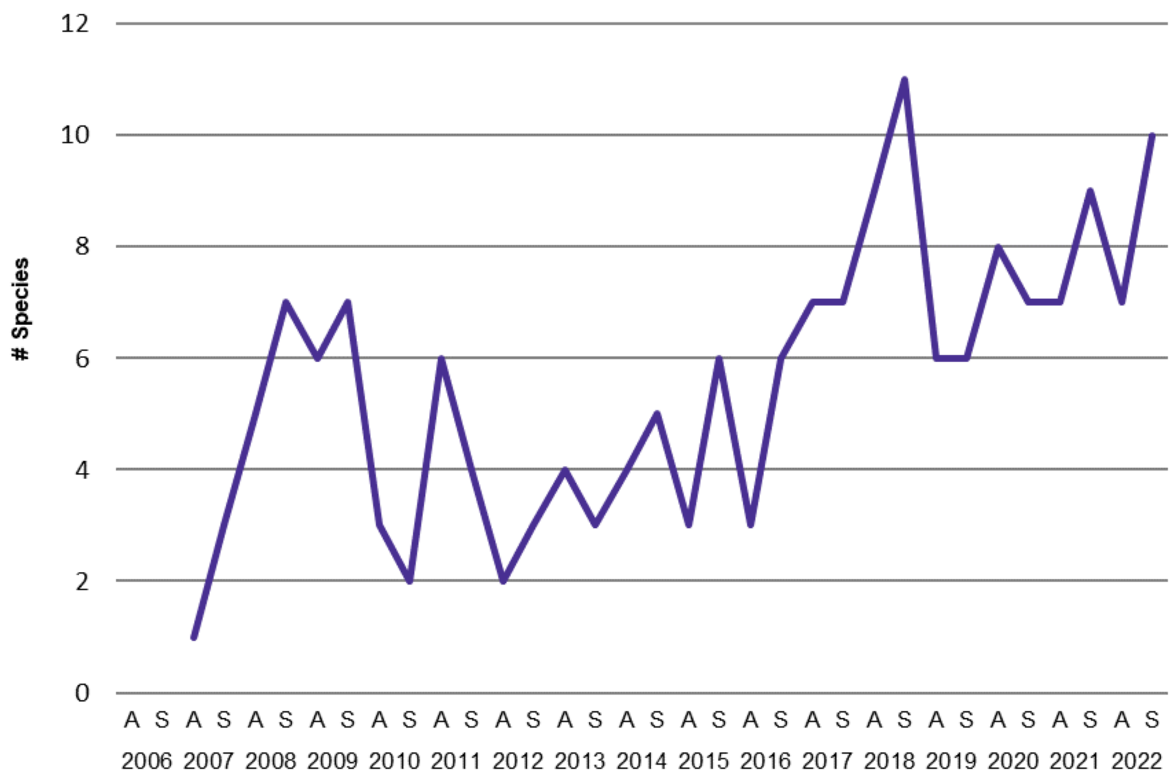


Figure 6-12: Number of Threatened Species in the CLW Area over time

6.6.5 Implemented / Proposed Improvements

Monitoring and inspections during the next Reporting Period will be undertaken to assess the effectiveness of the management measures for Clarence Colliery in accordance with the revised WRBMP, subject to its approval from the DPE.

Further consultation with DPE regarding the latest revision to the WRBMP (Version 6), will be undertaken during the next Reporting Period. Revision of the WRBMP to be undertaken in the next Reporting Period as required.

6.6.6 Biodiversity Offsets

In accordance with Schedule 3, Condition 12A, Clarence has provided a suitable offset for the clearing of 4.1 hectares of Newnes Plateau Narrow-leaved Peppermint- Silvertop Ash layered open forest and the loss of related biodiversity values including threatened species. This offset is part of the Western Region Biodiversity Offset Strategy (WRBOS).

The WRBOS identifies retirement 204 ecosystem biodiversity offset credits by Clarence. Clarence's biodiversity offset requirements will be satisfied with the retirement of land utilising a Conservation Agreement in perpetuity under the *Biodiversity Conservation Act 2016*.

The conservation agreement for Carinya Lot 163 (**Figure 6-13**) was finalised in October 2020. Clarence Colliery submits an Annual Management report to BCS for the Carinya offset area as required by the WRBOS.

A draft Conservation Bond calculation was submitted to the Secretary with the WRBOS. The Conservation Bond is proposed to include the completion of management actions for the first 10 years of the WRBOS. The site has no active restoration. Management activities are limited to limiting human disturbance and maintaining site security, weed management, pest management and ecological monitoring.

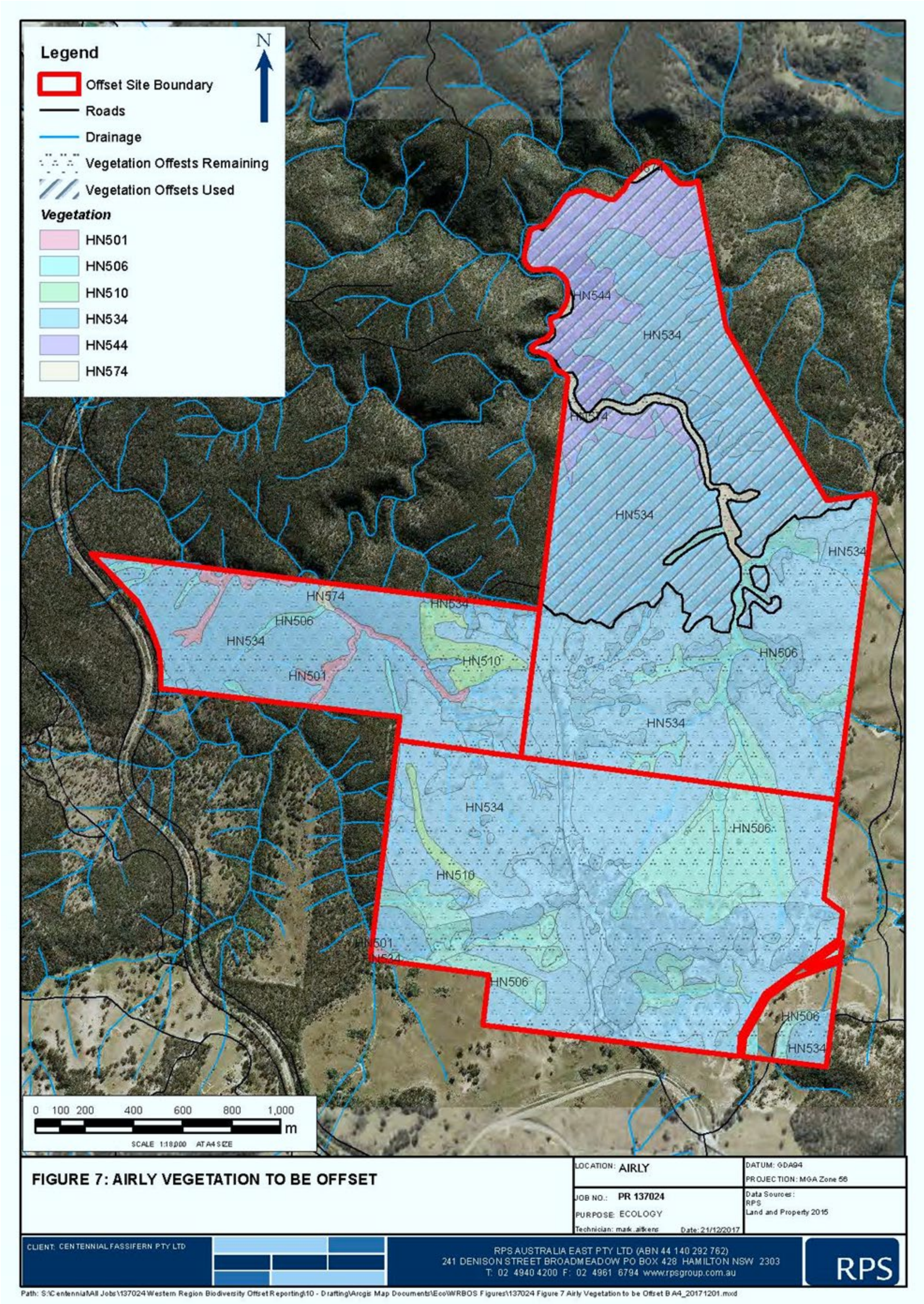


Figure 6-13: Carinya Offset Site & BioMetric Vegetation Types (BVTs)

6.7 HERITAGE

6.7.1 Environmental Management

Clarence Colliery manages Aboriginal heritage in accordance with the Western Region Aboriginal Cultural Heritage Management Plan (WRACHMP) dated September 2021. The WRACHMP was approved by DPE in 2021. WCS manages European heritage in accordance with the Historic Heritage Management Plan (HHMP) dated June 2018. The HHMP was approved by DPE in 2018 and satisfies Condition 30, Schedule 3 of DA 504-00.

The WRACHMP identified forty-seven registered Aboriginal Heritage Information Management System (AHIMS) items within the Clarence Colliery Lease Boundary.

In accordance with the WRACHMP monitoring program, Clarence Colliery will record the condition of the site before mining (baseline survey and baseline check) and the condition of the site after mining (post mining initial condition) and post mining (secondary condition check) and thus has been separated into three phases.

- Phase 1: Baseline recording (prior to site being undermined)
- Phase 2: Post mining initial condition (immediately after undermining)
- Phase 3: Post mining secondary condition (approximately 8 months after undermining)

There are no heritage items within the Clarence Lease Boundary which are listed on the Commonwealth Heritage Register, on the NSW State Heritage Register (SHR), or the s170 registers (state owned items). There are no known unlisted heritage items in the Clarence Lease Boundary (HHMP 2018).

6.7.2 Environmental Performance

During the Reporting Period, Phase 1, Phase 2 and Due Diligence inspections were undertaken as required by the WRACHMP, inducing:

- **Phase 1**: RPS were engaged by Centennial Coal Company Limited to prepare a baseline recording report of AHIMS sites 45-1-0185, 45-1-0186, and 45-1-0188 that are located over the 915 and 919 panels. The Phase 1 inspection was conducted on 22 February 2022.
- **Phase 2**: RPS were engaged by Centennial Coal Company Limited to conduct a Phase 2 inspection of AHIMS sites 45-1-2872, 45-1-2874 and 45-1-2875 that are located over the 915 panel. The Phase 1 inspection was conducted on 7 December 2021 with the Phase 2 inspection completed on the 10 October 2022.
    - Phase 1 and Phase 2 visual inspection have now been completed. No mining related impacts have been observed.
- **Due Diligence:** RPS were engaged by Centennial Coal Company Limited to prepare an Aboriginal heritage due diligence assessment letter report for proposed 900 subsidence line installation at the Clarence. The visual inspection of the proposed subsidence line was conducted on 7 December 2021 with Centennial Environment and Community Officer, Isobel J. Standfast and Registered Aboriginal Party Sharon Brown (Gundungurra Tribal Council Aboriginal Corporation).
    - Three isolated artefacts and one artefact scatter were identified during the visual inspection of the proposed subsidence line (AHIMS sites 45-1-283, 45-1-2872, 45-1-2874 and 45-1-2875). The ground visibility was moderate to high with exposed surfaces and vehicle track disturbance. The ground surfaces

were inspected with Registered Aboriginal Party Sharon Brown for stone artefacts. Additionally, the trees in the open woodland were inspected for modified/scar trees, however, no trees showed signs of cultural modifications.

- **Due Diligence:** Umwelt (Australia) Pty Ltd (Umwelt) were engaged by Centennial Coal Company Pty Limited (Centennial) to undertake an Aboriginal Heritage Due Diligence Assessment to assess the potential impacts associated with proposed construction of a new dewatering bore and ancillary infrastructure (Project Area) at the Clarence Colliery. A visual inspection of the Project Area was undertaken by Umwelt on 6 December 2022.
    - Through a review of environmental and archaeological context for the Project Area, no Aboriginal sites are located within the footprint of the proposed works, and the Project area itself generally retains low archaeological potential.

For the complete Phase 1, Phase 2 and Due Diligence inspection reports refer to **Appendix 6**.

6.7.3 Comparisons Against Predictions

Page 114 of the 900 Area SMP Written Report (2013) states that Clarence Colliery has identified no discernible impacts on the surface of previously mined areas using the partial extraction mining methods, and as such it is expected that mining in the 900 Area will also have no impacts on any Aboriginal cultural heritage sites. A similar statement is made in the 800 Area SMP Report (2011).

During the Reporting Period Phase 2 inspections above 915 panel confirmed no mining related impacts have been observed at 45-1-2872, 45-1-2874 and 45-1-2875, therefore the SMP predictions are upheld.

6.7.4 Long Term Analysis

There have been no recorded impacts to Aboriginal Heritage items at Clarence.

6.7.5 Implemented / Proposed Improvements

The Western Region Aboriginal Cultural Heritage Committee (ACHC) Meetings were held in May and October 2022. Clarence Colliery will continue to undertake Western Region ACHC Meetings in the next Reporting Period.

Clarence Colliery will continue to manage and monitor Aboriginal Cultural Heritage in accordance with the WRAHMP.

The pre-clearance permit systems in the WRAHMP provides the land disturbance due diligence process, implemented by the site and is considered appropriate for the management of Aboriginal heritage items.

6.8 MINE SUBSIDENCE

6.8.1 Environmental Management

Clarence Colliery currently operates under several Subsidence Management Plans (SMP). During 2022, the following SMP applications and variations occurred:

- 900 Area - A variation to the 900 Area SMP was submitted on 28th of February 2022. This was Clarence's sixth variation and sought a modification to the extraction layouts of the 906, 915 and 917 panels within the 900 area. This variation also requested the extension of the 900 Area SMP expiry date to the 24th December 2025 to coincide with the expected completion of extraction in the 900 Area SMP. This 900 Area SMP variation received approval on 12th April 2022

- 800 Area – There were no SMP variations to the 800 Area in the 2022 Reporting Period. The last variation to the 800 Area SMP was submitted on 5th March 2021. This was Clarence's seventh variation and sought a modification to the extraction layouts of the 818A, 822 and 801S panels within the 800 area and requested the extension of the 800 area SMP expiry date to the 24th December 2025. This was approved on the 13th May 2021.
- 700W Area – There were no SMP variations to the 700W Area in the 2022 Reporting Period. The last variation to the 700 Area SMP was submitted on 11th of May 2021. This was Clarence's sixth variation and requested the extension of the 700W area SMP expiry date to the 1st June 2025. Approval for this variation was granted on 28th May 2021.

A request to reduce environmental monitoring associated with expired SMPs was submitted to the NSW Resource Regulator on the 21st March 2014. A response was received 2nd April 2015. The approval to reduce environmental monitoring in the Eastern Area was not forthcoming and monitoring was completed throughout 2016, 2017, 2018, 2019, 2020, 2021 and 2022, again showing no impacts from subsidence. Clarence is currently reviewing environmental monitoring being undertaken for consultation with the NSW Resource Regulator.

6.8.2 Environmental Performance

During 2022, the following mining activities included:

- Development of the 804, 805 and 919 panels;
- Extraction of the 821 and 822 panels; and
- Development and Extraction of the 906 and 915 panels.

Clarence Colliery in accordance with SMP approvals, also submits a Subsidence Management Status Report (SMSR) each quarter to the NSW Resource Regulator.

During the Reporting Period, the following subsidence monitoring was undertaken:

- Annual survey of the 800A line on the 16th February 2022 and an 822 Panel post extraction survey on the 8th December 2022;
- 800G line surveyed on the 10th February 2022;
- 800J line surveyed on the 10th February 2022;
- 800I line surveyed on the 8th February 2022;
- 800D line surveyed on the 11th January 2022;
- 800E line surveyed on the 10th January 2022;
- Resurvey of the 700A line on the 28th June 2022;
- Resurvey of the 700B line on the 28th June 2022;
- Resurvey of the 700F line on the 22nd December 2022;

- 900B line was due for an annual survey during the SMSR March-June 2022 quarter, however due to an Australian Defence Force munitions clean-up program access was not available. The 900B line was surveyed 28th August 2022;
- The 800B, 800C, 800D and 800E lines were due for an annual survey during the SMSR March-June 2022 quarter, however due to damage to surface access tracks, access was not available. Track repairs were being arranged and these lines will be resurveyed at the next available opportunity.
- The U, H and I lines were due for an annual survey during the SMSR March-June 2022 quarter, however due to an Australian Defence Force munitions clean-up program access was not available to these subsidence lines. These lines will be resurveyed at the next available opportunity.
- 900A line surveyed 16th October 2022;
- 900D line surveyed 18th July 2022;
- 903 line surveyed 20th October 2022.
- 707, W and Z lines were due for an annual survey during the 2022 year, however was not surveyed due to resourcing priorities and track damage. Track repairs are being arranged and these lines will be resurveyed at the next available opportunity.

Subsidence Monitoring

Subsidence monitoring results from previously extracted panels are discussed in detail in the SMSR's. A summary of 2022 results are provided below. Subsidence charts from the surveys of the lines carried out in 2022 are provided in **Appendix 7**.

Subsidence and environmental monitoring have been carried out generally in accordance with the relevant Subsidence and Environmental Monitoring Programs required under the various SMP approvals.

All subsidence results during 2022 are below the 100mm maximum predicted with the exception of 900D line results.

- From survey results obtained on 18th July 2022 on the 900D line, maximum subsidence of 104mm was recorded and eight marks have reached or exceeded the 100mm threshold. It is noted that these results have an acceptable error of +/- 25mm for survey monitoring of this type.
- Despite exceeding the approved 100mm subsidence limit, no evidence of environmental harm was observed. The following actions were taken in response to this exceedance:
    - All stakeholders as required by the Clarence Colliery 900 Area SMP approval were notified;
    - A follow up visual inspection for any signs of environmental harm in the vicinity of the subsidence line was conducted; none were found.
    - An investigative geotechnical report was commissioned to examine reasons for the greater than predicted subsidence. It was identified that relatively soft floor (as a consequence of reduced interburden thickness localised in the area of 908/910 Panel) was a contributing factor.

- The subsidence data relating to the 908 and 910 Panels was incorporated into the Clarence subsidence model to accurately inform future panel design. Consideration is now given to interburden thickness.

Flora and fauna monitoring have shown no measurable impact from mining.

No effect of land subsidence has been observed from the monitoring conducted over 2022.

Groundwater impact has been minimal with the main effects being at seam level. Piezometric height has decreased in the seam level aquifers as expected. There has been no adverse impact on upper aquifers (i.e. above the Mt York Claystone) as a consequence of mining activities (including the Clarence aquifer). Piezometers and inspections within swamps have found no impact from mining.

Surface water quality monitoring indicates no adverse impact from mining with upstream and downstream results for Farmers Creek (700 Area).

Cliffline and pagoda photographic monitoring, combined with visual surface inspections, has found no evidence of any mining related impact.

6.8.3 Comparisons Against Predictions

The panel geometry and mine plan is designed around the need to achieve subsidence that is limited to a value well within that considered to be characteristic of 'elastic' overburden behaviour (i.e. no caving to surface), which is defined as 100±25 mm (SEA, 2005). This limit is conditioned within Development Consent DA 504-00 Schedule 3, which states that: 'The Applicant shall ensure that surface subsidence generated by the development does not exceed the criteria listed in Table 1 (First Workings – 20mm subsidence, 1.0mm/m tilt, 1.0mm/m horizontal strain. Partial Extraction – 100mm subsidence, 3.0mm/m tilt, 2.0mm/m horizontal strain).' It should be noted that 900D line is outside of DA 504-00.

6.8.4 Long Term Analysis

All subsidence results for the past 5 years since 2018-2022 have been below the 100mm maximum predicted (with the exception of the older panels within the Eastern Area and the recent 900D exceedance as discussed above).

6.8.5 Implemented / Proposed Improvements

Clarence Colliery will continue to implement the approved SMPs during the next Reporting Period. DA 504-00 (MOD7) included the addition of conditions for future secondary extraction at Clarence to be undertaken in accordance with an approved Extraction Plan. At the time of preparing this 2022 Annual Review, a new Extraction Plan for the 918/920 Areas was under preparation and anticipated for submission into the DPE for approval in the next Reporting Period.

6.9 OTHER MATTERS

6.9.1 Waste

Condition 24, Schedule 3 of DA 504-00 states Clarence Colliery must minimise the amount of waste generated by the development to the satisfaction of the Planning Secretary. During the Reporting Period the following items are collected to minimise waste to landfill including, waste oil, oily water and oil filters, paper and cardboard packaging, scrap steel, other recyclables (e.g. glass and plastics) and solid wastes.

All general waste is collected by licensed waste contractor for disposed at Licensed land fill site. **Table 6-18** provides a summary of the waste recycled and disposed during the reporting period with a comparison on waste consumed over the last 5 years.

In 2022, 516.208 tonnes of waste was sent offsite for disposal with 219.93 tonnes of recycled waste, at a total yield recycling rate of 42.44%. This compares to a recycling rate of 39.65% in 2021 and 45.7% in 2020. Total offsite waste has been decreasing since 2019.

Table 6-18: Waste Summary

	2018	2019	2020	2021	2022
Recycling					
Hazardous Recycled (Waste Oil, Oily Water / kL, Batteries, Oil Filters / tonnes)	82.280	31.658	31.400	23.704	21.102
Non-Hazardous Recycled (Paper & Cardboard, Scrap Steel / tonnes)	256.925	310.661	280.858	230.343	197.991
Total Waste Recycled	**339.205**	**342.319**	**312.258**	**254.047**	**219.093**
Disposal					
Hazardous Disposal (Oily Rags / tonnes)	9.908	30.934	24.533	16.322	15.840
Non-Hazardous Disposal (Mixed Solid Waste / tonnes)	373.169	377.450	346.126	370.365	281.275
Total Waste Disposal	**383.077**	**408.384**	**370.659**	**386.687**	**297.115**
Total Offsite Waste					
Waste recycled and disposed	**722.282**	**750.703**	**682.917**	**640.734**	**516.208**
Percentage Waste Recycled	*46.96%*	*45.60%*	*45.72%*	*39.65%*	*42.44%*

7 WATER MANAGEMENT

Clarence Colliery have developed a site-specific Water Management Plan (WMP) as part of a Regional Water Management Plan (RWMP) to address Conditions 5, 6, 6A, 6B, 7, 8, 9, 10, 11 and 12 of Schedule 3, of DA 504-00. The DPE approved the WMP in May 2017. The WMP has been developed to address the approvals and licensing requirements through the completion of the following:

- Collate and review existing information and studies relating to the operation of the water management system at Clarence Colliery;
- Establish an understanding of the water management system at the site;
- Categorise the existing conditions that are specific to water management requirements;
- Identify the clean, dirty, and contaminated water management systems and maximise the separation of these systems;
- Undertake a review of the capacity of dirty and contaminate surface water storages in accordance with Managing Urban Stormwater: Soils and Construction, Volume 1, and Volume 2E (Landcom 2004; DECC 2008);
- Undertake a water quality assessment and review existing water quality assessment criteria;
- Manage water discharged from the site, in terms of volume and quality, to a level that is acceptable for environmental management and community expectations and in accordance with EPL conditions;
- Minimise water discharges from the premises by maximising, where practicable, opportunities for the reuse and recycling of water on site;
- Determine the future water management requirements; and
- Review and develop water monitoring requirements.

7.1 WATER LICENSES

Clarence Colliery holds two water access licenses (WAL), in which **Table 7-1** displays passive take/inflows and active pumping against entitlements. It is noted that water takes are reported over the financial year (i.e. the Water Year), which is from 1 July 2021 to 30 June 2022. During the Reporting Period, WAL36479 was compliant with the assigned entitlement. WAL41882 was inactive during the Reporting Period.

Table 7-1: Water Licenses and Take

Licence	Water sharing plan, source and management zone	Entitlement (ML)	Passive take/inflows (ML)	Active pumping (ML)	TOTAL (ML)
WAL36479	Sydney Basin Richmond Groundwater Source	6,623	0	5,503	5,503
WAL41882	Sydney Basin Coxs River Groundwater Source	1,095	0	0	0

7.2 WATER BALANCE

A site water balance model has been developed for Clarence Colliery to quantify water transfers within the site under existing operational conditions using various rainfall patterns (GHD 2022). A schematic of the overall water management system is presented in **Figure 7-1**. A summary of the predicted average annual inputs and outputs for the Clarence Colliery water management system for the 2022 calendar year is provided in **Table 7-2**. Results were based on the predicted average site conditions in 2022.

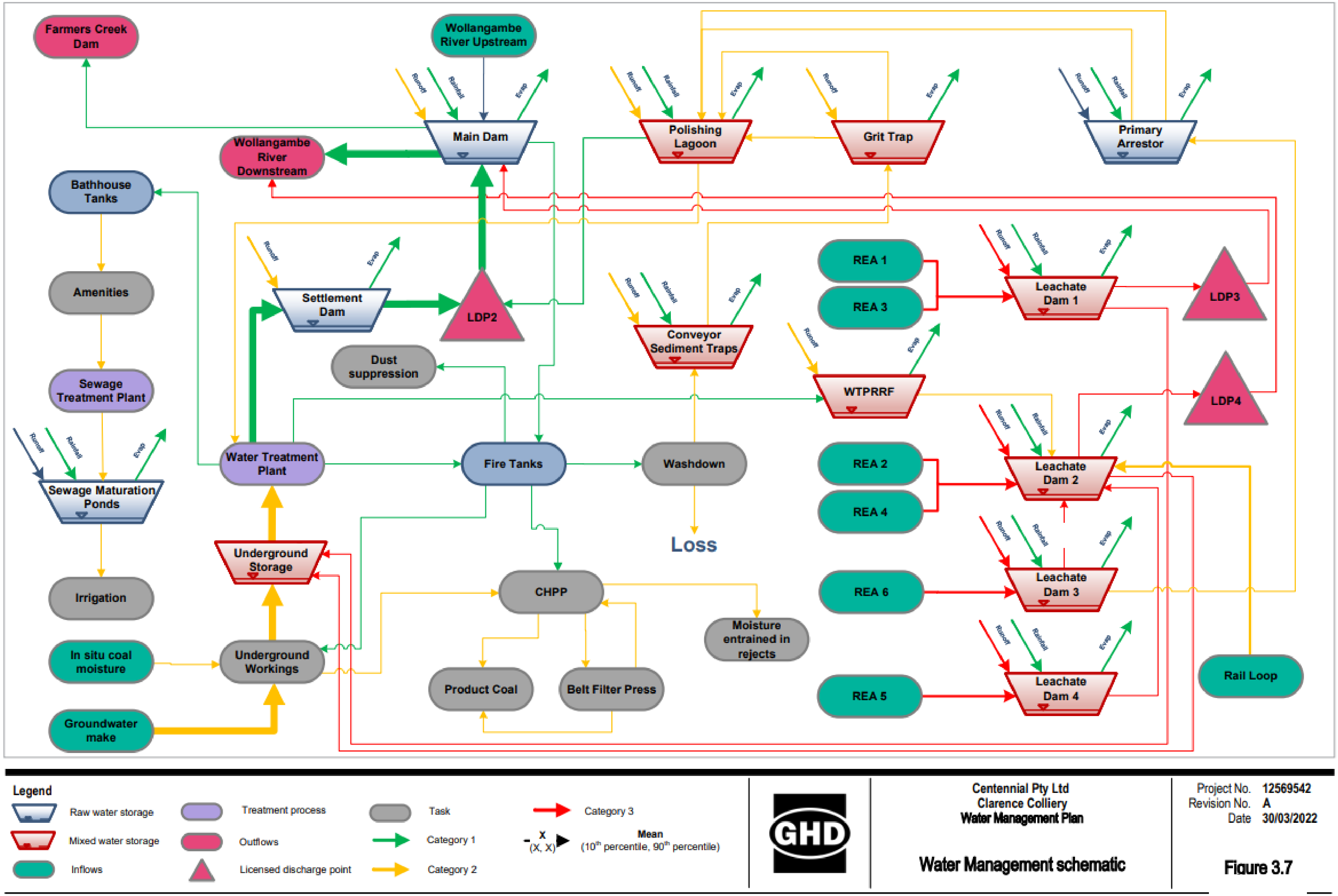
Table 7-2 shows that the largest transfer at Clarence Colliery is the dewatering of groundwater inflows to the underground workings to the WTP and discharge to the Wollangambe River via LDP002. Main Dam is located downstream of LDP002, which is where site operational demands of approximately 600 ML/year on average are extracted under 10WA103852[3]. Water from the Main Dam is pumped to the three fire tanks for use as process water (e.g. underground process water and washery make-up water) and as a permanent supply of water for fire-fighting purposes.

Table 7-2: Site Water Balance – Clarence Colliery

Clarence Colliery 2022 Water Balance	Volume (ML)
Water Sources (Inflows)	
Direct rainfall onto storages	14
Catchment runoff	329
Groundwater inflows into underground workings	6005
In-situ coal moisture	188
Transfers from Main Dam	833
Total Inputs (rounded)	**7369**
Water Loss (Outflows)	
Evaporation from storages	14
Discharge through LDP002	6926
Discharge through LDP003	0
Discharge through LDP004	0
Irrigation	18
Dust suppression losses	265
Wash down losses	27
Coal product	569
Moisture entrained in reject material	75
Total Outputs (rounded)	**7895**
Change in Storage	
Total Change in Storages	**-527**
Water Balance	
Change in water inventory (inputs – outputs – change in storage)	**0**

[3] Clarence holds joint water supply works approval 10WA103852 with Lithgow City Council (LCC) and water use approval 10UA103853, linked to Water Access Licence WAL26195 for 1293 units for the transfer of water stored in Main Dam to Farmers Creek Dam as part of the Clarence Water Transfer Scheme.

Figure 7-1: Site Water Management Schematic



7.3 SURFACE WATER

7.3.1 Environmental Management

The water management system at Clarence Colliery is comprised of clean, dirty, coal contact and leachate water. Sources of water at the site include rainfall, catchment runoff and groundwater inflow to the underground mine workings.

Surface water monitoring is undertaken in accordance with the Clarence Colliery Water Management Plan, Development Consent DA 504-00 and Environment Protection Licence 726 requirements.

The site has also developed trigger action response plans (TARP) to identify and manage potentially adverse impacts, as well as assist with managing the site's surface water during storm events.

Surface water monitoring at Clarence Colliery includes:

- **Discharge water quality monitoring** monthly during discharge events as per the requirements of EPL 726 and the WMP at Licensed Discharge Point (LDP) LDP002, LDP003 and LDP004.[4]
- **Discharge volume monitoring** is undertaken at LDP002 continuously in accordance with the requirements of EPL 726. Discharges through LDP003 and LDP004 are estimated.
- **Monthly surface water quality monitoring** at the following locations including Main Dam; Polishing Lagoon, Leachate Dam 1, Leachate Dam 2, Farmers Creek below Lithgow Dam No. 2, Farmers Creek at Cooerwull Road Bridge, Wollangambe River US, Wollangambe River DS (note this monitoring point is also water quality monitoring Point 9 identified by EPL 726).
- **Quarterly surface water quality monitoring** at the following locations including Farmers Creek US and Farmers Creek DS.
- **Stream health monitoring** including watercourse stability monitoring (only if triggered by subsidence greater than predictions) and aquatic ecology monitoring (see **Section 6.6**).

Surface water monitoring results are compared against relevant concentration limits or criteria.

Water quality limits are specified by EPL726 for LDP002, LDP003 and LDP004. These limits do not apply to discharges from LDP003 and LDP004 when the discharge occurs solely as a result of rainfall measured at the site which exceeds 56 mm over any consecutive five-day period.

EPL 726 also specifies a volumetric limit of 25,000 KL/day for discharges through LDP002. However, discharges through LDP002 may exceed this limit on any day where greater than 10 mm of rainfall is recorded on site.

Performance criteria have also been developed for the Wollangambe River and Farmers Creek, and form the basis of the TARP in the WMP. Water quality monitored at the Wollangambe River DS monitoring site is assessed against site specific guideline values (SSGVs). SSGVs are based on a review of ANZECC (2000) default guideline values (DGVs)

[4] Note that EPL 726 specifies monitoring requirements and concentration limits for LDP001, however this LDP is not currently used and hence has been excluded from the monitoring program.

and water quality observed at reference sites. Water quality monitored at Farmers Creek is assessed against the 80th percentile historical concentrations for Farmers Creek**.**

The key surface water monitoring, as specified in EPL 726, is required at four locations as detailed in **Table 7-3**.

Table 7-3: Surface Water Discharge Monitoring Locations

Monitoring Point Reference	Description / Creek Catchment
LDP002	Discharge from the Water Treatment Plant via drainage channel to Main Dam. The Polishing Lagoon also discharges from this point however only after high rainfall events.
LDP003	Discharge from Leachate Dam 1 to Main Dam.
LDP004	Discharge from Leachate Dam 2 to the Wollangambe River downstream of Main Dam.
Wollangambe River DS (EPL Point 9)	Wollangambe River downstream of LDP002 (and main dam).

7.3.2 Environmental Performance

Discharge Water (LDP002)

As required by EPL 726 conditions and the WMP, water discharged from LDP002 is tested monthly (with some additional analytes tested monthly during discharge) and analysed against the applicable concentration limits. During the Reporting Period LDP002 discharged daily. A summary of LDP002 water quality sampling results from discharge events during the Reporting Period are presented in **Table 7-4**.

Long term water quality monitoring results and trends for LDP002 are provided in **Appendix 8**.

During the Reporting Period water quality monitoring for LDP002 has been undertaken in accordance with EPL726 and the WMP. LDP002 did not comply with EPL water quality limits on several occasions during the Reporting Period in January, March, July, October, November and December. As required by EPL726 and the WMP, exceedances of the EPL limits for LDP002 were reported to the EPA. For further information refer to **Section 11**. [5]

Table 7-4: Summary of Water Quality Results at LDP002

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 Limit
Physiochemical						
pH	12	12	6.5	8.20	8.5	6 – 8.5
Electrical Conductivity (µs/cm)	12	12	231	346	572	N/S

[5] The non-compliances are reported in **Table 1.1** (Statement of Compliance) and **Section 11.**

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 Limit
Total Suspended Solids (mg/L)	12	12	0	8.25	**46**	30
Major Ions						
Chloride (mg/L)	12	12	11	18.9	25	25
Sulfate (mg/L)	12	12	79	102.3	149	250
Nutrients						
Total Fluoride (mg/L)	12	12	LOR	0.04	0.1	1
Total Nitrogen (mg/L)	12	12	LOR	0.17	**0.9**	0.25
Total Phosphorus (mg/L)	12	12	LOR	0.01	**0.06**	0.02
Dissolved Metals						
Arsenic (mg/L)	12	12	LOR	LOR	LOR	0.013
Boron (mg/L)	12	12	LOR	LOR	LOR	0.1
Cadmium (mg/L)	12	12	LOR	LOR	0.0002	0.0002
Chromium (mg/L)	12	12	LOR	LOR	LOR	0.001
Cobalt (mg/L)	12	12	0.0007	0.0072	**0.0683**	0.0025
Copper (mg/L)	12	12	LOR	LOR	0.0001	0.0014
Iron (mg/L)	12	12	LOR	LOR	LOR	0.3
Lead (mg/L)	12	12	LOR	LOR	LOR	0.0034
Lithium (mg/L)	12	12	0.012	0.02	0.024	0.1
Manganese (mg/L)	12	12	0.006	0.05	0.36	0.5
Mercury (mg/L)	12	12	LOR	LOR	LOR	0.00006
Nickel (mg/L)	12	12	0.003	0.016	**0.133**	0.011
Silver (mg/L)	12	12	LOR	LOR	LOR	0.0005
Zinc (mg/L)	12	12	LOR	0.009	**0.047**	0.008
Selenium (mg/L)	12	12	LOR	0.13	0.6	0.005
Other						
Oil and Grease	12	12	LOR	LOR	LOR	10

Notes: *N/S = Performance criteria or site-specific guideline values are not specified within either the Clarence Colliery Water Management Plan (2017) or EPL 726. LOR means limit of reporting. The **bolded** text indicates a non-compliance at least once with WMP and EPL726 limits.

Discharge Water (LDP003)

As required by EPL 726 conditions and the WMP, water discharged from LDP003 is tested monthly during discharges and analysed against the applicable concentration limits.

During the Reporting Period LDP003 discharged on 3 days during the month of July in 2022. Rainfall recorded on site between the 3-7 July was 195.2mm. A summary of LDP003 water quality sampling results from discharge events during the Reporting Period are presented in **Table 7-5**.

During the Reporting Period water quality monitoring for LDP003 has been undertaken in accordance with EPL 726 and the WMP. LDP003 complied with EPL water quality limits during the Reporting Period in consideration of the of rainfall measured at the site exceeding 56 mm prior to the discharge.

Table 7-5: Summary of Water Quality Results at LDP003

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 limit
Physiochemical						
pH	1	1	5.3	5.3	**5.3**	6 – 8.5
Electrical Conductivity (µs/cm)	1	1	1811	1811	1811	N/S
Total Suspended Solids (mg/L)	1	1	115	115	**115**	30
Major Ions						
Chloride	1	1	2	2	2	25
Sulfate	1	1	79	79	79	250
Nutrients						
Total Fluoride (mg/L)	1	1	0.1	0.1	0.1	1
Total Nitrogen (mg/L)	1	1	1.0	1.0	**1.0**	0.25
Total Phosphorus (mg/L)	1	1	0.06	0.06	0.06	0.02
Dissolved Metals						
Arsenic (mg/L)	1	1	LOR	LOR	LOR	0.013
Boron (mg/L)	1	1	LOR	LOR	LOR	0.1
Cadmium (mg/L)	1	1	0.0007	0.0007	**0.0007**	0.0002
Chromium (mg/L)	1	1	LOR	LOR	LOR	0.001
Cobalt (mg/L)	1	1	0.385	0.385	**0.385**	0.0025
Copper (mg/L)	1	1	0.006	0.006	**0.006**	0.0014
Iron (mg/L)	1	1	0.08	0.08	0.08	0.3
Lead (mg/L)	1	1	LOR	LOR	LOR	0.0034

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 limit
Lithium (mg/L)	1	1	0.031	0.031	0.031	0.1
Manganese (mg/L)	1	1	1.26	1.26	1.26	0.5
Mercury (mg/L)	1	1	LOR	LOR	LOR	0.00006
Nickel (mg/L)	1	1	1.01	1.01	**1.01**	0.011
Silver (mg/L)	1	1	LOR	LOR	LOR	0.0005
Zinc (mg/L)	1	1	1.09	1.09	1.09	0.008
Selenium (mg/L)	1	1	LOR	LOR	LOR	0.005
Other						
Oil and Grease (mg/L)	1	1	LOR	LOR	LOR	10

Notes: *N/S = Performance criteria or site-specific guideline values are not specified within either the Clarence Colliery Water Management Plan (2017) or EPL 726. LOR means limit of reporting. The **bolded** text indicates a non-compliance with WMP and EPL726 limits, however these limits do not apply when the discharge occurs solely as a result of rainfall measured at the site which exceeds 56 mm over any consecutive five-day period. As the site recorded 195.2mm of rainfall from 3-7 July 2022 therefore the limits do not apply.

Discharge Water (LDP004)

As required by EPL 726 conditions and the WMP, water discharged from LDP004 is tested monthly during discharges and analysed against the applicable concentration limits.

During the Reporting Period LDP004 discharged for 2 days during the month of January and 4 days during the month of July in 2022. Rainfall recorded on site from 8-12 January 2022 was 81.2mm and 195.2mm of rainfall from 3-7 July 2022. A summary of LDP004 water quality sampling results from discharge events during the Reporting Period are presented in **Table 7-6**.

During the Reporting Period water quality monitoring for LDP004 has been undertaken in accordance with EPL 726 and the WMP. LDP004 complied with EPL water quality limits during the Reporting Period in consideration of the of rainfall measured at the site exceeding 56 mm prior to the discharges.

Table 7-6: Summary of Water Quality Results at LDP004

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 limit
Physiochemical						
pH	2	2	**3.1**	3.15	**3.2**	6 – 8.5
Electrical Conductivity (µs/cm)	2	2	630	722.5	815	N/S

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	EPL726 limit
Total Suspended Solids (mg/L)	2	2	**34**	38.00	**42**	30
Major Ions						
Chloride	2	2	LOR	LOR	LOR	25
Sulfate	2	2	**296**	328.5	**361**	250
Nutrients						
Total Fluoride (mg/L)	2	2	LOR	0.20	0.20	1
Total Nitrogen (mg/L)	2	2	LOR	0.10	0.20	0.25
Total Phosphorus (mg/L)	2	2	LOR	0.02	**0.03**	0.02
Dissolved Metals						
Arsenic (mg/L)	2	2	LOR	LOR	LOR	0.013
Boron (mg/L)	2	2	LOR	LOR	LOR	0.1
Cadmium (mg/L)	2	2	**0.0057**	0.00605	**0.0064**	0.0002
Chromium (mg/L)	2	2	0.001	0.003	**0.005**	0.001
Cobalt (mg/L)	2	2	**2.35**	2.73	**3.11**	0.0025
Copper (mg/L)	2	2	**0.101**	0.165	**0.228**	0.0014
Iron (mg/L)	2	2	LOR	2.44	**2.44**	0.3
Lead (mg/L)	2	2	**0.016**	0.019	**0.021**	0.0034
Lithium (mg/L)	2	2	0.028	0.04	0.055	0.1
Manganese (mg/L)	2	2	**5.54**	8.77	**12.00**	0.5
Mercury (mg/L)	2	2	LOR	LOR	LOR	0.00006
Nickel (mg/L)	2	2	**5.27**	6.05	**6.82**	0.011
Silver (mg/L)	2	2	LOR	0.01	**0.01**	0.0005
Zinc (mg/L)	2	2	**6.46**	7.10	**7.73**	0.008
Selenium (mg/L)	2	2	0.01	0.01	0.01	0.005
Other						
Oil and Grease (mg/L)	2	2	LOR	LOR	LOR	10

Notes: *N/S = Performance criteria or site-specific guideline values are not specified within either the Clarence Colliery Water Management Plan (2017) or EPL 726. LOR means limit of reporting. The **bolded** text indicates an non-compliance at least once with WMP and EPL726 limits, however these limits do not apply when the discharge occurs solely as a result of rainfall measured at the site which exceeds 56 mm over any consecutive five-day period. As the site recorded 81.2mm of rainfall from 8-12 January 2022 and 195.2mm of rainfall from 3-7 July 2022 therefore the limits do not apply.

LDP002, LDP003 and LDP004 Discharge Volumes

The volume of water discharged is required to be monitored daily at the licenced discharge points LDP002, LDP003 and LDP004 in accordance with EPL 726. The total volume discharged from LDP002 may exceed 25,000kL/day on any day where greater than 10mm of rainfall is recorded at the premises, for that day.

Table 7-7 provides the discharge volume results for the Annual Review period. **Figure 7-2** displays the daily discharge volumes for LDP002 during the reporting period.

Table 7-7: LDP002, LDP003 and LDP004 Discharge Volumes

Discharge Point	No. of Measurements made	Lowest result (KL)	Mean result (KL)	Highest result (KL)	EPL Limit (KL/day)	Comments
LDP002	365	3,356.2	16,768.8	42,767.1[1]	25,000	Continuous Monitoring
LDP003	3	N/A	491	843[2]	N/A	Discharge in July
LDP004	6	N/A	2800	5391[3]	N/A	Discharge in January & July

[1] All occasions where discharge was >25,000Kl/day coincided with >10mm of rainfall, and included the following dates 6-8 March (144.6mm), 3-5 July (161.2mm), 8 October (14.4mm, over 24hr period), and 14 November (34.8mm)

[2] Estimate during discharge over 3 days in July of 843KL.

[3] Estimate during discharge over 2 days in January of <1000KL. Estimate during discharge over 4 days in July of 5391KL.

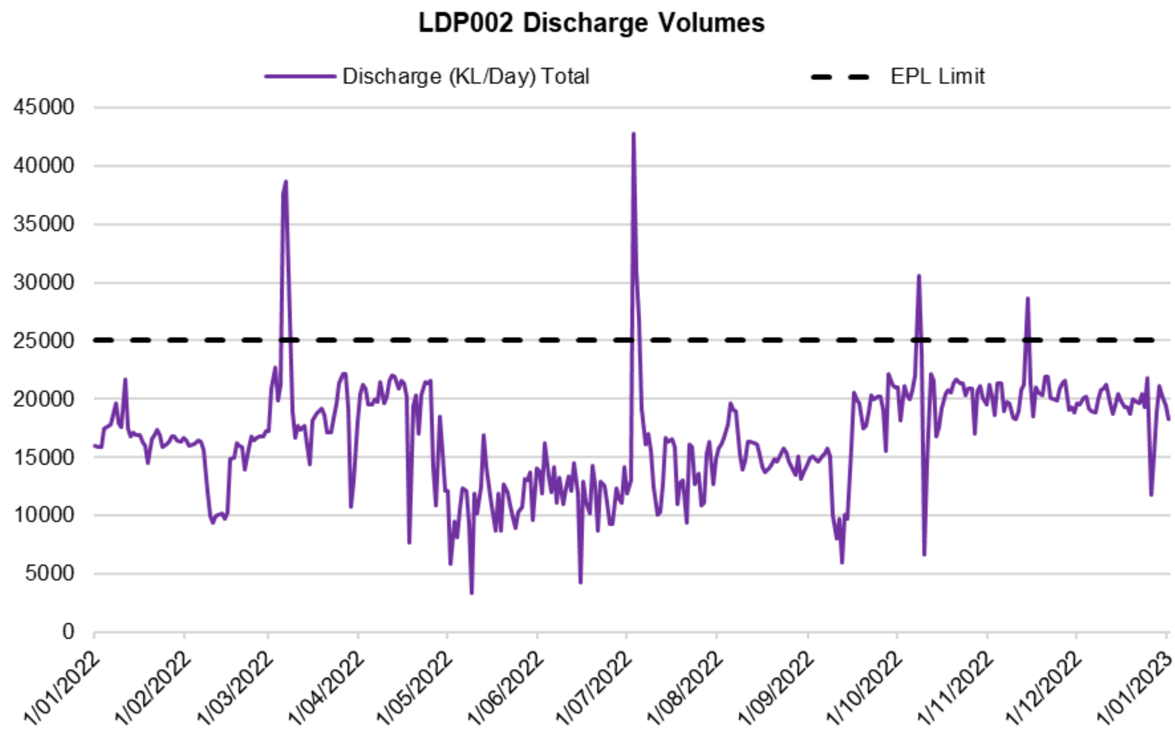


Figure 7-2: Summary of LDP002 Daily Discharge Volumes

Wollangambe Downstream Water Quality (EPL Point 9)

Wollangambe Downstream (EPL Point 9) is located downstream of LDP002 in the Wollangambe River. The requirement to undertake water quality monitoring at this point was introduced into EPL 726 in March 2017.

Water quality criteria is not specified in EPL 726 for EPL Point 9. The WMP (May 2017) specifies site-specific guideline values (SSGVs) that are based on a review ANZECC (2000) default guideline values (DGVs). DGVs for a species protection level of 99% were used for the Wollangambe River due to high conservation value of the receiving environment within the Blue Mountains National Park.

Table 7-8 below summarises the water quality monitoring results against SSGVs during the Reporting Period. Water quality monitoring results are presented graphically in **Appendix 8.**

Table 7-8: Summary of Water Quality Results at Wollangambe River Downstream

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	SSGV limit
Physiochemical						
Dissolved Oxygen	12	12	7.1	8.63	9.9	N/S
Electrical Conductivity	12	12	**184**	268	**313**	100
pH	12	12	**5.5**	7.0	8.5	5.7 - 9.0
Temperature	12	12	6.3	12.71	17.2	N/S
Total Suspended Solids	12	12	0	2.17	9	25
Turbidity	12	12	0.6	3.97	12	25
Major Ions						
Bicarbonate	12	12	10	18.3	36	N/S
Carbonate	12	12	LOR	LOR	LOR	N/S
Hydroxide	12	12	LOR	LOR	LOR	N/S
Total Alkalinity	12	12	10	18.3	36	N/S
Calcium	12	12	23	30.0	37	N/S
Chloride	12	12	13	15.2	18	N/S
Magnesium	12	12	6	8.0	11	N/S
Potassium	12	12	2	2.3	3	N/S
Sodium	12	12	3	3.7	6	N/S
Sulfate	12	12	62	78.1	101	N/S
Total Hardness	12	12	82	107.8	138	N/S
Nutrients						
Ammonia	12	12	LOR	0.02	0.06	0.32
Nitrate	12	12	LOR	0.20	**1.04**	0.03
Nitrite	12	12	LOR	LOR	LOR	N/S

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	SSGV limit
Nitrate + Nitrite	12	12	0.01	0.20	**1.05**	0.1
Total Fluoride	12	12	LOR	LOR	LOR	N/S
TKN	12	12	LOR	0.18	1	N/S
Total Nitrogen	12	12	LOR	0.36	**1.5**	0.24
Total Phosphorus	12	12	LOR	0.01	**0.04**	0.02
Dissolved Metals						
Aluminium	12	12	0.03	0.05	0.09	0.11
Arsenic	12	12	LOR	LOR	LOR	0.001
Barium	12	12	0.015	0.02	0.02	0.011
Beryllium	12	12	LOR	LOR	LOR	N/S
Boron	12	12	LOR	LOR	LOR	0.05
Cadmium	12	12	LOR	LOR	LOR	0.0001
Chromium	12	12	LOR	LOR	LOR	0.00001
Cobalt	12	12	0.007	0.017	0.023	N/S
Copper	12	12	LOR	0.00025	0.003	0.001
Iron	12	12	LOR	0.25	0.41	0.8
Lead	12	12	LOR	LOR	LOR	0.001
Lithium	12	12	0.012	0.01	0.017	0.001
Manganese	12	12	0.087	0.14	0.21	1.2
Mercury	12	12	LOR	LOR	LOR	0.00006
Molybdenum	12	12	LOR	LOR	LOR	0.001
Nickel	12	12	0.02	0.03	0.017	0.008
Silver	12	12	LOR	LOR	LOR	0.00002
Selenium	12	12	LOR	LOR	LOR	N/S
Strontium	12	12	0.04	0.05	0.06	0.004
Vanadium	12	12	LOR	LOR	LOR	N/S
Zinc	12	12	0.018	0.03	0.05	0.012
Total Metals						
Aluminium	12	12	0.07	0.15	0.26	N/S
Arsenic	12	12	LOR	LOR	LOR	N/S
Barium	12	12	0.016	0.019	0.023	N/S
Beryllium	12	12	LOR	LOR	LOR	N/S
Boron	12	12	LOR	LOR	LOR	N/S
Cadmium	12	12	LOR	LOR	LOR	N/S
Cobalt	12	12	0.011	0.017	0.023	N/S

Pollutant	No. of samples required by licence	No. of samples collected and analysed	Lowest sample value	Mean of sample	Highest sample value	SSGV limit
Copper	12	12	LOR	0.001	0.003	N/S
Iron	12	12	LOR	0.25	0.41	N/S
Lead	12	12	LOR	LOR	LOR	N/S
Manganese	12	12	0.12	0.18	0.25	N/S
Nickel	12	12	0.03	0.04	0.058	N/S
Mercury	12	12	LOR	LOR	LOR	N/S
Molybdenum	12	12	LOR	LOR	LOR	N/S
Selenium	12	12	LOR	LOR	LOR	N/S
Silver	12	12	LOR	LOR	LOR	N/S
Strontium	12	12	0.034	0.049	0.066	N/S
Vanadium	12	12	LOR	LOR	LOR	N/S
Zinc	12	12	0.03	0.06	0.10	N/S
Other						
Oil and Grease	12	12	LOR	LOR	LOR	N/S
Dissolved Organic Carbon	12	12	2	3	5	N/S
Total Organic Carbon	12	12	1	2	3	N/S

7.3.3 Comparisons Against Predictions

Section 3.8.3 of the WMP (Version 3) discusses discharge frequency predictions for each of the Licenced Discharge Points at Clarence.

Discharge frequency for each LDP location has been estimated from the water balance modelling. Scenarios assessed included a future conditions which considered minor differences in groundwater predictions. The accuracy of the annual exceedance probability of discharge from the site water balance model are limited by the daily rainfall record, daily time step of the hydraulic simulations and the use of the sub-module, the Australian Water Balance Model (AWBM). Therefore, these estimates should be considered as relative indicators only and are unlikely to reflect the actual design performance of these water management structures.

Discharge frequency has been assessed through the use of a cumulative probability distribution. The modelling indicates that LDP002 discharge are predicted to be mostly within a typical discharge rate of 17 ML/day to 20 ML/day (50th percentile is equal to 0.5 cumulative frequency), although discharges due to rare rainfall events are expected in less than 5% of years.

Modelling predicts discharges through LDP003 are likely to occur often with an estimated daily maximum of up to 29 ML/day under rare rainfall conditions. Modelling predicts that discharges through LDP004 were simulated to occur in approximately 25% of years under future conditions, with an estimated daily maximum discharge of up to 36 ML/day under rare rainfall conditions.

During the Reporting Period discharge volumes from LDP002 were within predicted expectation. Discharge volumes from LDP003 and LDP004 were below predicted expectation.

Modification 2 (MOD2) of DA 504-00 was for the establishment of reject emplacement area (REA) VI to the south of the 'Run of Mine' (ROM) area, upgrade facilities and increase personnel. MOD2 was approved in June 2014. MOD2 predicted all rainfall falling directly on REA VI will be captured in the leachate management system described above and will not have the potential to impact upon the quality of water entering the Newnes Plateau Hanging Swamp (NPHS).

7.3.4 Long Term Analysis

Long-term water quality results for the period 2018 to 2022 at LDP002 and Wollangambe Downstream (EPL Point 9) are provided in **Appendix 8**, including comparison against their relevant water quality criteria or guideline values.

A five-year summary of water quality and water volume discharge exceedances from LDP002 is presented in **Table 7-9**. It is important to note that these exceedances are of a minor nature, and the limits are extremely low to ensure neutral or beneficial impact to the surrounding environment. It is therefore determined that these exceedances have not resulted in material harm to the environment, as reported to the relevant government agencies within the reporting period.

Table 7-9: 5 Year Water Quality and Volume Exceedance Summary

Reporting Period	LDP002 Water Quality	LDP002 Water Volume	Total Exceedances
2018	10	0	10
2019	5	0	5
2020	7	0	7
2021	7	0	7
2022	6	0	6

7.3.5 Implemented / Proposed Improvements

Clarence completed a review of the WMP in September 2021 (Version 2) to incorporate regulator comments, responses to actions from the 2020 Independent Environmental Audit (IEA) and Modification 6 (MOD 6). During this Reporting Period the WMP (Version 3) was revised in June 2022 to include Leachate Dam 4 and response to regulator comments. At the time of preparing the 2022 Annual Review WMP (Version 3) had not been approved.

Further consultation with DPE regarding the latest revision to the WMP (Version 3) will be undertaken during the next Reporting Period.

The site will continue to focus on improvements to the water management and monitoring system to ensure ongoing compliance with the WMP's SSGVs and EPL limits applicable to Clarence Colliery.

Centennial has been working closely with the EPA for several years as part of a Pollution Reduction Program (PRP) focused on discharges into the Wollangambe River. Clarence has committed to the cessation of discharge via LDP002 and is working with the EPA, the Lithgow City Council and DPE to meet this obligation.

Clarence is dedicated to ensuring compliance in our wide range of environmental performance indicators and takes any non-compliances very seriously. As with all exceedances, non-compliances or incidents that have occurred at Clarence Colliery, a complete and detailed report has been supplied to the EPA and DPE for the Reporting Period.

7.4 GROUNDWATER

As part of the development consent, Clarence was required to establish several environmental monitoring programs. These programs include the Clarence Water Management Plan (WMP) (Version 1) and the Clarence 800 Area Subsidence Management Plan (SMP).

The WMP and SMP detail intensive monitoring programmes that have been implemented to monitor potential impacts from underground mining on the groundwater regime, and in particular, the Newnes Plateau Shrub Swamps (NPSS) and Newnes Plateau Hanging Swamps (NPHS) which are Endangered Ecological Community under the *Environmental Protection and Biodiversity Conservation* (EPBC) *Act 1999*.

Clarence Colliery engaged EMM Consulting Pty Ltd (EMM) to undertake a review of groundwater monitoring undertaking during the Reporting Period. Summaries from EMM are provided throughout the following sections, with their complete report provide in **Appendix 9**.

EMM's groundwater data analysis presents a review of observed anomalies and possible mining-induced groundwater-related impacts during the reporting period (01 January 2022 to 31 December 2022). Any observed impacts that exceed trigger levels set out in the WMP and SMP are also identified so that appropriate management or engineering solutions may be implemented.

7.4.1 Environmental Management

As required by the WMP, the groundwater monitoring program at Clarence Colliery includes 18 vibrating wire piezometers (VWPs) and 17 standpipes. All VWPs are continuously logged for piezometric head and groundwater levels. Groundwater levels are recorded every three hours using installed loggers in monitoring standpipes. Data is downloaded every two months.

The groundwater monitoring network is established to detect potential impacts to groundwater systems due to mining and subsidence. The network consists of the following:

- **Swamp piezometers**: are installed in eleven swamps above mining operations to detect potential mining-related impacts on the swamp groundwater regimes. Groundwater data loggers record groundwater levels on a daily basis.
- **Open borehole standpipe piezometers** (standpipe piezometers): are installed within the perched and shallow groundwater systems to detect potential mining-related impacts on the Clarence Aquifer (Shallow groundwater system). Groundwater data loggers record groundwater levels on a daily basis.
- **Vibrating wire piezometers** (VWP): a network of VWPs measure pore pressure in multiple hydrogeological horizons above the Katoomba Seam to detect mining-related impacts within the shallow and deep groundwater systems. Additionally, VWPs are used to detect any mining induced hydraulic connectivity between the shallow and deep groundwater systems. Data is recorded by data loggers on a daily basis.

Following download, data is analysed for any trends or potential mining related impacts and presented in in the Subsidence Management Status Report (SMSR) submitted to relevant stakeholders every 4 months as required by the SMP. At the time of the preparation of the Annual Review the latest SMSR report was submitted in November, summarising the results until 31st October 2022.

7.4.2 Environmental Performance

Swamp Piezometers

Ten swamp piezometers and three shallow piezometers (targeting the Burralow Formation and Banks Wall Sandstone) were installed during 2022. These piezometers were installed to collect baseline monitoring data for proposed mining developments. Data loggers were installed in the three shallow piezometers (PA1, PA6 and PA3) in mid-December 2022. Therefore, limited data is available and trends at PA1, PA6 and PA3 have not been discussed in this report.

Hydrographs for monitoring sites have been compared to daily CRD (mm) to distinguish between meteorological trends and potential mining impacts. The dashed red vertical lines indicate the reporting period (1 January 2022 to 31 December 2022).

General groundwater level trends and trigger status during the reporting period are detailed in **Table 7-10**. A general overview of historical observations, mining history and hydrographs for swamp piezometers is provided in the EMM report (**Appendix 9**).

Table 7-10: Swamp Piezometer Trigger Status 2022

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CS1	Swamp sediments	Decommissioned – piezometer damaged by bushfire.
MW05	Swamp sediments	No trigger – increasing trend.
HVU1	Swamp sediments	No trigger level defined in the WMP – stable trend.
HS1	Swamp sediments	No trigger – fluctuating with rainfall.
HS2	Swamp sediments	No trigger – fluctuating with rainfall.
HS3	Swamp sediments	No trigger – fluctuating with rainfall.
PSE1	Swamp sediments	No trigger – exceeds trigger level however, there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are highly variable, trending with the CRD and peaking with rainfall.
PSE2	Swamp sediments	No trigger – exceeds trigger level however, there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are highly variable, trending with the CRD and peaking with rainfall.

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
OS1	Swamp sediments	No trigger – slight increasing trend.
PG1	Swamp sediments	No trigger – stable trend.
PG2	Swamp sediments	No trigger – exceeds trigger level however there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are stable, peaking with rainfall.
CSP1 (BSE1)	Swamp sediments	No trigger level defined – stable trend, still settling due to recent instalment.
CSP2 (BSE2)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
CSP4 (PHS1)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
CSP5 (PHS2)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
MU1 (CSP6)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
MU2 (CSP7)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
UD1 (CSP8)	Swamp sediments	No trigger level defined in the WMP – slight decreasing trend.
UD2 (CSP9)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
BN1 (CSP10)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
BN2 (CSP11)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.

Shallow Groundwater System

Standpipe piezometer groundwater levels have been reviewed against their respective trigger values in the WMP. Where triggers have occurred, the groundwater level response has been assessed against the TARP to determine if a mining impact has occurred and if further investigation is required.

General comments on historical observations and mining history for open borehole standpipe piezometers and hydrographs are provided in EMM's report (**Appendix 9**). Comments on groundwater level trends and standpipe piezometer trigger status during the reporting period are detailed in **Table 7-11**.

Table 7-11: Open borehole standpipe piezometer trigger status (2022)

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP4	Banks Wall Sandstone	No trigger – increasing trend.
CLRP5	Banks Wall Sandstone	No trigger – increasing trend.
CLRP7	Banks Wall Sandstone	No trigger – increasing trend.
CLRP8	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CLRP10	Banks Wall Sandstone	Below the trigger value from early August 2019 until late April 2022. Increasing trend throughout the reporting period, corresponding to the CRD.
CLRP15	Burra-Moko head Formation/Caley Formation	No trigger – groundwater levels show an increasing trend.
CLRP28	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CLRP31	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CC113	Banks Wall Sandstone	No trigger level defined in the WMP – decommissioned.

Vibrating Wire Piezometers

VWP piezometric pressures have been reviewed against their respective trigger values in the WMP. Where triggers have been realised, the piezometric response has been assessed against the TARP to determine if a mining impact has occurred and if further investigation is required.

General comments on historical observations, mining history and hydrographs for VWP's are provided in EMM's report (**Appendix 9**). Each VWP contains several piezometers (piezo) which target certain formations and depths. This along with comments on piezometric pressure trends and trigger status are detailed in **Table 7-12**.

Table 7-12: Vibrating Wire Piezometer Trigger Status (2022)

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP1	#1 Katoomba Seam (175 m bgl)	No trigger – stable trend.
	#2 Burra-Moko head Formation/Caley Formation (150 m bgl)	No trigger – slight increasing trend, likely due to above average rainfall.

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
	#3 Banks Wall Sandstone (100 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
	#4 Banks Wall Sandstone (60 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
CLRP2	#1 Katoomba Seam (276 m bgl)	Communication was lost with this piezo in August 2007 due to mining.
	#2 Banks Wall Sandstone (190 m bgl)	Exceeded trigger level from 1/11/14 to 10/03/2022. Increasing trend during the reporting period likely due to above average rainfall.
	#3 Banks Wall Sandstone (130 m bgl)	Exceeded trigger level from 30/12/17 to 18/01/2022. Increasing trend during the reporting period likely due to above average rainfall.
	#4 Banks Wall Sandstone (70 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
CLRP3	#1 Burra-Moko head Formation/Caley Formation (198 m bgl)	No trigger – stable trend.
	#2 Banks Wall Sandstone (138 m bgl)	No trigger – stable trend.
	#3 Banks Wall Sandstone (85 m bgl)	No trigger – stable trend.
CLRP6	#1 Burra-Moko head Formation/Caley Formation (160 m bgl)	Communication with this piezo was lost in October 2011.
	#2 Banks Wall Sandstone (100 m bgl)	Limited data due to logger issues, not enough data available to determine trends.
	#3 Banks Wall Sandstone (60 m bgl)	Limited data due to logger issues, not enough data available to determine trends.
CLRP11	#1 Burra-Moko head Formation/Caley Formation (165 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#2 Burra-Moko head Formation/Caley Formation (134.5 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#3 Banks Wall Sandstone (74.5 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#4 Banks Wall Sandstone (61 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP12	#1 Burra-Moko head Formation/Caley Formation (230 m bgl)	Access restrictions due to nearby sand quarry – decommissioned.
	#2 Burra-Moko head Formation/Caley Formation (180 m bgl)	
	#3 Banks Wall Sandstone (120 m bgl)	
	#4 Banks Wall Sandstone (100 m bgl)	
CLRP13	#1 Burra-Moko head Formation/Caley Formation (240 m bgl)	No trigger levels defined in the WMP. Depressurisation in early May, likely due to the mining of panel 822 40m south of CLRP13. Stable after depressurisation.
	#2 Burra-Moko head Formation/Caley Formation (210 m bgl)	No trigger levels defined in the WMP. Pressure increase in early May and stabilisation from late May, trending towards pressure before the increase in early May. Likely due to the mining of panel 822 40m south of CLRP13.
	#3 Banks Wall Sandstone (140 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#4 Banks Wall Sandstone (110 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#5 Banks Wall Sandstone (80 m bgl)	No trigger levels defined in the WMP. Increasing trend.
CLRP14	#1 Burra-Moko Head Formation (220 m bgl)	No trigger – Slight increasing trend, likely due to above average rainfall.
	#2 Burra-Moko Head Formation (185 m bgl)	No trigger – Stable trend.
	#3 Banks Wall Sandstone (130 m bgl)	Communication was lost with this piezo in December 2018.
	#4 Banks Wall Sandstone (100 m bgl)	Communication was lost with this piezo in April 2019.
CLRP15	#1 Burra-Moko Head Formation (160 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Burra-Moko Head Formation (130 m bgl)	No trigger levels defined in the WMP. Increasing trend.
	#3 Banks Wall Sandstone (90 m bgl)	No trigger levels defined in the WMP. Sharp increase in early July likely due to rainfall, slow decline thereafter.
	#4 Banks Wall Sandstone (60 m bgl)	No trigger levels defined in the WMP. Malfunctioned in 2019.

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP16	#1 Burra-Moko Head Formation (115 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Burra-Moko Head Formation (70 m bgl)	No trigger – Stable trend.
CLRP17	#1 Burra-Moko Head Formation (200 m bgl)	Communication was lost with this piezo in October 2015.
	#2 Burra-Moko Head Formation (170 m bgl)	No trigger – slight depressurisation response in August 2021 from mining Panel 818A. Gradual increase during the reporting period.
	#3 Banks Wall Sandstone (70 m bgl)	No trigger – gradual increase during the reporting period.
CLRP18	#1 Burra-Moko Head Formation/Caley Formation (230 m bgl)	Exceeded trigger value from 2/08/17 to 10/04/22. Increasing trend, likely due to above average rainfall.
	#2 Banks Wall Sandstone (75 m bgl)	Communication was lost with this piezo in February 2021.
CLRP19	#1 Burra-Moko Head Formation (170 m bgl)	Exceeded trigger value from 1/1/21 continuing throughout the reporting period. Depressurisation response in August 2021 due to mining Panel 818A. Continued declining trend during the reporting period.
	#2 Burra-Moko Head Formation (120 m bgl)	No trigger – Stable trend.
	#3 Banks Wall Sandstone (90 m bgl)	No trigger – Gradual increase during the reporting period.
CLRP22	#1 Burra-Moko Head Formation (220 m bgl)	Communication was lost with this piezo in November 2020 due to subsidence.
	#2 Banks Wall Sandstone (90 m bgl)	Exceeded trigger value from 1/1/19 to 29/09/22. Gradual increase during the reporting period.
CLRP27	#1 Katoomba Seam (275 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Caley Formation (220 m bgl)	No trigger levels defined in the WMP. Inconsistent data, possibly unsaturated.
	#3 Caley Formation (190 m bgl)	No trigger levels defined in the WMP. Fluctuating, decreasing trend.
	#4 Banks Wall Sandstone (130 m bgl)	No trigger levels defined in the WMP. Fluctuating, no trend apparent.
	#5 Banks Wall Sandstone (90 m bgl)	No trigger levels defined in the WMP. Communication was lost with this piezo in August 2021 due to a malfunction.

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP29	#1 Katoomba Seam (260 m bgl)	No trigger levels defined in the WMP. Increasing trend, possibly due to above average rainfall.
	#2 Katoomba Seam (248 m bgl)	No trigger levels defined in the WMP. Increasing trend, possibly due to above average rainfall.
	#3 Caley Formation (189 m bgl)	No trigger levels defined in the WMP. Increasing trend, due to above average rainfall.
	#4 Banks Wall Sandstone (70 m bgl)	No trigger levels defined in the WMP. Increasing trend, due to above average rainfall.
CLRP33	#1 Katoomba Seam (287 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#2 Caley Formation (276 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#3 Burra-Moko Head Formation (236 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#4 Banks Wall Sandstone (67 m bgl)	No trigger levels defined in the WMP. Stable trend.
CC114	#1 Burra-Moko Head Formation (165 m bgl)	No trigger – stable trend.
	#2 Burra-Moko Head Formation (135 m bgl)	No trigger – stable trend.
	#3 Banks Wall Sandstone (75 m bgl)	No trigger – increasing trend.
	#4 Banks Wall Sandstone (45 m bgl)	No trigger – slight increasing trend.
CC115	#1 Burra-Moko Head Formation (270 m bgl)	No trigger – depressurisation response in August 2021 due to mining of panel 818A. Increasing trend plateauing towards the end of the reporting period.
	#2 Burra-Moko Head Formation (200 m bgl)	No trigger – depressurisation response in August 2021 due to mining Panel 818A.Increasing trend following depressurisation.
	#3 Banks Wall Sandstone (170 m bgl)	No trigger – depressurisation response in August 2021 due to mining Panel 818A. Stable during the reporting period.
	#4 Banks Wall Sandstone (120 m bgl)	No trigger – increasing trend.

REA III GROUNDWATER MONITORING PROGRAM

Three groundwater monitoring piezometers were installed (REA302, REA304 and REA305) with REA III in 2016. All piezometers were drilled at least 2 – 2.5m below the base of REA III. Currently, groundwater level is measured quarterly, and the water is sampled for quality bi-annually. A summary of the last 12 months quality data is displayed below in **Table 7-13**. REA III standing water heights are displayed in **Appendix 9**.

Table 7-13: Summary of REA III Groundwater Monitoring Results

Parameter	REA302		REA304		REA305	
mg/L	Jun-22	Dec-22	Jun-22	Dec-22*	Jun-22	Dec-22
Ph (Ph units)	6.0	7.01	6.5	-	3.0	3.72
Sulfate as SO4	510	423	410	-	788	680
Electrical Conductivity	953	936	948	-	1277	1180
Dissolved Aluminium	0.02	<0.01	0.08	-	45.8	34.3
Dissolved Arsenic	<0.001	<0.001	<0.001	-	0.002	0.004
Dissolved Beryllium	0.013	0.005	0.001	-	0.183	0.165
Dissolved Barium	0.013	0.013	0.022	-	0.016	0.018
Dissolved Cadmium	0.0002	0.0005	0.0002	-	0.0167	0.0159
Dissolved Chromium	<0.001	<0.001	<0.001	-	0.002	0.002
Dissolved Cobalt	0.728	0.295	0.029	-	9.40	6.18
Dissolved Copper	0.003	<0.001	<0.001	-	0.082	0.108
Dissolved Lead	<0.001	<0.001	<0.001	-	0.030	0.022
Dissolved Lithium	0.055	0.043	0.016	-	0.381	0.363
Dissolved Manganese	6.10	2.47	0.452	-	8.93	5.85
Dissolved Molybdenum	<0.001	<0.001	<0.001	-	<0.001	<0.001
Dissolved Nickel	1.88	0.782	0.146	-	22.8	15.6
Dissolved Selenium	<0.01	<0.01	<0.01	-	0.04	0.02
Dissolved Strontium	0.170	0.138	0.308	-	0.347	0.297
Dissolved Vanadium	<0.01	<0.01	<0.01	-	<0.01	<0.01
Dissolved Zinc	1.48	0.634	0.181	-	22.3	14.8
Dissolved Iron	0.0	<0.05	0	-	0	3.18

Notes: * No sample available for December analysis due to possible obstruction in the bore. To be further investigated in the next Reporting Period.

7.4.3 Comparison Against Predictions

Page 87 of the 900 Area SMP Written Report (2013) discusses the groundwater environment at the time of the submission and discusses predicted impacts. The Aurecon (2013) report referenced in the document concludes that the proposed mining will have no significant impact on the groundwater regime on both a local and regional scale provided subsidence is maintained at the predicted low levels. Consequently it is highly unlikely that there will be an impact to the shallow groundwater regime in areas adjacent to the proposed mining areas.

As discussed within **Section 6.8**, subsidence remined within the predicted low levels. The results reported above in **Section 7.4.2**, groundwater levels remained unimpacted by mining activities during the Reporting Period.

As predicted in MOD2, groundwater flow will originate from the south-west of the site in the area surrounding the access road to the mine and has minimal potential to be disrupted by the establishment of REA VI. However the western portion of the REA VI is proposed to be located in close proximity to the southern portion of the NPHS posing a greater risk to the NPHS. As described in Section 7.4, excavation for the establishment of the REA VI will be restricted to ensure no disruption to groundwater seepage to the hanging swamp.

7.4.4 Long Term Analysis

Where groundwater triggers are investigated and found to be a result of mining related activity as defined in the Clarence Water Management Plan, this is considered an exceedance. A five-year summary of exceedances is presented in **Table 7-14**.

Table 7-14: 5 Year Groundwater Exceedance Summary

Reporting Period	Groundwater Levels	Groundwater Quality	Total Exceedances
2018	0	0	0
2019	0	0	0
2020	0	0	0
2021	0	0	0
2022	0	0	0

7.4.5 Implemented / Proposed Improvements

The Clarence Colliery WMP will be updated during the next reporting period to include the most current groundwater model and TARP triggers will be reviewed and updated where required based on the model.

8 REHABILITATION

Clarence Colliery manages rehabilitation in accordance with the Rehabilitation Management Plan (RMP).

The RMP was prepared in accordance with the NSW Resources Regulator (NSW RR) Form and Way-Rehabilitation Management Plan for Large Mines (NSW RR, July 2021) required under the Mining Regulation 2016 and submitted on the 29 July 2022 via the MSW RR Portal.

The RMP also satisfies Condition 29, Schedule 3 of DA 504-00, and the requirements of ML1353, ML1354, ML1583, ML1721 and CCL705. The RMP describes the management of rehabilitation at the Clarence Colliery. The RMP is available on the website https://www.centennialcoal.com.au/operations/clarence/

The Forward Program sets out the three-year forecast for both proposed surface disturbance and rehabilitation schedule for Clarence Colliery.

This section addresses the annual rehabilitation reporting requirements for the Annual Review as required by Condition 5, Schedule 5 of DA 504-00. Annual reporting requirements in the RMP will be reported in the Annual Rehabilitation Report and Forward Program (ARR&FP) and submitted using the online form accessible via the NSW Resource Regulator's mine rehabilitation portal.

8.1.1 Summary of Rehabilitation

Table 8-1: Rehabilitation Status

Mine Area Type	Previous Reporting Period (Actual) 2021 (ha)	This Reporting Period (Actual) 2022 (ha)	Next Reporting Period (Forecast) 2023 (ha)
A. Total mine footprint[1]	101.72	101.72	102.76
B. Total active disturbance[2]	76.76	76.76	76.73
C. Land being prepared for rehabilitation[3]	0	0	1.07
D. Land under active rehabilitation[4]	24.96	24.96	24.96
E. Completed rehabilitation[5]	<0	0	0

Notes: [1] **Total Mine Footprint:** includes all areas within a mining lease that either have at some point in time or continue to pose a rehabilitation liability due to mining and associated activities. As such it is the sum of total active disturbance, decommissioning, landform establishment, growth medium development, ecosystem establishment, ecosystem development and relinquished lands. Please note that subsidence remediation areas are excluded. [2] **Total Active Disturbance:** includes all areas requiring rehabilitation [3] **Land being prepared for rehabilitation:** includes the sum of mine disturbed land that is under the following rehabilitation phases – decommissioning, landform establishment and growth medium development. [4] **Land under active rehabilitation:** includes areas under rehabilitation and being managed to achieve relinquishment – includes 'ecosystem and land use establishment' and 'ecosystem and land use sustainability [5] **Completed rehabilitation**: requires formal sign off from DRE that the area has successfully net the rehabilitation land use objectives or completion criteria

At the end of the Reporting Period, total of approximately 24.96 hectares (ha) of native woodland rehabilitation had been completed at Clarence Colliery across REAs I, II, III, IV and VI. Rehabilitation activities on REA II were completed in 1996, while REA I and III were rehabilitated in 2002. The rehabilitation of REA IV started in late 2012 with final completion in late 2016. Rehabilitation works on of REA VI started in 2019 with approximately 2.0 ha established.

Final land use at Clarence Colliery is not specified under tenement and Developmental Consent conditions. The post-mining land use goal is to provide a low maintenance, geotechnically stable and safe landform that is commensurate with the surrounding area.

The preferred post-mining land use is to return disturbed areas around Clarence Colliery to a woodland/forest community commensurate with the adjacent native vegetation. Some water bodies and drainage structures will be maintained to manage surface water flows and provide water resources for native fauna.

For further information refer to the RMP.

8.1.2 Rehabilitation Monitoring

The 2022 monitoring survey involved the established six rehabilitation monitoring sites and three control (analogue) sites used in recent years (**Table 8-2**).

Annual rehabilitation monitoring has been undertaken at Clarence since 2012, tracking rehabilitation success against previous completion criteria and informing any maintenance requirements. Centennial have undertaken a Rehabilitation Review to establish a site-specific monitoring program to support the ongoing refinement of rehabilitation objectives and completion criteria assessment, and alignment with associated guidelines. This includes transitioning Centennial operations to the NSW Biodiversity Assessment Method ('BAM', OEH 2020) to align with new rehabilitation objectives and completion criteria assessment (refer to the RMP).

Analogue sites are a central component of the rehabilitation monitoring program at Clarence and are used to derive target benchmarks against which rehabilitation performance can be assessed, particularly with reference to species diversity, assemblages and vegetation structure. The analogue sites are located in nearby areas of undisturbed native vegetation representative of local vegetation type and condition, and generally mapped as 'Exposed Blue Mountains Sydney Peppermint – Silver-top Ash Shrubby Woodland'.

Each monitoring site consists of a standardised 50m long transect, with a nested 10m x 30m plot and 1m x1m quadrats. To facilitate repeated measurements over time, all sites were permanently located with metal star pickets at the start and end points of the 50m line, and their geographical coordinates recorded using a GPS (±3m accuracy).

An overview of the monitoring program is presented in **Table 8-2** and **Figure 8-1**.

Table 8-2: Clarence Rehabilitation Monitoring Sites

Site Code	Type	Rehabilitation Establishment	Slope (deg)	Coordinates (GDA94 Zone 56)	
				Easting	Northing
RHB 1	Rehabilitation	2002	12	244291	6294105
RHB 2	Rehabilitation	1996	12	244563	6293796
RHB 3a	Rehabilitation	2002	17	244665	6294303
RHB3b	Rehabilitation	2002	22	244752	6294210
RHB 4b	Rehabilitation	2016	20	244299	6293670
RHB 6a	Rehabilitation	2019	20	243889	6293733
ANA 1	Analogue	N/A	3	244632	6293686

Site Code	Type	Rehabilitation Establishment	Slope (deg)	Coordinates (GDA94 Zone 56)	
				Easting	Northing
ANA 2	Analogue	N/A	12	244659	6294391
ANA 3	Analogue	N/A	10	244521	6294450

Gingra Ecological Surveys (GES) was commissioned by Clarence Colliery to undertake the 2022 annual rehabilitation monitoring. A summary of the 2022 rehabilitation monitoring program is provided below with the complete report provided in **Appendix 10**.

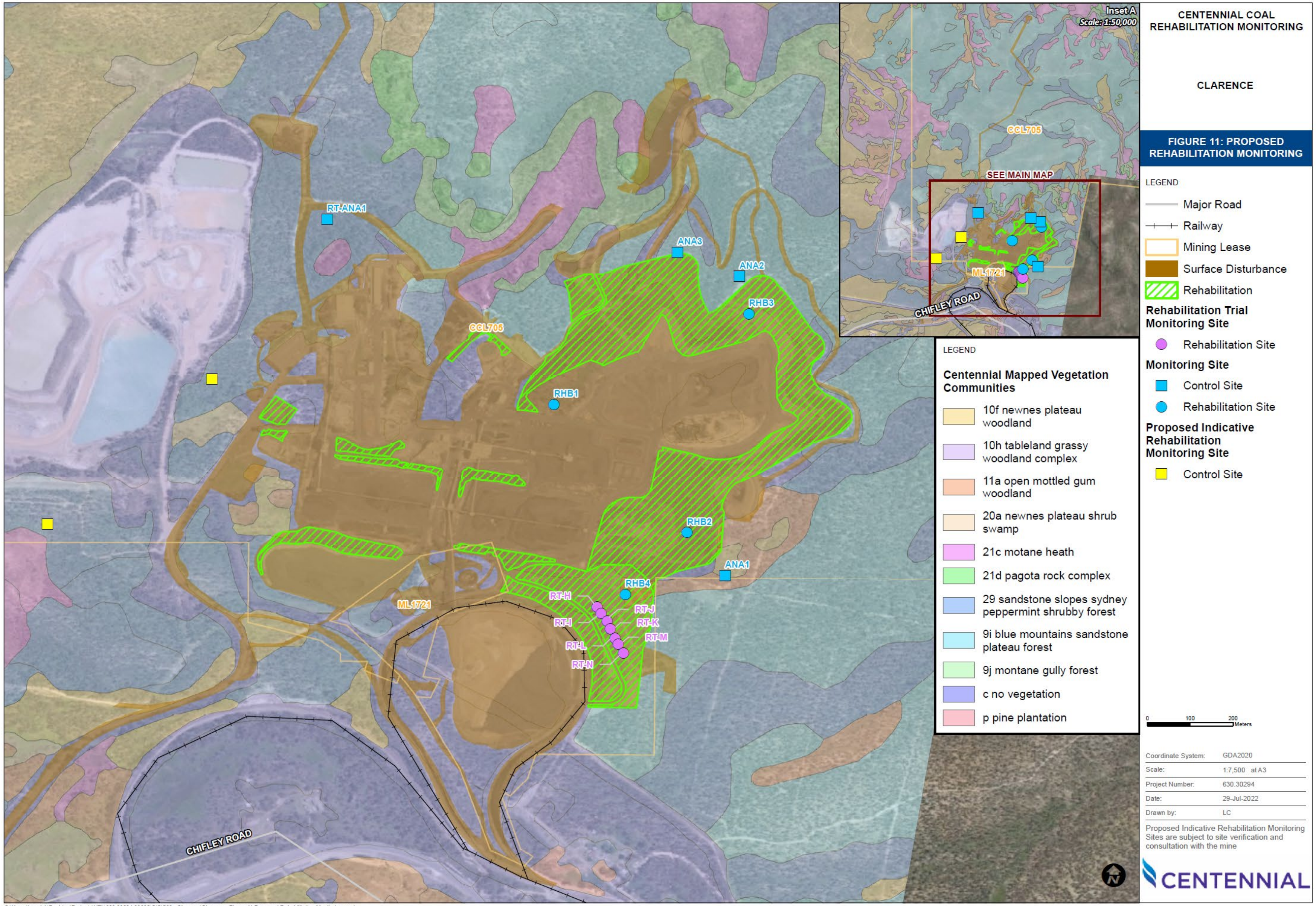
The rehabilitation monitoring program has been designed to measure the progress of rehabilitation against the objectives and completion criteria developed for the RMP. In accordance with the RMP criteria, results are presented according to the three main attributes of the Biodiversity Assessment Method (BAM), namely: composition, structure and function.

The native plant species composition of the rehabilitation areas is trending towards that of analogue sites. The presence of a number of difficult to propagate species such as members of the Ericaceae family including *Brachyloma daphnoides*, *Epacris pulchella, Leucopogon lanceolatus* and *Monotoca scoparia* is an indicator of the success of rehabilitation (GES, 2023).

Table 13 of the RMP presents draft completion criteria for a number of parameters. For vegetation composition the RMP suggests that the presence of 1 tree species, 2 shrub species and 6 ground layer species characteristic of the target vegetation type represents an adequate degree of floristic diversity to meet a completion criterion. The BAM data collected in 2022 shows that half of rehabilitation plots meet this criterion with the number of tree, shrub and ground layer species being comparable to analogue plots. At RHB 1, RHB 4B and RHB 6, tree diversity was low, which may indicate a need for supplementary seeding or planting of tubestock to improve eucalypt diversity. Shrub and ground layer diversity was at least adequate at all rehabilitation plots with levels comparable to or exceeding those at the analogue plots (GES, 2023).

The rehabilitation area currently provides woodland habitat of varying age and structure suitable for the bird species which inhabit the bushland areas surrounding the mine. The proximity of this more intact bushland means that a range of woodland birds were recorded opportunistically during the field survey, including Australian Magpie, Australian Raven, Pied Currawong, Crimson Rosella, Yellow-Tailed Black Cockatoo, Superb Lyrebird, Whitethroated Treecreeper, White-eared Honeyeater, Rufous Whistler, Superb Fairy-wren and Grey Shrike-thrush. The area also supports native mammals with Eastern Grey Kangaroo scats being observed during the field survey (GES, 2023).

Figure 8-1: Clarence Colliery Rehabilitation Monitoring



8.2 DECOMMISSIONING

There were no decommissioning activities at Clarence Colliery during the Reporting Period.

8.3 OTHER REHABILITATION ACTIVITIES

There were exploration activities undertaken at the site during the reporting period. These works included two exploration boreholes completed on the Newnes Plateau (see **Section 4.3**).

Other rehabilitation management and maintenance activities undertaken during the reporting period include:

- Ongoing monitoring, site inspections identifying weeds, erosion and sediment control, pest species; and
- Weed control was undertaken.

8.4 REHABILITATION TRIALS AND RESEARCH

Clarence Colliery proposes to undertake trials to improve ground cover within existing rehabilitation areas during the LOM. These trials will involve supplementary planting of native grasses and shrubs. Species may include but not be limited to: Basket Grass *(Lomandra longifolia*), Poa Tussock (*Poa labillardierei*), *Rytidosperma pallidum* (*Joycea pallida*), Sunshine Wattle (*Acacia terminalis*), Silky Hakea (*Hakea sericea*), Red-stemmed Wattle (*Acacia rubida*), Yellow Tea Tree (*Leptospermum polygalifolium*) and *Geranium solanderi*.

In addition to these trials, SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Clarence to implement a rehabilitation trial within Reject Emplacement Area 4 (REA 4) at the colliery. The results of the proposed trials will be used to identify suitable methods for the rehabilitation of REA 3. The trial design will test the most effective methods to minimise erosion, maximise biodiversity and promote long term cost effective rehabilitation. This will be completed by trailing a variety of:

- Erosion control products;
- Ameliorants including Nitrohumus® and topsoil stripped from REA 5; and
- Native seed species endemic to the Newnes Plateau

The rehabilitation trial forms part of a 'High Risk Activity Notification' process to allow for operational activities in preparation for the rehabilitation and decommissioning of REA 3. Monitoring reports are delivered annually to capture the following:

- Estimated soil loss from each trial area, with a comparison to the average soil loss rates (year 1 only)
- Ecological trends
- Assessment of rehabilitation performance against prescribed criteria (as set out in the Clarence Mining Operations Plan 'MOP')
- Recommendations for any necessary remedial works and/or changes to treatment that provide cost effective improvements to rehabilitation performance

Appendix 11 describes the methods and results of the annual monitoring survey undertaken within REA4 in December 2022 (SLR, 2023). A summary of the annual monitoring survey of this rehabilitation trial is provided below.

Monitoring data collected at year three (2022) has been compared to baseline data from 2019 and data from year one (2020) and year two (2021), enabling comparison of several rehabilitation techniques (growth medium, erosion control and supplementary planting) applied at the seven trial plots.

Results of the surveys suggest that Site K (vital polykelp with cover crop) and Site L (jute mesh, cover crop) are currently performing the best, and Site H (straw mulch without cover crop) and Site N (no treatment, cover crop) are performing the worst.

The EFA data continues to return a strong improvement from the previous results, however, most of the components are below the values required to meet MOP completion criteria. Additionally, the trial plots are generally stable and there are currently minimal remediation actions recommended. The next annual monitoring survey will be required in November-December 2023.

It is recommended that the analogue site is re-surveyed in future annual monitoring events, to allow comparison of results to areas of natural bushland (and target vegetation for the rehabilitation) over time.

8.5 NEXT REPORTING PERIOD

In 2023, the following major activities will be conducted:

- Material balance considering change of excavation depths in REA 5;
- Consider pit top rehabilitation material balance;
- Continued annual rehabilitation monitoring across REAs 1, 2, 3 and 4; and
- Continued progressive rehabilitation of Reject Emplacement Area REA 3.

9 COMMUNITY CONSULTATION

Clarence Colliery consults with the community through forums such as, the Clarence Colliery Community Consultative Committee and community organised events. Meetings of the Clarence Colliery Community Consultative Committee (CCC) were held on:

- 15 February; and
- 20 September.

Representatives of the Lithgow and Clarence community, appointed community representatives, relevant government organisations and company representatives attended the meetings. A detailed presentation was provided to attendees at each CCC meeting on the Mine's production, geological update, subsidence results, environmental monitoring, Extraction Plan updates, approval updates and upcoming projects. Key agenda items discussed in 2022, included:

- Environmental compliance and community complaints summary;
- Environmental performance summary;
- Update on the REA III fines removal project;
- Update on Clarence pipeline project associated with planned cessation of discharge from LDP002;
- Update on MOD 7 and MOD 8;
- Update on proposed Extraction Plan; and
- Aboriginal cultural heritage monitoring update

Extensive community consultation with landowners in and around the Clarence Colliery mining lease area is undertaken. As there are no current or proposed workings underneath private properties, no mining related subsidence has been reported or measured. In general, the Clarence Colliery community consultation has been conducted during the CCC meetings.

Clarence Colliery continues to support the local community through various sponsorship avenues to the following community activities, groups, and associations in 2022.

9.1 COMMUNITY COMPLAINTS

During the 2022 Reporting Period, there were no community complaints received. **Table 9-1** below summarises the annual community complaints received by Clarence Colliery since 2017.

A complaint register is made publicly available on the Centennial Coal website in accordance with Schedule 5 Condition 11 of DA 504-00
https://www.centennialcoal.com.au/operations/clarence/

Table 9-1: Record of Annual Community Complaints for 2017 to 2022

Community Complaints						
Year	**Air**	**Water**	**Noise**	**Waste**	**Other**	**Total**
2017	0	0	1	0	1	2
2018	0	0	0	0	1*	1
2019	0	0	0	0	0	0
2020	0	0	0	0	0	0
2021	0	0	0	0	0	0
2022	0	0	0	0	0	0

*Related to trucks driving on Bells Line of Road – was not confirmed that Centennial Clarence was the source of this complaint.

10 INDEPENDENT ENVIRONMENTAL AUDIT

The three yearly Independent Environmental Audit (IEA) was conducted from November-December 2020. The IEA found that Clarence was compliant with 88% of conditions across 11 approvals and a total of 260 conditions. A total of 30 recommendations were given to address the identified non-compliances. A response to the IEA recommendations was submitted to DPIE in February 2021 and an update provided in the 2021 Annual Review.

A summary of the remaining actions from the IEA and their status is provided in **Table 10-1**.

Table 10-1: Non-Compliance Findings and Action Status from 2020 IEA Report

IEA Recommendation	Response to Recommendation	Status at end of Reporting Period
R8 CLA IEA 2020 Advise BCD of the current status of the long-term security for the biodiversity offset for the clearing of 4.1 hectares of Newnes Plateau Narrow-leaved Peppermint – Silver-top Ash Layered Open Forest and the loss of related biodiversity values, including for threatened species.	Centennial will advise BCD as recommended.	**Complete** Addressed in Section 3 of the Western Region Biodiversity Offset Strategy.
R9 CLA IEA 2020 Asses opportunities to consistently achieve night noise impact assessment criteria in DA504 Sch 3 – 15 (Noise Impact Assessment Criteria) and EPL L5.1 (Noise Limits)	A study has been undertaken – a suggestion was to move the monitoring point to a place closer to that of the receptors. Clarence will consult with regulatory authorities regarding this.	**Complete (and ongoing)**
R14 CLA IEA 2020 Place the 2020 EMS on the CC website and provide copies of, or links to, the 2020 EMS to relevant agencies, Council, and the CCC.	Actioned.	**Complete (and ongoing)** All documents are on the Centennial Coal website.

IEA Recommendation	Response to Recommendation	Status at end of Reporting Period
R17 CLA IEA 2020 Following approval of revised management plans, completion of ARs and the IEA; provide copies of the documents, or links to the documents, to Council, the relevant agencies, CCC and on the CC website.	Noted.	**Complete (and ongoing)** Approved Management Plans, Annual Reviews and IEA documents are on the Centennial Coal website.
R20 CLA IEA 2020 Arrange an annual on site meeting over the life of the project, to inspect the results of rehabilitation works, with invitations to representatives from Council, the Department of Conservation and Land Management, National Parks and Wildlife Service and Department of Mineral Resources (or equivalent agency).	Regulatory authorities (Resources Regulator, EPA, Local Council) visit site at least annually. Clarence will investigate whether this is sufficient to meet this condition, and if not, will implement such an annual meeting.	**Not yet complete**
R22 CLA IEA 2020 To improve rehabilitation performance, undertake progressive rehabilitation of REAs including: • Assess the status of current cumulative rehabilitation areas against forecasts in the 2018 -2022 MOP Amendment A and report in ARs. • Implement recommendations from the 2020 annual rehabilitation monitoring report. Continue to conduct an annual independent review of rehabilitation performance by competent persons and implement recommendations.	Results of the annual monitoring will be presented in the Annual Review and discussed against the MOP forecasts.	**Complete (and ongoing)** Rehabilitation monitoring is conducted annually by an independent contractor. The MOP was superseded by the RMP in 2022. The RMP includes a monitoring program which will be implemented in 2023.
R23 CLA IEA 2020 Consult with the Soil Conservation Service (now within DPIE) during topsoil stripping and stockpiling associated with Reject Emplacement Area and V; or seek that approval that this condition is not required for future work	Consultation has been achieved through the HRA process – Clarence will investigate whether this condition is still relevant.	**Partially completed** Relevance of condition not yet confirmed.
R29 CLR IEA 2020 Increase security deposit to $285,000 to meet the Notification Assessment for rehabilitation obligations for ML 1583 (DRG, 8 October 2020).	This is related to the separation of ML1583 from the man Clarence RCE. Centennial will respond to this appropriately.	**Complete**

11 INCIDENTS AND NON-COMPLIANCES DURING THE REPORTING PERIOD

During the 2022 calendar year Reporting Period there were a total of 6 reportable incidents and non-compliances (excluding community complaints).

Table 11-1 provides a summary of the incidents and non-compliances, including the actions taken by Clarence Colliery in response to the incident/non-compliance.

Table 11-1: Incidents and Non-Compliances during the Reporting Period

Compliance[6]	Overview of incident/non-compliance	Description of incident/non-compliance	Actions	Status of Actions
Non-Compliance 1	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On 19 January 2022, a routine monthly grab sample was taken from LDP002, in which a dissolved zinc result of 0.012mg/L exceeded the compliance limit of 0.008mg/L. Due to the very small concentration of the exceedance, it was determined that no actual and/or potential material harm has been caused to the environment.	A follow up sample was taken at the discharged point on Wednesday 2 February 2022.	**Complete**
Non-Compliance 2	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On 7 Match 2022, a routine monthly grab sample was taken from LDP002, in which the following exceedances were detected: • Dissolved cobalt result of 0.0683mg/L, the compliance limit is 0.0025mg/L • Dissolved nickel result of 0.133, the compliance limit is 0.011mg/L • Dissolved zinc result of 0.047mg/L, the compliance limit is 0.008mg/L • TSS result of 48mg/L, the compliance limit is 30mg/L. Due to the very small concentration of the exceedance, it was determined that no actual and/or potential material harm has been caused to the environment.	The flow through the site Water Treatment Plant (WTP) was reduced to restrict the amount of water being discharged via LDP002 as much as practicable during the rainfall event.	**Complete**

[6] See Compliance Status Key beneath Table 1-2 for risk level, colour code and description.

Compliance[6]	Overview of incident/non-compliance	Description of incident/non-compliance	Actions	Status of Actions
Non-Compliance 3	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On 13 July 2022, a routine monthly grab sample was taken from LDP002, which showed an elevated reading of Total Nitrogen of 0.8mg/L against the EPL limit 0.25mg/L. It is noted that within the 14-day period before the non-compliance, over 200mm of rain was recorded on site.	The Water Treatment Plant operation was ensured to be functioning as designed.	**Complete**
Non-Compliance 4	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On 19 October 2022, a routine monthly grab sample was taken from LDP002, which showed an elevated reading of the following: • Dissolved zinc result of 0.01mg/L, the EPL limit is 0.008mg/L • Total Nitrogen result of 0.4mg/L, the EPL limit is 0.25mg/L.	A re-sample was organised to confirm results. Water Treatment Plant operation was ensured to be functioning as designed.	**Complete**
Non-Compliance 5	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On 16 November 2022, a routine monthly grab sample was taken from LDP002, in which a dissolved zinc reading of 0.01mg/L exceeded the concentration limit of 0.008mg/L. Due to a very small concentration of the exceedance, it was determined that no actual and/or potential material harm has been caused to the environment.	A re-test and re-sample was organised to confirm results. Water Treatment Plant operation was ensured to be functioning as designed.	**Complete**
Non-Compliance 6	Exceedance of concentration limits as per EPL 726, Condition L2.4 and DA 504-00 Schedule 3, Condition 9(b)	On Wednesday 14 December 2022, a monthly routine grab sample was taken from LDP002, in which the following exceedances were detected: • Total Nitrogen results of 0.3mg/L, the EPL limit is 0.25mg/L • Total Phosphorus result of 0.06mg/L, the EPL limit is 0.02mg/L. Due to a very small concentration of the exceedance, it as determined that no actual and/or potential material harm has been caused on the environment.	The Water Treatment Plant operation was ensured to be functioning as designed.	**Complete**

12 ACTIVITES TO BE COMPLETED IN THE NEXT REPORTING PERIOD

Table 12-1 presents activities that are currently planned for the next Reporting Period.

Table 12-1: Forecast Operations for 2022

Improvement Actions
• A sound power level assessment was proposed to be conducted during the 2022 reporting period to determine possible areas of improvement associated with the equipment currently in service at Clarence. This monitoring assessment was postponed during the reporting period and will now be undertaken in 2023.
Management Plan Revisions
• Clarence completed a review of the WMP in September 2021 (Version 2) to incorporate regulator comments, responses to actions from the 2020 Independent Environmental Audit (IEA) and Modification 6 (MOD 6). During this Reporting Period the WMP (Version 3) was revised in June 2022 to include Leachate Dam 4 and response to regulator comments. At the time of preparing the 2022 Annual Review WMP (Version 3) had not been approved. Further consultation with DPE regarding the latest revision to the WMP (Version 3) will be undertaken during the next Reporting Period. • Further consultation with DPE regarding the latest revision to the WRBMP (Version 6), will be undertaken during the next Reporting Period. Revision of the WRBMP to be undertaken in the next Reporting Period as required.
Condition Triggers
• In accordance with Condition 13(b) in Schedule 5 of DA 504-00 strategies, plans, and programs required under the consent will be reviewed within three months of the submission of this annual review. If necessary, the strategies, plans, and programs required under the approval will be revised and within 4 weeks of the review the revised documents must be submitted for the approval of the Secretary.
• In accordance with Condition 28 in Schedule 3 of DA 504-00 a Mine Closure Strategy for the Clarence Colliery will be developed in consultation with Council, Resources Regulator, DPE Water and EPA, and to the satisfaction of the Planning Secretary.

13 REFERENCES

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EMM (2019a). *Clarence Colliery: Modification to DA 504-00 Statement of Environmental Effects (Mod 4)*, Prepared for Centennial Coal Company Limited

EMM (2019b). *Clarence Colliery: Modification to DA 504-00 – Employee Increase (Mod 5)*, Prepared for Centennial Coal Company Limited

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GHD (2013). *Environmental Assessment: Clarence Colliery Reject Emplacement Area VI, Section 75W Modification to Development Consent DA 504-00 (Mod 2)*, Prepared for Centennial Coal Company Limited

Gingra Ecological Surveys (2022a). *Flora Monitoring Program – Summer Report* 2022, Prepared for Clarence Colliery Pty Ltd.

Gingra Ecological Surveys (2022b). *Flora Monitoring Program – Autumn Report* 2022, Prepared for Clarence Colliery Pty Ltd.

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Marine Pollution Research Pty Ltd (2022). *Wollangambe River Aquatic Ecology – Autumn 2022 Data Report*, Prepared for Clarence Colliery Pty Ltd.

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Marine Pollution Research Pty Ltd (2022). *Dingo Creek Catchment Aquatic Ecology – Spring 2022 Data Report*, Prepared for Clarence Colliery Pty Ltd.

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RPS (2022b). *Phase 1 heritage monitoring of AHIMS sites 45-1-0185, 45-1-0186, 45-1-0188 (915 and 919 panels)*, Prepared for Clarence Colliery Pty Ltd.

RPS (2022c). *Phase 2 Heritage Monitoring AHIMS Sites 45-1-2872, 45-1-2874 and 45-1-2875*, Prepared for Clarence Colliery Pty Ltd.

SLR (2013). *Clarence Colliery Pty Ltd Air Quality Impact Assessment*, Report Number 630.10123-R6, Prepared for Clarence Colliery Pty Ltd.

SLR (2023). *Reject Emplacement Area 4 Rehabilitation Trial Annual Monitoring*, SLR Ref No: 630.12944-R01-v2.0, Prepared for Clarence Colliery Pty Ltd.

Umwelt (2023). *Dewatering Borehole Aboriginal Heritage Due Diligence Assessment*, Prepared for Centennial Coal Company Pty Limited.

PLANS

Plan Reference	Plan Name
Plan 1	CL2095 – Production for 2022 Shown Monthly
Plan 2	CL2032 – Plan Showing Subsidence Monitoring

LEGEND

- EXISTING BOREHOLE / PIEZOMETERS
- COLLIERY HOLDING BOUNDARY
- NEWNES PLATEAU HANGING SWAMP
- NEWNES PLATEAU SHRUB SWAMP
- SWAMP PIEZOMETERS
- SURFACE DRAINAGE
- RIVERS\CREEKS
- ROADS\TRACKS
- FAULT
- STRIKE SLIP FAULT
- MODERATE ROOF ZONE
- STRUCTURED ROOF ZONE
- INTRUSION

NOTE:
1. The workings and scale shown on this plan are **indicative only**
2. Mine workings pre 2005 - refer to hard copy Mine Working Plan (in I.S.G.format)
3. Current mine workings - refer to digital mine working plan
4. Any queries on the workings - refer to the survey department at Clarence Colliery
5. The workings for the month that are shown (coloured hatching) are correct to the best of my knowledge (Mine Surveyor - Karl Harisson)

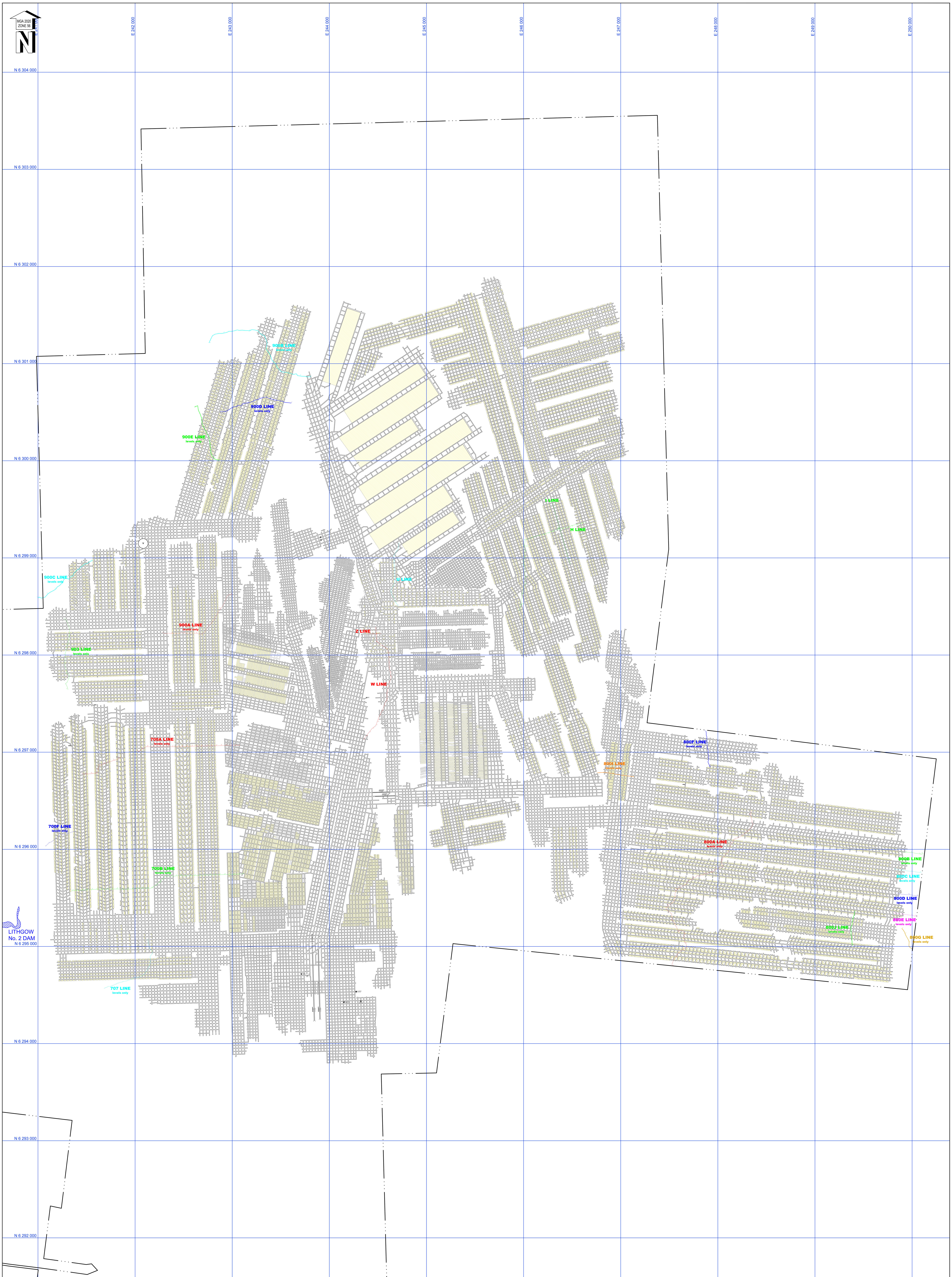
DATE	03.01.2023
SEAM	KATOOMBA
REFERENCE	
N:\Plans\EOM\2022\Monthly & Quarterly_prodn_2022.dwg	
SCALE	DIAGRAM

PRODUCTION FOR 2022 SHOWN MONTHLY

ENVIRONMENTAL REPORT

CENTENNIAL CLARENCE

DRG. No. CL2095



NOTE
- The workings and scale shown on this plan are **indicative only**
- Mine workings pre 2005 - refer to hard copy Mine Working Plan (in I.S.G.format)
- Current mine workings - refer to digital mine working plan
- Any queries on the workings - refer to the survey department at Clarence Colliery

LEGEND

SUBSIDENCE LINES

700 A	800 A	800 F	900 A	900 B	W & Z
700 B	800 B	800 G	903	900 D	H & I
707	800 C	800 I	900 C	900 E	U
716 F	800 D	800 J			
	800 E				

WORKINGS

EXTRACTION

COLLIERY HOLDING

PLAN SHOWING SUBSIDENCE MONITORING

WORKINGS CHARTED TO 31/12/2022

DATE	27/04/2023
SCALE	NOT TO SCALE
DRG. No.	CL2032

REFERENCE
N:\Plans\Surface\Subsidence\SMP_Reports

CENTENNIAL
CLARENCE

THIS DRAWING IS THE PROPERTY OF CLARENCE COLLIERY PTY. LTD.

APPENDICES

Appendix No.	Appendix Name
1	Annual Review Reporting Requirements Checklist
2	Noise Monitoring Report
3	Flora Monitoring Reports
4	Fauna Monitoring Reports
5	Aquatic Monitoring Reports
6	Heritage Inspection Reports
7	Subsidence Monitoring Results
8	Water Quality Monitoring Results
9	Groundwater Monitoring Report
10	Rehabilitation Monitoring Report
11	REA IV Rehabilitation Monitoring Report

Appendix 1: Annual Review Reporting Requirements

Approval / Condition	Requirement	Annual Review Section
DA 504-00, Schedule 5 Condition 5	The applicant must prepare and submit an annual review to the Planning Secretary and the relevant agencies. This report must:	This document
	(a) Identify the standards and performance measures that apply to the development	Section 3
	(b) Describe the works carried out in the last 12 months	Section 4, 6, 7, and 8
	(c) Describe the works that will be carried out in the next 12 months	Section 12
	(d) Include a summary of complaints received during the past year, and compare this to the complaints received in previous years	Section 9
	(e) Include a summary of the monitoring results for the development during the past year	Section 6 to 8
	(f) Include an analysis of these monitoring results against the relevant: • Impact assessment criteria • Monitoring results from previous years • Predications in the EIS	Section 6 to 8
	(g) Identify any trends in the monitoring results over the life of the development	Section 6 to 8
	(h) Identify any non-compliance during the previous year	Section 1 & 11
	(i) Describe what actions were, or are being taken to ensure compliance	Section 11
DA 504-00, Schedule 3 Condition 7	The Water Balance must: (a) include details of all water extracted, dewatered, transferred, used and/or discharged by the mine; and (b) provide for the annual re-calculation of the water balance and reporting of the review in the Annual Review.	Section 7.2
DA 504-00, Schedule 3 Condition 12	Each year, the Applicant must: (a) review the Water Management Plan; (b) update each sub-plan; and (c) report the results of this review in the Annual Review, including; (d) the results of monitoring; (e) details of the review for each sub-plan; (f) amendments to the sub-plans; and (g) details of the measures undertaken / proposed to address any identified issues.	

Approval / Condition	Requirement	Annual Review Section
DA 504-00, Schedule 3 Condition 23	The Applicant must: (a) monitor the greenhouse gas emissions generated by the development; (b) investigate ways to reduce greenhouse gas emissions on site; and (c) report on these investigations in the Annual Review, to the satisfaction of the Planning Secretary.	

Appendix 2: Attended Noise Monitoring Report

CLARENCE COLLIERY

Annual Noise Monitoring
November 2022

Prepared for:

Clarence Colliery Pty Ltd
Centennial Western Accounts
Locked Bag 1002
WALLERAWANG NSW 2845

SLR Ref: 630.12945-R04
Version No: -v1.0
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PREPARED BY

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BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.12945-R04-v1.0	19 December 2022	Nicholas Vandenberg/ Adam Sirianni	Martin Davenport	Martin Davenport

CONTENTS

DOCUMENT REFERENCES

TABLES

FIGURES

APPENDICES

1 Introduction

SLR Consulting Australia Pty Ltd (SLR) has been engaged by Clarence Colliery to conduct annual noise compliance monitoring for 2022 for the Clarence Colliery as guided by the Centennial Coal Noise Management Plan Western Region (NMP) April 2018.

The purpose of this assessment was to determine the noise contribution from Clarence Colliery operations, in accordance with the Clarence Colliery Environment Protection Licence (EPL) No. 726 and the Conditions of Approval (CoA) DA 504-00 Mod 5.

The report uses specialist acoustic terminology. An explanation of common terms is provided in **Appendix A**.

2 Relevant Noise Criteria

2.1 Conditions of Approval Noise Limits

Condition 15 of the Development Approval DA 504-00 provides noise impact assessment criteria. The noise limits are applicable to noise "generated from the premises, excluding train loading and rail operations" and are reproduced in **Table 1**. EPL 726 provides the same noise limits for site operations.

Table 1 Noise Impact Assessment Criteria dBA

Land	Day $L_{Aeq(15min)}$	Evening $L_{Aeq(15min)}$	Night $L_{Aeq(15min)}$
Any residence on privately-owned land	38	36	35

Note: Daytime 7.00 am - 6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 7.00 am, On Sundays and Public Holidays, Daytime 8.00 am -6.00 pm; Evening 6.00 pm - 10.00 pm; Night-time 10.00 pm - 8.00 am.

Notes:

a. *For the purpose of these noise criteria, 5dB(A) must be added to the measured level if the noise is substantially tonal or impulsive in character.*

b. *The noise criteria do not apply where the Applicant and the affected landowner have reached a negotiated agreement in regard to noise, and a copy of the agreement has been forwarded to the Secretary and EPA.*

c. *Noise from the development is to be measured at the most affected point or within the residential boundary, or at the most affected point within 30 metres of a dwelling (rural situations) where the dwelling is more than 30 metres from the boundary, to determine compliance with the LAeq(15 minute) noise limits in the above table. Where it can be demonstrated that direct measurement of noise from the development is impractical, the EPA may accept alternative means of determining compliance (see Chapter 11 of the NSW Industrial Noise Policy). The modification factors in Section 4 of the NSW Industrial Noise Policy shall also be applied to the measured noise levels where applicable.*

d. *The noise criteria apply under prevailing meteorological conditions (winds up to 3m/s), except under conditions of temperature inversions. Noise impacts that may be enhanced by temperature inversions must be addressed by:*

- *documenting noise complaints received to identify any higher level of impacts or patterns of temperature inversions; and*
- *where levels of noise complaints indicate a higher level of impact then actions to quantify and ameliorate any enhanced impacts under temperature inversion conditions shall be developed and implemented.*

Condition M4 of EPL 726 also specifies requirements relating to noise monitoring:

M4.1 The licensee must undertake yearly (in-line with the reporting period) noise monitoring as outlined below, to determine compliance with the noise limits stipulated by condition L5.1:

a. 1 day attended noise monitoring covering the day, evening and night time periods; and

b. 5 days unattended noise monitoring (monitor and logger) covering each day, evening and night time periods.

M4.2 The results of the noise monitoring required by condition M4.1, and an interpretation of these results, must be provided as an attachment to each corresponding years Annual Return.

M4.3 The licensee, following the receipt of a noise related complaint and if required by the EPA, must undertake noise monitoring as required by the EPA to determine compliance with the noise limits stipulated by condition L5.1.

M4.4 The results of the noise monitoring required by condition M4.3, and an interpretation of these results, must be provided to the EPA within 21 days of the completion of the noise monitoring.

3 Operational Noise Monitoring Methodology

3.1 General Requirements

The noise measurements and assessments in this report have been prepared in accordance with Australian Standard AS 1055-1997 "*Description and Measurement of Environmental Noise*" Part 1, 2 and 3 and with reference to the *Noise Policy for Industry* (NPfI) and the NMP.

The objectives of the noise monitoring assessment were as follows:

- Measure the noise contribution from Clarence Colliery operations at the CNM1 as per the long-term noise monitoring locations outlined in the NMP.
- Determine all sources of noise within each of the noise surveys, including estimated contribution or maximum level of each source.
- Assess the noise emissions of Clarence Colliery operations, in relation to the EPL 726 and DA 504-00 limits for the site and with regard to wind speed and direction during the noise surveys.

3.2 Operator Attended Noise Monitoring

The acoustic instrumentation used during the monitoring programme has been designed to comply with the requirements of AS IEC 61672.1 – 2004 *Electroacoustics—Sound level meters - Specifications* and carries current National Association of Testing Authorities (NATA) or manufacturer calibration certificates.

Instrument calibration was checked before and after each measurement survey and the variation in calibrated levels did not exceed ±0.5 dBA.

3.2.1 Methodology

Operator attended noise measurements were conducted during the day, evening and night-time periods at one attended monitoring location.

Operator attended noise measurements were conducted using two one-third octave integrating B&K 2270 sound level meters (s/n 3008204 and 3029485). Calibration certificates for all acoustic instrumentation used throughout the monitoring programme is provided in **Appendix B**.

3.2.2 Annual Attended Noise Monitoring Locations

Operator attended noise surveys were conducted at the location noted in **Table 2** to determine the character and contribution of noise sources, including Clarence Colliery pit top operations, in relation to the total ambient noise level.

An aerial photograph showing the approximate locations of the noise monitoring locations is provided in **Figure 1**.

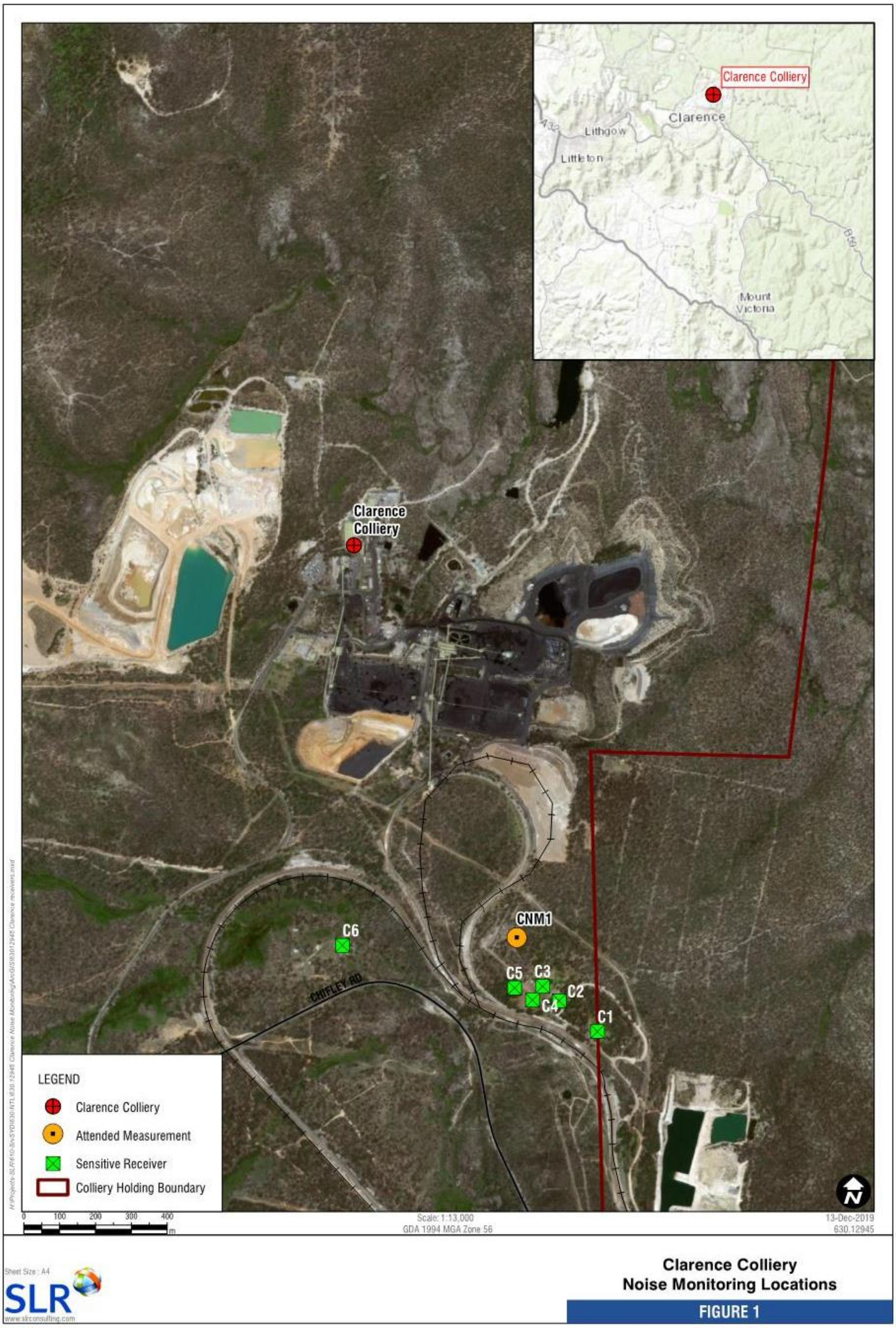
Table 2 Noise Monitoring Location

Location	Description
CNM1	To the south east of Clarence Colliery and representative of the surrounding residential receivers.

3.3 Unattended Noise Monitoring

A B&K 2250-L Noise Logger (S/N 3005904) was deployed at monitoring location CNM1. The unattended noise logger was programmed to continuously record statistical noise level indices in 15 minute intervals including the L_{Amax}, L_{A1}, L_{A10}, L_{A90}, L_{A99}, L_{Amin} and L_{Aeq}.

Figure 1 Attended Noise Monitoring Locations



4 Results and Discussion

4.1 Results of Operator Attended Monitoring

Operator attended noise measurements were conducted during the daytime, evening and night-time periods commencing on Tuesday 29 November 2022 and concluding in the early morning on Wednesday 30 November 2022.

Weather conditions during the surveys were relatively warm with temperatures up to 17°C during the day and down to 9°C during the night.

Moderate wind conditions up to 3 m/s from the north and east were measured during the daytime and evening and approximately 3 m/s from the east during the night-time..

A summary of the operator attended measurements, including the estimated contribution of noise sources, is shown in **Table 3** noting that the noise limits are applicable to noise *"generated from the premises, excluding train loading and rail operations"* as outlined in **Section 2.1**.

Table 3 Attended Noise Survey Results Location – CNM1

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Day	30/11/2022 10:34 13°C 1.5m: 0-2 m/s N 10m: 3m/s N	60	47	41	37	40	38 dBA LAeq(15minute)	*Site related noise events:* FEL – 35 to 40 dBA Reverse Beep audible HV Haul Truck – 43 to 50 dBA **Clarence Colliery Contribution – 38 dBA LAeq(15minute)** *Other noise events:* *Birds – 41 to 60 dBA*
Evening	29/11/2022 18:00 18 °C 1.5m: 1-3m/s E 10m: 3.6m/s E	60	45	43	36	40	36 dBA LAeq(15minute)	*Site related noise events:* FEL audible at times – <38 dBA Site hum <33 dBA **Clarence Colliery Contribution – 32-33 dBA LAeq(15minute)** *Other noise events:* Traffic – 39 to 47 dBA" Trees – 37 to 48 dBA Birds – 34 to 60 dBA
Night	30/11/2022 01:36 9 °C 1.5m: 2-3 m/s E 10m:2.8m/s E	52	50	45	36	42	35 dBA LAeq(15minute)	*Site related noise events:* *Dozer – 33 to 38 dBA* *site hum – 32 to 34 dBA* **Clarence Colliery Contribution - 36 dBA LAeq(15minute)** *Other noise events:* Wind – 40 to 47 dBA Train 43 to 53 dBA

4.1.1 Discussion of Results

As the noise level measured at CNM1 is above the criteria of 35 dBA, simultaneous noise measurements were also completed at Location C3. The results from the simultaneous measurement at both CNM1 and C3 are detailed in **Table 4** and **Table 5**.

Table 4 Noise Measurement at CNM1

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Night	30/11/2022 01:36 9 °C 1.5m: 2-3 m/s E 10m:2.8m/s E	52	50	45	36	42	35 dBA LAeq(15minute)	*Site related noise events:* *Dozer – 33 to 38 dBA* *site hum – 32 to 34 dBA* **Clarence Colliery Contribution - 36 dBA LAeq(15minute)** *Other noise events:* Wind – 40 to 47 dBA Train 43 to 53 dBA

Table 5 Noise Measurement at C3

Period	Date/Start Time/ Weather	Primary Noise Descriptor (dBA re 20 µPa)					Criteria	Description of Noise Emissions and Typical Maximum Noise Levels (dBA)
		LAmax	LA1	LA10	LA90	LAeq		
Night	30/11/2022 01:36 9 °C 1.5m: 2-3 m/s E 10m:2.8m/s E	62	60	47	35	48	35 dBA LAeq(15minute)	*Site related noise events:* **Clarence Colliery Not Audible** *Other noise events:* *Train – 45 to 60 dBA* *Wind at times – 36 to 40 dBA* *Traffic- 40 to 41 dBA*

4.1.2 Noise Compliance Assessment

The contributions from Clarence Colliery operations are summarised in **Table 6**.

Table 6 Component Ranking and Overall Clarence Colliery Noise Contribution

Location	Estimated LAeq(15minute) Contribution dBA			Noise Criteria LAeq(15minute) dBA			Compliance		
	Day	Evening	Night	Day	Evening	Night	Day	Evening	Night
CNM1	38	<33	<35[1]	38	36	35	Yes	Yes	Yes

Note: Based on the measured estimated contribution at C3 as Clarence operations were not noted to be audible during the measurement period.

The above shows that the noise levels complied with the appropriate criteria in all periods during the monitoring survey.

4.2 Results of the Unattended Noise Monitoring

The noise monitoring equipment was deployed on Tuesday 29 November 2022 and collected on Tuesday 6 December 2022. Due to a logger malfunction during the monitoring period, the data was deemed not to be usable and therefore has been discarded.

5 Conclusion

An assessment of noise emissions from Clarence Colliery has been conducted by SLR in November 2022.

Operator attended noise measurements were conducted at noise monitoring location CNM1 during the daytime, evening and night-time periods commencing on Tuesday 29 November 2022 and concluding in the early morning on Wednesday 30 November 2022. Supplementary noise monitoring was also conducted at C3.

The assessment and analysis of the measured data has shown that Clarence Colliery noise emission levels were in compliance with the PA/EPL/CoA noise limits at all monitoring locations during the day, evening and night-time noise monitoring periods during the survey.

APPENDIX A

Acoustic Terminology

1 Sound Level or Noise Level

The terms ‘sound’ and ‘noise’ are almost interchangeable, except that in common usage ‘noise’ is often used to refer to unwanted sound.

Sound (or noise) consists of minute fluctuations in atmospheric pressure capable of evoking the sense of hearing. The human ear responds to changes in sound pressure over a very wide range. The loudest sound pressure to which the human ear responds is ten million times greater than the softest. The decibel (abbreviated as dB) scale reduces this ratio to a more manageable size by the use of logarithms.

The symbols SPL, L or L_P are commonly used to represent Sound Pressure Level. The symbol L_A represents A-weighted Sound Pressure Level. The standard reference unit for Sound Pressure Levels expressed in decibels is 2 x 10^{-5} Pa.

2 ‘A’ Weighted Sound Pressure Level

The overall level of a sound is usually expressed in terms of dBA, which is measured using a sound level meter with an ‘A-weighting’ filter. This is an electronic filter having a frequency response corresponding approximately to that of human hearing.

People’s hearing is most sensitive to sounds at mid frequencies (500 Hz to 4000 Hz), and less sensitive at lower and higher frequencies. Thus, the level of a sound in dBA is a good measure of the loudness of that sound. Different sources having the same dBA level generally sound about equally loud.

A change of 1 dBA or 2 dBA in the level of a sound is difficult for most people to detect, whilst a 3 dBA to 5 dBA change corresponds to a small but noticeable change in loudness. A 10 dBA change corresponds to an approximate doubling or halving in loudness. The table below lists examples of typical noise levels

Sound Pressure Level (dBA)	Typical Source	Subjective Evaluation
130	Threshold of pain	Intolerable
120	Heavy rock concert	Extremely noisy
110	Grinding on steel	
100	Loud car horn at 3 m	Very noisy
90	Construction site with pneumatic hammering	
80	Kerbside of busy street	Loud
70	Loud radio or television	
60	Department store	Moderate to quiet
50	General Office	
40	Inside private office	Quiet to very quiet
30	Inside bedroom	
20	Recording studio	Almost silent

Other weightings (eg B, C and D) are less commonly used than A-weighting. Sound Levels measured without any weighting are referred to as ‘linear’, and the units are expressed as dB(lin) or dB.

3 Sound Power Level

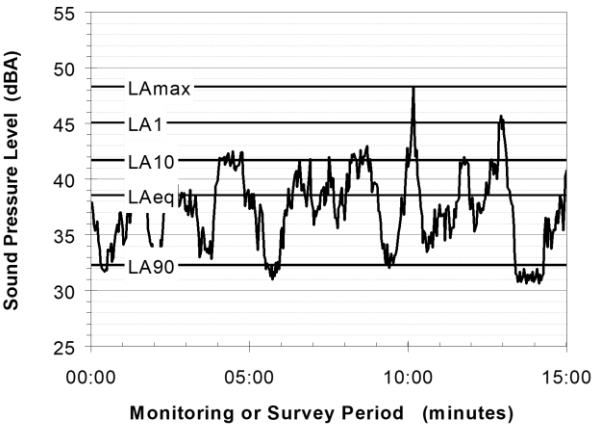
The Sound Power of a source is the rate at which it emits acoustic energy. As with Sound Pressure Levels, Sound Power Levels are expressed in decibel units (dB or dBA), but may be identified by the symbols SWL or L_w, or by the reference unit 10^{-12} W.

The relationship between Sound Power and Sound Pressure may be likened to an electric radiator, which is characterised by a power rating, but has an effect on the surrounding environment that can be measured in terms of a different parameter, temperature.

4 Statistical Noise Levels

Sounds that vary in level over time, such as road traffic noise and most community noise, are commonly described in terms of the statistical exceedance levels L_{AN}, where L_{AN} is the A-weighted sound pressure level exceeded for N% of a given measurement period. For example, the L_{A1} is the noise level exceeded for 1% of the time, L_{A10} the noise exceeded for 10% of the time, and so on.

The following figure presents a hypothetical 15 minute noise survey, illustrating various common statistical indices of interest.



Of particular relevance, are:

L_{A1} The noise level exceeded for 1% of the 15 minute interval.

L_{A10} The noise level exceeded for 10% of the 15 minute interval. This is commonly referred to as the average maximum noise level.

L_{A90} The noise level exceeded for 90% of the sample period. This noise level is described as the average minimum background sound level (in the absence of the source under consideration), or simply the background level.

L_{Aeq} The A-weighted equivalent noise level (basically the average noise level). It is defined as the steady sound level that contains the same amount of acoustical energy as the corresponding time-varying sound.

When dealing with numerous days of statistical noise data, it is sometimes necessary to define the typical noise levels at a given monitoring location for a particular time of day. A standardised method is available for determining these representative levels.

This method produces a level representing the ‘repeatable minimum’ L_{A90} noise level over the daytime and night-time measurement periods, as required by the EPA. In addition, the method produces mean or ‘average’ levels representative of the other descriptors (L_{Aeq}, L_{A10}, etc).

5 Tonality

Tonal noise contains one or more prominent tones (ie distinct frequency components) and is normally regarded as more offensive than ‘broad band’ noise.

6 Impulsiveness

An impulsive noise is characterised by one or more short sharp peaks in the time domain, such as occurs during hammering.

7 Frequency Analysis

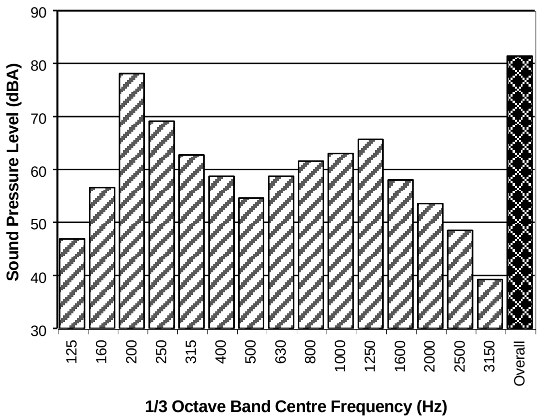
Frequency analysis is the process used to examine the tones (or frequency components) which make up the overall noise or vibration signal. This analysis was traditionally carried out using analogue electronic filters but is now normally carried out using Fast Fourier Transform (FFT) analysers.

The units for frequency are Hertz (Hz), which represent the number of cycles per second.

Frequency analysis can be in:

- Octave bands (where the centre frequency and width of each band is double the previous band)
- 1/3 octave bands (3 bands in each octave band)
- Narrow band (where the spectrum is divided into 400 or more bands of equal width)

The following figure shows a 1/3 octave band frequency analysis where the noise is dominated by the 200 Hz band. Note that the indicated level of each individual band is less than the overall level, which is the logarithmic sum of the bands.



8 Vibration

Vibration may be defined as cyclic or transient motion. This motion can be measured in terms of its displacement, velocity or acceleration. Most assessments of human response to vibration or the risk of damage to buildings use measurements of vibration velocity. These may be expressed in terms of 'peak' velocity or 'rms' velocity.

The former is the maximum instantaneous velocity, without any averaging, and is sometimes referred to as 'peak particle velocity', or PPV. The latter incorporates 'root mean squared' averaging over some defined time period.

Vibration measurements may be carried out in a single axis or alternatively as triaxial measurements. Where triaxial measurements are used, the axes are commonly designated vertical, longitudinal (aligned toward the source) and transverse.

The common units for velocity are millimetres per second (mm/s). As with noise, decibel units can also be used, in which case the reference level should always be stated. A vibration level V, expressed in mm/s can be converted to decibels by the formula 20 log (V/V_o), where V_o is the reference level (10^{-9} m/s). Care is required in this regard, as other reference levels may be used by some organizations.

9 Human Perception of Vibration

People are able to 'feel' vibration at levels lower than those required to cause even superficial damage to the most susceptible classes of building (even though they may not be disturbed by the motion). An individual's perception of motion or response to vibration depends very strongly on previous experience and expectations, and on other connotations associated with the perceived source of the vibration. For example, the vibration that a person responds to as 'normal' in a car, bus or train is considerably higher than what is perceived as 'normal' in a shop, office or dwelling.

10 Over-Pressure

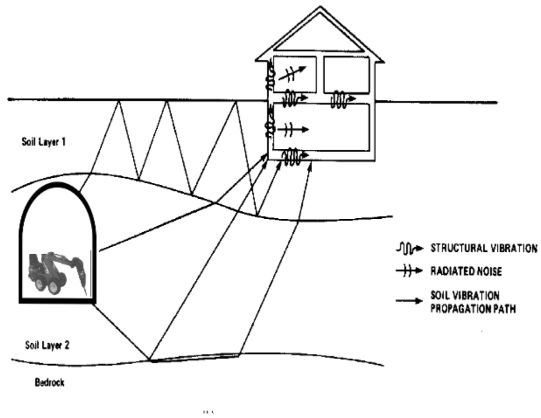
The term 'over-pressure' is used to describe the air pressure pulse emitted during blasting or similar events. The peak level of an event is normally measured using a microphone in the same manner as linear noise (ie unweighted), at frequencies both in and below the audible range.

11 Ground-borne Noise, Structure-borne Noise and Regenerated Noise

Noise that propagates through a structure as vibration and is radiated by vibrating wall and floor surfaces is termed 'structure-borne noise', 'ground-borne noise' or 'regenerated noise'. This noise originates as vibration and propagates between the source and receiver through the ground and/or building structural elements, rather than through the air.

Typical sources of ground-borne or structure-borne noise include tunnelling works, underground railways, excavation plant (eg rockbreakers), and building services plant (eg fans, compressors and generators).

The following figure presents the various paths by which vibration and ground-borne noise may be transmitted between a source and receiver for construction activities occurring within a tunnel.



The term 'regenerated noise' is also used in other instances where energy is converted to noise away from the primary source. One example would be a fan blowing air through a discharge grill. The fan is the energy source and primary noise source. Additional noise may be created by the aerodynamic effect of the discharge grill in the airstream. This secondary noise is referred to as regenerated noise

APPENDIX B

Calibration Certificates

CERTIFICATE OF CALIBRATION

CERTIFICATE NO: SLM32569

EQUIPMENT TESTED: Sound Level Meter

Manufacturer:	B&K		
Type No:	2270	**Serial No:**	3008204
Mic. Type:	4189	**Serial No:**	2983643
Pre-Amp. Type:	ZC0032	**Serial No:**	29477
Filter Type:	1/3 Octave	**Test No:**	F032568

Owner: SLR Consulting Australia Pty Ltd
120 High Street
North Sydney, NSW 2060

Tests Performed: IEC 61672-3:2013 & IEC 61260-3:2016

Comments: All Test passed for Class 1. (See overleaf for details)

CONDITIONS OF TEST:

Ambient Pressure	1003	hPa ±1 hPa	**Date of Receipt :**	11/05/2022
Temperature	22	°C ±1° C	**Date of Calibration :**	13/05/2022
Relative Humidity	69	% ±5%	**Date of Issue :**	13/05/2022

Acu-Vib Test Procedure: AVP10 (SLM) & AVP06 (Filters)

CHECKED BY: .... **AUTHORISED SIGNATURE:** ....

Hein Soe

Accredited for compliance with ISO/IEC 17025 - Calibration
Results of the tests, calibration and/or measurements included in this document are traceable to SI units through reference equipment that has been calibrated by the Australian National Measurement Institute or other NATA accredited laboratories demonstrating traceability.

This report applies only to the item identified in the report and may not be reproduced in part.

The uncertainties quoted are calculated in accordance with the methods of the ISO Guide to the Uncertainty of Measurement and quoted at a coverage factor of 2 with a confidence interval of approximately 95%.

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Accredited Lab No. 9262
Acoustic and Vibration Measurements

Acu-Vib Electronics
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Head Office & Calibration Laboratory
Unit 14, 22 Hudson Ave. Castle Hill NSW 2154
(02) 9680 8133
www.acu-vib.com.au

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AVCERT10.14 Rev.2.0 14/04/2021

HBK HOTTINGER BRÜEL & KJÆR
The Calibration Laboratory
Skodsborgvej 307, DK-2850 Nærum, Denmark

ilac-MRA DANAK CAL Reg.No. 307 Member of EA MLA

CERTIFICATE OF CALIBRATION

No: CDK2007175

CALIBRATION OF

Sound Level Meter:	Brüel & Kjær Type 2270	No: 3029485 Id: -
Microphone:	Brüel & Kjær Type 4189	No: 3260622
PreAmplifier:	Brüel & Kjær Type ZC-0032	No: 30123
Supplied Calibrator:	None	
Software version:	BZ7222 Version 4.7.6	Pattern Approval: -
Instruction manual:	BE1712-22	

CUSTOMER

SLR Consulting Australia Pty Ltd
Sub Base Platypus
Tenancy 201 / 120 High Street
2060 North Sydney
New South Wales, Australia

CALIBRATION CONDITIONS

Preconditioning: 4 hours at 23°C ± 3°C
Environment conditions: *See actual values in sections.*

SPECIFICATIONS

The Sound Level Meter Brüel & Kjær Type 2270 has been calibrated in accordance with the requirements as specified in IEC 61672-1:2013 class 1. Procedures from IEC 61672-3:2013 were used to perform the periodic tests. The accreditation assures the traceability to the international units system SI.

PROCEDURE

The measurements have been performed with the assistance of Brüel & Kjær Sound Level Meter Calibration System 3630 with application software type 7763 (version 8.2 - DB: 8.20) by using procedure B&K proc 2270, 4189 (IEC 61672:2013).

RESULTS

Calibration Mode: **Calibration as received.**

The reported expanded uncertainty is based on the standard uncertainty multiplied by a coverage factor $k = 2$ providing a level of confidence of approximately 95 %. The uncertainty evaluation has been carried out in accordance with EA-4/02 from elements originating from the standards, calibration method, effect of environmental conditions and any short time contribution from the device under calibration.

Date of calibration: 2020-10-30

Date of issue: 2020-10-30

Susanne Jørgensen
Susanne Jørgensen
Calibration Technician

Erik Bruus
Approved Signatory

CERTIFICATE OF CALIBRATION

CERTIFICATE NO: C32987

EQUIPMENT TESTED : Sound Level Calibrator

Manufacturer: GRAS
Type No: 42AG **Serial No:** 280551
Owner: SLR Consulting Australia Pty Ltd
120 High Street
North Sydney, NSW 2060
Tests Performed: Measured Output Pressure level, Frequency & Distortion
Comments: See Details Overleaf. All test passed.

Parameter	Pre-Adj	Adj Y/N	Output: (dB re 20 μPa)	Frequency (Hz)	THD&N (%)
Level1:	NA	N	94.05 dB	1000.00 Hz	0.40 %
Level2:	NA	N	114.07 dB	1000.00 Hz	0.50 %
Level3:	NA	N	94.08 dB	251.20 Hz	0.40 %
Level4:	NA	N	114.09 dB	251.20 Hz	0.50 %
Uncertainty			±0.11 dB	±0.05%	±0.20 %

Uncertainty (at 95% c.l.) k=2

CONDITION OF TEST:

Ambient Pressure	1012 hPa ±1 hPa	**Date of Receipt :**	27/06/2022
Temperature	23 °C ±1° C	**Date of Calibration :**	27/06/2022
Relative Humidity	40 % ±5%	**Date of Issue :**	27/06/2022

Acu-Vib Test AVP02 (Calibrators)
Procedure: Test Method: AS IEC 60942 - 2017

CHECKED BY: ....

AUTHORISED SIGNATURE: ....
Hein Soe

Accredited for compliance with ISO/IEC 17025 - Calibration
Results of the tests, calibration and/or measurements included in this document are traceable to SI units through reference equipment that has been calibrated by the Australian National Measurement Institute or other NATA accredited laboratories demonstrating traceability.

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The uncertainties quoted are calculated in accordance with the methods of the ISO Guide to the Uncertainty of Measurement and quoted at a coverage factor of 2 with a confidence interval of approximately 95%.

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AVCERT02.2 Rev.2.0 14.04.2021

HBK HOTTINGER BRÜEL & KJÆR

Service Note

Service Request:	Date (DD-MM-YYYY)	Page
CAS-590304-Z2F9G6	17 Aug 2022	2 of 3

For all queries please contact:

Hottinger Brüel & Kjær Australia
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3 Thomas Holt Drive
Macquarie Park NSW 2113
Tel: (02) 9889 8888
Fax: (02) 9889 8866
auinfo@hbkworld.com

SLR Consulting Australia Pty Ltd
Sub Base Platypus
Tenancy 201 / 120 High Street
2060 North Sydney NSW
Australia

Customer Tel.: +61 2 9428 8162
Customer fax.:
e-mail: jrasquinha@slrconsulting.com

Customer Reference:

31624

Dear Customer,
We would like to thank you for your confidence in us and for allowing us to carry out the service of your instrumentation.

Product:	Serial Number:	Service Requested:	Accessories:
-2250-L-D00-	3005904	Calibration	

Activity Type:	Service Details:	Certificate Number:
Calibration		CAU2200578

Products/Spare Parts:

Quantity:	Name:	Description:
1	SLM-ADV-CAF-	SLM Advanced, Accredited Calibration incl. microphone according to latest applicable Sound Level Meter standard, e.g. IEC61672.

Repair Warranty
All repairs performed are warranted for 90 days on the parts used for repair only..

Tests Performed
All tests performed are in accordance with manufacturer's procedures, Australian and/or International standars where applicable.

Test Equipment
Measurements are performed using test equipment equal to, or better than, specified in manufacturer's procedures. Traceability and validity is approved under our quality system.

Thank you and best regards,
Hottinger Brüel & Kjaer Service Centre

Hottinger Brüel & Kjær Australia
A Division of Spectris Australia Pty Ltd
ACN 001 216 128 • ABN 51 001 216 128
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Appendix 3: Flora Monitoring Reports

Appendix	Report Name
Appendix 3A	Flora Monitoring Program - Summer Report 2022 (Gingra Ecological Surveys, 2022a)
Appendix 3B	Flora Monitoring Program - Autumn Report 2022 (Gingra Ecological Surveys, 2022b)
Appendix 3C	Flora Monitoring Program - Spring Report 2022 (Gingra Ecological Surveys, 2022c)

Flora Monitoring Program
Clarence Colliery
Summer Report 2022

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1.0 INTRODUCTION

This report describes monitoring of flora monitoring sites at a range of areas within the Clarence Colliery lease area. Six broad areas are now subject to monitoring; Clarence East (Eastern SMP area), Clarence West (also known as the '700 area'), Outbye, 800 Area, 900 Area and Pagoda Swamp.

The flora monitoring program commenced at Clarence Colliery in July 2004. Initially, eight sites supporting heath and pagoda complex vegetation were included; six at Clarence East and two at Clarence West. Clarence East includes areas to the north and east of the Clarence Pit Top, in the catchment of the Bungleboori and Wollangambe Creeks. Mining within the Clarence Eastern SMP area was completed in February 2009. Clarence West is located to the north-west of the Clarence Pit Top. The monitoring sites are in the catchments of Farmers Creek or upper Bungleboori Creek. Mining is currently undertaken in the Clarence West SMP area. Subsequently sites in the outbye area which stretches across Bungleboori Creek about 3km south-east of Mount Horne were added to the program. In 2009 eight sites were added in the Clarence 800 Area located in the section of Newnes State Forest which is bordered by Blue Mountains National Park. Another three sites are located along tributaries of Paddys Creek. A new site was established in February 2021. This is in Pagoda Swamp, which is located to the south of Waratah Ridge, south-west of Mount Horne.

During 2016, Gingra Ecological Surveys recommenced monitoring swamp sites in the Clarence East and Clarence West areas. For a period between 2008 and 2013 these swamps were monitored by the University of Queensland.

This report provides information on monitoring undertaken in summer 2022. Locations of the sites and their sampling dates in summer 2022 are provided in Table 1. The Outbye plots CLAO_03 and CLAO_04 were unable to be surveyed due to a significant washout along the access track to those plots.

Table 1. Locations of Flora Survey Sites

Site	Location	Type	Easting (GDA)	Northing (GDA)	Survey Date
Clarence East					
PAG_01	Gorilla Rock	Impact	246753	6300035	25/01/2022
PAG_02	Gorilla Rock	Impact	246755	6299924	25/01/2022
PAG_03	Waratah East	Impact	247251	6300707	25/01/2022
PAG_04	Waratah East	Impact	246938	6300784	25/01/2022
PAG_05	Waratah North	Control	247962	6303960	25/01/2022
PAG_06	Waratah North	Control	247888	6303910	25/01/2022
BNS_01	Bungleboori North Swamp	Impact	245582	6302273	25/01/2022
BNS_02	Bungleboori North Swamp	Impact	246290	6303633	24/01/2022
Clarence West					
CLW_01	Heath	Impact	241774	6295584	09/02/2022
CLW_02	Swamp	Impact	242596	6295527	09/02/2022
CLW_03	Happy Valley Swamp	Impact	241923	6296954	09/02/2022
CLW_04	Hanging swamp	Impact	241904	6298016	26/01/2022
CLW_05	Pine Swamp	Control	240804	6300186	26/01/2022
CLW_06	Heath—Paddys Creek Ridge	Control	240472	6299171	26/01/2022
Outbye					
CLAO_01	S of Bungleboori Creek	Impact	245023	6297763	10/02/2022
CLAO_02	S of Bungleboori Creek	Impact	245092	6297707	10/02/2022
CLAO_03	N of Bungleboori Creek	Impact	245504	6298627	Not surveyed
CLAO_04	N of Bungleboori Creek	Impact	245294	6299168	Not surveyed
800 Area					
CLAE_01	Gully N of Dumbano Fire Trail dam	Impact	248971	6295894	10/02/2022
CLAE_02	Heath ridge	Impact	247495	6295216	10/02/2022
CLAE_03	Heath ridge	Impact	247271	6295388	10/02/2022
CLAE_04	Secret Swamp	Impact	247203	6296462	09/02/2022
CLAE_05	Secret Swamp	Impact	247159	6296404	09/02/2022
CLAE_06	Olearia Swamp	Impact	247648	6296165	09/02/2022
CLAE_07	Olearia Swamp	Impact	247701	6296288	09/02/2022
CLAE_08	Olearia Swamp	Impact	247789	6296830	09/02/2022
900 Area					
PSB_01	Paddys Swamp Branch	Impact	241338	6298523	26/01/2022
PSB_02	Paddys Swamp Branch	Impact	241404	6298617	26/01/2022
PS_03	Paddys Swamp (lower)	Impact	241822	6299156	26/01/2022
Pagoda Swamp		/3			
PAS_01	Pagoda Swamp	Impact	242878	6300496	24/01/2022

The entire study area was subject to the Gospers Mountain bushfire, which burnt through the area from November to December 2019. Most sites were affected by very high intensity fire, but fire intensity at a small number of plots was patchier with small areas of shrubs and ground cover plants remaining unburnt. Plots with some unburnt patches included PAG_01, PAG_03, PAG_05, CLAO_01, CLAO_03 and CLAO_04.

At the swamp sites the bushfire had burnt above ground vegetation with only very localised patches of surface peat consumption. No deep consumption of peat deposits was observed in the study area.

Previously, in October 2013, an extensive bush fire, known as the State Mine Fire, burnt through the study area. That bushfire was also of high intensity and the vegetation across the study area was showing clear signs of recovery by November 2019, although in many places the tree canopy had not returned to the canopy height and breath of September 2013.

Above average rainfall has been recorded since February 2020. Total rainfall over the 2020-21 summer was somewhat above average and wet weather continued into March 2021 when 193 mm was recorded at Lithgow. April 2021 was the driest April in the last 40 years and May rainfall was slightly below the long-term average. Winter and early spring rainfall in 2021 was about average. November 2021 had the highest rainfall recorded in Lithgow for that month since records began. January 2022 was also very wet whilst December and February were close to average.

In 2021 mining proceeded to the north-east of Bungleboori Creek towards the southern end of Pagoda Swamp area (now subject to systematic flora monitoring) and in the Clarence East area to the south of CLAE_01. Mining also occurred on the south side of Bungleboori Creek, east of the Outbye area and away from any areas of sensitive vegetation communities subject to monitoring.

2.0 SURVEY METHODS

Permanently marked 20 m x 20 m (400 m^2) quadrats have been established at each monitoring site. The sites are sampled three times each year (in summer, autumn and spring).

Monitoring surveys involve recording vegetation structure, dominant species, estimated cover and height for each stratum, full floristics, estimated cover abundance for each species using a modified Braun-Blanquet scale (see below) and condition ranking for plant species using a five point scale (see below). Observations of general condition of vegetation in less sensitive forest and woodland habitats are also recorded, where relevant, as are fauna sightings.

Modified Braun-Blanquet Scale

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

Condition Scale

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

3.0 RESULTS

<u>3.1. Clarence East & Clarence West Heath & Pagoda Sites</u>

3.1.1 Plant Condition

There were few observations of plant disease at the heath and pagoda sites. At PAG_02 *Philotheca obovalis* plants had leaf yellowing associated with waterlogging. At PAG_05 *Banksia penicillata* plants had signs of leaf predation and *Hakea pachyphylla* plants had leaf yellowing. At PAG_06 *Hakea dactyloides* plants had signs of leaf predation. At CLW_01 *Allocasuarina nana* plants had branch dieback.

These observations are consistent with the post fire recovery phase and the expected response given the extremely wet weather conditions in the months preceding the survey.

3.1.2 Species Richness

Species richness figures for the Clarence East and West pagoda and heath sites are presented in Appendices 1A and 1B.

Species richness at these plots in summer 2022 were broadly similar to spring 2021 levels with increased richness at all pagoda heath plots. The levels in summer 2022 are similar to average species richness in 2016, a similar stage in post-fire recovery.

This indicates that ecosystem function is operating in a consistent manner following these significant disturbance events.

3.1.3 Exotic Species

Prior to the 2019 bushfire, the only instance of a record for an exotic plant species over the history of monitoring Clarence East and West pagoda and heath sites was a single Catsear (*Hypochaeris radicata*) plant observed in spring 2010 at PAG_04.

Exposed soils following the 2019 bushfire has allowed germination of wind transported weeds, primarily members of the Asteraceae (daisy) family. In May 2020, Catsear (*Hypochaeris radicata*) plants were present at PAG_02 and PAG_04. Catsear was again present at PAG_04 in November

2020. These exotic species have not successfully established at the heath and pagoda sites which were weed free in summer 2022.

3.1.4 Increaser and Decreaser Species

Changes in species abundance and distribution can indicate changing environmental conditions, including changes associated with development.

In response to bushfire some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground. Germination may not place immediately as seeds may have dormancy mechanisms which delay germination,

An assessment of species which showed a change in cover/abundance was conducted in 2009 well before the impact of the 2013 bush fire. The species which showed variation in cover/abundance included:

- *Xanthosia pilosa* at site PAG_01, which had shown a decline from common to rare or uncommon. This species was recorded as uncommon at this site in spring 2012 and rare in summer 2013 with the abundance previously having been stable since July 2004. The first post-fire record of this species at the site was in summer 2015 when it was recorded as common. The abundance of this species was relatively stable in 2018-19. *Xanthosia pilosa* was recorded (rare) in May 2020 and **C/A** 3 (common) at each sampling in 2021 and in summer 2022.

- *Amperea xiphoclada* was first recorded at PAG_02 in May 2009. It was not recorded at the site again until February 2014 when it was rare. It was again recorded as rare in spring 2014, was not detected in summer 2015 and was recorded as rare in autumn 2015 and uncommon in spring 2015. It was recorded as rare in autumn 2016 and then not recorded between spring 2016 and autumn 2018. It was again recorded (rare) in spring 2018, not recorded in summer 2019, and again recorded as rare in autumn 2019, but not recorded in the drying conditions in spring 2019. In summer 2020, it had resprouted postfire from basal rootstocks and was again recorded (rare) in May 2020, but was not detected within the plot since November 2020 until summer 2022 when it was recorded as rare.

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_04 has previously been observed to have declined in abundance from common with lower levels of species abundance recorded between May 2006 and May 2009. The cover/abundance ranking of this species was then stable between October 2009 and May 2013. Cover/abundance scores for this species have been stable (C/A rank 3 – common) since summer 2014. All *Banksia ericifolia* plants were dead in summer 2020. In May 2020 seedlings of *Banksia ericifolia* had germinated and its cover/abundance ranking was 2 (uncommon) In November 2020 its cover/abundance ranking was again 2. In February 2021 it was recorded as rare, in May and September 2021 and summer 2022 it was recorded as uncommon.

- *Mirbelia rubiifolia* at site CLW_06 had previously been reported (Autumn 2010) as having increased in abundance from rare or uncommon to common. The species was recorded as uncommon in summer 2013. Cover/abundance scores for this species was the highest ever recorded at this plot in summer and autumn 2019 (C/A rank 4 – cover 5-20%) but was recorded as common in spring 2019. This species was not recorded at this plot in 2020, but resprouting plants were observed in summer 2021 (C/A rank 3, common). *Mirbelia rubiifolia* was again recorded as common in autumn 2021 and uncommon (C/A 2) in spring 2021. In summer 2022 it had increased in abundance and was recorded as common.

Changes in cover/abundance which became evident in the period from 2010 to May 2013 included:

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_01 had shown an overall increase from rare or uncommon to common. The cover/abundance score for this species in spring 2019 was 4, 5-20% cover. The 2013 fire did not burn intensely across this plot and many shrub plants escaped damage. A lesser number survived the December 2019, fire but cover/abundance was recorded as 2 uncommon in summer and autumn 2020. From November 2020 to September 2021, it was recorded with a **C/A** ranking of 3 (common) and in summer 2022 it was recorded as uncommon.

- *Cassytha glabella* at site PAG_02 had shown an increase from not recorded or rare to common. This species was recorded as common at this site in summer 2013. Since February 2014 it usually has been recorded as rare, but its cover/abundance score in summer and autumn 2017 was 2 (uncommon). In spring 2017 *Cassytha glabella* was not detected. In summer and autumn 2018 it was recorded as rare and in spring 2018 it was uncommon. This species was not detected within the plot in summer 2019. In autumn and spring 2019 it was recorded as uncommon. It was not recorded in 2020 or early 2021 but was recorded as uncommon in spring 2021 ands rare in summer 2022. *Cassytha glabella* has shown a delayed post-fire recovery at several plots following both the 2013 and 2019 bushfires.

- The prostrate shrub *Pseudanthus divaricatissimus* was a new record for PAG_02 in autumn 2010. This species was recorded as rare in summer 2013. This species was detected within the plot for the first time since the October 2013 fire in summer 2019 but not recorded in autumn or spring 2019. It has not been recorded from summer 2020 to summer 2022.

- The sedge, *Lepidosperma filiforme*, was not detected at PAG_03 between autumn 2011 and autumn 2012. From 2014 onwards, it was recorded as rare, but was not recorded in autumn 2016. From spring 2016 through to spring 2017 it again has been recorded as rare but was not recorded in summer 2018. In autumn 2018 it was recorded as uncommon and in spring 2018 it was rare, whilst in summer 2019 it was uncommon. It was again recorded as rare in autumn and spring 2019. It was not recorded in summer 2020 but recorded in autumn (uncommon) and spring (rare). It was recorded as rare again in summer and autumn 2021, but not recorded in spring 2021. In summer 2022 it was recorded as uncommon.

Species recorded at sites in February 2014 which had not previously been recorded at those locations were:

- *Eucalyptus piperita* was recorded as rare at PAG_02. This sapling has been recorded consistently since February 2014. It was again recorded in summer 2021, but not detected since.
- *Goodenia bellidifolia*, *Lomandra glauca*, *Patersonia sericea* and *Schoenus villosus* at control plot PAG_05. In autumn 2019 both *Goodenia bellidifolia* (rare) and *Lomandra glauca* (uncommon) were recorded, but none of the 3 species were recorded in spring. *Schoenus villosus* resprouted from basal rootstocks following the bushfire. In spring 2020 it had flower buds and ranked with a C/A score of 2, uncommon. *Goodenia bellidifolia* (common) was the only of these species present in spring 2020. In summer 2022 *Goodenia bellidifolia* was recorded as common and *Schoenus villosus* was recorded as uncommon.
- *Aristida ramosa* at CLW_01. This species has not been recorded since autumn 2016.

- *Arthropodium milleflorum*, *Cyathochaeta diandra* and *Lagenophora stipitata* at CLW_06. *Cyathochaeta diandra* was recorded as uncommon and *Lagenophora stipitata* as rare in spring 2015. None of these species were recorded in either autumn or spring 2016 or summer 2017. Both *Cyathochaeta diandra* and *Lagenophora stipitata* were again recorded in spring 2019 (C/A 1, rare). The two other species were not recorded in spring 2019. In spring 2020, *Lagenophora stipitata* and *Cyathochaeta diandra* had a C/A score of 1, rare. In summer 2021, only *Cyathochaeta diandra* (C/A 2, uncommon) was observed. None of these species were recorded in autumn or spring 2021 or summer 2022.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as common at PAG_02 in summer 2014. It was flowering in spring 2016, which allowed for it to be identified to species level for the first time. In summer and autumn 2019, it was recorded at PAG_02 but suffering from leaf dieback and it was not recorded in spring 2019. It was not recorded in summer 2020, but had germinated by autumn 2020, with a C/A score of 3 (common), its presence continuing through to summer 2021.

Species recorded in autumn 2015 which had not been recorded at sites prior to the bush fire were:

- *Actinotus helianthi* at PAG_01 (common) and PAG_02 (common). This species was recorded at PAG_01 (common) between autumn 2016 and summer 2017, but rare in autumn 2017 and not recorded in spring 2017. It was again present in spring 2018 and summer 2019 (C/A common) and autumn 2019 (C/A uncommon). At PAG_02 it was uncommon in autumn and spring 2016, common in summer and autumn 2017, uncommon in spring 2017 and common in summer and autumn 2018, then uncommon between spring 2018 and autumn 2019. In spring 2019 at PAG_01 it was recorded as uncommon and at PAG_02 it was recorded as rare and senescent. At PAG_02 in autumn 2020 it was recorded as uncommon, whilst at PAG_01 it was recorded as common. In summer and autumn 2021 *Actinotus helianthi* was common at both these plots. In spring 2021 *Actinotus helianthi* was recorded as common at PAG_01 and uncommon at PAG_02. It was again recorded at both plots in summer 2022.
- *Actinotus forsythii* at PAG_03 (common). These plants had died by spring 2015. There was no evidence of seedling plants in summer 2020. Seeds of this plant had germinated by autumn 2020 and it was recorded as common in autumn and spring. In summer 2021 it was recorded as common and flowering at PAG_03; at PAG_04 it had a C/A rank of 4 (>5% cover); at PAG_05 and PAG_06 it was uncommon. In autumn 2021 it was common and setting seed at PAG_03 and PAG_04, and it was recorded as uncommon at PAG_05. The species was not recorded within any plot in spring 2021 or summer 2022; this is consistent with the usual post-fire response of this species which is classed as a fire ephemeral.
- *Cyathochaeta diandra* at PAG_02 (rare). This species has not been recorded again since summer 2016.
- *Goodenia decurrens* at PAG_03 (rare), consistently present from spring 2015 to spring 2019 (rare), in a sheltered location at the foot of the pagoda. This plant remained in summer 2020 in an unburnt section of the plot and has persisted since.
- *Haemodorum planifolium* at CLW_01 (common) and CLW_06 (rare). In summer 2017 this species was recorded as common at CLW_01 and uncommon at CLW_06. In autumn and spring 2017 this species was rare at each of these two sites. In summer and autumn 2018, it was not recorded at CLW_01 and rare at CLW_06. The remaining leaves died off by spring 2018, when it was not recorded, and it was not present in 2019. It was not found at CLW_06 in summer 2020 but at CLW_01 it had already emerged with a C/A score of 3, common. From spring 2020 until autumn 2021 *Haemodorum planifolium* has been recorded as uncommon at CLW_06 and common at CLW_01. In summer 2022 it was recorded as common at both these plots.

3.2. Clarence East and West Swamp Sites

3.2.1 Plant Condition

At CLW_02 *Eucalyptus mannifera* had branch dieback due to waterlogging. Two *Cassinia aculeata* plants were dead. At CLW_04 *Olearia quercifolia* plants continued to suffer stem dieback due to a fungal pathogen.

These were the only observed instances of plant disease at the Clarence East and West Swamp sites.

3.2.2 Species Richness

Species richness data for Clarence East and West Swamp sites is presented in Appendices 2A and 2B.

In summer 2020 species richness at three swamp sites, CLW_04, CLW_05 and BNS_02, were at the same level or higher than prior to the bushfire, reflecting early recovery of some swamp species due to increased swamp water levels related to post-fire rainfall.

In autumn 2020, species richness at many of the plots was at the high end of the previously reported range, with the level at BNS_02 around double the previous high. These high numbers are attributable to open areas with the swamps providing an opportunity for growth of otherwise suppressed ground layer species.

Significantly higher levels of species richness compared to counts prior to the December 2019 bushfire continued to prevail in summer 2022. At all but one plot species richness was greater than that recorded in spring 2021. This is partly due to flowering of summer grasses, making them easier to detect. The decline at the majority of these swamp plots through 2021, followed by a summer increase, is consistent with a normal post fire trend.

3.2.3 Exotic Species

Some of the Clarence West swamp sites have been subject to disturbance prior to any impact of mining with the establishment of a pine plantation in the catchment of some swamps being a notable factor.

Radiata Pine (*Pinus radiata*) was previously recorded at BNS_01. The hot bushfire killed the pines, and no live Radiata Pine plants have been recorded since autumn 2020. In summer 2022, two exotic plants, Catsear (*Hypochaeris radicata*) and Fleabane (*Conyza* sp.) were recorded at this plot.

At BNS_02 the exotic species Catsear (*Hypochaeris radicata*), C/A 1 (rare) and Blackberry (*Rubus anglocandicans*), C/A 1 (rare) were recorded. Exotic species richness and abundance have declined since summer 2021.

Catsear (*Hypochaeris radicata*) was not recorded at CLW_02 in summer 2022, having previously been recorded as rare. Fleabane (*Conyza* sp.) was recorded as uncommon in spring 2020 and summer 2021 and rare in autumn 2021, then not recorded in spring 2021 and summer 2022.

At CLW_03 two exotic species were recorded, Catsear (*Hypochaeris radicata*) and Fleabane (*Conyza* sp.). Previously, three exotic species, all daisies, were recorded in summer 2021; Fleabane

(*Conyza sp.*) C/A 2 (uncommon), Spear Thistle (*Cirsium vulgare*), C/A 1 (rare) and Catsear (*Hypochaeris radicata*), C/A 1 (rare). In autumn 2021, Yorkshire Fog (*Holcus lanatus*), C/A 2, uncommon, Catsear (*Hypochaeris radicata*), C/A 1, rare and Spear Thistle (*Cirsium vulgare*), C/A 1, rare were the three exotic species recorded in this plot.

In summer 2022, five exotic species were recorded at CLW_05, the grass Yorkshire Fog (*Holcus lanatus*), Catsear (*Hypochaeris radicata*), Fleabane (*Conyza* sp.), Blackberry (*Rubus anglocandicans*) and Spear Thistle (*Cirsium vulgare*).

The 2021 results indicate a decline in species richness and abundance of weeds within Clarence East & West swamps. The plots suffering from historical disturbance had a higher abundance of weed species, particularly notable at CLW_05.

3.2.4 Increaser and Decreaser Species

In 2008 the following changes in species cover/abundance were discussed:

> At CLW_02, there had been a decline in cover/abundance of Prickly-leaved Tea-tree (*Leptospermum continentale*). Species observed in 2008 which had not previously been recorded included *Deyeuxia gunniana* and *Baloskion australe*.
>
> At CLW_03, there had been no noticeable decline in the cover/abundance of plant species, but a number of swamp associated plants had an increased ranking apparently due to improved rainfall from 2006. Species observed in 2008 which had not previously been recorded included Sneezeweed (*Centipeda minima*), two grasses (*Dichelachne* sp. and *Deyeuxia* sp.), *Patersonia fragilis*, and the exotic species, Cudweed (*Gamochaeta* sp.).
>
> At CLW_04, there had been no consistent increase or decline in common species occurring at that site. Species observed in 2008 which had not previously been recorded included *Juncus continuus* and *Lepyrodia anarthria*.
>
> At CLW_05, there has been a decline in cover of Woolly Tea-tree (*Leptospermum grandiflorum*) and *Deyeuxia gunniana,* and an increasing abundance of *Geranium homeanum*. Species observed in 2008 which had not previously been recorded included a plume grass (*Dichelachne* sp.), *Senecio hispidulus*, *Senecio linearifolius*, and the exotic species Fleabane (*Conyza* sp.) and Blackberry (*Rubus anglocandicans*).

In relation to these species and sites the following records were made in summer 2022:

Leptospermum continentale was present (C/A 1, rare) at CLW_02. Previously this species recovered following the 2013 bush fire to baseline levels recorded in 2006. More recently, this species was not recorded as alive in summer 2020. In summer 2021 and autumn 2021 it was recorded as uncommon (C/A 2). In autumn 2021 *Deyeuxia gunniana* was recorded as uncommon (C/A 2) and was seeding. It was not recorded in spring 2021, but again recorded in summer 2022 as uncommon. *Baloskion australe* has not been recorded since 2020.

At CLW_03 Sneezeweed (*Centipeda minima*) (C/A 1; rare) was present in autumn 2019, but not recorded in 2020 or 2021. In autumn 2021 *Deyeuxia quadriseta* was recorded as common (C/A 3). Neither species was detected in spring 2021. In summer 2022 neither *Centipeda minima* nor *Deyeuxia quadriseta* were recorded, At CLW_04 *Juncus continuus* was not detected in spring 2021 or summer 2022. *Lepyrodia anarthria* was recorded as common (C/A 3) at both seasonal surveys.

At CLW_05, *Leptospermum grandifolium* was recorded (C/A 3; common, cover <5%) from autumn 2020 to summer 2022. *Geranium homeanum* (C/A 3, common) was also present in summer 2022.

3.3 Clarence Outbye

3.3.1 Plant Condition

There were no instances of plant disease at either of the Outbye plots surveyed in summer 2022.

3.3.2 Species Richness

Species richness figures for the Outbye sites are presented in Appendices 3A and 3B.

The species richness counts for CLAO_01 and CLAO_02 recorded in summer 2022 were below levels recorded prior to the 2019 bushfire.

3.2.3 Exotic Species

No exotic species were recorded at either of the two Clarence Outbye sites surveyed in summer 2022. This is consistent with previous records for these weed-free plots.

3.2.4 Increaser and Decreaser Species

Following the autumn 2010 monitoring survey it was reported that several species were recorded at monitoring sites for the first time, as detailed below.

At CLAO_01, species recorded for the first time in 2010 included *Banksia spinulosa* and *Gompholobium glabratum*. *B. spinulosa* has not been recorded since autumn 2017 having been recorded as uncommon in autumn 2016. *G. glabratum* was recorded in summer 2012, when it was rare, but was not recorded in summer or autumn 2013. It had not been recorded at this site since the 2013 bush fire, but in autumn 2018 was present (C/A 2, uncommon). It has not been recorded since the December 2019 bushfire.

At CLAO_02, species recorded for the first time in autumn 2010 included *Boronia floribunda*, *Cryptostylis subulata*, *Hibbertia serpyllifolia* and *Lepidosperma filiforme*.

Boronia floribunda had been recorded as uncommon since autumn 2018 but was rare in autumn 2019 and not recorded since spring 2019. *Cryptostylis subulata* was recorded as common in autumn 2018 and rare in spring 2018 but not detected in summer 2019. In autumn 2019 it was recorded as uncommon not recorded since. *Lepidosperma filiforme* was recorded in spring 2019 (C/A 2, uncommon). None of these species were recorded in 2020 or 2021. In summer 2022 it was recorded for the first time after the 2019 bushfire (C/A 1, rare).

At CLAO_03, species recorded for the first time in autumn 2010 included *Mitrasacme polymorpha*, *Ochrosperma oligomerum* (formerly *Ochrosperma monticola*) and *Petrophile pulchella*. *P. pulchella* (uncommon) was the only one of these species detected at the site in autumn 2013.

In autumn and spring 2018 none of these three species were recorded. In summer 2019, *Ochrosperma oligomerum* was recorded as uncommon. The three species were then recorded in the plot from autumn 2019 to spring 2020. In summer 2021 a *Petrophile pulchella* seedling was detected near the centre of the plot, and this species was again detected in spring 2021 (C/A 1, rare).

At CLAO_04, species recorded for the first time in autumn 2010 were *Conospermum taxifolium* and *Pseudanthus divaricatissimus*.

Both species were recorded as rare at the site in autumn 2016, but only *Conospermum taxifolium* was present in spring 2016. Neither species was recorded in summer 2017. Both *Pseudanthus divaricatissimus* (uncommon) and *Conospermum taxifolium* (rare) were recorded in spring 2017. Neither species was recorded in summer or autumn 2018. In spring 2018 and summer 2019 *Pseudanthus divaricatissimus* was recorded as rare. Neither species was recorded in autumn or spring 2019. In summer 2020 *Pseudanthus divaricatissimus* was recorded (C/A 1, rare). Neither species had been recorded since autumn 2020, but *Conospermum taxifolium* was present in spring 2021.

A number of plant species were first detected at a particular site in summer 2014, following the October 2013 bush fire. These included:

Bossiaea heterophylla at CLAO_02, not subsequently detected from spring 2014 to summer 2017, recorded as rare in autumn 2017, not recorded in spring 2017 and recorded as rare again in summer and autumn 2018. In summer 2019 it was recorded as uncommon and in autumn 2019 as rare, but not recorded in spring 2019. It has not been detected within the plot since the 2019 bushfire.

Thysanotus juncifolius at CLAO_03, not subsequently detected since 2014. It regenerated from seed after the 2019 bushfire and in summer 2021 was recorded as common (C/A 3) but was not observed in autumn or spring 2021.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as uncommon at CLAO_01 in autumn 2014. It was again recorded as rare at the site in spring 2016, but not recorded from summer 2017 onwards. It was also first recorded at CLAO_03 (uncommon) in summer 2015.Between spring 2016 and spring 2017 it was recorded as common, but its C/A score was 2, uncommon in summer 2018 and it was recorded again as common in autumn and spring 2018, uncommon in summer 2019 and rare in autumn 2019, then not recorded until autumn 2021 when it was recorded as common. It was again recorded as common in spring 2021, but not recorded in summer 2022.

One species, *Lindsaea linearis* was recorded for the first time at CLAO_01 in spring 2015. It has not been recorded at that site since spring 2016, despite suitably wet conditions in 2020-21.

In spring 2016 *Drosera peltata* was recorded for the first time at CLAO_02. *Drosera peltata* was present and flowering at CLAO_02 in spring 2016 but was not recorded between summer 2017 and autumn 2020. In spring 2020 it was recorded as common but was not recorded in 2021 or summer 2022, despite the above average rainfall recorded over that period. *Drosera peltata* can survive in the soil as an underground rhizome, responding to wet conditions.

A number of new post fire records of species within Outbye monitoring plots were made in summer 2016.

These included:

Thelionema caespitosum at CLAO_01 (rare in summer 2017, uncommon in autumn and spring 2017 and autumn 2018, absent between spring 2018 and spring 2019). In summer 2020 this species was again detected (C/A 2, uncommon), but it was not detected in autumn 2020. In spring 2020 it was detected (C/A 1, rare) and in summer 2021 it was recorded as common (C/A 3). It was not recorded in summer 2022.

Pimelea linifolia at CLAO_02 (not present summer 2017, rare in autumn 2017, uncommon in spring 2017, then not recorded until autumn 2021 (C/A 1, rare). This species was not recorded in the plot in summer 2022.

Rytidosperma sp. at CLAO_02 - not detected since 2016.

Gompholobium uncinatum at CLAO_03 (present in summer and autumn 2017; rare; not detected in spring 2017 or summer 2018, rare in autumn 2018, common in spring 2018, but not detected since.

Pimelea linifolia at CLAO_03 and CLAO_04 was not present in 2017 or 2018 but present at both CLAO_03 and CLAO_04 in summer 2019, then just CLAO_03 in autumn 2019 and within neither plot since spring 2019. At CLAO_04 in spring 2020 it was recorded as rare and in summer 2021 it was recorded as uncommon (C/A 2) but was not again recorded in autumn or spring 2021.

Epacris microphylla at CLAO_04 (consistently present since summer 2017, recorded as uncommon in autumn 2018 and common between spring 2018 and spring 2019). In spring 2020 it was not recorded but recorded in summer 2021 (C/A 2, uncommon) and in autumn and spring 2021 (C/A 3, common).

There are no clear long-term trends indicating a change in abundance of the more common shrub or ground layer species present at each site.

3.4 Clarence 800 Area

3.4.1 Plant Condition

At CLAE_01 *Banksia spinulosa* and *Pultenaea scabra* plants had leaf yellowing due to waterlogging. At CLAE_04 *Isopogon anemonifolius* plants had severe dieback due to waterlogging.

High water levels were observed in autumn 2021 to have caused plant disease at CLAE_05 with *Banksia ericifolia* plants having leaf yellowing. No *Banksia ericifolia* plants were observed at this plot in spring 2021 or summer 2022. *Banksia marginata* seedlings had leaf yellowing due to waterlogging. At CLAE_07 *Hakea laevipes* plants had leaf ends affected by dieback. The cause was unable to be determined. *Patersonia fragilis* plants had extensive leaf yellowing due to prolonged soil saturation. At CLAE_08 *Pultenaea divaricata* and *Daviesia latifolia* plants had leaf yellowing due to waterlogging. At CLAE_04 an *Isopogon anemonifolius* plant had severe dieback due to leaf yellowing due to waterlogging.

Apart from the impacts of the prolonged wet weather conditions, plant health was good with no sign of plant disease.

3.4.2 Species Richness

Species richness figures for the Clarence 800 Area sites are presented in Appendices 4A and 4B.

Table 3 shows species richness figures following the 2013 and 2019 bushfires. The levels in summer 2022 were similar to previously recorded levels.

PLOT	2019 BUSHFIRE INTENSITY	DEC 2013	FEB 2014	FEB 2020	MAY 2020	NOV 2020	FEB 2021	MAY 2021	OCT 2021	FEB 2022
CLAE_01	Very High	27	53	24	54	57	66	55	57	58
CLAE_02	Very High	26	27	23	34	27	40	34	26	33
CLAE_03	High	19	29	21	32	32	35	32	33	31
CLAE_04	Very High	20	36	21	39	38	33	40	39	39
CLAE_05	Very High	19	40	19	49	54	50	45	47	43
CLAE_06	Very High	30	45	18	36	34	38	35	38	34
CLAE_07	Very High	15	28	19	29	26	27	22	20	25
CLAE_08	Very High	15	19	8	30	31	38	30	33	30

Table 3. Species Richness Post-fire. Clarence 800 Area Sites

For the period prior to the October 2013 bush fire total species richness ranges from a high of 298 records in spring 2012 to a low of 252 records in autumn 2010. The total number of species records in autumn 2013 was 266, which fell within the range of previous records. In summer and autumn 2012, there were 274 records.

Species richness in summer 2014 was within the pre-fire range with 277 records. Subsequent germination of seedlings in the post-fire environment saw species richness exceed pre-fire levels with 324 records in autumn 2014, 317 records in spring 2014, 307 records in summer 2015, 310 records in autumn 2015 and 304 records in spring 2015.

The number of records in summer 2016, 328, exceeded previous species richness totals for the Clarence East site. In autumn 2016 there was a similar level (327 records) of species richness. The number for autumn 2017 was 321, slightly lower than the level for the previous autumn. In spring 2017, the total number of records was 283, 8% lower than the corresponding season in 2016. The summer 2018 number was 289; the last two years have seen an increase in species records from spring to summer. In autumn 2018, the total was 310, consistent with a post-fire pattern of higher species richness in autumn. The total number of plant records in spring 2018 was 294, there were 292 records in summer 2019 and 323 records in autumn 2019. In spring 2019 the number declined to 282, the same level as that recorded in spring 2017.

In summer 2020, the total number of records was 153, somewhat lower than the December 2013 number of 171. This may reflect the very high fire intensity at almost all plots in 2019. By autumn 2020 the number had reached 300, with an exceptional rise in species detected at CLAE_08. The spring 2020 number was 299, showing a stable situation during the autumn-spring period. In summer 2021 the totals species records amounted to 327, just below the record high established in summer 2016. In summer 2022 there were 291 records, similar to the level in autumn and spring 2021.

The section of Olearia Swamp where CLAE_08 is located experienced very intense fire, followed by a high level of sediment movement associated with heavy rainfall in February 2020. The more open spaces and changed soil profile has enabled germination and establishment of pioneer and woodland species.

Recent total species counts for the Clarence 800 sites are shown in Figure 1. Apart from the impact of the December 2019 bushfire, they indicate a seasonal response to rainfall conditions with higher numbers of ground layer and flowering plants detected during seasons following above average rainfall and lower numbers every spring. The Figure shows an initial post-fire decline, then an increase and subsequent decline.

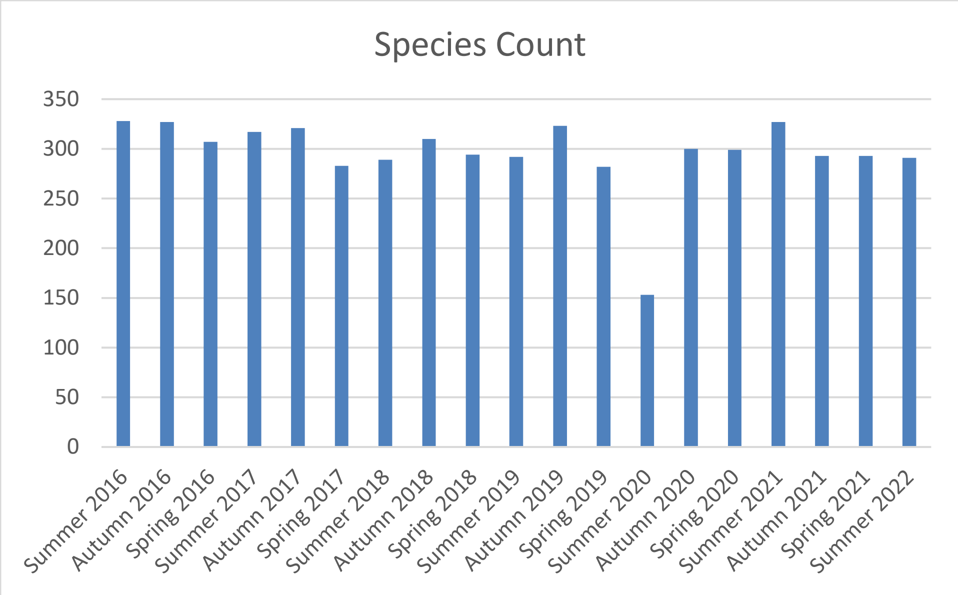

Figure 1. Seasonal Total Species Counts for 800 Area Monitoring Plots

3.4.3 Exotic Species

There have been few records of exotic species at the 800 area sites since monitoring commenced.

Fleabane (*Conyza* sp.) was recorded as rare at CLAE_08 in summer 2010 and Yorkshire Fog (*Holcus lanatus*) was recorded as rare at CLAE_08 in autumn 2012. Disturbance associated with damage by feral pigs was recorded in proximity to this site in April 2009.

In autumn 2021 two exotic species were found at CLAE_08, Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded as rare and Common Sow Thistle (*Sonchus oleraceus*) as rare. No exotic species were recorded in this plot in spring 2021. Catsear (*Hypochaeris radicata*) was recorded as common in summer 2022. The number of exotic species has declined since summer 2021 when 3 species were recorded, and their abundance has declined as well.

Fleabane had been recorded at CLAE_06 in spring 2020 for the first time since monitoring of that plot commenced but was not again detected in 2021 or summer 2022. Another exotic daisy, Cudweed (*Gamochaeta* sp.) was present (C/A 1, rare). Fleabane was recorded at CLAE_04 (C/A 1, rare) and CLAE_05 (C/A 1, rare) in summer 2021, but these plants had died by autumn and no exotic plants were recorded at the plot in spring 2021. In summer 2022 Fleabane and Catsear were recorded as rare at CLAE_05.

These occurrences of pioneer weed species are associated with the impact of the December 2019 bush fire. As predicted, they have declined with time since fire, although there are sporadic re-occurrences with seed germination in response to rainfall.

3.4.4 Increaser and Decreaser Species

Some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground.

Before the fire, in spring 2012, the following plant species were recorded within a particular monitoring site for the first time:

Baumea rubiginosa	CLAE_01
Lomandra filiformis	CLAE_01
Lomandra cylindrica	CLAE_01
Schizaea bifida	CLAE_01
Gompholobium uncinatum	CLAE_02
Thelymitra ixioides	CLAE_03
Baumea rubiginosa	CLAE_04
Boronia microphylla	CLAE_04
Drosera peltata	CLAE_04 (* **3**)
Billardiera scandens	CLAE_05
Rhytidosporum procumbens	CLAE_05
Lambertia formosa	CLAE_06
Tetrarrhena juncea	CLAE_06
Isolepis habra	CLAE_07

NOTE
* Recorded again in summer 2022 with cover/abundance score.

A number of plant species were first detected at a particular site in summer 2014, following the bush fire. These included:

Arthropodium milleflorum	CLAE_01
Cyathochaeta diandra	CLAE_01
Dianella prunina	CLAE_01 (* **1**)
Dodonaea triquetra	CLAE_01
Hibbertia obtusifolia	CLAE_01
Lomandra multiflora	CLAE_01
Cyathochaeta diandra	CLAE_02 (* **2**)
Thysanotus juncifolius	CLAE_02
Drosera binata	CLAE_04
Epacris pulchella	CLAE_04
Gahnia filifolia	CLAE_04
Viola sieberiana	CLAE_05 (* **1**)
Celmisia longifolia	CLAE_06
Drosera binata	CLAE_06 (* **1**)
Hakea teretifolia	CLAE_06
Juncus planifolius	CLAE_06 (* **3**)
Lomandra multiflora	CLAE_06
Microlaena stipoides	CLAE_06
Schoenus villosus	CLAE_06 (* **3**)
Thelymitra pauciflora	CLAE_06
Thysanotus sp.	CLAE_06
Viola sieberiana	CLAE_06 (* **3**)
Entolasia stricta	CLAE_07

Microlaena stipoides	CLAE_07
Xyris complanatus	CLAE_07
Hakea teretifolia	CLAE_08 (*** 1**)

NOTE
* Recorded again in summer 2022 with cover/abundance score.

Between spring 2015 and summer 2020 the early disturbance responder *Juncus planifolius* had not been recorded at CLAE_06, having been recorded there following the 2013 bushfire. Seeds had germinated and the species was observed to be common in autumn and spring 2020 but had declined to uncommon by summer 2021. It was again recorded as common in summer 2022.

In summer 2014 *Lomandra glauca* was recorded at CLAE_02 having not been recorded at that site since April 2009. It was recorded as common at this site in autumn 2015, but not recorded in spring 2015 or summer 2016. In autumn 2016, it was again recorded as rare and in spring 2016 was recorded as uncommon, as it was in autumn 2017. It was not recorded within this plot in spring 2017 but recorded again in summer 2018 as uncommon, in autumn 2018 as rare and not recorded in spring 2018. In summer 2019 it was recorded as common, but it was not recorded between autumn 2019 and summer 2020. It was recorded as common in autumn 2020 and uncommon in spring 2020, the common again in summer 2021, but recorded as rare in autumn 2021, then not recorded in spring 2021 or summer 2022.

In autumn and spring 2014, *Lobelia dentata* was recorded at CLAE_01 having not previously been recorded at that site. It was not subsequently recorded until spring 2020, a similar post-fire response to that observed previously. It was again recorded in summer 2021 (C/A 1, rare), but not recorded in autumn or spring 2021 or summer 2022.

In spring 2019, *Schizaea bifida* was recorded for the first time at CLAE_03. It has not been recorded subsequently at this site.

3.5 Clarence 900 Area

Sites were established along different sections of Paddys Swamp in the Clarence 900 area in November 2014. This area was affected by the October 2013 bushfire. The sites burnt again in December 2019.

There are a range of human disturbance factors already operating in the vicinity of the two sites in the upper catchment (PSB_01 and PSB_02). This includes drainage works associated with earlier operation of the sand quarry 600 metres to the south, extensive new clearing of the quarry and a trail bike track to the north of PSB_01. Site PS_03 is located in the main section of Paddys Swamp, in an area substantially free of past human disturbance, although an old, defunct pipeline passes by the eastern edge of the swamp.

3.5.1 Species Richness

Species richness data for the three Paddys Swamp sites is presented in Appendix 5.

Species richness at the Paddys Swamp sites in summer 2022 was above pre-fire levels at PSB_02 and within the previously recorded range at PSB_01 and PS_03.

3.5.2 Plant Condition

Plant health was generally good with just one recorded instance of plant disease. At PSB_01 a *Banksia spinulosa* plant was suffering from leaf predation.

3.5.3 Exotic Species

One exotic species, Catsear (*Hypochaeris radicata*) has regularly been recorded at PSB_01, but was not observed in spring 2019, nor after the bushfire in 2020 until spring 2021 when it was recorded again within the plot (C/A 1, rare). It was not recorded in summer 2022.

Previously, both Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded at PSB_02 in summer 2021. In autumn just Catsear was recorded, C/A 1, rare. In spring 2021 neither of these exotic plant species were recorded. In summer 2022 Catsear was again recorded, C/A 1, rare.

Fleabane (*Conyza* sp.) was recorded for the first time at PS_03 in spring 2020, with a cover/abundance ranking of 1 (rare). This exotic species was not recorded there in 2021 or summer 2022.

3.5.4 Increaser and Decreaser Species

The rare grass, *Notochloe microdon*, had been recorded regularly at PSB_02 with a cover/abundance score of 2 (uncommon) in autumn 2016. It was not recorded at that site in spring 2016, probably due to lack of flowering material. It was again found in summer 2017 with a cover/abundance score of 2 (uncommon). It was not recorded within this plot between 2018 and 2021. In summer 2022 it was present, C/A 1, rare.

In spring 2016 this grass was found at PS_03 with a cover/abundance score of 2 (uncommon) but was not detected in 2017. In summer 2018 it was recorded as rare but has not been recorded since that time.

In 2021 a number of new post-fire records were made at the Pagoda Swamp plots.

At PSB_01 a seedling of *Eucalyptus blaxlandii* was found in autumn and spring 2021 It was also observed in the plot in summer 2022. Both *Hibbertia obtusifolia* and *Hibbertia riparia* were recorded for the first time in spring 2021. Neither species was recorded in summer 2022. *Poa sieberiana* subsp. *sieberiana* was recorded for the first time post-fire, but not again recorded in summer 2022. A *Persoonia mollis* seedling was also detected, but not present in summer 2022.

At PSB_02 seedlings of *Eucalyptus blaxlandii* were also recorded. These were not observed in summer 2022. *Banksia marginata* seedlings were observed for the first time post-fire in autumn and spring 2021. *Banksia marginata* was recorded as common in summer 2022. *Schoenus imberbis* was recorded within the plot for the first time in spring 2021, but not recorded in summer 2022.

At PS_03 the fern *Calochlaena dubia* was recorded for the first time in autumn 2021. This species was not present in summer 2022. *Cassinia aculeata* was recorded for the first time in spring 2021. In summer 2022 it was rare.

3.6 Pagoda Swamp

A new monitoring survey plot was established at Pagoda Swamp in February 2021. During 2021 mining operations approached the southern end of this Swamp.

Nineteen plant species were recorded within the plot in summer 2021, 26 species were recorded in autumn 2021 and 20 species were recorded in spring 2021 when the Swamp was exceptionally wet. In summer 2022, 26 species were again recorded. There was some vegetation damage with shrubs being pushed over by water during a November storm.

No records of plant disease have been made at this plot over the monitoring period

There were no exotic species present within the swamp plot in summer 2022.

4.0 DISCUSSION

Plant condition in summer 2022 was affected by high rainfall with many instances of leaf yellowing and death due to waterlogging. Plant disease associated with pathogens was not observed.

The occurrences of exotic plant species in summer 2022 were consistent with a post-fire decline with new germination in response to rainfall. Occurrences of weeds continue to be at plots with a disturbance history involving proximity to clearing and pine plantation, logging, feral animals and recreational use.

As the plots were all bush fire affected, with most sites suffering a very high intensity fire in December 2019, future surveys will be necessary to determine whether the recovery trajectory continues to be consistent with past events, or whether particular plots have a different trajectory due to factors other than fire intensity. The trajectory following the October 2013 had indicated that ecosystem function across the study area was normal. On the current trajectory following the December 2019 bushfire it is indicated that ecosystem functioning is normal at all undermined plots.

There have been no indications of residual effects of subsidence in areas undermined previously, particularly in the Clarence East area where mining occurred in 2019-20. The patterns of species richness, species composition and plant disease relate strongly to bush fire impacts and recovery and seasonal weather conditions, including two years of above average rainfall with no indication of a mining effect.

Appendix 1. Plant Species Richness at Clarence East and West Heath Sites

Appendix 1A. Long-term average species richness

Site	Location	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
PAG_01	Gorilla Rock	40.5	38.8	41.0	40.7	39.3	39.7	44.3	45.3	47.3	42.5	42.3	46.7	45.3	46.0
PAG_02	Gorilla Rock	19.5	24.0	27.0	25.0	23.7	28.0	30.3	30.3	26.7	28.0	30.7	34.3	32.7	31.7
PAG_03	Waratah East	28.0	27.8	26.7	27.7	30.0	29.3	29.0	30.3	32.7	30.0	29.3	30.3	32.7	32.7
PAG_04	Waratah East	20.5	21.8	21.3	20.0	22.7	21.3	23.0	22.0	23.7	21.7	23.0	22.0	19.7	20.7
PAG_05	Waratah North	25.0	22.3	23.7	23.7	27.0	25.7	26.3	29.0	28.7	27.0	36.7	39.3	39.7	35.7
PAG_06	Waratah North	25.0	27.8	29.3	29.0	28.7	33.7	31.3	30.3	30.7	32.7	27.7	27.0	30.3	32.3
CLW_01	Farmers Creek heath	–	–	30.0	33.5	32.7	35.0	36.7	37.3	41.3	38.5	36.3	39.7	41.0	43.7
CLW_06	Paddys Creek Ridge	–	–	28.0	29.5	29.7	36.7	39.0	35.3	35.3	37.5	36.3	39.7	42.7	45.7

Ave, average

1 pre-fire average for burnt sites.

Appendix 1B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum
PAG_01	Gorilla Rock	45	47	46	45	45	47	28	35	43	45	45	42	45
PAG_02	Gorilla Rock	36	36	30	31	39	30	24	23	27	27	31	29	32
PAG_03	Waratah East	31	33	37	32	36	31	28	34	33	27	29	27	31
PAG_04	Waratah East	20	19	23	18	22	19	9	24	21	20	22	20	25
PAG_05	Waratah North	36	41	37	35	36	34	16	33	31	34	33	32	35
PAG_06	Waratah North	29	34	28	30	32	29	11	29	29	34	30	27	29
CLW_01	Farmers Creek heath	39	41	41	38	42	38	25	29	42	40	39	42	37
CLW_06	Paddys Creek Ridge	39	44	38	43	40	39	23	35	40	45	39	34	40

Aut, autumn; Spr, spring; Sum, summer

Appendix 2. Plant Species Richness at Clarence West Swamp Sites—Clarence Colliery

Appendix 2A. Long-term average species richness

Site	Location	2005	2006	2007	2008	2009	2010	2011	2012	2013	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave
CLW_02	Old Bells Swamp	NS	21.0	17.5	19.7	25.0	32.7	34.7	35.7	37.0	26.0	28.3
CLW_03	Happy Valley Swamp	NS	23.0	28.5	34.0	37.5	38.7	33.0	30.3	31.5	31.0	28.3
CLW_04	Dark Swamp	NS	21.0	23.0	22.3	24.5	25.0	26.5	25.3	25.0	20.0	19.7
CLW_05	Pine Swamp	NS	26.0	27.0	35.3	47.0	47.3	47.0	43.0	34.0	30.0	27.7
BNS_01	Bungleboori North	31.0	29.0	28.0	30.5	39.7	43.3	39.5	41.0	36.3	21.0	22.7
BNS_02	Bungleboori North	14.5	13.3	14.5	14.3	15.3	15.3	15.5	15.5	15.3	14.5	13.3

Ave, average

1 pre-fire average

NS Not surveyed

Appendix 2B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum
CLW_02	Old Bells Swamp	28	36	27	30	27	19	11	26	25	33	26	24	26
CLW_03	Happy Valley Swamp	26	26	24	26	28	24	14	26	33	37	29	25	32
CLW_04	Dark Swamp	19	18	18	22	22	16	23	24	26	25	21	24	23
CLW_05	Pine Swamp	29	29	24	24	29	20	20	29	23	34	29	27	36
BNS_01	Bungleboori North	21	31	17	22	19	20	14	25	28	32	29	26	30
BNS_02	Bungleboori North	15	15	14	13	14	15	16	27	30	39	36	28	31

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 3. Plant Species Richness at Outbye Sites—Clarence Colliery

Appendix 3A. Long-term average species richness

Site	Location	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Spring	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAO_01	S of Bungleboori Creek	26	33.5	31	33.7	34.3	33.0	30.3	36.7	38.3	35.7
CLAO_02	S of Bungleboori Creek	24	28.5	26	29.7	29.3	28.5	24.3	30.7	29.0	31.0
CLAO_03	N of Bungleboori Creek	29	31.5	33	34.0	35.0	34.0	25.0	33.0	34.7	32.7
CLAO_04	N of Bungleboori Creek	26	31.0	31	33.7	34.7	31.5	26.0	36.3	35.3	35.0

Ave, average

1 pre-fire average

Appendix 3B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum
CLAO_01	S of Bungleboori Creek	36	35	31	35	38	33	22	22	30	29	30	28	25
CLAO_02	S of Bungleboori Creek	29	33	27	27	30	33	11	19	24	21	22	24	26
CLAO_03	N of Bungleboori Creek	33	36	32	37	32	27	25	25	25	25	25	29	NS
CLAO_04	N of Bungleboori Creek	34	35	35	36	37	35	25	27	26	29	24	31	NS

Aut, autumn; Spr, spring; Sum, summer
NS Not surveyed

Appendix 4. Plant Species Richness at Clarence 800 Area Sites

Appendix 4A. Long-term average species richness

Site	Location	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAE_01	Dumbano Fire Trail dam	58.0	57.3	59.3	58.7	56.0	60.3	62.7	65.0	64.0
CLAE_02	Heath ridge	33.0	30.7	35.0	34.3	31.0	32.3	37.7	40.0	38.0
CLAE_03	Heath ridge	36.0	34.3	37.3	37.7	34.5	31.0	34.7	39.0	35.3
CLAE_04	Secret swamp	35.5	37.0	36.0	35.3	39.5	38.3	44.0	44.3	43.7
CLAE_05	Secret swamp	42.5	40.7	38.7	43.3	40.5	49.3	46.3	48.7	45.7
CLAE_06	Olearia swamp	28.0	29.3	29.7	32.0	33.0	44.0	35.3	37.7	35.7
CLAE_07	Olearia swamp	24.0	28	26.0	25.3	25.0	30.0	32.0	32.3	31.0
CLAE_08	Olearia swamp	14.0	15.7	15.3	15.3	14.5	20.3	14.3	14.0	13.7

Ave, average

1 pre-fire average

Appendix 4B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum
CLAE_01	Dumbano Fire Trail dam	60	64	58	62	65	63	24	53	56	66	55	57	58
CLAE_02	Heath ridge	39	41	37	35	43	29	23	34	27	40	34	26	33
CLAE_03	Heath ridge	33	37	38	35	30	38	21	32	32	35	32	33	31
CLAE_04	Secret swamp	40	40	41	40	39	37	21	39	38	33	40	39	39
CLAE_05	Secret swamp	44	48	47	42	55	39	19	47	54	50	45	47	43
CLAE_06	Olearia swamp	34	35	32	36	38	33	18	36	34	38	35	38	34
CLAE_07	Olearia swamp	26	30	28	29	38	26	18	29	26	27	22	20	25
CLAE_08	Olearia swamp	13	15	13	13	14	13	8	30	31	38	30	33	30
Sum		289	310	294	292	322	278	152	300	298	327	293	293	291

Aut, autumn; Spr, spring; Sum, summer

Appendix 5. Plant Species Richness at Paddys Swamp Sites

Appendix 5A. Long-term average species richness

Site	Location	2014	2015	2016	2017
		Spr	Ave	Ave	Ave
PSB_01	Paddys Swamp Branch	37	44.7	43.0	48.3
PSB_02	Paddys Swamp Branch	23	25.0	23.3	22.7
PS_03	Paddys Swamp	NS	NS	28.0	26.3

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 5B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum
PSB_01	Paddys Swamp Branch	43	56	40	50	50	43	26	36	39	46	39	42	43
PSB_02	Paddys Swamp Branch	19	16	13	19	15	14	16	24	25	24	25	21	27
PS_03	Paddys Swamp	26	28	22	30	30	22	25	31	28	34	26	26	32

Flora Monitoring Program
Clarence Colliery
Autumn Report 2022

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1.0 INTRODUCTION

This report describes monitoring of flora monitoring sites at a range of areas within the Clarence Colliery lease area. Six broad areas are now subject to monitoring: Clarence East (Eastern SMP area), Clarence West (also known as the '700 area'), Outbye, 800 Area, 900 Area and Pagoda Swamp.

The flora monitoring program commenced at Clarence Colliery in July 2004. Initially, eight sites supporting heath and pagoda complex vegetation were included: six at Clarence East and two at Clarence West. Clarence East includes areas to the north and east of the Clarence Pit Top, in the catchment of the Bungleboori and Wollangambe Creeks. Mining within the Clarence Eastern SMP area was completed in February 2009. Clarence West is located to the north-west of the Clarence Pit Top. The monitoring sites are in the catchments of Farmers Creek or upper Bungleboori Creek. Mining is currently undertaken in the Clarence West SMP area. Subsequently sites in the outbye area which stretches across Bungleboori Creek about 3km south-east of Mount Horne were added to the program. In 2009 eight sites were added in the Clarence 800 Area located in the section of Newnes State Forest which is bordered by Blue Mountains National Park. Another three sites are located along tributaries of Paddys Creek. A new site was established in February 2021. This is in Pagoda Swamp, which is located to the south of Waratah Ridge, south-west of Mount Horne.

During 2016, Gingra Ecological Surveys recommenced monitoring swamp sites in the Clarence East and Clarence West areas. For a period between 2008 and 2013 these swamps were monitored by the University of Queensland.

This report provides information on monitoring undertaken in autumn 2022. Locations of the sites and their sampling dates in autumn 2022 are provided in Table 1. Ten plots in the north of the study area usually accessed along Waratah Ridge Road were unable to be surveyed as the Road was closed to enable retrieval and disposal of military waste.

Table 1. Locations of Flora Survey Sites

Site	Location	Type	Easting (GDA)	Northing (GDA)	Survey Date
Clarence East					
PAG_01	Gorilla Rock	Impact	246753	6300035	Not surveyed
PAG_02	Gorilla Rock	Impact	246755	6299924	Not surveyed
PAG_03	Waratah East	Impact	247251	6300707	Not surveyed
PAG_04	Waratah East	Impact	246938	6300784	Not surveyed
PAG_05	Waratah North	Control	247962	6303960	Not surveyed
PAG_06	Waratah North	Control	247888	6303910	Not surveyed
BNS_01	Bungleboori North Swamp	Impact	245582	6302273	Not surveyed
BNS_02	Bungleboori North Swamp	Impact	246290	6303633	Not surveyed
Clarence West					
CLW_01	Heath	Impact	241774	6295584	18/05/2022
CLW_02	Swamp	Impact	242596	6295527	18/05/2022
CLW_03	Happy Valley Swamp	Impact	241923	6296954	25/05/2022
CLW_04	Hanging swamp	Impact	241904	6298016	25/05/2022
CLW_05	Pine Swamp	Control	240804	6300186	16/05/2022
CLW_06	Heath—Paddys Creek Ridge	Control	240472	6299171	16/05/2022
Outbye					
CLAO_01	S of Bungleboori Creek	Impact	245023	6297763	19/05/2022
CLAO_02	S of Bungleboori Creek	Impact	245092	6297707	19/05/2022
CLAO_03	N of Bungleboori Creek	Impact	245504	6298627	Not surveyed
CLAO_04	N of Bungleboori Creek	Impact	245294	6299168	Not surveyed
800 Area					
CLAE_01	Gully N of Dumbano Fire Trail dam	Impact	248971	6295894	18/05/2022
CLAE_02	Heath ridge	Impact	247495	6295216	17/05/2022
CLAE_03	Heath ridge	Impact	247271	6295388	17/05/2022
CLAE_04	Secret Swamp	Impact	247203	6296462	17/05/2022
CLAE_05	Secret Swamp	Impact	247159	6296404	17/05/2022
CLAE_06	Olearia Swamp	Impact	247648	6296165	17/05/2022
CLAE_07	Olearia Swamp	Impact	247701	6296288	17/05/2022
CLAE_08	Olearia Swamp	Impact	247789	6296830	17/05/2022
900 Area					
PSB_01	Paddys Swamp Branch	Impact	241338	6298523	16/05/2022
PSB_02	Paddys Swamp Branch	Impact	241404	6298617	16/05/2022
PS_03	Paddys Swamp (lower)	Impact	241822	6299156	16/05/2022
Pagoda Swamp		/3			
PAS_01	Pagoda Swamp	Impact	242878	6300496	20/06/2022

The entire study area was subject to the Gospers Mountain bushfire, which burnt through the area from November to December 2019. Most sites were affected by very high intensity fire, but fire intensity at a small number of plots was patchier with small areas of shrubs and ground cover plants remaining unburnt. Plots with some unburnt patches included PAG_01, PAG_03, PAG_05, CLAO_01, CLAO_03 and CLAO_04.

At the swamp sites the bushfire had burnt above ground vegetation with only very localised patches of surface peat consumption. No deep consumption of peat deposits was observed in the study area.

Previously, in October 2013, an extensive bush fire, known as the State Mine Fire, burnt through the study area. That bushfire was also of high intensity and the vegetation across the study area was showing clear signs of recovery by November 2019, although in many places the tree canopy had not returned to the canopy height and breath of September 2013.

Above average rainfall has been recorded since February 2020. Total rainfall over the 2020-21 summer was somewhat above average and wet weather continued into March 2021 when 193 mm was recorded at Lithgow. April 2021 was the driest April in the last 40 years and May rainfall was slightly below the long-term average. Winter and early spring rainfall in 2021 was about average. November 2021 had the highest rainfall recorded in Lithgow for that month since records began. January 2022 was also very wet whilst December and February were close to average. March 2022 rainfall was the wettest for that month in over 30 years whilst April and May were close to average.

In 2021 mining proceeded to the north-east of Bungleboori Creek towards the southern end of Pagoda Swamp area (now subject to systematic flora monitoring) and in the Clarence East area to the south of CLAE_01. Mining also occurred on the south side of Bungleboori Creek, east of the Outbye area and away from any areas of sensitive vegetation communities subject to monitoring.

2.0 SURVEY METHODS

Permanently marked 20 m x 20 m (400 m^2) quadrats have been established at each monitoring site. The sites are sampled three times each year (in summer, autumn and spring).

Monitoring surveys involve recording vegetation structure, dominant species, estimated cover and height for each stratum, full floristics, estimated cover abundance for each species using a modified Braun-Blanquet scale (see below) and condition ranking for plant species using a five point scale (see below). Observations of general condition of vegetation in less sensitive forest and woodland habitats are also recorded, where relevant, as are fauna sightings.

Modified Braun-Blanquet Scale

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

Condition Scale

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

3.0 RESULTS

3.1. Clarence East & Clarence West Heath & Pagoda Sites

3.1.1 Plant Condition

At CLW_01 *Phyllota squarrosa* plants had leaf yellowing with one dead plant. At CLW_06 *Isopogon anemonifolius* plants had leaf dieback due to waterlogging. Leaves of *Mirbelia platyloboides* plants were suffering from leaf predation.

3.1.2 Species Richness

Species richness figures for the Clarence East and West pagoda and heath sites are presented in Appendices 1A and 1B.

Species richness at the two plots surveyed in autumn 2022 were similar to previous records.

3.1.3 Exotic Species

Prior to the 2019 bushfire, the only instance of a record for an exotic plant species over the history of monitoring Clarence East and West pagoda and heath sites was a single Catsear (*Hypochaeris radicata*) plant observed in spring 2010 at PAG_04.

Exposed soils following the 2019 bushfire has allowed germination of wind transported weeds, primarily members of the Asteraceae (daisy) family. In May 2020, Catsear (*Hypochaeris radicata*) plants were present at PAG_02 and PAG_04. Catsear was again present at PAG_04 in November 2020. These exotic species have not successfully established at the heath and pagoda sites which were weed free in summer 2022.

No exotic plant species were recorded at the two plots which were able to be surveyed in autumn 2022.

3.1.4 Increaser and Decreaser Species

Changes in species abundance and distribution can indicate changing environmental conditions, including changes associated with development.

In response to bushfire some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground. Germination may not place immediately as seeds may have dormancy mechanisms which delay germination,

An assessment of species which showed a change in cover/abundance was conducted in 2009 well before the impact of the 2013 bush fire. The species which showed variation in cover/abundance included:

- *Xanthosia pilosa* at site PAG_01, which had shown a decline from common to rare or uncommon. This species was recorded as uncommon at this site in spring 2012 and rare in summer 2013 with the abundance previously having been stable since July 2004. The first post-fire record of this species at the site was in summer 2015 when it was recorded as common. The abundance of this species was relatively stable in 2018-19. *Xanthosia pilosa* was recorded (rare) in May 2020 and **C/A** 3 (common) at each sampling in 2021 and in summer 2022.

- *Amperea xiphoclada* was first recorded at PAG_02 in May 2009. It was not recorded at the site again until February 2014 when it was rare. It was again recorded as rare in spring 2014, was not detected in summer 2015 and was recorded as rare in autumn 2015 and uncommon in spring 2015. It was recorded as rare in autumn 2016 and then not recorded between spring 2016 and autumn 2018. It was again recorded (rare) in spring 2018, not recorded in summer 2019, and again recorded as rare in autumn 2019, but not recorded in the drying conditions in spring 2019. In summer 2020, it had resprouted postfire from basal rootstocks and was again recorded (rare) in May 2020, but was not detected within the plot since November 2020 until summer 2022 when it was recorded as rare.

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_04 has previously been observed to have declined in abundance from common with lower levels of species abundance recorded between May 2006 and May 2009. The cover/abundance ranking of this species was then stable between October 2009 and May 2013. Cover/abundance scores for this species have been stable (C/A rank 3 – common) since summer 2014. All *Banksia ericifolia* plants were dead in summer 2020. In May 2020 seedlings of *Banksia ericifolia* had germinated and its cover/abundance ranking was 2 (uncommon) In November 2020 its cover/abundance ranking was again 2. In February 2021 it was recorded as rare, in May and September 2021 and summer 2022 it was recorded as uncommon.

- *Mirbelia rubiifolia* at site CLW_06 had previously been reported (Autumn 2010) as having increased in abundance from rare or uncommon to common. The species was recorded as uncommon in summer 2013. Cover/abundance scores for this species was the highest ever recorded at this plot in summer and autumn 2019 (C/A rank 4 – cover 5-20%) but was recorded as common in spring 2019. This species was not recorded at this plot in 2020, but resprouting plants were observed in summer 2021 (C/A rank 3, common). *Mirbelia rubiifolia* was again recorded as common in autumn 2021 and uncommon (C/A 2) in spring 2021. In summer and autumn 2022 it was recorded as common.

Changes in cover/abundance which became evident in the period from 2010 to May 2013 included:

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_01 had shown an overall increase from rare or uncommon to common. The cover/abundance score for this species in spring 2019 was 4, 5-20% cover. The 2013 fire did not burn intensely across this plot and many shrub plants escaped damage. A lesser number survived the December 2019, fire but cover/abundance was recorded as 2 uncommon in summer and autumn 2020. From November 2020 to September 2021, it was recorded with a **C/A** ranking of 3 (common) and in summer 2022 it was recorded as uncommon.

- *Cassytha glabella* at site PAG_02 had shown an increase from not recorded or rare to common. This species was recorded as common at this site in summer 2013. Since February 2014 it usually has been recorded as rare, but its cover/abundance score in summer and autumn 2017 was 2 (uncommon). In spring 2017 *Cassytha glabella* was not detected. In summer and autumn 2018 it was recorded as rare and in spring 2018 it was uncommon. This species was not detected within the plot in summer 2019. In autumn and spring 2019 it was recorded as uncommon. It was not recorded in 2020 or early 2021 but was recorded as uncommon in spring 2021 ands rare in summer 2022. *Cassytha glabella* has shown a delayed post-fire recovery at several plots following both the 2013 and 2019 bushfires.

- The prostrate shrub *Pseudanthus divaricatissimus* was a new record for PAG_02 in autumn 2010. This species was recorded as rare in summer 2013. This species was detected within the plot for the first time since the October 2013 fire in summer 2019 but not recorded in autumn or spring 2019. It has not been recorded from summer 2020 to summer 2022.

- The sedge, *Lepidosperma filiforme*, was not detected at PAG_03 between autumn 2011 and autumn 2012. From 2014 onwards, it was recorded as rare, but was not recorded in autumn 2016. From spring 2016 through to spring 2017 it again has been recorded as rare but was not recorded in summer 2018. In autumn 2018 it was recorded as uncommon and in spring 2018 it was rare, whilst in summer 2019 it was uncommon. It was again recorded as rare in autumn and spring 2019. It was not recorded in summer 2020 but recorded in autumn (uncommon) and spring (rare). It was recorded as rare again in summer and autumn 2021, but not recorded in spring 2021. In summer 2022 it was recorded as uncommon.

Species recorded at sites in February 2014 which had not previously been recorded at those locations were:

- *Eucalyptus piperita* was recorded as rare at PAG_02. This sapling has been recorded consistently since February 2014. It was again recorded in summer 2021, but not detected since.
- *Goodenia bellidifolia*, *Lomandra glauca*, *Patersonia sericea* and *Schoenus villosus* at control plot PAG_05. In autumn 2019 both *Goodenia bellidifolia* (rare) and *Lomandra glauca* (uncommon) were recorded, but none of the 3 species were recorded in spring. *Schoenus villosus* resprouted from basal rootstocks following the bushfire. In spring 2020 it had flower buds and ranked with a C/A score of 2, uncommon. *Goodenia bellidifolia* (common) was the only of these species present in spring 2020. In summer 2022 *Goodenia bellidifolia* was recorded as common and *Schoenus villosus* was recorded as uncommon.
- *Aristida ramosa* at CLW_01. This species has not been recorded since autumn 2016.
- *Arthopodium milleflorum*, *Cyathochaeta diandra* and *Lagenophora stipitata* at CLW_06. *Cyathochaeta diandra* was recorded as uncommon and *Lagenophora stipitata* as rare in spring 2015. None of these species were recorded in either autumn or spring 2016 or summer 2017. Both *Cyathochaeta diandra* and *Lagenophora stipitata* were again recorded in spring 2019 (C/A 1, rare). The two other species were not recorded in spring 2019. In spring 2020, *Lagenophora stipitata* and *Cyathochaeta diandra* had a C/A score of 1, rare. In summer 2021, only *Cyathochaeta diandra* (C/A 2, uncommon) was observed. None of these species were recorded from autumn 2021 to autumn 2022.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as common at PAG_02 in summer 2014. It was flowering in spring 2016, which allowed for it to be identified to species level for the first time. In summer and autumn 2019, it was recorded at PAG_02 but suffering from leaf dieback and it was not recorded in spring 2019. It was not recorded in summer 2020, but had germinated by autumn 2020, with a C/A score of 3 (common), its presence continuing through to summer 2021.

Species recorded in autumn 2015 which had not been recorded at sites prior to the bush fire were:

- *Actinotus helianthi* at PAG_01 (common) and PAG_02 (common). This species was recorded at PAG_01 (common) between autumn 2016 and summer 2017, but rare in autumn 2017 and not recorded in spring 2017. It was again present in spring 2018 and summer 2019 (C/A common) and autumn 2019 (C/A uncommon). At PAG_02 it was uncommon in autumn and spring 2016, common in summer and autumn 2017, uncommon in spring 2017 and common in summer and autumn 2018, then uncommon between spring 2018 and autumn 2019. In spring 2019 at PAG_01 it was recorded as uncommon and at PAG_02 it was recorded as rare and senescent. At PAG_02 in autumn 2020 it was recorded as uncommon, whilst at PAG_01 it was recorded as common. In summer and autumn 2021 *Actinotus helianthi* was common at both these plots. In spring 2021 *Actinotus helianthi* was recorded as common at PAG_01 and uncommon at PAG_02. It was again recorded at both plots in summer 2022.
- *Actinotus forsythii* at PAG_03 (common). These plants had died by spring 2015. There was no evidence of seedling plants in summer 2020. Seeds of this plant had germinated by autumn 2020 and it was recorded as common in autumn and spring. In summer 2021 it was recorded as common and flowering at PAG_03; at PAG_04 it had a C/A rank of 4 (>5% cover); at PAG_05 and PAG_06 it was uncommon. In autumn 2021 it was common and setting seed at PAG_03 and PAG_04, and it was recorded as uncommon at PAG_05. The species was not recorded within any plot in spring 2021 or summer 2022; this is consistent with the usual post-fire response of this species which is classed as a fire ephemeral.
- *Cyathochaeta diandra* at PAG_02 (rare). This species has not been recorded again since summer 2016.
- *Goodenia decurrens* at PAG_03 (rare), consistently present from spring 2015 to spring 2019 (rare), in a sheltered location at the foot of the pagoda. This plant remained in summer 2020 in an unburnt section of the plot and has persisted since.
- *Haemodorum planifolium* at CLW_01 (common) and CLW_06 (rare). In summer 2017 this species was recorded as common at CLW_01 and uncommon at CLW_06. In autumn and spring 2017 this species was rare at each of these two sites. In summer and autumn 2018, it was not recorded at CLW_01 and rare at CLW_06. The remaining leaves died off by spring 2018, when it was not recorded, and it was not present in 2019. It was not found at CLW_06 in summer 2020 but at CLW_01 it had already emerged with a C/A score of 3, common. From spring 2020 until autumn 2021 *Haemodorum planifolium* has been recorded as uncommon at CLW_06 and common at CLW_01. In autumn 2022 it was recorded as common at CLW_01 and rare at CLW_06.

3.2. Clarence East and West Swamp Sites

3.2.1 Plant Condition

At CLW_02 *Poa sieberiana* subsp. *cyanophylla* plants had severe dieback ad branch dieback due to waterlogging. At CLW_03 *Cassinia aculeata* plants had dieback due to waterlogging. At CLW_04 *Olearia quercifolia* plants continued to suffer dieback due to a fungal pathogen. Also at that site, *Grevillea acanthifolia* plants had leaf dieback due to waterlogging. At CLW_05 *Eucalyptus radiata* seedlings had dieback due to waterlogging and *Pteridium esculentum* plants had seasonal dieback due to morning frosts.

3.2.2 Species Richness

Species richness data for Clarence East and West Swamp sites is presented in Appendices 2A and 2B.

In summer 2020 species richness at three swamp sites, CLW_04, CLW_05 and BNS_02, were at the same level or higher than prior to the bushfire, reflecting early recovery of some swamp species due to increased swamp water levels related to post-fire rainfall.

In autumn 2020, species richness at many of the plots was at the high end of the previously reported range, with the level at BNS_02 around double the previous high. These high numbers are attributable to open areas with the swamps providing an opportunity for growth of otherwise suppressed ground layer species.

Significantly higher levels of species richness compared to counts prior to the December 2019 bushfire continued to prevail in summer 2022. At all but one plot species richness was greater than that recorded in spring 2021. This is partly due to flowering of summer grasses, making them easier to detect. The decline at the majority of these swamp plots through 2021, followed by a summer increase, is consistent with a normal post fire trend.

Whilst there was a decline in species richness in autumn 2022 compared to summer counts, the levels are within the previously recorded range and consistent with normal post-fire trends.

3.2.3 Exotic Species

Some of the Clarence West swamp sites have been subject to disturbance prior to any impact of mining with the establishment of a pine plantation in the catchment of some swamps being a notable factor.

Radiata Pine (*Pinus radiata*) was previously recorded at BNS_01. The hot bushfire killed the pines, and no live Radiata Pine plants have been recorded since autumn 2020. In summer 2022, two exotic plants, Catsear (*Hypochaeris radicata*) and Fleabane (*Conyza* sp.) were recorded at this plot.

At BNS_02 the exotic species Catsear (*Hypochaeris radicata*), C/A 1 (rare) and Blackberry (*Rubus anglocandicans*), C/A 1 (rare) were recorded. Exotic species richness and abundance have declined since summer 2021.

Catsear (*Hypochaeris radicata*) was not recorded at CLW_02 in summer 2022, having previously been recorded as rare. Fleabane (*Conyza* sp.) was recorded as uncommon in spring 2020 and summer 2021 and rare in autumn 2021, then not recorded in from spring 2021 to autumn 2022.

At CLW_03 the only exotic species recorded was Catsear (*Hypochaeris radicata*). and Fleabane (*Conyza* sp.). Previously in summer 2021, three exotic species, all daisies, were recorded; Fleabane (*Conyza sp.*) C/A 2 (uncommon), Spear Thistle (*Cirsium vulgare*), C/A 1 (rare) and Catsear (*Hypochaeris radicata*), C/A 1 (rare). In autumn 2021, Yorkshire Fog (*Holcus lanatus*), C/A 2, uncommon, Catsear (*Hypochaeris radicata*), C/A 1, rare and Spear Thistle (*Cirsium vulgare*), C/A 1, rare were the three exotic species recorded in this plot.

In autumn 2022, three exotic species were recorded at CLW_05, the grass Yorkshire Fog (*Holcus lanatus*), Catsear (*Hypochaeris radicata*) and Fleabane (*Conyza* sp.) Neither Blackberry (*Rubus anglocandicans*) nor Spear Thistle (*Cirsium vulgare*) were recorded at the site in autumn.

The 2021 results indicate a decline in species richness and abundance of weeds within Clarence East & West swamps. The plots suffering from historical disturbance had a higher abundance of weed species, particularly notable at CLW_05.

3.2.4 Increaser and Decreaser Species

In 2008 the following changes in species cover/abundance were discussed:

> At CLW_02, there had been a decline in cover/abundance of Prickly-leaved Tea-tree (*Leptospermum continentale*). Species observed in 2008 which had not previously been recorded included *Deyeuxia gunniana* and *Baloskion australe*.
>
> At CLW_03, there had been no noticeable decline in the cover/abundance of plant species, but a number of swamp associated plants had an increased ranking apparently due to improved rainfall from 2006. Species observed in 2008 which had not previously been recorded included Sneezeweed (*Centipeda minima*), two grasses (*Dichelachne* sp. and *Deyeuxia* sp.), *Patersonia fragilis*, and the exotic species, Cudweed (*Gamochaeta* sp.).
>
> At CLW_04, there had been no consistent increase or decline in common species occurring at that site. Species observed in 2008 which had not previously been recorded included *Juncus continuus* and *Lepyrodia anarthria*.
>
> At CLW_05, there has been a decline in cover of Woolly Tea-tree (*Leptospermum grandiflorum*) and *Deyeuxia gunniana,* and an increasing abundance of *Geranium homeanum*. Species observed in 2008 which had not previously been recorded included a plume grass (*Dichelachne* sp.), *Senecio hispidulus*, *Senecio linearifolius*, and the exotic species Fleabane (*Conyza* sp.) and Blackberry (*Rubus anglocandicans*).

In relation to these species and sites the following records were made in summer 2022:

Leptospermum continentale was not observed at CLW_02. Previously this species recovered following the 2013 bush fire to baseline levels recorded in 2006. More recently, this species was not recorded as alive in summer 2020. In summer 2021 and autumn 2021 it was recorded as uncommon (C/A 2). In autumn 2021 *Deyeuxia gunniana* was recorded as uncommon (C/A 2) and was seeding. It was not recorded in spring 2021, but again recorded in summer 2022 as uncommon. In autumn 2022 *Deyeuxia gunniana* was common. *Baloskion australe* has not been recorded since 2020.

At CLW_03 Sneezeweed (*Centipeda minima*) (C/A 1; rare) was present in autumn 2019, but not recorded in 2020 or 2021. In autumn 2021 *Deyeuxia quadriseta* was recorded as common (C/A 3). Neither species was detected in spring 2021. In summer and autumn 2022 neither *Centipeda minima* nor *Deyeuxia quadriseta* were recorded,

At CLW_04 *Juncus continuus* was not detected between spring 2021 and autumn 2022. *Lepyrodia anarthria* was recorded as common (C/A 3) at both seasonal surveys.

At CLW_05, *Leptospermum grandifolium* was recorded (C/A 4; common, cover >5%) in autumn 2022. *Geranium homeanum* (C/A 3, common) was also present in autumn 2022.

3.3 Clarence Outbye

3.3.1 Plant Condition

There were no instances of plant disease at either of the Outbye plots surveyed in autumn 2022.

3.3.2 Species Richness

Species richness figures for the Outbye sites are presented in Appendices 3A and 3B.

The species richness counts for CLAO_01 and CLAO_02 recorded in autumn 2022 were similar to levels recorded in spring 2021.

3.2.3 Exotic Species

No exotic species were recorded at either of the two Clarence Outbye sites surveyed in summer 2022. This is consistent with previous records for these weed-free plots.

3.2.4 Increaser and Decreaser Species

Following the autumn 2010 monitoring survey it was reported that several species were recorded at monitoring sites for the first time, as detailed below.

At CLAO_01, species recorded for the first time in 2010 included *Banksia spinulosa* and *Gompholobium glabratum*. *B. spinulosa* has not been recorded since autumn 2017 having been recorded as uncommon in autumn 2016. *G. glabratum* was recorded in summer 2012, when it was rare, but was not recorded in summer or autumn 2013. It had not been recorded at this site since the 2013 bush fire, but in autumn 2018 was present (C/A 2, uncommon). It has not been recorded since the December 2019 bushfire.

At CLAO_02, species recorded for the first time in autumn 2010 included *Boronia floribunda*, *Cryptostylis subulata*, *Hibbertia serpyllifolia* and *Lepidosperma filiforme*.

Boronia floribunda had been recorded as uncommon since autumn 2018 but was rare in autumn 2019 and not recorded since spring 2019. *Cryptostylis subulata* was recorded as common in autumn 2018 and rare in spring 2018 but not detected in summer 2019. In autumn 2019 it was recorded as uncommon not recorded since. *Lepidosperma filiforme* was recorded in spring 2019 (C/A 2, uncommon). In summer 2022 it was recorded for the first time after the 2019 bushfire (C/A 1, rare). *Hibbertia serpyllifolia* has not been recorded at the plot since the 2019 bushfire.

At CLAO_03, species recorded for the first time in autumn 2010 included *Mitrasacme polymorpha*, *Ochrosperma oligomerum* (formerly *Ochrosperma monticola*) and *Petrophile pulchella*. *P. pulchella* (uncommon) was the only one of these species detected at the site in autumn 2013.

In autumn and spring 2018 none of these three species were recorded. In summer 2019, *Ochrosperma oligomerum* was recorded as uncommon. The three species were then recorded in the plot from autumn 2019 to spring 2020. In summer 2021 a *Petrophile pulchella* seedling was detected near the centre of the plot, and this species was again detected in spring 2021 (C/A 1, rare).

At CLAO_04, species recorded for the first time in autumn 2010 were *Conospermum taxifolium* and *Pseudanthus divaricatissimus*.

Both species were recorded as rare at the site in autumn 2016, but only *Conospermum taxifolium* was present in spring 2016. Neither species was recorded in summer 2017. Both *Pseudanthus divaricatissimus* (uncommon) and *Conospermum taxifolium* (rare) were recorded in spring 2017. Neither species was recorded in summer or autumn 2018. In spring 2018 and summer 2019 *Pseudanthus divaricatissimus* was recorded as rare. Neither species was recorded in autumn or spring 2019. In summer 2020 *Pseudanthus divaricatissimus* was recorded (C/A 1, rare). Neither species had been recorded since autumn 2020, but *Conospermum taxifolium* was present in spring 2021.

A number of plant species were first detected at a particular site in summer 2014, following the October 2013 bush fire. These included:

Bossiaea heterophylla at CLAO_02, not subsequently detected from spring 2014 to summer 2017, recorded as rare in autumn 2017, not recorded in spring 2017 and recorded as rare again in summer and autumn 2018. In summer 2019 it was recorded as uncommon and in autumn 2019 as rare, but not recorded in spring 2019. It has not been detected within the plot since the 2019 bushfire.

Thysanotus juncifolius at CLAO_03, not subsequently detected since 2014. It regenerated from seed after the 2019 bushfire and in summer 2021 was recorded as common (C/A 3) but was not observed in autumn or spring 2021.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as uncommon at CLAO_01 in autumn 2014. It was again recorded as rare at the site in spring 2016, but not recorded from summer 2017 onwards. It was also first recorded at CLAO_03 (uncommon) in summer 2015.Between spring 2016 and spring 2017 it was recorded as common, but its C/A score was 2, uncommon in summer 2018 and it was recorded again as common in autumn and spring 2018, uncommon in summer 2019 and rare in autumn 2019, then not recorded until autumn 2021 when it was recorded as common. It was again recorded as common in spring 2021, but not recorded in summer or autumn 2022.

One species, *Lindsaea linearis* was recorded for the first time at CLAO_01 in spring 2015. It has not been recorded at that site since spring 2016, despite suitably wet conditions in 2020-21.

In spring 2016 *Drosera peltata* was recorded for the first time at CLAO_02. *Drosera peltata* was present and flowering at CLAO_02 in spring 2016 but was not recorded between summer 2017 and autumn 2020. In spring 2020 it was recorded as common but was not recorded in 2021 or summer or autumn 2022, despite the above average rainfall recorded over that period. *Drosera peltata* can survive in the soil as an underground rhizome, responding to wet conditions.

A number of new post fire records of species within Outbye monitoring plots were made in summer 2016.

These included:

Thelionema caespitosum at CLAO_01 (rare in summer 2017, uncommon in autumn and spring 2017 and autumn 2018, absent between spring 2018 and spring 2019). In summer 2020 this species was again detected (C/A 2, uncommon), but it was not detected in autumn 2020. In spring 2020 it was detected (C/A 1, rare) and in summer 2021 it was recorded as common (C/A 3). It was not recorded in summer or autumn 2022.

Pimelea linifolia at CLAO_02 (not present summer 2017, rare in autumn 2017, uncommon in spring 2017, then not recorded until autumn 2021 (C/A 1, rare). This species was not recorded in the plot in summer or autumn 2022.

Rytidosperma sp. at CLAO_02 - not detected since 2016.

Gompholobium uncinatum at CLAO_03 (present in summer and autumn 2017; rare; not detected in spring 2017 or summer 2018, rare in autumn 2018, common in spring 2018, but not detected since.

Pimelea linifolia at CLAO_03 and CLAO_04 was not present in 2017 or 2018 but present at both CLAO_03 and CLAO_04 in summer 2019, then just CLAO_03 in autumn 2019 and within neither plot since spring 2019. At CLAO_04 in spring 2020 it was recorded as rare and in summer 2021 it was recorded as uncommon (C/A 2) but was not again recorded in autumn or spring 2021.

Epacris microphylla at CLAO_04 (consistently present since summer 2017, recorded as uncommon in autumn 2018 and common between spring 2018 and spring 2019). In spring 2020 it was not recorded but recorded in summer 2021 (C/A 2, uncommon) and in autumn and spring 2021 (C/A 3, common).

There are no clear long-term trends indicating a change in abundance of the more common shrub or ground layer species present at each site.

3.4 Clarence 800 Area

3.4.1 Plant Condition

At CLAE_01 *Banksia spinulosa*, *Isopogon anemonifolius* and *Acacia asparagoides* plants had leaf yellowing due to waterlogging.

Several plant species at CLAE_02 were showing signs of dieback. Blue Mountains Mallee (*Eucalyptus stricta*) and *Hakea laevipes* plants were affected by leaf predation. Waterlogging was the cause of dieback for *Isopogon anemonifolius, Gonocarpus tetragynus* and *Dampiera stricta* plants.

At CLAE_04 *Banksia marginata* and *Pultenaea subspicata* plants had dieback due to waterlogging.

At CLAE_08 *Pultenaea divaricata*, *Eucalyptus piperita* and *Acacia terminalis* plants had leaf yellowing due to waterlogging. Dieback of eucalypt seedlings which germinate in swamps is a normal occurrence which part of the dynamics of the swamp ecosystem.

Apart from the impacts of the prolonged wet weather conditions, plant health was good with no sign of plant disease.

3.4.2 Species Richness

Species richness figures for the Clarence 800 Area sites are presented in Appendices 4A and 4B.

Table 3 shows some species richness figures following the 2013 and 2019 bushfires. The levels in autumn 2022 were similar to autumn 2021 levels with the exception of CLAE_04 and CLAE_08 where species richness was lower in 2022.

PLOT	2019 BUSHFIRE INTENSITY	DEC 2013	FEB 2014	FEB 2020	MAY 2020	FEB 2021	MAY 2021	OCT 2021	FEB 2022	MAY 2022
CLAE_01	Very High	27	53	24	54	66	55	57	58	53
CLAE_02	Very High	26	27	23	34	40	34	26	33	29
CLAE_03	High	19	29	21	32	35	32	33	31	33
CLAE_04	Very High	20	36	21	39	33	40	39	39	31
CLAE_05	Very High	19	40	19	49	50	45	47	43	40
CLAE_06	Very High	30	45	18	36	38	35	38	34	34
CLAE_07	Very High	15	28	19	29	27	22	20	25	19
CLAE_08	Very High	15	19	8	30	38	30	33	30	24

Table 3. Species Richness Post-fire. Clarence 800 Area Sites

For the period prior to the October 2013 bush fire total species richness ranges from a high of 298 records in spring 2012 to a low of 252 records in autumn 2010. The total number of species records in autumn 2013 was 266, which fell within the range of previous records. In summer and autumn 2012, there were 274 records.

Species richness in summer 2014 was within the pre-fire range with 277 records. Subsequent germination of seedlings in the post-fire environment saw species richness exceed pre-fire levels with 324 records in autumn 2014, 317 records in spring 2014, 307 records in summer 2015, 310 records in autumn 2015 and 304 records in spring 2015.

The number of records in summer 2016, 328, exceeded previous species richness totals for the Clarence East site. In autumn 2016 there was a similar level (327 records) of species richness. The number for autumn 2017 was 321, slightly lower than the level for the previous autumn. In spring 2017, the total number of records was 283, 8% lower than the corresponding season in 2016. The summer 2018 number was 289; the last two years have seen an increase in species records from spring to summer. In autumn 2018, the total was 310, consistent with a post-fire pattern of higher species richness in autumn. The total number of plant records in spring 2018 was 294, there were 292 records in summer 2019 and 323 records in autumn 2019. In spring 2019 the number declined to 282, the same level as that recorded in spring 2017.

In summer 2020, the total number of records was 153, somewhat lower than the December 2013 number of 171. This may reflect the very high fire intensity at almost all plots in 2019. By autumn 2020 the number had reached 300, with an exceptional rise in species detected at CLAE_08. The spring 2020 number was 299, showing a stable situation during the autumn-spring period. In summer 2021 the totals species records amounted to 327, just below the record high established in summer 2016. In summer 2022 there were 291 records, similar to the level in autumn and spring 2021. The total declined to 263 in autumn 2022.

The section of Olearia Swamp where CLAE_08 is located experienced very intense fire, followed by a high level of sediment movement associated with heavy rainfall in February 2020. The more open spaces and changed soil profile has enabled germination and establishment of pioneer and woodland species.

Recent total species counts for the Clarence 800 sites are shown in Figure 1. The Figure shows an initial post-fire decline, then an increase and subsequent decline.

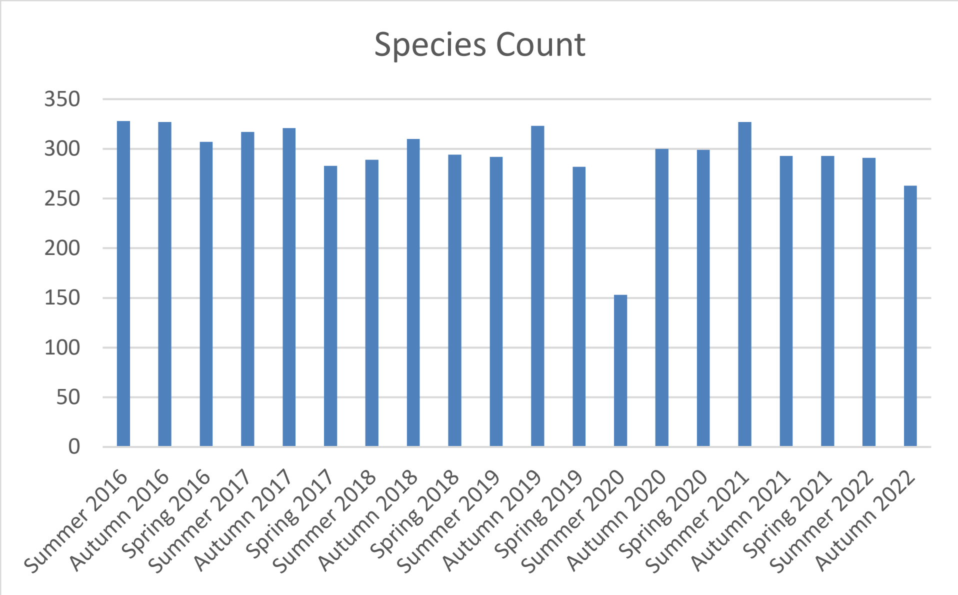

Figure 1. Seasonal Total Species Counts for 800 Area Monitoring Plots

3.4.3 Exotic Species

There have been few records of exotic species at the 800 area sites since monitoring commenced.

Fleabane (*Conyza* sp.) was recorded as rare at CLAE_08 in summer 2010 and Yorkshire Fog (*Holcus lanatus*) was recorded as rare at CLAE_08 in autumn 2012. Disturbance associated with damage by feral pigs was recorded in proximity to this site in April 2009.

In autumn 2021 two exotic species were found at CLAE_08, Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded as rare and Common Sow Thistle (*Sonchus oleraceus*) as rare. No exotic species were recorded in this plot in spring 2021. Catsear (*Hypochaeris radicata*) was recorded as common in summer 2022. The number of exotic species has declined since summer 2021 when 3 species were recorded, and their abundance has declined as well.

Fleabane had been recorded at CLAE_06 in spring 2020 for the first time since monitoring of that plot commenced but was not again detected in 2021 or summer 2022. Another exotic daisy, Cudweed (*Gamochaeta* sp.) was present (C/A 1, rare). Fleabane was recorded at CLAE_04 (C/A 1, rare) and CLAE_05 (C/A 1, rare) in summer 2021, but these plants had died by autumn and no exotic plants were recorded at the plot in spring 2021. In summer 2022 Fleabane and Catsear were recorded as rare at CLAE_05.

In autumn 2022 there was only one record for an exotic species, Catsear (*Hypochaeris radicata*) at CLAE_05 (C/A 1, rare).

These occurrences of pioneer weed species are associated with the impact of the December 2019 bush fire. As predicted, they have declined with time since fire, although there are sporadic re-occurrences with seed germination in response to rainfall.

3.4.4 Increaser and Decreaser Species

Some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground.

Before the fire, in spring 2012, the following plant species were recorded within a particular monitoring site for the first time:

Baumea rubiginosa	CLAE_01
Lomandra filiformis	CLAE_01
Lomandra cylindrica	CLAE_01 (* **2**)
Schizaea bifida	CLAE_01
Gompholobium uncinatum	CLAE_02
Thelymitra ixioides	CLAE_03
Baumea rubiginosa	CLAE_04
Boronia microphylla	CLAE_04
Drosera peltata	CLAE_04
Billardiera scandens	CLAE_05
Rhytidosporum procumbens	CLAE_05
Lambertia formosa	CLAE_06
Tetrarrhena juncea	CLAE_06
Isolepis habra	CLAE_07

NOTE
* Recorded again in autumn 2022 with cover/abundance score.

A number of plant species were first detected at a particular site in summer 2014, following the bush fire. These included:

Arthropodium milleflorum	CLAE_01
Cyathochaeta diandra	CLAE_01
Dianella prunina	CLAE_01 (* **2**)
Dodonaea triquetra	CLAE_01
Hibbertia obtusifolia	CLAE_01
Lomandra multiflora	CLAE_01
Cyathochaeta diandra	CLAE_02 (* **2**)
Thysanotus juncifolius	CLAE_02
Drosera binata	CLAE_04
Epacris pulchella	CLAE_04
Gahnia filifolia	CLAE_04
Viola sieberiana	CLAE_05 (* **1**)
Celmisia longifolia	CLAE_06
Drosera binata	CLAE_06
Hakea teretifolia	CLAE_06
Juncus planifolius	CLAE_06 (* **3**)
Lomandra multiflora	CLAE_06
Microlaena stipoides	CLAE_06
Schoenus villosus	CLAE_06 (* **2**)
Thelymitra pauciflora	CLAE_06
Thysanotus sp.	CLAE_06
Viola sieberiana	CLAE_06
Entolasia stricta	CLAE_07

Microlaena stipoides	CLAE_07
Xyris complanatus	CLAE_07
Hakea teretifolia	CLAE_08

NOTE
* Recorded again in autumn 2022 with cover/abundance score.

Between spring 2015 and summer 2020 the early disturbance responder *Juncus planifolius* had not been recorded at CLAE_06, having been recorded there following the 2013 bushfire. Seeds had germinated and the species was observed to be common in autumn and spring 2020 but had declined to uncommon by summer 2021. It was again recorded as common in summer and autumn 2022.

In summer 2014 *Lomandra glauca* was recorded at CLAE_02 having not been recorded at that site since April 2009. It was recorded as common at this site in autumn 2015, but not recorded in spring 2015 or summer 2016. In autumn 2016, it was again recorded as rare and in spring 2016 was recorded as uncommon, as it was in autumn 2017. It was not recorded within this plot in spring 2017 but recorded again in summer 2018 as uncommon, in autumn 2018 as rare and not recorded in spring 2018. In summer 2019 it was recorded as common, but it was not recorded between autumn 2019 and summer 2020. It was recorded as common in autumn 2020 and uncommon in spring 2020, the common again in summer 2021, but recorded as rare in autumn 2021, then not subsequently recorded.

In autumn and spring 2014, *Lobelia dentata* was recorded at CLAE_01 having not previously been recorded at that site. It was not subsequently recorded until spring 2020, a similar post-fire response to that observed previously. It was again recorded in summer 2021 (C/A 1, rare), but not recorded between autumn 2021 and autumn 2022.

In spring 2019, *Schizaea bifida* was recorded for the first time at CLAE_03. It has not been recorded subsequently at this site.

3.5 Clarence 900 Area

Sites were established along different sections of Paddys Swamp in the Clarence 900 area in November 2014. This area was affected by the October 2013 bushfire. The sites burnt again in December 2019.

There are a range of human disturbance factors already operating in the vicinity of the two sites in the upper catchment (PSB_01 and PSB_02). This includes drainage works associated with earlier operation of the sand quarry 600 metres to the south, extensive new clearing of the quarry and a trail bike track to the north of PSB_01. Site PS_03 is located in the main section of Paddys Swamp, in an area substantially free of past human disturbance, although an old, defunct pipeline passes by the eastern edge of the swamp.

3.5.1 Species Richness

Species richness data for the three Paddys Swamp sites is presented in Appendix 5.

Species richness at the Paddys Swamp sites in autumn 2022 was within the previously recorded range and quite similar to autumn 2021 levels.

3.5.2 Plant Condition

Plant health was generally good with just one recorded instance of plant disease. At PSB_01 a *Banksia spinulosa* plant was suffering from leaf predation.

3.5.3 Exotic Species

One exotic species, Catsear (*Hypochaeris radicata*) has regularly been recorded at PSB_01, but was not observed in spring 2019, nor after the bushfire in 2020 until spring 2021 when it was recorded again within the plot (C/A 1, rare). It was not recorded in summer or autumn 2022.

Previously, both Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded at PSB_02 in summer 2021. In 2021 just Catsear was recorded, C/A 1, rare. In spring 2021 neither of these exotic plant species were recorded. Catsear was again recorded in summer and autumn 2022, C/A 1, rare.

Fleabane (*Conyza* sp.) was recorded for the first time at PS_03 in spring 2020, with a cover/abundance ranking of 1 (rare). This exotic species was not recorded there in 2021 or in 2022 to date.

3.5.4 Increaser and Decreaser Species

The rare grass, *Notochloe microdon*, had been recorded regularly at PSB_02 with a cover/abundance score of 2 (uncommon) in autumn 2016. It was not recorded at that site in spring 2016, probably due to lack of flowering material. It was again found in summer 2017 with a cover/abundance score of 2 (uncommon). It was not recorded within this plot between 2018 and 2021. In summer and autumn 2022 it was present, C/A 1, rare.

In spring 2016 this grass was found at PS_03 with a cover/abundance score of 2 (uncommon) but was not detected in 2017. In summer 2018 it was recorded as rare but has not been recorded since that time.

In 2021 a number of new post-fire records were made at the Pagoda Swamp plots.

At PSB_01 a seedling of *Eucalyptus blaxlandii* was found in autumn and spring 2021 It was also observed in the plot in summer 2022, but not in autumn 2022. Both *Hibbertia obtusifolia* and *Hibbertia riparia* were recorded for the first time in spring 2021. Neither species was recorded in summer or autumn 2022. *Poa sieberiana* subsp. *sieberiana* in spring 2021 was recorded for the first time post-fire, but not again recorded in summer 2022. A *Persoonia mollis* seedling was also detected in spring 2021, but not recorded in summer 2022. It was located within the plot in autumn 2022.

At PSB_02 seedlings of *Eucalyptus blaxlandii* were also recorded in spring 2021. These were not observed in summer or autumn 2022. *Banksia marginata* seedlings were observed for the first time post-fire in autumn and spring 2021. *Banksia marginata* was recorded as common in summer and autumn 2022. *Schoenus imberbis* was recorded within the plot for the first time in spring 2021, but not recorded in summer or autumn 2022.

At PS_03 the fern *Calochlaena dubia* was recorded for the first time in autumn 2021. This species was not present in summer 2022. *Cassinia aculeata* was recorded for the first time in spring 2021. In summer 2022 it was rare, but it was not recorded in autumn 2022.

3.6 Pagoda Swamp

A new monitoring survey plot was established at Pagoda Swamp in February 2021. During 2021 mining operations approached the southern end of this Swamp.

Nineteen plant species were recorded within the plot in summer 2021, 26 species were recorded in autumn 2021 and 20 species were recorded in spring 2021 when the Swamp was exceptionally wet. In summer 2022, 26 species were again recorded. There was some vegetation damage with shrubs being pushed over by water during a November storm. In June 2022 sixteen species were recorded.

No records of plant disease have been made at this plot over the monitoring period

There were no exotic species present within the swamp plot in summer 2022.

4.0 DISCUSSION

Plant condition in autumn 2022 was affected by high rainfall with many instances of leaf yellowing and death due to waterlogging with the period of above average rainfall now reaching 27 months in duration. Plant disease associated with pathogens was limited to few observations.

The occurrences of exotic plant species in summer and autumn 2022 were consistent with a post-fire decline with new germination in response to rainfall. Occurrences of weeds continue to be at plots with a disturbance history involving proximity to clearing and pine plantation, logging, feral animals and recreational use.

As the plots were all bush fire affected, with most sites suffering a very high intensity fire in December 2019, future surveys will be necessary to determine whether the recovery trajectory continues to be consistent with past events, or whether particular plots have a different trajectory due to factors other than fire intensity. The trajectory following the October 2013 had indicated that ecosystem function across the study area was normal. On the current trajectory following the December 2019 bushfire it is indicated that ecosystem functioning is normal at all undermined plots.

There have been no indications of residual effects of subsidence in areas undermined previously, particularly in the Clarence East area where mining occurred in 2019-20. The patterns of species richness, species composition and plant disease relate strongly to bush fire impacts and recovery and seasonal weather conditions, including over two years of above average rainfall with no indication of a mining effect.

Appendix 1. Plant Species Richness at Clarence East and West Heath Sites

Appendix 1A. Long-term average species richness

Site	Location	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
PAG_01	Gorilla Rock	40.5	38.8	41.0	40.7	39.3	39.7	44.3	45.3	47.3	42.5	42.3	46.7	45.3	46.0
PAG_02	Gorilla Rock	19.5	24.0	27.0	25.0	23.7	28.0	30.3	30.3	26.7	28.0	30.7	34.3	32.7	31.7
PAG_03	Waratah East	28.0	27.8	26.7	27.7	30.0	29.3	29.0	30.3	32.7	30.0	29.3	30.3	32.7	32.7
PAG_04	Waratah East	20.5	21.8	21.3	20.0	22.7	21.3	23.0	22.0	23.7	21.7	23.0	22.0	19.7	20.7
PAG_05	Waratah North	25.0	22.3	23.7	23.7	27.0	25.7	26.3	29.0	28.7	27.0	36.7	39.3	39.7	35.7
PAG_06	Waratah North	25.0	27.8	29.3	29.0	28.7	33.7	31.3	30.3	30.7	32.7	27.7	27.0	30.3	32.3
CLW_01	Farmers Creek heath	–	–	30.0	33.5	32.7	35.0	36.7	37.3	41.3	38.5	36.3	39.7	41.0	43.7
CLW_06	Paddys Creek Ridge	–	–	28.0	29.5	29.7	36.7	39.0	35.3	35.3	37.5	36.3	39.7	42.7	45.7

Ave, average

1 pre-fire average for burnt sites.

Appendix 1B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022	
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
PAG_01	Gorilla Rock	45	47	46	45	45	47	28	35	43	45	45	42	45	NS
PAG_02	Gorilla Rock	36	36	30	31	39	30	24	23	27	27	31	29	32	NS
PAG_03	Waratah East	31	33	37	32	36	31	28	34	33	27	29	27	31	NS
PAG_04	Waratah East	20	19	23	18	22	19	9	24	21	20	22	20	25	NS
PAG_05	Waratah North	36	41	37	35	36	34	16	33	31	34	33	32	35	NS
PAG_06	Waratah North	29	34	28	30	32	29	11	29	29	34	30	27	29	NS
CLW_01	Farmers Creek heath	39	41	41	38	42	38	25	29	42	40	39	42	37	37
CLW_06	Paddys Creek Ridge	39	44	38	43	40	39	23	35	40	45	39	34	40	37

Aut, autumn; Spr, spring; Sum, summer.

NS Not surveyed

Appendix 2. Plant Species Richness at Clarence West Swamp Sites—Clarence Colliery

Appendix 2A. Long-term average species richness

Site	Location	2005	2006	2007	2008	2009	2010	2011	2012	2013	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave
CLW_02	Old Bells Swamp	NS	21.0	17.5	19.7	25.0	32.7	34.7	35.7	37.0	26.0	28.3
CLW_03	Happy Valley Swamp	NS	23.0	28.5	34.0	37.5	38.7	33.0	30.3	31.5	31.0	28.3
CLW_04	Dark Swamp	NS	21.0	23.0	22.3	24.5	25.0	26.5	25.3	25.0	20.0	19.7
CLW_05	Pine Swamp	NS	26.0	27.0	35.3	47.0	47.3	47.0	43.0	34.0	30.0	27.7
BNS_01	Bungleboori North	31.0	29.0	28.0	30.5	39.7	43.3	39.5	41.0	36.3	21.0	22.7
BNS_02	Bungleboori North	14.5	13.3	14.5	14.3	15.3	15.3	15.5	15.5	15.3	14.5	13.3

Ave, average

1 pre-fire average

NS Not surveyed

Appendix 2B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022	
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
CLW_02	Old Bells Swamp	28	36	27	30	27	19	11	26	25	33	26	24	26	23
CLW_03	Happy Valley Swamp	26	26	24	26	28	24	14	26	33	37	29	25	32	30
CLW_04	Dark Swamp	19	18	18	22	22	16	23	24	26	25	21	24	23	19
CLW_05	Pine Swamp	29	29	24	24	29	20	20	29	23	34	29	27	36	30
BNS_01	Bungleboori North	21	31	17	22	19	20	14	25	28	32	29	26	30	NS
BNS_02	Bungleboori North	15	15	14	13	14	15	16	27	30	39	36	28	31	NS

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 3. Plant Species Richness at Outbye Sites—Clarence Colliery

Appendix 3A. Long-term average species richness

Site	Location	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Spring	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAO_01	S of Bungleboori Creek	26	33.5	31	33.7	34.3	33.0	30.3	36.7	38.3	35.7
CLAO_02	S of Bungleboori Creek	24	28.5	26	29.7	29.3	28.5	24.3	30.7	29.0	31.0
CLAO_03	N of Bungleboori Creek	29	31.5	33	34.0	35.0	34.0	25.0	33.0	34.7	32.7
CLAO_04	N of Bungleboori Creek	26	31.0	31	33.7	34.7	31.5	26.0	36.3	35.3	35.0

Ave, average

1 pre-fire average

Appendix 3B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022	
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
CLAO_01	S of Bungleboori Creek	36	35	31	35	38	33	22	22	30	29	30	28	25	29
CLAO_02	S of Bungleboori Creek	29	33	27	27	30	33	11	19	24	21	22	24	26	24
CLAO_03	N of Bungleboori Creek	33	36	32	37	32	27	25	25	25	25	25	29	NS	NS
CLAO_04	N of Bungleboori Creek	34	35	35	36	37	35	25	27	26	29	24	31	NS	NS

Aut, autumn; Spr, spring; Sum, summer
NS Not surveyed

Appendix 4. Plant Species Richness at Clarence 800 Area Sites

Appendix 4A. Long-term average species richness

Site	Location	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAE_01	Dumbano Fire Trail dam	58.0	57.3	59.3	58.7	56.0	60.3	62.7	65.0	64.0
CLAE_02	Heath ridge	33.0	30.7	35.0	34.3	31.0	32.3	37.7	40.0	38.0
CLAE_03	Heath ridge	36.0	34.3	37.3	37.7	34.5	31.0	34.7	39.0	35.3
CLAE_04	Secret swamp	35.5	37.0	36.0	35.3	39.5	38.3	44.0	44.3	43.7
CLAE_05	Secret swamp	42.5	40.7	38.7	43.3	40.5	49.3	46.3	48.7	45.7
CLAE_06	Olearia swamp	28.0	29.3	29.7	32.0	33.0	44.0	35.3	37.7	35.7
CLAE_07	Olearia swamp	24.0	28	26.0	25.3	25.0	30.0	32.0	32.3	31.0
CLAE_08	Olearia swamp	14.0	15.7	15.3	15.3	14.5	20.3	14.3	14.0	13.7

Ave, average

1 pre-fire average

Appendix 4B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022	
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
CLAE_01	Dumbano Fire Trail dam	60	64	58	62	65	63	24	53	56	66	55	57	58	53
CLAE_02	Heath ridge	39	41	37	35	43	29	23	34	27	40	34	26	33	29
CLAE_03	Heath ridge	33	37	38	35	30	38	21	32	32	35	32	33	31	33
CLAE_04	Secret swamp	40	40	41	40	39	37	21	39	38	33	40	39	39	31
CLAE_05	Secret swamp	44	48	47	42	55	39	19	47	54	50	45	47	43	40
CLAE_06	Olearia swamp	34	35	32	36	38	33	18	36	34	38	35	38	34	34
CLAE_07	Olearia swamp	26	30	28	29	38	26	18	29	26	27	22	20	25	19
CLAE_08	Olearia swamp	13	15	13	13	14	13	8	30	31	38	30	33	30	24
Sum		289	310	294	292	322	278	152	300	298	327	293	293	291	263

Aut, autumn; Spr, spring; Sum, summer

Appendix 5. Plant Species Richness at Paddys Swamp Sites

Appendix 5A. Long-term average species richness

Site	Location	2014	2015	2016	2017
		Spr	Ave	Ave	Ave
PSB_01	Paddys Swamp Branch	37	44.7	43.0	48.3
PSB_02	Paddys Swamp Branch	23	25.0	23.3	22.7
PS_03	Paddys Swamp	NS	NS	28.0	26.3

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 5B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022	
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut
PSB_01	Paddys Swamp Branch	43	56	40	50	50	43	26	36	39	46	39	42	43	38
PSB_02	Paddys Swamp Branch	19	16	13	19	15	14	16	24	25	24	25	21	27	25
PS_03	Paddys Swamp	26	28	22	30	30	22	25	31	28	34	26	26	32	25

Flora Monitoring Program
Clarence Colliery
Spring and Annual Report 2022

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1.0 INTRODUCTION

This report describes monitoring of flora monitoring sites at a range of areas within the Clarence Colliery lease area. Six broad areas are now subject to monitoring: Clarence East (Eastern SMP area), Clarence West (also known as the '700 area'), Outbye, 800 Area, 900 Area and Pagoda Swamp.

The flora monitoring program commenced at Clarence Colliery in July 2004. Initially, eight sites supporting heath and pagoda complex vegetation were included: six at Clarence East and two at Clarence West. Clarence East includes areas to the north and east of the Clarence Pit Top, in the catchment of the Bungleboori and Wollangambe Creeks. Mining within the Clarence Eastern SMP area was completed in February 2009. Clarence West is located to the north-west of the Clarence Pit Top. The monitoring sites are in the catchments of Farmers Creek or upper Bungleboori Creek. Mining is currently undertaken in the Clarence West SMP area. Subsequently sites in the outbye area which stretches across Bungleboori Creek about 3km south-east of Mount Horne were added to the program. In 2009 eight sites were added in the Clarence 800 Area located in the section of Newnes State Forest which is bordered by Blue Mountains National Park. Another three sites are located along tributaries of Paddys Creek. A new site was established in February 2021. This is in Pagoda Swamp, which is located to the south of Waratah Ridge, south-west of Mount Horne.

During 2016, Gingra Ecological Surveys recommenced monitoring swamp sites in the Clarence East and Clarence West areas. For a period between 2008 and 2013 these swamps were monitored by the University of Queensland.

This report provides information on monitoring undertaken in spring 2022. Locations of the sites and their sampling dates in spring 2022 are provided in Table 1. Ten plots in the north of the study area usually accessed along Waratah Ridge Road were unable to be surveyed as the Road was closed to enable retrieval and disposal of military waste.

Table 1. Locations of Flora Survey Sites

Site	Location	Type	Easting (GDA)	Northing (GDA)	Survey Date
Clarence East					
PAG_01	Gorilla Rock	Impact	246753	6300035	26/09/2022
PAG_02	Gorilla Rock	Impact	246755	6299924	26/09/2022
PAG_03	Waratah East	Impact	247251	6300707	26/09/2022
PAG_04	Waratah East	Impact	246938	6300784	26/09/2022
PAG_05	Waratah North	Control	247962	6303960	05/10/2022
PAG_06	Waratah North	Control	247888	6303910	05/10/2022
BNS_01	Bungleboori North Swamp	Impact	245582	6302273	15/11/2022
BNS_02	Bungleboori North Swamp	Impact	246290	6303633	14/11/2022
Clarence West					
CLW_01	Heath	Impact	241774	6295584	12/10/2022
CLW_02	Swamp	Impact	242596	6295527	12/10/2022
CLW_03	Happy Valley Swamp	Impact	241923	6296954	14/11/2022
CLW_04	Hanging swamp	Impact	241904	6298016	12/10/2022
CLW_05	Pine Swamp	Control	240804	6300186	04/10/2022
CLW_06	Heath—Paddys Creek Ridge	Control	240472	6299171	04/10/2022
Outbye					
CLAO_01	S of Bungleboori Creek	Impact	245023	6297763	14/11/2022
CLAO_02	S of Bungleboori Creek	Impact	245092	6297707	14/11/2022
CLAO_03	N of Bungleboori Creek	Impact	245504	6298627	Not surveyed
CLAO_04	N of Bungleboori Creek	Impact	245294	6299168	Not surveyed
800 Area					
CLAE_01	Gully N of Dumbano Fire Trail dam	Impact	248971	6295894	28/10/2022
CLAE_02	Heath ridge	Impact	247495	6295216	27/10/2022
CLAE_03	Heath ridge	Impact	247271	6295388	27/10/2022
CLAE_04	Secret Swamp	Impact	247203	6296462	27/10/2022
CLAE_05	Secret Swamp	Impact	247159	6296404	27/10/2022
CLAE_06	Olearia Swamp	Impact	247648	6296165	27/10/2022
CLAE_07	Olearia Swamp	Impact	247701	6296288	27/10/2022
CLAE_08	Olearia Swamp	Impact	247789	6296830	27/10/2022
900 Area					
PSB_01	Paddys Swamp Branch	Impact	241338	6298523	12/10/2022
PSB_02	Paddys Swamp Branch	Impact	241404	6298617	12/10/2022
PS_03	Paddys Swamp (lower)	Impact	241822	6299156	12/10/2022
Pagoda Swamp		/3			
PAS_01	Pagoda Swamp	Impact	242878	6300496	04/10/2022

The entire study area was subject to the Gospers Mountain bushfire, which burnt through the area from November to December 2019. Most sites were affected by very high intensity fire, but fire intensity at a small number of plots was patchier with small areas of shrubs and ground cover plants remaining unburnt. Plots with some unburnt patches included PAG_01, PAG_03, PAG_05, CLAO_01, CLAO_03 and CLAO_04.

At the swamp sites the bushfire had burnt above ground vegetation with only very localised patches of surface peat consumption. No deep consumption of peat deposits was observed in the study area.

Previously, in October 2013, an extensive bush fire, known as the State Mine Fire, burnt through the study area. That bushfire was also of high intensity and the vegetation across the study area was showing clear signs of recovery by November 2019, although in many places the tree canopy had not returned to the canopy height and breath of September 2013.

Above average rainfall has been recorded since February 2020. Total rainfall over the 2020-21 summer was somewhat above average and wet weather continued into March 2021 when 193 mm was recorded at Lithgow. April 2021 was the driest April in the last 40 years and May rainfall was slightly below the long-term average. Winter and early spring rainfall in 2021 was about average. November 2021 had the highest rainfall recorded in Lithgow for that month since records began. January 2022 was also very wet whilst December and February were close to average. March 2022 rainfall was the wettest for that month in over 30 years and July 2022 also saw very high rainfall. By the end of November the total rainfall at Lithgow had exceeded the previous annual total record.

In 2022 mining proceeded to the north-east of Bungleboori Creek towards the Pagoda Swamp area and in the Clarence East area.

2.0 SURVEY METHODS

Permanently marked 20 m x 20 m (400 m^2) quadrats have been established at each monitoring site. The sites are sampled three times each year (in summer, autumn and spring).

Monitoring surveys involve recording vegetation structure, dominant species, estimated cover and height for each stratum, full floristics, estimated cover abundance for each species using a modified Braun-Blanquet scale (see below) and condition ranking for plant species using a five point scale (see below). Observations of general condition of vegetation in less sensitive forest and woodland habitats are also recorded, where relevant, as are fauna sightings.

Modified Braun-Blanquet Scale

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

Condition Scale

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

3.0 RESULTS

3.1. Clarence East & Clarence West Heath & Pagoda Sites

3.1.1 Plant Condition

At PAG_01 and PAG_03 some *Actinotus helianthi* plants had died and *Stylidium graminifolium* plants had leaf discoloration due to waterlogging. At PAG_02 *Acacia asparagoides* plants were affected by leaf predation. At PAG_03 leaf damage was observed on *Phyllota squarrosa* plants due to browsing. Senescent *Actinotus helianthi* plants were also observed at PAG_04. Also, at PAG_04 *Caustis pentandra* plants had branch dieback. At PAG_05 *Banksia ericifolia* and *Banksia penicillata* plants were suffering leaf predation due to insect attack. Severe dieback of *Stylidium lineare* plants was also observed, due to waterlogging. At PAG_06 *Banksia penicillata* plants were suffering leaf predation due to insect attack. At CLW_01 *Phyllota squarrosa* plants showed signs of leaf predation. Several other plant species at this site had dieback associated with wtaerlogging. At CLW_06 *Leptospermum trinervium* plants had leaf dieback due to waterlogging. Leaves of *Mirbelia rubiifolia* and *Xanthorrhoea media* were suffering leaf discoloration due to waterlogging.

3.1.2 Species Richness

Species richness figures for the Clarence East and West pagoda and heath sites are presented in Appendices 1A and 1B.

Species richness at the two plots surveyed in spring 2022 were similar to previous records, apart from at PAG_01 where species richness was slightly higher than previous records.

3.1.3 Exotic Species

Prior to the 2019 bushfire, the only instance of a record for an exotic plant species over the history of monitoring Clarence East and West pagoda and heath sites was a single Catsear (*Hypochaeris radicata*) plant observed in spring 2010 at PAG_04.

Exposed soils following the 2019 bushfire has allowed germination of wind transported weeds, primarily members of the Asteraceae (daisy) family. In May 2020, Catsear (*Hypochaeris radicata*) plants were present at PAG_02 and PAG_04. Catsear was again present at PAG_04 in November 2020. These exotic species have not successfully established at the heath and pagoda sites which were weed free in summer 2022.

No exotic plant species were recorded in spring 2022.

3.1.4 Increaser and Decreaser Species

Changes in species abundance and distribution can indicate changing environmental conditions, including changes associated with development.

In response to bushfire some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground. Germination may not place immediately as seeds may have dormancy mechanisms which delay germination,

An assessment of species which showed a change in cover/abundance was conducted in 2009 well before the impact of the 2013 bush fire. The species which showed variation in cover/abundance included:

- *Xanthosia pilosa* at site PAG_01, which had shown a decline from common to rare or uncommon. This species was recorded as uncommon at this site in spring 2012 and rare in summer 2013 with the abundance previously having been stable since July 2004. The first post-fire record of this species at the site was in summer 2015 when it was recorded as common. The abundance of this species was relatively stable in 2018-19. *Xanthosia pilosa* was recorded (rare) in May 2020 and **C/A** 3 (common) at each sampling in 2021 and in summer and spring 2022.

- *Amperea xiphoclada* was first recorded at PAG_02 in May 2009. It was not recorded at the site again until February 2014 when it was rare. It was again recorded as rare in spring 2014, was not detected in summer 2015 and was recorded as rare in autumn 2015 and uncommon in spring 2015. It was recorded as rare in autumn 2016 and then not recorded between spring 2016 and autumn 2018. It was again recorded (rare) in spring 2018, not recorded in summer 2019, and again recorded as rare in autumn 2019, but not recorded in the drying conditions in spring 2019. In summer 2020, it had resprouted postfire from basal rootstocks and was again recorded (rare) in May 2020, but was not detected within the plot since November 2020 until summer 2022 when it was recorded as rare. It was not detected in spring 2022.

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_04 has previously been observed to have declined in abundance from common with lower levels of species abundance recorded between May 2006 and May 2009. The cover/abundance ranking of this species was then stable between October 2009 and May 2013. Cover/abundance scores for this species have been stable (C/A rank 3 – common) since summer 2014. All *Banksia ericifolia* plants were dead in summer 2020. In May 2020 seedlings of *Banksia ericifolia* had germinated and its cover/abundance ranking was 2 (uncommon) In November 2020 its cover/abundance ranking was again 2. In February 2021 it was recorded as rare, in May and September 2021 and summer 2022 it was recorded as uncommon and in spring 2022 it was recorded as common with many seedlings apparent.

- *Mirbelia rubiifolia* at site CLW_06 had previously been reported (Autumn 2010) as having increased in abundance from rare or uncommon to common. The species was recorded as uncommon in summer 2013. Cover/abundance scores for this species was the highest ever recorded at this plot in summer and autumn 2019 (C/A rank 4 – cover 5-20%) but was recorded as common in spring 2019. This species was not recorded at this plot in 2020, but resprouting plants were observed in summer 2021 (C/A rank 3, common). *Mirbelia rubiifolia* was again recorded as common in autumn 2021 and uncommon (C/A 2) in spring 2021. Through 2022 it was recorded as common.

Changes in cover/abundance which became evident in the period from 2010 to May 2013 included:

- Heath-leaved Banksia (*Banksia ericifolia*) at site PAG_01 had shown an overall increase from rare or uncommon to common. The cover/abundance score for this species in spring 2019 was 4, 5-20% cover. The 2013 fire did not burn intensely across this plot and many shrub plants escaped damage. A lesser number survived the December 2019, fire but cover/abundance was recorded as 2 uncommon in summer and autumn 2020. From November 2020 to September 2021, it was recorded with a **C/A** ranking of 3 (common) and in summer 2022 it was recorded as uncommon. In spring 2022 it was recorded as common.

- *Cassytha glabella* at site PAG_02 had shown an increase from not recorded or rare to common. This species was recorded as common at this site in summer 2013. Since February 2014 it usually has been recorded as rare, but its cover/abundance score in summer and autumn 2017 was 2 (uncommon). In spring 2017 *Cassytha glabella* was not detected. In summer and autumn 2018 it was recorded as rare and in spring 2018 it was uncommon. This species was not detected within the plot in summer 2019. In autumn and spring 2019 it was recorded as uncommon. It was not recorded in 2020 or early 2021 but was recorded as uncommon in spring 2021 ands rare in summer 2022, then not recorded in spring 2022. *Cassytha glabella* has shown a delayed post-fire recovery at several plots following both the 2013 and 2019 bushfires.

- The prostrate shrub *Pseudanthus divaricatissimus* was a new record for PAG_02 in autumn 2010. This species was recorded as rare in summer 2013. This species was detected within the plot for the first time since the October 2013 fire in summer 2019 but not recorded in autumn or spring 2019. It has not been recorded from summer 2020 to spring 2022.

- The sedge, *Lepidosperma filiforme*, was not detected at PAG_03 between autumn 2011 and autumn 2012. From 2014 onwards, it was recorded as rare, but was not recorded in autumn 2016. From spring 2016 through to spring 2017 it again has been recorded as rare but was not recorded in summer 2018. In autumn 2018 it was recorded as uncommon and in spring 2018 it was rare, whilst in summer 2019 it was uncommon. It was again recorded as rare in autumn and spring 2019. It was not recorded in summer 2020 but recorded in autumn (uncommon) and spring (rare). It was recorded as rare again in summer and autumn 2021, but not recorded in spring 2021. In summer and spring 2022 it was recorded as uncommon.

Species recorded at sites in February 2014 which had not previously been recorded at those locations were:

- *Eucalyptus piperita* was recorded as rare at PAG_02. This sapling has been recorded consistently since February 2014. It was again recorded in summer 2021, but not detected since.
- *Goodenia bellidifolia*, *Lomandra glauca*, *Patersonia sericea* and *Schoenus villosus* at control plot PAG_05. In autumn 2019 both *Goodenia bellidifolia* (rare) and *Lomandra glauca* (uncommon) were recorded, but none of the 3 species were recorded in spring. *Schoenus villosus* resprouted from basal rootstocks following the bushfire. In spring 2020 it had flower buds and ranked with a C/A score of 2, uncommon. *Goodenia bellidifolia* (common) was the only of these species present in spring 2020. In summer 2022 *Goodenia bellidifolia* was recorded as common and *Schoenus villosus* was recorded as uncommon.
- *Aristida ramosa* at CLW_01. This species has not been recorded since autumn 2016.

- *Arthopodium milleflorum*, *Cyathochaeta diandra* and *Lagenophora stipitata* at CLW_06. *Cyathochaeta diandra* was recorded as uncommon and *Lagenophora stipitata* as rare in spring 2015. None of these species were recorded in either autumn or spring 2016 or summer 2017. Both *Cyathochaeta diandra* and *Lagenophora stipitata* were again recorded in spring 2019 (C/A 1, rare). The two other species were not recorded in spring 2019. In spring 2020, *Lagenophora stipitata* and *Cyathochaeta diandra* had a C/A score of 1, rare. In summer 2021, only *Cyathochaeta diandra* (C/A 2, uncommon) was observed. None of these species were recorded from autumn 2021 to autumn 2022. In spring 2022 *Cyathochaeta diandra* was recorded as common. The other two species were not recorded.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as common at PAG_02 in summer 2014. It was flowering in spring 2016, which allowed for it to be identified to species level for the first time. In summer and autumn 2019, it was recorded at PAG_02 but suffering from leaf dieback and it was not recorded in spring 2019. It was not recorded in summer 2020, but had germinated by autumn 2020, with a C/A score of 3 (common), its presence continuing through to spring 2022.

Species recorded in autumn 2015 which had not been recorded at sites prior to the bush fire were:

- *Actinotus helianthi* at PAG_01 (common) and PAG_02 (common). This species was recorded at PAG_01 (common) between autumn 2016 and summer 2017, but rare in autumn 2017 and not recorded in spring 2017. It was again present in spring 2018 and summer 2019 (C/A common) and autumn 2019 (C/A uncommon). At PAG_02 it was uncommon in autumn and spring 2016, common in summer and autumn 2017, uncommon in spring 2017 and common in summer and autumn 2018, then uncommon between spring 2018 and autumn 2019. In spring 2019 at PAG_01 it was recorded as uncommon and at PAG_02 it was recorded as rare and senescent. At PAG_02 in autumn 2020 it was recorded as uncommon, whilst at PAG_01 it was recorded as common. In summer and autumn 2021 *Actinotus helianthi* was common at both these plots. In spring 2021 *Actinotus helianthi* was recorded as common at PAG_01 and uncommon at PAG_02. It was again recorded at both plots in summer 2022. IN spring 2022 it was common at PAG_01 and uncommon at PAG_02.
- *Actinotus forsythii* at PAG_03 (common). These plants had died by spring 2015. There was no evidence of seedling plants in summer 2020. Seeds of this plant had germinated by autumn 2020 and it was recorded as common in autumn and spring. In summer 2021 it was recorded as common and flowering at PAG_03; at PAG_04 it had a C/A rank of 4 (>5% cover); at PAG_05 and PAG_06 it was uncommon. In autumn 2021 it was common and setting seed at PAG_03 and PAG_04, and it was recorded as uncommon at PAG_05. The species was not recorded within any plot from spring 2021 onwards; this is consistent with the usual post-fire response of this species which is classed as a fire ephemeral.
- *Cyathochaeta diandra* at PAG_02 (rare). This species has not been recorded again since summer 2016.
- *Goodenia decurrens* at PAG_03 (rare), consistently present from spring 2015 to spring 2019 (rare), in a sheltered location at the foot of the pagoda. This plant remained in summer 2020 in an unburnt section of the plot and has persisted since.
- *Haemodorum planifolium* at CLW_01 (common) and CLW_06 (rare). In summer 2017 this species was recorded as common at CLW_01 and uncommon at CLW_06. In autumn and spring 2017 this species was rare at each of these two sites. In summer and autumn 2018, it was not recorded at CLW_01 and rare at CLW_06. The remaining leaves died off by spring 2018, when it was not recorded, and it was not present in 2019. It was not found at CLW_06 in summer 2020 but at CLW_01 it had already emerged with a C/A score of 3, common. From spring 2020 until autumn 2021 *Haemodorum planifolium* has been recorded as

uncommon at CLW_06 and common at CLW_01. In autumn and spring 2022 it was recorded as common at CLW_01 and rare at CLW_06.

3.2. Clarence East and West Swamp Sites

3.2.1 Plant Condition

At CLW_02 *Poa sieberiana* subsp. *cyanophylla*, *Grevillea acanthifolia*, *Patersonia fragilis* and *Lomandra filiformis* subsp. *coriacea* plants had dieback due to waterlogging. No signs of disease were recorded at CLW_03. At CLW_04 *Olearia quercifolia* plants were affected by severe dieback due to a fungal pathogen. At CLW_05 one *Leptospermum grandifolium* plant had leaf discoloration due to waterlogging, *Juncus continuus* plants had dead stems, a *Eucalyptus pauciflora* sapling had leaf dieback and *Celmisia longifolia* plants had been browsed.

No signs of plant disease were observed at either of the BNS_01 or BNS_02 plots.

3.2.2 Species Richness

Species richness data for Clarence East and West Swamp sites is presented in Appendices 2A and 2B.

In summer 2020 species richness at three swamp sites, CLW_04, CLW_05 and BNS_02, were at the same level or higher than prior to the bushfire, reflecting early recovery of some swamp species due to increased swamp water levels related to post-fire rainfall.

In autumn 2020, species richness at many of the plots was at the high end of the previously reported range, with the level at BNS_02 around double the previous high. These high numbers are attributable to open areas with the swamps providing an opportunity for growth of otherwise suppressed ground layer species.

Significantly higher levels of species richness compared to counts prior to the December 2019 bushfire continued to prevail in summer 2022. At all but one plot species richness was greater than that recorded in spring 2021. This is partly due to flowering of summer grasses, making them easier to detect. The decline at the majority of these swamp plots through 2021, followed by a summer increase, is consistent with a normal post fire trend.

Whilst there was a decline in species richness in autumn 2022 compared to summer counts, the levels are within the previously recorded range and consistent with normal post-fire trends.

In spring 2022 species richness was lower. The very wet conditions met that small ground layer plants had either died, or were difficult to detect due to the saturated conditions.

3.2.3 Exotic Species

Some of the Clarence West swamp sites have been subject to disturbance prior to any impact of mining with the establishment of a pine plantation in the catchment of some swamps being a notable factor.

Radiata Pine (*Pinus radiata*) was previously recorded at BNS_01. The hot bushfire killed the pines, and no live Radiata Pine plants have been recorded since autumn 2020. In spring 2022, no exotic plants were recorded at this plot.

At BNS_02 there were no exotic species recorded. Exotic species richness and abundance have declined since summer 2021.

Catsear (*Hypochaeris radicata*) was not recorded at CLW_02 in summer 2022, having previously been recorded as rare. Fleabane (*Conyza* sp.) was recorded as uncommon in spring 2020 and summer 2021 and rare in autumn 2021, then not recorded in from spring 2021 to autumn 2022. No exotic species were recorded at CLW_02 in spring 2022.

At CLW_03 the only exotic species recorded was Catsear (*Hypochaeris radicata*). Previously in summer 2021, three exotic species, all daisies, were recorded; Fleabane (*Conyza sp.*) C/A 2 (uncommon), Spear Thistle (*Cirsium vulgare*), C/A 1 (rare) and Catsear (*Hypochaeris radicata*), C/A 1 (rare). In autumn 2021, Yorkshire Fog (*Holcus lanatus*), C/A 2, uncommon, Catsear (*Hypochaeris radicata*), C/A 1, rare and Spear Thistle (*Cirsium vulgare*), C/A 1, rare were the three exotic species recorded in this plot.

In spring 2022, three exotic species were recorded at CLW_05, the grass Yorkshire Fog (*Holcus lanatus*), Catsear (*Hypochaeris radicata*) and Fleabane (*Conyza* sp.) Neither Blackberry (*Rubus anglocandicans*) nor Spear Thistle (*Cirsium vulgare*) were recorded at the site in autumn or spring.

The 2022 results indicate a decline in species richness and abundance of weeds within Clarence East & West swamps. The plots suffering from historical disturbance had a higher abundance of weed species, particularly notable at CLW_05.

3.2.4 Increaser and Decreaser Species

In 2008 the following changes in species cover/abundance were discussed:

> At CLW_02, there had been a decline in cover/abundance of Prickly-leaved Tea-tree (*Leptospermum continentale*). Species observed in 2008 which had not previously been recorded included *Deyeuxia gunniana* and *Baloskion australe*.
>
> At CLW_03, there had been no noticeable decline in the cover/abundance of plant species, but a number of swamp associated plants had an increased ranking apparently due to improved rainfall from 2006. Species observed in 2008 which had not previously been recorded included Sneezeweed (*Centipeda minima*), two grasses (*Dichelachne* sp. and *Deyeuxia* sp.), *Patersonia fragilis*, and the exotic species, Cudweed (*Gamochaeta* sp.).
>
> At CLW_04, there had been no consistent increase or decline in common species occurring at that site. Species observed in 2008 which had not previously been recorded included *Juncus continuus* and *Lepyrodia anarthria*.
>
> At CLW_05, there has been a decline in cover of Woolly Tea-tree (*Leptospermum grandiflorum*) and *Deyeuxia gunniana,* and an increasing abundance of *Geranium homeanum*. Species observed in 2008 which had not previously been recorded included a plume grass (*Dichelachne* sp.), *Senecio hispidulus*, *Senecio linearifolius*, and the exotic species Fleabane (*Conyza* sp.) and Blackberry (*Rubus anglocandicans*).

In relation to these species and sites the following records were made in spring 2022:

Leptospermum continentale was not observed at CLW_02. Previously this species recovered following the 2013 bush fire to baseline levels recorded in 2006. More recently, this species was not recorded as alive in summer 2020. In summer 2021 and autumn 2021 it was recorded as uncommon (C/A 2). In autumn 2021 *Deyeuxia gunniana* was recorded as uncommon (C/A 2) and was seeding. It was not recorded in spring 2021, but again recorded in summer 2022 as uncommon. In autumn 2022 *Deyeuxia gunniana* was common, but was not recorded in spring 2022, perhaps due to the extensive standing water present across the plot.. *Baloskion australe* had not been recorded since 2020 but in spring 2022 was present with a C/A score of 2, uncommon.

At CLW_03 Sneezeweed (*Centipeda minima*) (C/A 1; rare) was present in autumn 2019, but not recorded in 2020 or 2021. In autumn 2021 *Deyeuxia quadriseta* was recorded as common (C/A 3). Neither species was detected in spring 2021, nor throughout 2022.

At CLW_04 *Juncus continuus* was not detected between spring 2021 and spring 2022. *Lepyrodia anarthria* was recorded as common (C/A 3) throughout 2022.

At CLW_05, *Leptospermum grandifolium* was recorded (C/A 4; common, cover >5%) in spring 2022. *Geranium homeanum* (C/A 3, common) was also present in autumn and spring 2022.

3.3 Clarence Outbye

Only the two southern outbye plots CLAO_01 and CLAO_02 were able to be surveyed in spring 2022 due to the Wartime Remnants Clean up Project.

3.3.1 Plant Condition

There was a single instance of plant disease at the Outbye plots CLAO_01 in autumn 2022 where several *Isopogon anemonifolius* plants had died due to waterlogging.

3.3.2 Species Richness

Species richness figures for the Outbye sites are presented in Appendices 3A and 3B.

The species richness counts for CLAO_01 and CLAO_02 recorded in autumn and spring 2022 were similar to levels recorded in spring 2021.

3.2.3 Exotic Species

No exotic species were recorded at either of the two Clarence Outbye sites surveyed in summer 2022. This is consistent with previous records for these weed-free plots.

3.2.4 Increaser and Decreaser Species

Following the autumn 2010 monitoring survey it was reported that several species were recorded at monitoring sites for the first time, as detailed below.

At CLAO_01, species recorded for the first time in 2010 included *Banksia spinulosa* and *Gompholobium glabratum*. *B. spinulosa* has not been recorded since autumn 2017 having been recorded as uncommon in autumn 2016. *G. glabratum* was recorded in summer 2012, when it was rare, but was not recorded in summer or autumn 2013. It had not been recorded at this site since the 2013 bush fire, but in autumn 2018 was present (C/A 2, uncommon). It has not been recorded since the December 2019 bushfire.

At CLAO_02, species recorded for the first time in autumn 2010 included *Boronia floribunda*, *Cryptostylis subulata*, *Hibbertia serpyllifolia* and *Lepidosperma filiforme*.

Boronia floribunda had been recorded as uncommon since autumn 2018 but was rare in autumn 2019 and not recorded since spring 2019. *Cryptostylis subulata* was recorded as common in autumn 2018 and rare in spring 2018 but not detected in summer 2019. In autumn 2019 it was recorded as uncommon not recorded since. *Lepidosperma filiforme* was recorded in spring 2019 (C/A 2, uncommon). In summer 2022 it was recorded for the first time after the 2019 bushfire (C/A 1, rare). but it was not recorded in autumn or spring 2022. *Hibbertia serpyllifolia* has not been recorded at the plot since the 2019 bushfire.

At CLAO_03, species recorded for the first time in autumn 2010 included *Mitrasacme polymorpha*, *Ochrosperma oligomerum* (formerly *Ochrosperma monticola*) and *Petrophile pulchella*. *P. pulchella* (uncommon) was the only one of these species detected at the site in autumn 2013.

In autumn and spring 2018 none of these three species were recorded. In summer 2019, *Ochrosperma oligomerum* was recorded as uncommon. The three species were then recorded in the plot from autumn 2019 to spring 2020. In summer 2021 a *Petrophile pulchella* seedling was detected near the centre of the plot, and this species was again detected in spring 2021 (C/A 1, rare).

At CLAO_04, species recorded for the first time in autumn 2010 were *Conospermum taxifolium* and *Pseudanthus divaricatissimus*.

Both species were recorded as rare at the site in autumn 2016, but only *Conospermum taxifolium* was present in spring 2016. Neither species was recorded in summer 2017. Both *Pseudanthus divaricatissimus* (uncommon) and *Conospermum taxifolium* (rare) were recorded in spring 2017. Neither species was recorded in summer or autumn 2018. In spring 2018 and summer 2019 *Pseudanthus divaricatissimus* was recorded as rare. Neither species was recorded in autumn or spring 2019. In summer 2020 *Pseudanthus divaricatissimus* was recorded (C/A 1, rare). Neither species had been recorded since autumn 2020, but *Conospermum taxifolium* was present in spring 2021.

A number of plant species were first detected at a particular site in summer 2014, following the October 2013 bush fire. These included:

Bossiaea heterophylla at CLAO_02, not subsequently detected from spring 2014 to summer 2017, recorded as rare in autumn 2017, not recorded in spring 2017 and recorded as rare again in summer and autumn 2018. In summer 2019 it was recorded as uncommon and in autumn 2019 as rare, but not recorded in spring 2019. It has not been detected within the plot since the 2019 bushfire.

Thysanotus juncifolius at CLAO_03, not subsequently detected since 2014. It regenerated from seed after the 2019 bushfire and in summer 2021 was recorded as common (C/A 3) but was not observed in autumn or spring 2021.

The grass, *Plintanthesis urvillei*, had not been recorded at any Clarence site prior to October 2013. It was first recorded as uncommon at CLAO_01 in autumn 2014. It was again recorded as rare at the site in spring 2016, but not recorded from summer 2017 onwards. It was also first recorded at CLAO_03 (uncommon) in summer 2015.Between spring 2016 and spring 2017 it was recorded as common, but its C/A score was 2, uncommon in summer 2018 and it was recorded again as common in autumn and spring 2018, uncommon in summer 2019 and rare in autumn 2019, then not recorded until autumn 2021 when it was recorded as common. It was again recorded as common in spring 2021, but not recorded in 2022. This is consistent with it's status as a fire ephemeral, germinating post-fire and declining with time since fire.

One species, *Lindsaea linearis* was recorded for the first time at CLAO_01 in spring 2015. It has not been recorded at that site since spring 2016, despite suitably wet conditions in 2020-21.

In spring 2016 *Drosera peltata* was recorded for the first time at CLAO_02. *Drosera peltata* was present and flowering at CLAO_02 in spring 2016 but was not recorded between summer 2017 and autumn 2020. In spring 2020 it was recorded as common but was not recorded in 2021 or 2022, despite the above average rainfall recorded over that period. *Drosera peltata* can survive in the soil as an underground rhizome, responding to wet conditions.

A number of new post fire records of species within Outbye monitoring plots were made in summer 2016.

These included:

Thelionema caespitosum at CLAO_01 (rare in summer 2017, uncommon in autumn and spring 2017 and autumn 2018, absent between spring 2018 and spring 2019). In summer 2020 this species was again detected (C/A 2, uncommon), but it was not detected in autumn 2020. In spring 2020 it was detected (C/A 1, rare) and in summer 2021 it was recorded as common (C/A 3). It was not recorded in 2022.

Pimelea linifolia at CLAO_02 (not present summer 2017, rare in autumn 2017, uncommon in spring 2017, then not recorded until autumn 2021 (C/A 1, rare). This species was not recorded in the plot in 2022.

Rytidosperma sp. at CLAO_02 - not detected since 2016.

Gompholobium uncinatum at CLAO_03 (present in summer and autumn 2017; rare; not detected in spring 2017 or summer 2018, rare in autumn 2018, common in spring 2018, but not detected since.

Pimelea linifolia at CLAO_03 and CLAO_04 was not present in 2017 or 2018 but present at both CLAO_03 and CLAO_04 in summer 2019, then just CLAO_03 in autumn 2019 and within neither plot since spring 2019. At CLAO_04 in spring 2020 it was recorded as rare and in summer 2021 it was recorded as uncommon (C/A 2) but was not again recorded in autumn or spring 2021.

Epacris microphylla at CLAO_04 (consistently present since summer 2017, recorded as uncommon in autumn 2018 and common between spring 2018 and spring 2019). In spring 2020 it was not recorded but recorded in summer 2021 (C/A 2, uncommon) and in autumn and spring 2021 (C/A 3, common).

There are no clear long-term trends indicating a change in abundance of the more common shrub or ground layer species present at each site.

<u>3.4 Clarence 800 Area</u>

3.4.1 Plant Condition

At CLAE_01 *Banksia spinulosa* plants had leaf yellowing due to waterlogging.

Two plant species at CLAE_02 were showing signs of leaf dieback and yellowing associated with waterlogging, *Conospermum taxifolium* and *Banksia spinulosa*. At the other heath site CLAE_03, *Isopogon anemonifolius* plants had dark discoloration due to waterlogging.

At CLAE_04 *Banksia spinulosa* plants had leaf yellowing due to waterlogging.

At CLAE_06 and CLAE_08, *Olearia quercifolia* plants were in good condition, with no signs of dieback or leaf damage.

Apart from the few identified impacts of the prolonged wet weather conditions, plant health was good.

3.4.2 Species Richness

Species richness figures for the Clarence 800 Area sites are presented in Appendices 4A and 4B.

Table 3 shows some species richness figures following the 2013 and 2019 bushfires. The levels in spring 2022 were similar to 2021 levels with the exception of CLAE_04 and CLAE_08 where species richness was lower in spring 2022.

PLOT	2019 BUSHFIRE INTENSITY	DEC 2013	FEB 2014	FEB 2020	MAY 2020	FEB 2021	MAY 2021	OCT 2021	FEB 2022	MAY 2022	NOV 2022
CLAE_01	Very High	27	53	24	54	66	55	57	58	53	60
CLAE_02	Very High	26	27	23	34	40	34	26	33	29	28
CLAE_03	High	19	29	21	32	35	32	33	31	33	34
CLAE_04	Very High	20	36	21	39	33	40	39	39	31	31
CLAE_05	Very High	19	40	19	49	50	45	47	43	40	49
CLAE_06	Very High	30	45	18	36	38	35	38	34	34	35
CLAE_07	Very High	15	28	19	29	27	22	20	25	19	21
CLAE_08	Very High	15	19	8	30	38	30	33	30	24	25

Table 3. Species Richness Post-fire. Clarence 800 Area Sites

For the period prior to the October 2013 bush fire total species richness ranges from a high of 298 records in spring 2012 to a low of 252 records in autumn 2010. The total number of species records in autumn 2013 was 266, which fell within the range of previous records. In summer and autumn 2012, there were 274 records.

Species richness in summer 2014 was within the pre-fire range with 277 records. Subsequent germination of seedlings in the post-fire environment saw species richness exceed pre-fire levels with 324 records in autumn 2014, 317 records in spring 2014, 307 records in summer 2015, 310 records in autumn 2015 and 304 records in spring 2015.

The number of records in summer 2016, 328, exceeded previous species richness totals for the Clarence East site. In autumn 2016 there was a similar level (327 records) of species richness. The number for autumn 2017 was 321, slightly lower than the level for the previous autumn. In spring 2017, the total number of records was 283, 8% lower than the corresponding season in 2016. The summer 2018 number was 289; the last two years have seen an increase in species records from spring to summer. In autumn 2018, the total was 310, consistent with a post-fire pattern of higher species richness in autumn. The total number of plant records in spring 2018 was 294, there were 292 records in summer 2019 and 323 records in autumn 2019. In spring 2019 the number declined to 282, the same level as that recorded in spring 2017.

In summer 2020, the total number of records was 153, somewhat lower than the December 2013 number of 171. This may reflect the very high fire intensity at almost all plots in 2019. By autumn 2020 the number had reached 300, with an exceptional rise in species detected at CLAE_08. The spring 2020 number was 299, showing a stable situation during the autumn-spring period. In summer 2021 the totals species records amounted to 327, just below the record high established in summer 2016. In summer 2022 there were 291 records, similar to the level in autumn and spring 2021. The total declined to 263 in autumn 2022, and then rose to 283 in spring 2022.

The section of Olearia Swamp where CLAE_08 is located experienced very intense fire, followed by a high level of sediment movement associated with heavy rainfall in February 2020. The more open spaces and changed soil profile had enabled germination and establishment of pioneer and woodland species. Species richness has fallen from the post-fire peak but remains above the range recorded prior to the 2019 bushfire.

Recent total species counts for the Clarence 800 sites are shown in Figure 1. The Figure shows an initial post-fire decline, then an increase to a peak in summer 2021 and a subsequent decline.

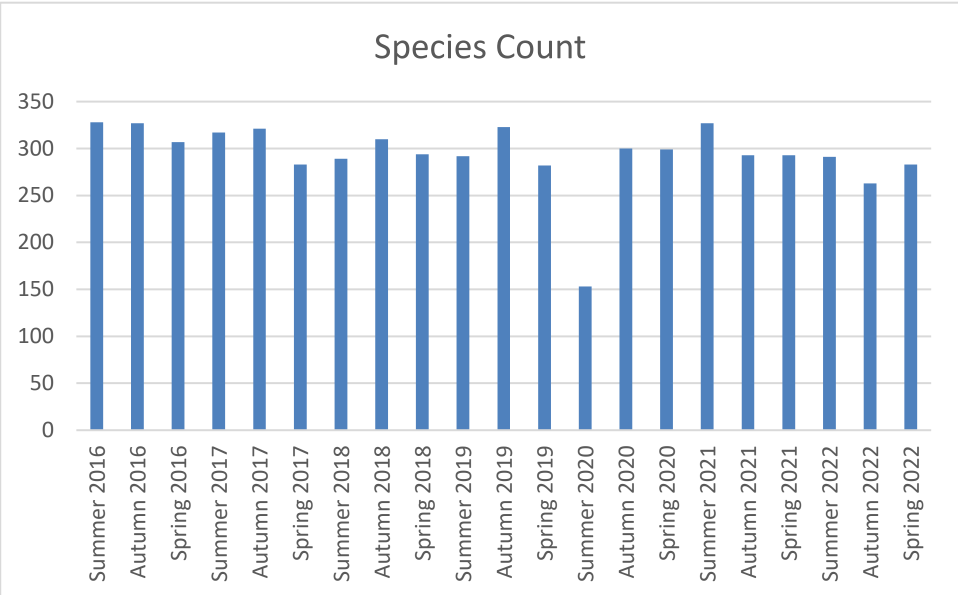

Figure 1. Seasonal Total Species Counts for 800 Area Monitoring Plots

3.4.3 Exotic Species

There have been few records of exotic species at the 800 area sites since monitoring commenced.

Fleabane (*Conyza* sp.) was recorded as rare at CLAE_08 in summer 2010 and Yorkshire Fog (*Holcus lanatus*) was recorded as rare at CLAE_08 in autumn 2012. Disturbance associated with damage by feral pigs was recorded in proximity to this site in April 2009.

In autumn 2021 two exotic species were found at CLAE_08, Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded as rare and Common Sow Thistle (*Sonchus oleraceus*) as rare. No exotic species were recorded in this plot in spring 2021. Catsear (*Hypochaeris radicata*) was recorded as common in summer 2022. In spring 2022 no exotic species were recorded at this plot. The number of exotic species has declined since summer 2021 when 3 species were recorded, and their abundance has declined as well.

Fleabane had been recorded at CLAE_06 in spring 2020 for the first time since monitoring of that plot commenced but was not again detected in 2021 or 2022. Another exotic daisy, Cudweed (*Gamochaeta* sp.) was present (C/A 1, rare) in spring 2020, but not recorded since. Fleabane was recorded at CLAE_04 (C/A 1, rare) and CLAE_05 (C/A 1, rare) in summer 2021, but these plants had died by autumn and no exotic plants were recorded at the plot in spring 2021.

In autumn 2022 there was only one record for an exotic species, Catsear (*Hypochaeris radicata*) at CLAE_05 (C/A 1, rare). In spring 2022 no exotic plant species were recorded.

These occurrences of pioneer weed species are associated with the impact of the December 2019 bush fire. As predicted, they have declined with time since fire, although there have been sporadic re-occurrences with seed germination in response to rainfall.

3.4.4 Increaser and Decreaser Species

Some species (resprouters) respond by regeneration from above and below ground plant structures, whilst in other species plants are killed outright by the fire and recruitment from seed is necessary for the species to persist at a particular location (obligate seeders). Some species may persist in the soil seed bank for extended periods. For these species fire may trigger a new germination event and these species will appear to be colonising the fire ground.

Before the fire, in spring 2012, the following plant species were recorded within a particular monitoring site for the first time:

Baumea rubiginosa	CLAE_01
Lomandra filiformis	CLAE_01 (*** 2**)
Lomandra cylindrica	CLAE_01 (*** 2**)
Schizaea bifida	CLAE_01
Gompholobium uncinatum	CLAE_02
Thelymitra ixioides	CLAE_03 (*** 2**)
Baumea rubiginosa	CLAE_04
Boronia microphylla	CLAE_04 (*** 1**)
Drosera peltata	CLAE_04
Billardiera scandens	CLAE_05
Rhytidosporum procumbens	CLAE_05
Lambertia formosa	CLAE_06
Tetrarrhena juncea	CLAE_06
Isolepis habra	CLAE_07

NOTE
* Recorded again in autumn 2022 with cover/abundance score.

A number of plant species were first detected at a particular site in summer 2014, following the bush fire. These included:

Arthropodium milleflorum	CLAE_01
Cyathochaeta diandra	CLAE_01
Dianella prunina	CLAE_01 (*** 1**)
Dodonaea triquetra	CLAE_01
Hibbertia obtusifolia	CLAE_01

Lomandra multiflora	CLAE_01
Cyathochaeta diandra	CLAE_02
Thysanotus juncifolius	CLAE_02
Drosera binata	CLAE_04
Epacris pulchella	CLAE_04
Gahnia filifolia	CLAE_04
Viola sieberiana	CLAE_05
Celmisia longifolia	CLAE_06
Drosera binata	CLAE_06 (*** 2**)
Hakea teretifolia	CLAE_06
Juncus planifolius	CLAE_06
Lomandra multiflora	CLAE_06
Microlaena stipoides	CLAE_06
Schoenus villosus	CLAE_06
Thelymitra pauciflora	CLAE_06
Thysanotus sp.	CLAE_06
Viola sieberiana	CLAE_06
Entolasia stricta	CLAE_07

Microlaena stipoides	CLAE_07
Xyris complanatus	CLAE_07
Hakea teretifolia	CLAE_08

NOTE
* Recorded again in autumn 2022 with cover/abundance score.

Between spring 2015 and summer 2020 the early disturbance responder *Juncus planifolius* had not been recorded at CLAE_06, having been recorded there following the 2013 bushfire. Seeds had germinated and the species was observed to be common in autumn and spring 2020 but had declined to uncommon by summer 2021. It was again recorded as common in summer and autumn 2022 but not present in spring 2022.

In summer 2014 *Lomandra glauca* was recorded at CLAE_02 having not been recorded at that site since April 2009. It was recorded as common at this site in autumn 2015, but not recorded in spring 2015 or summer 2016. In autumn 2016, it was again recorded as rare and in spring 2016 was recorded as uncommon, as it was in autumn 2017. It was not recorded within this plot in spring 2017 but recorded again in summer 2018 as uncommon, in autumn 2018 as rare and not recorded in spring 2018. In summer 2019 it was recorded as common, but it was not recorded between autumn 2019 and summer 2020. It was recorded as common in autumn 2020 and uncommon in spring 2020, the common again in summer 2021, but recorded as rare in autumn 2021, then not subsequently recorded.

In autumn and spring 2014, *Lobelia dentata* was recorded at CLAE_01 having not previously been recorded at that site. It was not subsequently recorded until spring 2020, a similar post-fire response to that observed previously. It was again recorded in summer 2021 (C/A 1, rare), but not recorded between autumn 2021 and spring 2022.

In spring 2019, *Schizaea bifida* was recorded for the first time at CLAE_03. It has not been recorded subsequently at this site.

3.5 Clarence 900 Area

Sites were established along different sections of Paddys Swamp in the Clarence 900 area in November 2014. This area was affected by the October 2013 bushfire. The sites burnt again in December 2019.

There are a range of human disturbance factors already operating in the vicinity of the two sites in the upper catchment (PSB_01 and PSB_02) of Paddys Swamp. This includes drainage works associated with earlier operation of the sand quarry 600 metres to the south, extensive new clearing of the quarry and a trail bike track to the north of PSB_01. Site PS_03 is located in the main section of Paddys Swamp, in an area substantially free of past human disturbance, although an old, defunct pipeline passes by the eastern edge of the swamp.

3.5.1 Species Richness

Species richness data for the three Paddys Swamp sites is presented in Appendix 5.

Species richness at the Paddys Swamp sites in spring 2022 was within the previously recorded range and similar to levels recorded in autumn 2022.

3.5.2 Plant Condition

Plant health less satisfactory than previous records with several instances of waterlogging associated plant disease. At PSB_01 *Banksia marginata* plants were suffering from leaf predation. Eucalypt saplings which had emerged following the 2019 bushfire were severely impacted with several dead *Eucalyptus radiata* plants. At PS_03 *Baumea rubiginosa* plants had leaf yellowing.

3.5.3 Exotic Species

One exotic species, Catsear (*Hypochaeris radicata*) has regularly been recorded at PSB_01, but was not observed in spring 2019, nor after the bushfire in 2020 until spring 2021 when it was recorded again within the plot (C/A 1, rare). It was not recorded in 2022.

Previously, both Fleabane (*Conyza* sp.) and Catsear (*Hypochaeris radicata*) were recorded at PSB_02 in summer 2021. In 2021 just Catsear was recorded, C/A 1, rare. In spring 2021 neither of these exotic plant species were recorded. Catsear was again recorded in summer and autumn 2022, C/A 1, rare. Neither species was recorded in spring 2022.

Fleabane (*Conyza* sp.) was recorded for the first time at PS_03 in spring 2020, with a cover/abundance ranking of 1 (rare). This exotic species was not recorded there in 2021 or 2022.

3.5.4 Increaser and Decreaser Species

The rare grass, *Notochloe microdon*, had been recorded regularly at PSB_02 with a cover/abundance score of 2 (uncommon) in autumn 2016. It was not recorded at that site in spring 2016, probably due to lack of flowering material. It was again found in summer 2017 with a cover/abundance score of 2 (uncommon). It was not recorded within this plot between 2018 and 2021. In summer and autumn 2022 it was present, C/A 1, rare, but not recorded in spring 2022.

In spring 2016 this grass was found at PS_03 with a cover/abundance score of 2 (uncommon) but was not detected in 2017. In summer 2018 it was recorded as rare but has not been recorded since that time.

In 2021 a number of new post-fire records were made at the Pagoda Swamp plots.

At PSB_01 a seedling of *Eucalyptus blaxlandii* was found in autumn and spring 2021 It was also observed in the plot in summer 2022, but not subsequently. Both *Hibbertia obtusifolia* and *Hibbertia riparia* were recorded for the first time in spring 2021. *Hibbertia obtusifolia* was again recorded in spring 2022 (C/A 1, rare), after neither species had been recorded in summer or autumn 2022. *Poa sieberiana* subsp. *sieberiana* in spring 2021 was recorded for the first time post-fire, but not again recorded in summer 2022. It was recorded as common in spring 2022. A *Persoonia mollis* seedling was also detected in spring 2021, but not recorded in summer 2022. It was located within the plot in autumn and spring 2022.

At PSB_02 seedlings of *Eucalyptus blaxlandii* were also recorded in spring 2021. These were not observed in 2022. *Banksia marginata* seedlings were observed for the first time post-fire in autumn and spring 2021. *Banksia marginata* was recorded as common in each season across 2022. *Schoenus imberbis* was recorded within the plot for the first time in spring 2021, but not recorded in 2022.

At PS_03 the fern *Calochlaena dubia* was recorded for the first time in autumn 2021. This species was not present in 2022. *Cassinia aculeata* was recorded for the first time in spring 2021. In summer 2022 it was rare, but it was not recorded in autumn 2022, then recorded as rare in spring 2022.

3.6 Pagoda Swamp

A new monitoring survey plot was established at Pagoda Swamp in February 2021. During 2021 mining operations approached the southern end of this Swamp.

Nineteen plant species were recorded within the plot in summer 2021, 26 species were recorded in autumn 2021 and 20 species were recorded in spring 2021 when the Swamp was exceptionally wet. In summer 2022, 26 species were again recorded. There was some vegetation damage with shrubs being pushed over by water during a November storm. In June 2022 sixteen species were recorded, followed by 21 species in spring 2022.

No records of plant disease have been made at this plot over the monitoring period

There were no exotic species present within the swamp plot in summer 2022. Catsear (*Hypochaeris radicata*) was recorded as uncommon in spring 2022.

4.0 DISCUSSION

Plant condition in spring 2022 was affected by record high rainfall with many instances of leaf yellowing and death due to waterlogging with the period of above average rainfall now reaching 33 months in duration and very wet months in January, March and July. Plant disease associated with pathogens was limited to very few observations.

The occurrences of exotic plant species in 2022 were consistent with a post-fire decline with limited new germination in response to the high rainfall. Occurrences of weeds continue to be at plots with a disturbance history involving proximity to clearing and pine plantation, logging, feral animals and recreational use.

As the plots were all bush fire affected, with most sites suffering a very high intensity fire in December 2019, future surveys will be necessary to determine whether the recovery trajectory continues to be consistent with past events, or whether particular plots have a different trajectory due to factors other than fire intensity. The trajectory following the October 2013 had indicated that ecosystem function across the study area was normal. On the current trajectory following the December 2019 bushfire it is indicated that ecosystem functioning at recent and historic undermined plots being no different to control plots.

There have been no indications of residual effects of subsidence in areas undermined previously, particularly in the Clarence East area where mining occurred in 2019-20. The patterns of species richness, species composition and plant disease relate strongly to bush fire impacts and recovery and the persistent wet conditions with almost three years above average rainfall There is no indication of a mining effect.

Appendix 1. Plant Species Richness at Clarence East and West Heath Sites

Appendix 1A. Long-term average species richness

Site	Location	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
PAG_01	Gorilla Rock	40.5	38.8	41.0	40.7	39.3	39.7	44.3	45.3	47.3	42.5	42.3	46.7	45.3	46.0
PAG_02	Gorilla Rock	19.5	24.0	27.0	25.0	23.7	28.0	30.3	30.3	26.7	28.0	30.7	34.3	32.7	31.7
PAG_03	Waratah East	28.0	27.8	26.7	27.7	30.0	29.3	29.0	30.3	32.7	30.0	29.3	30.3	32.7	32.7
PAG_04	Waratah East	20.5	21.8	21.3	20.0	22.7	21.3	23.0	22.0	23.7	21.7	23.0	22.0	19.7	20.7
PAG_05	Waratah North	25.0	22.3	23.7	23.7	27.0	25.7	26.3	29.0	28.7	27.0	36.7	39.3	39.7	35.7
PAG_06	Waratah North	25.0	27.8	29.3	29.0	28.7	33.7	31.3	30.3	30.7	32.7	27.7	27.0	30.3	32.3
CLW_01	Farmers Creek heath	–	–	30.0	33.5	32.7	35.0	36.7	37.3	41.3	38.5	36.3	39.7	41.0	43.7
CLW_06	Paddys Creek Ridge	–	–	28.0	29.5	29.7	36.7	39.0	35.3	35.3	37.5	36.3	39.7	42.7	45.7

Ave, average

1 pre-fire average for burnt sites.

Appendix 1B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022		
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr
PAG_01	Gorilla Rock	45	47	46	45	45	47	28	35	43	45	45	42	45	NS	49
PAG_02	Gorilla Rock	36	36	30	31	39	30	24	23	27	27	31	29	32	NS	33
PAG_03	Waratah East	31	33	37	32	36	31	28	34	33	27	29	27	31	NS	31
PAG_04	Waratah East	20	19	23	18	22	19	9	24	21	20	22	20	25	NS	25
PAG_05	Waratah North	36	41	37	35	36	34	16	33	31	34	33	32	35	NS	33
PAG_06	Waratah North	29	34	28	30	32	29	11	29	29	34	30	27	29	NS	30
CLW_01	Farmers Creek heath	39	41	41	38	42	38	25	29	42	40	39	42	37	37	43
CLW_06	Paddys Creek Ridge	39	44	38	43	40	39	23	35	40	45	39	34	40	37	37

Aut, autumn; Spr, spring; Sum, summer.

NS Not surveyed

Appendix 2. Plant Species Richness at Clarence West Swamp Sites—Clarence Colliery

Appendix 2A. Long-term average species richness

Site	Location	2005	2006	2007	2008	2009	2010	2011	2012	2013	2016	2017
		Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave
CLW_02	Old Bells Swamp	NS	21.0	17.5	19.7	25.0	32.7	34.7	35.7	37.0	26.0	28.3
CLW_03	Happy Valley Swamp	NS	23.0	28.5	34.0	37.5	38.7	33.0	30.3	31.5	31.0	28.3
CLW_04	Dark Swamp	NS	21.0	23.0	22.3	24.5	25.0	26.5	25.3	25.0	20.0	19.7
CLW_05	Pine Swamp	NS	26.0	27.0	35.3	47.0	47.3	47.0	43.0	34.0	30.0	27.7
BNS_01	Bungleboori North	31.0	29.0	28.0	30.5	39.7	43.3	39.5	41.0	36.3	21.0	22.7
BNS_02	Bungleboori North	14.5	13.3	14.5	14.3	15.3	15.3	15.5	15.5	15.3	14.5	13.3

Ave, average

1 pre-fire average

NS Not surveyed

Appendix 2B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022		
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr
CLW_02	Old Bells Swamp	28	36	27	30	27	19	11	26	24	33	26	24	26	23	20
CLW_03	Happy Valley Swamp	26	26	24	26	28	24	14	26	33	37	29	25	32	31	24
CLW_04	Dark Swamp	19	18	18	22	22	16	23	24	26	25	21	24	23	19	18
CLW_05	Pine Swamp	29	29	24	24	29	20	20	29	23	34	29	27	36	30	29
BNS_01	Bungleboori North	21	31	17	22	19	20	14	25	28	32	29	26	30	NS	21
BNS_02	Bungleboori North	15	15	14	13	14	15	16	27	30	39	36	28	31	NS	24

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 3. Plant Species Richness at Outbye Sites—Clarence Colliery

Appendix 3A. Long-term average species richness

Site	Location	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Spring	Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAO_01	S of Bungleboori Creek	26	33.5	31	33.7	34.3	33.0	30.3	36.7	38.3	35.7
CLAO_02	S of Bungleboori Creek	24	28.5	26	29.7	29.3	28.5	24.3	30.7	29.0	31.0
CLAO_03	N of Bungleboori Creek	29	31.5	33	34.0	35.0	34.0	25.0	33.0	34.7	32.7
CLAO_04	N of Bungleboori Creek	26	31.0	31	33.7	34.7	31.5	26.0	36.3	35.3	35.0

Ave, average

1 pre-fire average

Appendix 3B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022		
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr
CLAO_01	S of Bungleboori Creek	36	35	31	35	38	33	22	22	30	29	30	28	25	29	31
CLAO_02	S of Bungleboori Creek	29	33	27	27	30	33	11	19	24	21	22	24	26	24	23
CLAO_03	N of Bungleboori Creek	33	36	32	37	32	27	25	25	25	25	25	29	NS	NS	NS
CLAO_04	N of Bungleboori Creek	34	35	35	36	37	35	25	27	26	29	24	31	NS	NS	NS

Aut, autumn; Spr, spring; Sum, summer
NS Not surveyed

Appendix 4. Plant Species Richness at Clarence 800 Area Sites

Appendix 4A. Long-term average species richness

Site	Location	2009	2010	2011	2012	2013	2014	2015	2016	2017
		Ave	Ave	Ave	Ave	Ave[1]	Ave	Ave	Ave	Ave
CLAE_01	Dumbano Fire Trail dam	58.0	57.3	59.3	58.7	56.0	60.3	62.7	65.0	64.0
CLAE_02	Heath ridge	33.0	30.7	35.0	34.3	31.0	32.3	37.7	40.0	38.0
CLAE_03	Heath ridge	36.0	34.3	37.3	37.7	34.5	31.0	34.7	39.0	35.3
CLAE_04	Secret swamp	35.5	37.0	36.0	35.3	39.5	38.3	44.0	44.3	43.7
CLAE_05	Secret swamp	42.5	40.7	38.7	43.3	40.5	49.3	46.3	48.7	45.7
CLAE_06	Olearia swamp	28.0	29.3	29.7	32.0	33.0	44.0	35.3	37.7	35.7
CLAE_07	Olearia swamp	24.0	28	26.0	25.3	25.0	30.0	32.0	32.3	31.0
CLAE_08	Olearia swamp	14.0	15.7	15.3	15.3	14.5	20.3	14.3	14.0	13.7

Ave, average

1 pre-fire average

Appendix 4B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022		
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr
CLAE_01	Dumbano Fire Trail dam	60	64	58	62	65	63	24	53	56	65	55	57	58	52	60
CLAE_02	Heath ridge	39	41	37	35	43	29	23	34	27	40	33	26	33	29	28
CLAE_03	Heath ridge	33	37	38	35	30	38	21	32	32	35	32	33	31	33	34
CLAE_04	Secret swamp	40	40	41	40	39	37	21	39	37	33	40	38	39	31	31
CLAE_05	Secret swamp	44	48	47	42	55	39	19	47	53	50	45	47	43	40	49
CLAE_06	Olearia swamp	34	35	32	36	38	33	18	36	34	38	35	38	34	34	35
CLAE_07	Olearia swamp	26	30	28	29	38	26	18	29	26	27	22	20	25	18	21
CLAE_08	Olearia swamp	13	15	13	13	14	13	8	30	31	38	30	32	30	24	25
Sum		289	310	294	292	322	278	152	300	296	326	292	291	291	261	283

Aut, autumn; Spr, spring; Sum, summer

Appendix 5. Plant Species Richness at Paddys Swamp Sites

Appendix 5A. Long-term average species richness

Site	Location	2014	2015	2016	2017
		Spr	Ave	Ave	Ave
PSB_01	Paddys Swamp Branch	37	44.7	43.0	48.3
PSB_02	Paddys Swamp Branch	23	25.0	23.3	22.7
PS_03	Paddys Swamp	NS	NS	28.0	26.3

Aut, autumn; Spr, spring; Sum, summer

NS Not surveyed

Appendix 5B. Recent seasonal species richness counts

Site	Location	2018			2019			2020			2021			2022		
		Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr	Sum	Aut	Spr
PSB_01	Paddys Swamp Branch	43	56	40	50	50	43	26	36	39	46	39	42	43	38	38
PSB_02	Paddys Swamp Branch	19	16	13	19	15	14	16	24	25	24	25	21	27	25	24
PS_03	Paddys Swamp	26	28	22	30	30	22	25	31	28	34	26	26	32	25	28

Appendix 4: Fauna Monitoring Reports

Appendix	Report Name
Appendix 4A	Fauna Report – 900 Area Terrestrial Fauna Monitoring Report (Biodiversity Monitoring Services, 2022a)
Appendix 4B	Fauna Report – Western SMP Application Area Terrestrial Fauna Monitoring Report (Biodiversity Monitoring Services, 2022b)

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Fauna Report

900 Area (Panels 913 and 917) Terrestrial Fauna Monitoring Report (2022 Final)
for
Clarence Colliery Pty Ltd

Prepared for: Matt Ribas
Prepared by: Biodiversity Monitoring Services
Date: 3 February 2022

Document History

Report	Version	Prepared by	Checked by	Submission Method	Date
Fauna	Issue 1	Nicholas Tong	Andrew Lothian	email	3 Feb 2023

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FAUNA MONITORING OF 900 AREA AT CLARENCE COLLIERY

2022 FINAL

A report by Biodiversity Monitoring Services, February 2023

Table of Contents

Figures and tables

1.0 Background

With the expansion of mining into the central part of Clarence Colliery holdings it is necessary to monitor fauna populations within the area, particularly within any swamps considered as Endangered Ecological Communities. Clarence Colliery plans to extend their underground mining into an area termed the '900 Area'. An initial fauna survey was undertaken in spring 2014 and two sites were established:

1) ***Site A North*** Located along Paddy's Creek, a tributary to Bungleboori Creek. The site covers the creekline and surrounding woodland and low heathy shrub. Along the western edge of the site is a cliffline about 50 m high. Vegetation in the swamp was still growing back after the 2013 fire when the more recent fire hit. The creek was flowing during the survey. Site A North sampled land north of Panel 913 and 911. A new quarry operation began upstream of the site in January 2020. <u>Reduced sampling in autumn 2022</u>.

2) ***Site B South*** Also located along Paddy's Creek, but further towards the headwaters. The site covers the creekline and associated riparian area, as well as the surrounding woodland. At the time of the survey water in the creek was flowing. A deep trench had been dug beside the creek, presumably to drain the area. Site B South sampled land above Panel 915. A new quarry operation has begun upstream of the site in January 2020. It will be considered an impact site from spring 2022.

Both sites within Clarence Colliery 900 Area were surveyed for fauna during autumn and spring and summer 2022. The 900 Area sites were considered not undermined in seasonal reports, but mine mapping provided in December shows that B South is no longer a control site, being undermined in August 2022. It will be considered an impact from spring 2022 in final analyses. Though possibly under the influence of drawdown from October 2022, the site A North remains a control site for the end of year analyses. Paddy's swamp could also be considered within the influence of drawdown from July 2022, but also remains as a control site for the end of year analyses. The 900 Area is close to the Clarence Western Area. Three existing impact sites (CLW01, CLW05 and CLW04) are suitable for inclusion in the 900 Area analyses, though CLW04 will be left out of 2022 analyses due to reduced survey effort in autumn. Springvale undermined the previous Clarence control sites CLW01 and CLW05 in mid-late 2018, and have begun surveys of two replacement control sites in Nine Mile Swamp (downstream of CLW05) and Paddy's Swamp (between the 900 Area and CLW01). These sites will also be included in analyses for this area:

1) ***CLW01*** Located along the ridge to the east of the start of the (now cleared) pine plantation on Glowworm Rd. The site covers the low heath of the pagoda complex and surrounding woodland. This site was subject to extraction in spring 2018 so will be used as an impact site.

2) ***CLW04*** Located to the north of Old Bells Line of Rd to the south of Clarence 900 Area. The site samples shrub swamp and surrounding woodland. This site was undermined in April 2015 so can be used as an impact site. Threatening fire conditions in spring 2019 prevented survey of this site. <u>Not sampled in spring-summer 2019</u>. <u>Only sampled for two nights/three days in autumn 2022</u>.

3) ***CLW05*** Located to the east of Bungleboori camping area downslope of the (now cleared) Pine plantation. The site samples shrub swamp, as well as the surrounding woodland. The swamp has been dry over the last few years. The site only partially burnt in the 2013 State Mine fire, but fully burnt in the 2019 Gospers Mountain fire. This site was within the influence of drawdown from Springvale as of December 2018 so will be used as an impact site.

4) ***Nine Mile Swamp*** Located to the north east of Bungleboori camping area at the intersections of Nine Mile and Pine Swamps. The swamp is situated downslope of the (now cleared) pine plantation to the south, and some poisoned pine forest to the north. This site looked to have been affected by the 2013 State Mine fire, though this could have been management burning to protect the pine plantation. It burnt again in the 2019 Gospers Mountain fire. The swamp is a good representative of Newnes Plateau Shrub Swamp and is to be used as a control site.

5) ***Paddy's Swamp*** Located at the eastern edge of Springvale Colliery near the Clarence 900 Area. The swamp is surrounded by native woodland. The swamp is a good representative of Newnes Plateau Shrub Swamp and is to be used as a control site. This site currently sits over Panel 915 and may need to be moved upswamp to maintain Control status. Reduced sampling in spring 2022.

It is important to note that this baseline monitoring program has focussed on the Newnes Plateau Shrub Swamp and Hanging Swamp environments (albeit slightly different types) as they are considered to be the most sensitive habitat overlying the proposed mining area. It is also noted, that by virtue of the fauna monitoring methods, woodland habitats are also surveyed. The locations of the two fauna monitoring sites are shown in **Figure 1-1**, with surrounding monitoring sites from the Clarence Area also included. The main watercourses and roads are shown along with the Clarence mining lease boundary.

Survey areas within the Clarence 900 Area were directly affected by the 2013 State Mine fire. They were impacted again by the Gospers Mountain fire in mid-December 2019. Maps of the extents from each fire are shown in **Figure 1-2**. All sites included in the analysis burnt in 2013 and 2019. No summer surveys were conducted in 2019, and spring surveys for CLW02, CLW03, CLW04 and CLW06 had to be cancelled. Data used in the 2019 final report is pre fire, while all 2020-22 data is post fire.

Surveys were first undertaken during spring 2014 (after the State Mine fire), and were repeated in autumn, spring and summer thereafter to ensure a complete set of baseline data. The spring 2014 surveys used standardised methodology to establish baseline data for fauna populations to be used for on-going monitoring of the potential impacts from the development of Clarence 900 Area. The methodology used is similar to that applied to long-term fauna monitoring surveys by Centennial Coal throughout Newnes Plateau.

Table 1-1 provides information about each site, in terms of landscape characteristics and vegetation communities sampled. Vegetation communities were obtained from the Vegetation of the Western Blue Mountains mapping by Office of Environment and Heritage (OEH). In addition, habitat characteristics were measured at each site and these are provided in Section 4.

Table 1-1: Locations of the two monitoring sites at Clarence 900 Area

Site name	Easting	Northing	Landscape	Vegetation	Establishment date	Undermining date
A North	241839	6299342	Heath Swamp within steep-sided valley	Newnes Plateau Shrub Swamp (low disturbance), Newnes Plateau Hanging Swamp (low disturbance)	Spring 2014	NA October 2022 (potential drawdown?)
B South	241374	6298571	Woodland moving into heath swamp within shallow-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance), Tableland Mountain Gum – Snow Gum – Daviesia Montane Open Forest (high disturbance)	Spring 2014	August 2022 (extraction)
CLW01	240634	6299166	Pagoda heath above steep-sided valley	Newnes Plateau Tea Tree – Banksia – Mallee Heath (high disturbance)	Spring 2006	Spring 2018 (extraction)
CLW04	241899	6297998	Heath swamp within steep-sided valley	Newnes Plateau Shrub Swamp (low disturbance), Newnes Plateau Narrow-leaved Peppermint – Silver-top Ash Layered Open Forest (high disturbance)	Spring 2006	April 2015 (development) Nov 2015 (extraction)
CLW05	240772	6300158	Heath swamp within steep-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance)	Spring 2006	Dec 2018 (drawdown)
Nine Mile	242000	6301270	Heath Swamp within steep-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance)	Autumn 2018	NA
Paddy's Swamp	241375	6299055	Heath Swamp within steep-sided valley	Newnes Plateau Shrub Swamp (low disturbance)	Autumn 2018	NA July 2022 (potential drawdown?)

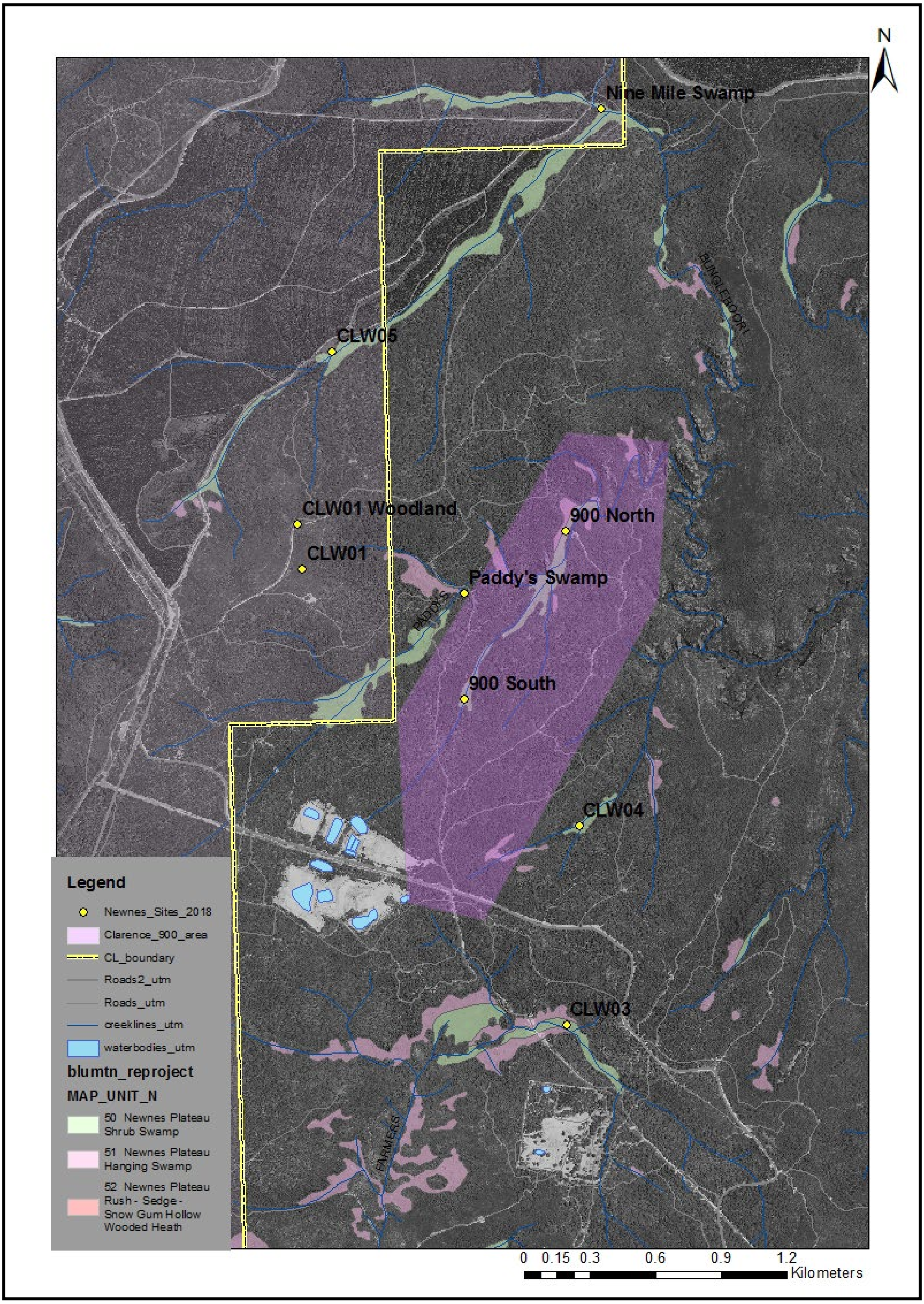

Figure 1-1: Locations of survey sites and nearby monitoring sites

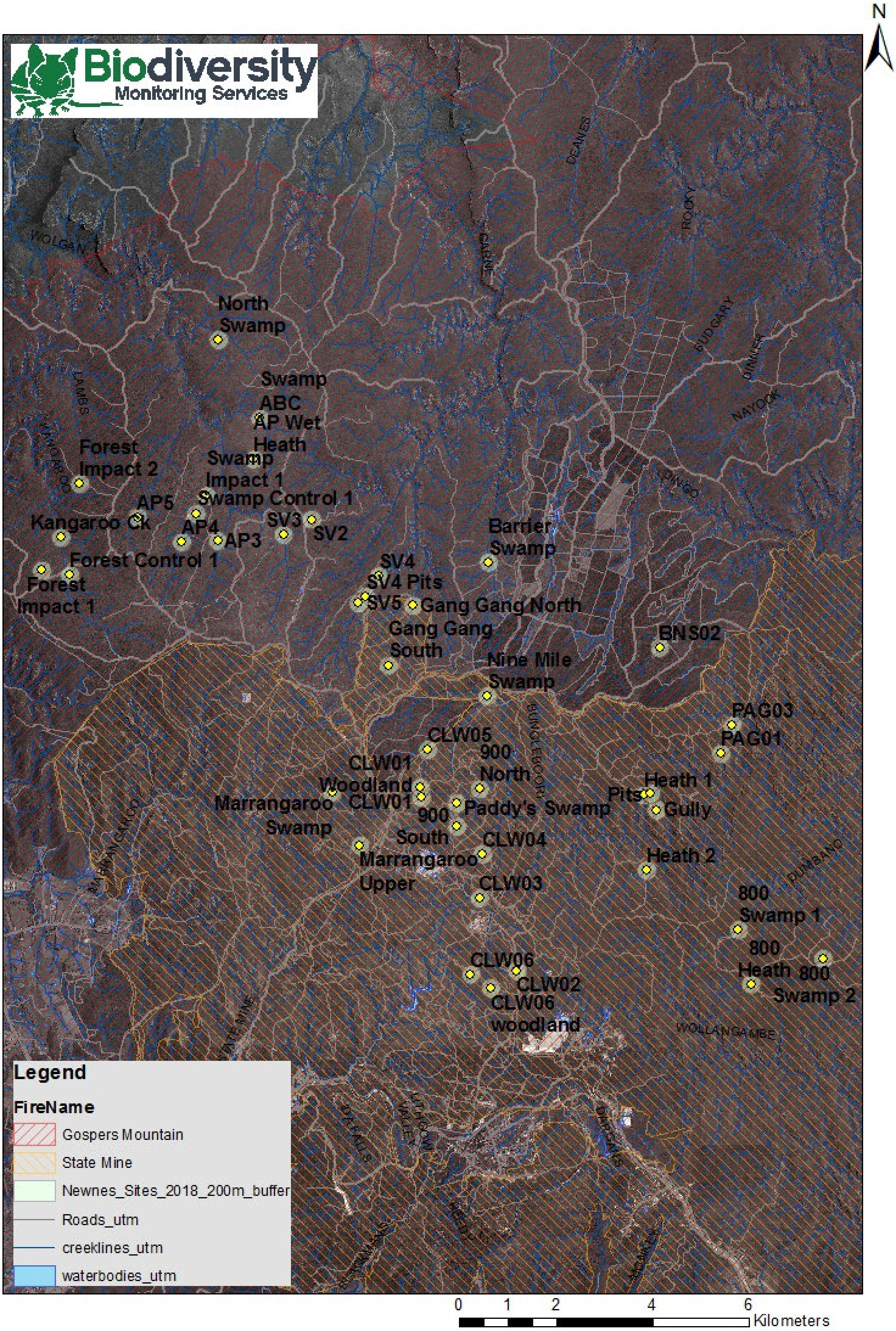

Figure 1-2: Extent of State Mine Fire in 2013 and Gospers Mountain Fire in 2019

2.0 Survey methodologies and survey efforts

The 900 Area sites were surveyed between the 16th and 20th May, the 31st October and 4th November, and 28th November and 9th December 2022 by Andrew Lothian, Nicholas Tong and Rachel Moore using NPWS Scientific Licence No. SL101725 and DPI's Animal Research Authority No. 16/559. Autumn surveys focussed on small mammals (including bats) colonising new areas, reptiles and birds still active. Spring surveys targeted breeding activity by birds. Summer surveys targeted the activity period for reptiles (Blue Mountains Water Skink), bats, amphibians and Giant Dragonfly.

Because of the amount of existing information available on the fauna populations within and surrounding the Clarence Colliery area (surveys have been undertaken for 15 years), it is now possible to refine the approach to undertaking baseline and monitoring surveys. Any data obtained from the surveys of the two sites in the 900 Area can be placed into the context of a large body of information about fauna populations inhabiting areas with different treatments at Newnes Plateau. Trap lines were established across each site to ensure the maximum sampling of the dominant habitats. Pit traps were established at both sites.

The methodology follows that established during surveys in previous years and other monitoring areas at Clarence, Angus Place and Springvale, to ensure consistency of approach and provide a basis for comparative studies. A summary of the survey effort at each site is given in **Tables 2-1** to **2-2**. A full description of the survey methodologies is provided below and in the BMS methods supplement[1]. The techniques used during the survey followed, as closely as possible, the draft working guidelines produced by DECC (2004)[2]. Although these guidelines are in draft form and still subject to review, they provide an important direction on survey methodology, including suggested survey effort. The survey techniques have remained constant over the years during the surveys undertaken at Newnes Plateau. This will continue into the future to ensure comparative data is obtained. The survey techniques are consistent with methodologies outlined in the *Clarence Colliery 900 Area SMP Environmental Monitoring Program*. Results from 18 years of surveys on Newnes Plateau have shown that little additional information about mammalian fauna is obtained during summer. Hence, summer surveys normally focus on threatened species likely to be active during this season (i.e. Giant Dragonfly and Blue Mountains Water Skink), as well as avifauna (particularly summer migrants), bats, reptiles and amphibians.

Targeted surveys for each of the threatened species known from the locality were undertaken and **Table 2-3** summarises the methods used for each group of species.

[1] BMS (2017). *Methodologies Supplement (2017)* - Methodologies Used to Conduct Terrestrial Fauna Surveys and Monitoring (2017).

[2] DECC (2004). *Threatened Species Survey & Assessment: Guidelines for Developments and Activities - Working Draft Report*, prepared by DECC.

Table 2-1: Different techniques used during the autumn and spring surveys

Survey technique	A North	B South	Nine Mile	Paddy's Swamp
Ground Elliott traps	25	25	25	25
Tree-mounted Elliott traps	5	5	5	5
Hair funnels	5	5	5	5
Ground Tomahawk traps	3	3	3	3
Tree-mounted Tomahawk traps	3	3	3	3
Large Elliott traps	2	2	2	2
Glider tubes	2	2	2	2
Pit traps	-	-	-	3
Remote IR cameras	2	2	2	2
Anabat recording	Yes	Yes	Yes	Yes
Call broadcasting	Yes	-	Yes	-
Bird counts	Yes	Yes	Yes	Yes
Litter searches	Yes	Yes	Yes	Yes
Amphibian searches	Yes	Yes	Yes	Yes
Reptile walk	Yes	Yes	Yes	Yes
Rock turning	300	-	-	-

Table 2-2: Number of trap nights undertaken during autumn and spring surveys

Survey technique	Autumn	Spring	Total
Ground Elliott traps	175	200	400
Tree-mounted Elliott traps	35	40	80
Hair funnels	35	40	80
Tomahawk traps	42	48	96
Large Elliott traps	14	16	32
Glider tubes	14	16	32
Pit traps	-	-	64
Remote IR cameras	16	16	32
Anabat recording	4	4	12
Rock/log turning	300	300	600
Spotlighting transects	8.0 km; 1.0 hr	21.0 km; 4.25 hr	29.0 km; 5.25 hr

Table 2-3: Methods used to target threatened species

Fauna group	Targeted survey methodology
Threatened amphibians	Searching preferred habitat, pit trapping, call analysis, reptile funnels
Threatened reptiles	Searching preferred habitat, searching under rocks, pit trapping, reptile funnels, tiles
Threatened diurnal birds	General observation, call recognition
Threatened nocturnal birds	General observation, spotlighting, call broadcasting
Threatened arboreal marsupials	General observation, tree traps, spotlighting, call broadcasting, hair tubes, pit trapping, detection of characteristic sap cuts and scratches on trunks, scat identification
Threatened large ground marsupials	General observation, ground traps, spotlighting, searching for characteristic diggings, hair tubes, recognition of tracks, scat identification
Threatened small ground mammals	Elliott trapping, pit trapping, hair tubes, recognition of tracks
Threatened bats	Ultrasonic call detection (Anabat)
Threatened invertebrates	Searches in preferred habitats

As each Elliott trap was laid, habitat description of the trap site was recorded. This included the upper, middle and lower storey vegetation, as well as the ground cover, within an area formed by a one metre radius around each trap. For example, if 10 trap sites out of a trap line of 25 Elliott traps contained a shrub, then it was estimated that the shrub cover in that survey site was 40%.

AUTUMN AND SPRING SURVEYS

Methodologies used in autumn and spring surveys are as follows:

a. Elliott Trapping

Twenty-five small (8x10x33cm) Elliott traps were laid in straight lines for five days through the habitats at each site. This is equivalent to 100 trap nights over four consecutive nights at each site. The traps were baited with a mixture of rolled oats, peanut butter and bacon fat, and a small piece of dacron was placed within each trap (as protection against the cold). A freezer bag was placed over the end of each trap to prevent the contents becoming wet from the rain. At each trap site a description of the physical characteristics of the habitat within a one metre radius was noted. This information was used in the analysis of habitat values.

To sample any small arboreal mammals, five small Elliott traps were mounted on trees at equal distances along each transect (20 trap nights over five consecutive days at each site). Aluminium tree mounts were attached to trees and a baited Elliott trap attached to the mount. The tree trunk and trap were sprayed with a honey-water mixture to assist in attracting any nectar or sap feeding arboreal mammals. Again, dacron and freezer bags were used to combat the cold and wet conditions.

b. Cage Traps

Three Tomahawk cage traps were laid on the ground and three Tomahawk traps were mounted on trees at each site (24 trap-nights). Two large Elliott traps were placed at each site (8 trap-nights). The large Elliott traps and the Tomahawk traps were baited with apple, muesli bar and chicken.

c. Spotlighting

Two forms of spotlighting transect were undertaken. Tracks within the 900 Area were spotlighted from a moving vehicle. In addition, spotlighting on foot was undertaken at the detailed fauna survey sites.

d. Hair Funnels

Hair funnels (from Faunatech) were used instead of large and small hair tubes. The design of the tapered hair funnels is such that both large and small animals can be detected by a single funnel. Five hair funnels were set out at each site for four nights and baited with a mixture of rolled oats, peanut butter and bacon fat. Where possible, some of the hair funnels were set onto 'habitat trees' (these were considered to be trees that showed signs of use by arboreal marsupials and had obvious hollows).

e. Glider Traps

Two vertical plastic tube traps were set up at each site and used as a tree-mounted pit-fall traps. These have been developed to trap small gliders (Squirrel and Sugar Gliders) and have been used successfully in coastal areas[3].

f. Remote Cameras

Tree-mounted remote cameras (Scoutguard, Reconyx and Swann) were used at selected sites to capture images of any animal using the area, particularly near the traps.

g. Bird Surveys

In addition to the results obtained from general observations and spotlighting, listening and observing periods were undertaken at the two sites. Taking into consideration the discussion in the working draft on methods to survey diurnal birds (DECC 2006), an area-search method was used at each site. A 30 minute search was used where the observer walked around each site, as well as observing and listening for calls from a single point. At each site up to four periods of observation were undertaken (two in the morning and two in the late afternoon).

h. Call Broadcasting

Calls of several species of nocturnal bird were broadcast during the night in the general area. Calls were broadcast through a megaphone for approximately five minutes, with a ten minute listening time. Calls from the Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*), Sooty Owl (*Tyto tenebricosa*), Southern Boobook (*Ninox boobook*), Tawny Frogmouth (*Podargus strigoides*), Eastern Barn Owl (*Tyto javanica*) and the White-throated Nightjar (*Eurostopodus mystacalis*). Koala (*Phascolarctos cinereus*), Yellow-bellied Glider (*Petaurus australis*), Squirrel Glider (*Petaurus norfolcensis*) and Sugar Glider (*Petaurus breviceps*) were also broadcast.

[3] Winning, G. and King, J. 2008. A new trap design for capturing squirrel gliders and sugar gliders. *Australian Mammalogy* **29**: 245-249.

i. Pitfall Traps

Pit traps were established at both sites.

j. Herpetological Searches

Systematic searches for reptiles and amphibians were undertaken within each habitat type at each survey site. Litter was raked and rocks and logs turned over. Loose bark was prised from the trunks of dead trees. Each search took approximately 30 minutes and was repeated at each site. Searches for amphibians took place at night using spotlights (particularly after rain) and recognition of characteristic calls. Spotlighting searches were also attempted for reptiles.

k. Bat Call Detection

An Anabat Express ultrasonic bat detector was placed at selected sites for two nights and any recorded bat calls analysed by Andrew Lothian and Glenn Hoye.

l. Animal Track Recognition

Areas of sand on tracks were inspected for evidence of animal movement. Paw prints and other animal signs were identified and recorded.

m. Opportunistic Observations

Any sightings of fauna were recorded whilst moving throughout the 900 area and located using a Global Positioning System (GPS). Any scats were collected and their contents analysed.

n. Estimation of Diversity

Because of the accumulation of data under formal survey conditions (consistent survey effort and techniques at each survey site) it is possible to calculate some comparisons and relationships from the results of the survey.

Total numbers and species richness (number of species per site) are the simplest measures used to determine biodiversity of a site. However, these indices miss the information that some species may be rare and others common. The Simpson's Index of Dominance (D) takes into account both the abundance patterns and the species richness of a community. This index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). It was possible to calculate Simpson's Index of Diversity for mammal, bird and sometimes reptile populations from each survey site for most survey periods.

An evenness score was also calculated. Evenness is a measure of the relative abundance of different species making up the richness of an area. A low value for evenness means that the sample is dominated by a large number of one or two species. A high evenness value means that most species in the sample have a similar abundance.

SUMMER SURVEY

An area that included each survey site and a surrounding buffer of about 1km radius was searched over a period of three days for signs of fauna. In particular, searches targeted threatened species such as the Giant Dragonfly and Blue Mountains Water Skink. Both these species are associated with wet areas so the swamps and creeklines were searched at and around each site. Bird surveys were also undertaken. The census period was at least 30 minutes at each site. Spotlighting surveys were also undertaken at each site, mainly on foot using a 50 watt light. Whilst spotlighting each site, calls from nocturnal fauna were also recorded (i.e. frogs, gliders, owls etc.). Of particular interest were threatened species that would be more active during the warm summer period. Fauna results from this summer survey are presented below.

3.0 Weather during the trapping survey

Data from weather station at Cooerwull Lithgow (from Bureau of Meteorology) is given in **Table 3-1**. Total monthly rainfall at Mount Boyce (from BOM) is graphed against the long-term average from 1994 to 2022 in **Figure 3-1**.

Table 3-1: Weather records from Lithgow during 2022 surveys

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
14/05/2022	11.1	21.2	0.2
15/05/2022	11.0	19.1	0.6
16/05/2022	8.7	16.6	0.2
17/05/2022	7.4	13.5	0
18/05/2022	5.2	12.5	0
19/05/2022	-1.7	12.2	0
20/05/2022	-1.0	9.5	0
29/10/2022	8.4	15.7	0
30/10/2022	5.6	19.4	0
31/10/2022	10.9	20.5	0
1/11/2022	7.6	13.3	29.6
2/11/2022	1.6	9.2	14.6
3/11/2022	3.4	14.4	0.2
4/11/2022	6.3	14.3	0
26/11/2022	4.6	21.8	0
27/11/2022	11.4	25.2	0
28/11/2022	8.8	19.5	7.8
29/11/2022	5.5	21.8	0
30/11/2022	8.7	19.9	0.4
01/12/2022	10.2	16.2	0
02/12/2022	10.0	16.7	0
03/12/2022	5.9	20.9	0
04/12/2022	7.0	23.6	0
05/12/2022	8.0	26.0	0
06/12/2022	730	22.4	3.4
07/12/2022	8.2	20.8	0
08/12/2022	10.1	16.9	2.2
09/12/2022	1.9	18.8	0

The extended dry periods of 2018-2019 were broken in 2020 with many months in 2020 and 2021 showing greater than average rainfall. Overall rainfall in 2022 was just over twice the long term average. Monthly rainfall was higher than the long-term average for nine of the 12 months, with considerable rainfall in March and July (**Figure 3-1**). Most of NSW has been in rainfall surplus over the last 36 months (**Figure 3-2**), particularly in the central tablelands/western slopes.

Only 1.0mm of rain fell over the autumn survey period, but 44.4mm of rain in the spring week hindered the effectiveness of some survey techniques (i.e. pitfall traps not able to be utilised at all sites). Forecast snow conditions closed the SCA, resulting in reduced number of nights sampling at CLW04 in autumn. Heavy rains and fallen trees prevented access to 900 North for one night in autumn. Paddy's could not be accessed via vehicle in spring, so was sampled on foot for three days only. There was considerably less rainfall over the summer survey period, though maximum and minimum temperatures were below average for summer. Wet/cloudy conditions led to generally lower maximum temperatures and higher minimum temperatures over the year. Cooler overnight temperatures resulted in few frogs seen or heard during summer surveys.

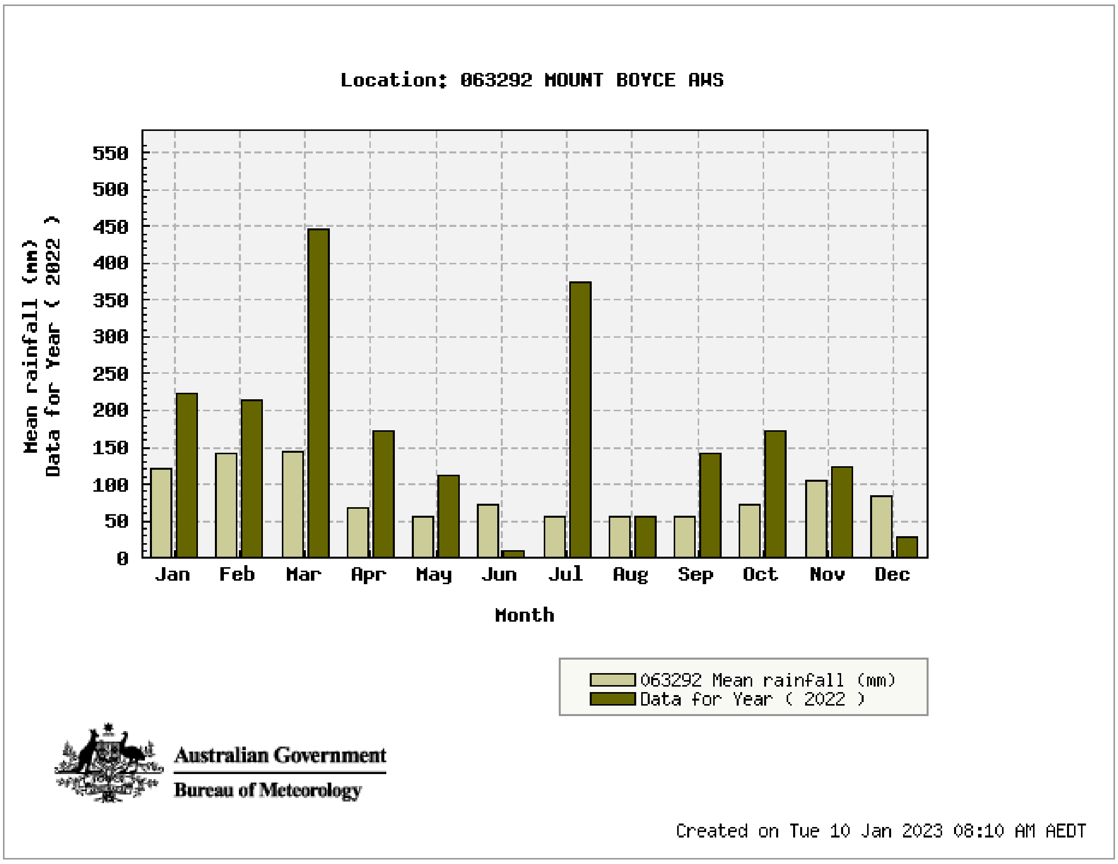

Figure 3-1: Total monthly rainfall in 2022 vs long-term mean monthly rainfall 1994-2022(BOM, 2022)

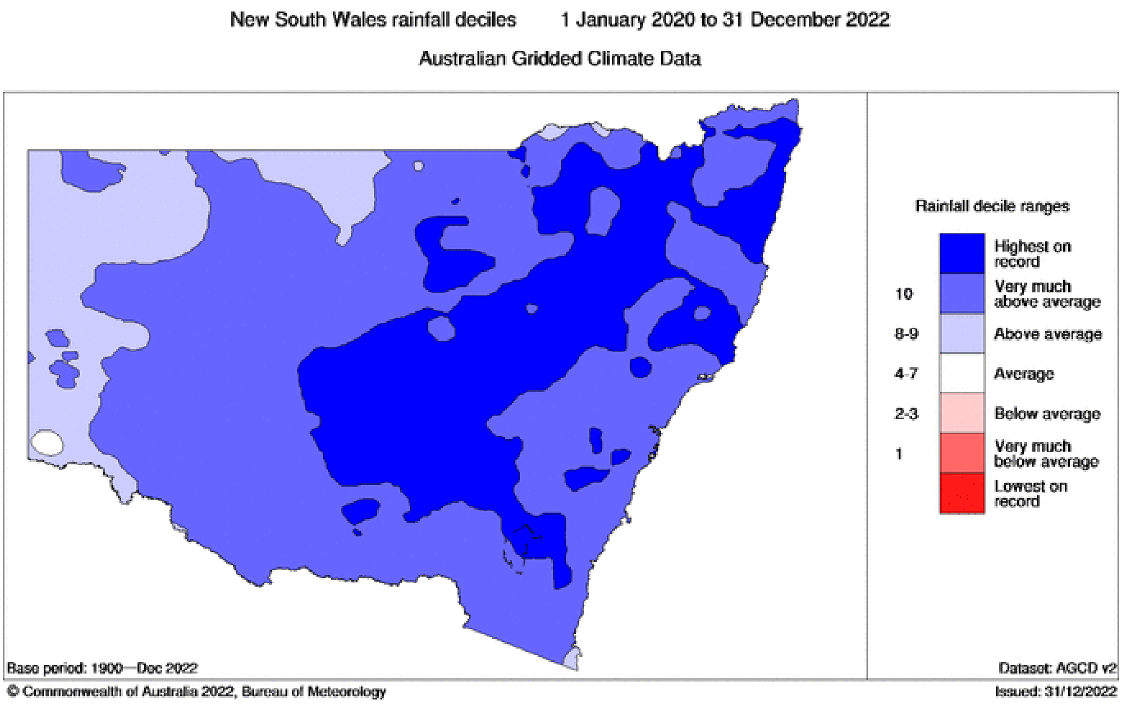

Figure 3-2: 48-month rainfall deficiency map (BOM, 2022)

4.0 Results - habitat measurement

Measurements from descriptions of each Elliott trap site were used to provide an index of habitat condition. It has been found that the use of walking transects to determine habitat condition in swamp and rocky areas did not provide an accurate picture of habitat characteristics. Consequently, information derived from the trap placement descriptions is now used. **Table 4-1** provides the data obtained from the autumn and spring surveys since 2014. Habitat assessment is illustrated in **Figures 4-1** and **4-2**.

Autumn analyses restricted to the two 900 Area site habitat cover characteristics showed no significant variation over time (One-way Repeated Measures ANOVA). There were however, a number of significant differences in the spring habitat cover characteristics over time (One-way Repeated Measures ANOVAs). Tree cover was significantly higher in 2020-21 compared to 2014-19; and higher in 2022 compared to 2019 ($p < 0.001$). Hollow cover was significantly lower in 2019 compared to 2016, 2020 and 2022 ($p = 0.016$). Tall shrub cover was significantly lower in 2020-21 compared to 2016-19; lower in 2014-15 and 2022 compared to 2017-19; and lower in 2016 compared to 2018 ($p <0.0001$). Tall sapling cover was significantly higher in 2021 compared to 2014, 2016-17, and 2020 ($p < 0.001$). Low shrub cover was significantly lower in 2020-21 compared to 2015-19 ($p < 0.001$). Low sapling cover was significantly higher in 2020-21 compared to 2014-19 and 2022; and significantly higher in 2014 and 2022 compared to 2019 ($p < 0.001$). Grass cover was significantly higher in 2020-21 compared to 2014-19; and higher in 2022 compared to 2014-16 ($p < 0.001$). Fern cover was significantly lower in 2020-21 compared to 2017-19; lower in 2022 compared to 2015-19; and lower in 2014 compared to 2018 ($p < 0.001$). Forb cover was significantly higher in 2020 compared to 2015-16 and 2018-19; and higher in 2022 compared to 2016 ($p < 0.001$). Cutting grass cover was significantly lower in 2016 compared to 2014-15 and 2020-21 ($p = 0.011$). Reed cover was significantly lower in 2020-21 compared to 2015-2019; and lower in 2022 compared to 2016-18 ($p < 0.001$). Litter cover was significantly lower in 2014 ($p < 0.001$). Log cover was significantly higher in 2020 compared to 2015 ($p = 0.013$). Rock cover was significantly higher in 2020 compared to 2014-19 ($p = 0.04$). All of these differences line up with expected changes post fire.

A series of t-tests were run on autumn impact and control site habitat characteristic data (including additional sites, pooled over the period 2015-2022. Low sapling, forb, cutting grass and vine covers were significantly higher in undermined sites ($p = 0.01$, $p < 0.001$, $p = 0.03$ and $p = 0.002$ respectively). Fern cover was significantly lower in undermined sites ($p = 0.003$). Spring t-tests were run on impact and control site habitat characteristics pooled over 2014-22. Fern and reed covers were significantly lower in undermined sites compared to control sites ($p < 0.001$ and $p = 0.028$ respectively). Grass, forb, vine and rock covers were significantly higher at undermined sites ($p = 0.001$, $p = 0.009$, $p < 0.001$ and $p = 0.046$ respectively). This does not tell us a lot about the impact of mining in the 900 Area, as the impact sites in these analyses exist outside of the 900 Area.

Mapping provided in December 2022 has confirmed that this area has now been subject to undermining. The section at the end of this report will conduct analysis with correct designation of sites. Results should be interpreted with caution, as most analyses suffered from low power which can obscure otherwise significant results.

The background level of variation in these sites will provide context for when this area becomes undermined. As with most areas on Newnes Plateau, the habitat characteristics vary from year to year due to changes in the prevailing weather each year. Many characteristics were increasing as they recovered from the 2013 fire, which occurred before sampling in this area started. Tall shrub, tall sapling, low shrub, fern and reed covers all fell after the most recent fire. Tree, low sapling, grass, forb and log covers all increased. Most of these increases are due to trap placement near cover in a post fire landscape, but the increase in grass (native grasses in particular) has been seen across the region with the good rains received this year.

Table 4-1: Overall mean habitat characteristics in autumn (A) and spring (S) each year

% Cover	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Tree	-	7	8	10	16	14	20	8	14	10	12	4	32	36	28	28	20	18
Tree hollow	-	2	0	3	4	6	8	2	4	2	2	2	6	6	4	4	2	4
Tall shrub	-	5	2	8	18	16	20	25	16	32	30	24	0	2	0	0	0	2
Tall sapling	-	12	14	16	14	13	22	14	18	20	28	22	4	12	28	28	24	18
Low shrub	-	78	76	84	96	90	90	97	96	95	50	96	30	48	70	56	78	84
Low sapling	-	45	34	36	36	36	40	36	36	33	28	8	74	78	82	66	58	50
Grass	-	18	26	22	20	18	26	30	36	32	32	14	48	40	62	50	50	38
Fern	-	28	54	38	66	41	62	42	70	57	68	72	34	50	40	48	52	42
Forb	-	69	58	55	38	51	58	70	50	59	46	42	54	80	74	70	72	80
Cutting grass	-	75	80	74	60	50	86	66	76	59	68	64	56	80	66	72	66	64
Reed (sedge)	-	46	68	62	70	70	80	70	60	71	72	62	42	36	34	44	54	40
Vine	-	0	0	4	0	5	4	8	0	8	4	0	0	2	2	0	8	10
Litter	-	80	98	98	100	99	100	98	100	100	100	100	100	100	100	100	100	100
Log	-	11	24	9	22	16	18	26	24	15	18	22	34	30	24	24	20	12
Rock	-	3	2	2	2	2	0	2	0	1	0	0	2	2	2	2	4	6

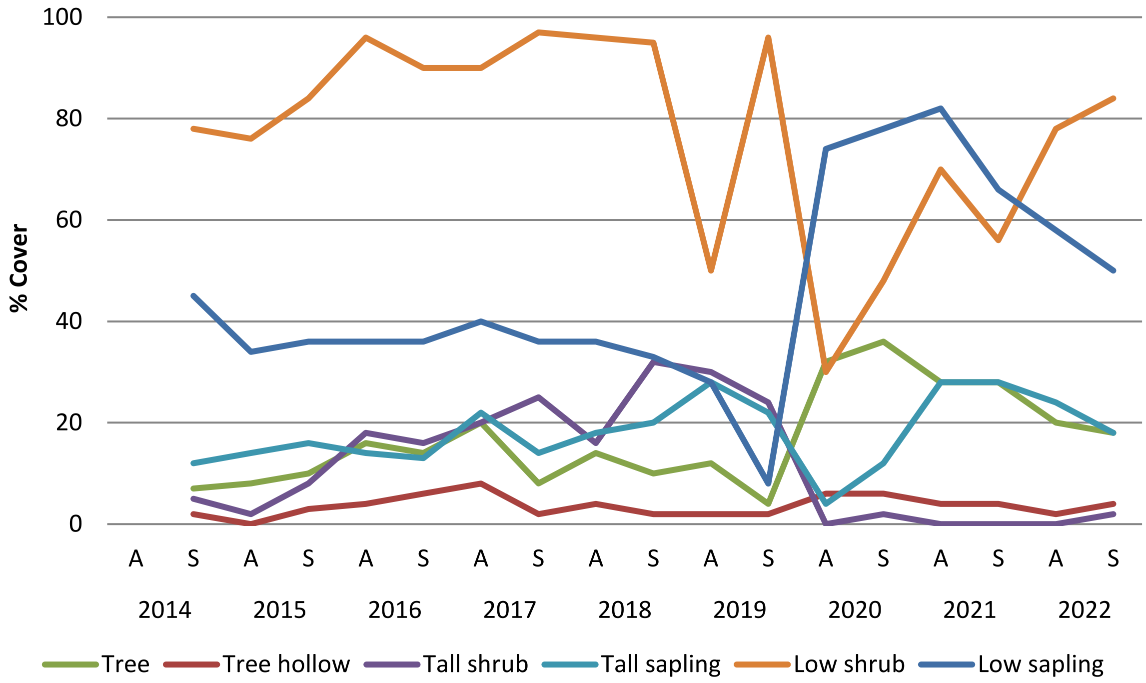

Figure 4-1: Overall mean habitat characteristics over time – upper and middle strata

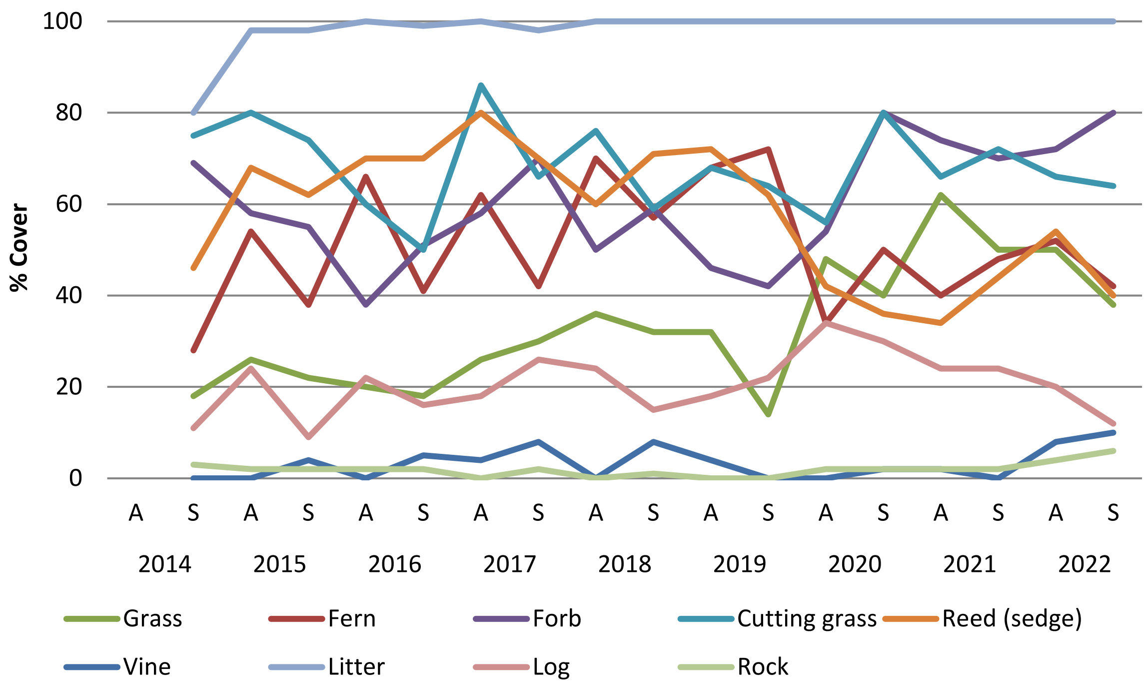

Figure 4-2: Overall mean habitat characteristics over time - lower strata and ground cover

Measurements of habitat characteristics derived from trap site descriptions have been used to provide an index of habitat complexity. This can then be used to determine changes in habitat through time in the study area. One index system used is that developed by Catling and Burt (1995[4]) called the Habitat Complexity Score. This system scores the following parameters: tree cover, tall and short shrub cover, ground cover, logs/rocks and litter cover. Parameter scores range from 0 to 3, hence the maximum score is 18 for a site overall. The Habitat Complexity Scores for each site are given in **Table 4-2**.

Despite the fire in 2019, the scores still indicate moderate habitat complexity. There are a number of reasons why this might be the case. As habitat features such as trees and logs are sought out for sheltering traps, structural complexity is artificially inflated. This system is a coarse method for assessing structural change in habitats. As it relies on presence/absence of cover components (rather than repeated cover estimates), and certain components can be biased by movements of the trap line, the scope to pick up changes from fire is limited if regrowth of certain components has already begun[5]. Also, since surveys in the area only began after the 2013 fire, traps have always been set near sparse cover in a post fire landscape.

Habitat Complexity Scores for the 900 Area were increasing slowly as sites recovered from the State Mine fire in October 2013 (**Figure 4-3**). Dry conditions in 2017-19 caused renewed decline in HCS, though the second fire did not drive scores as low as the first. Rainfall has seen an increase in 2020-22 scores, with spring 2021 presenting the highest HCS on record for the area. Autumn scores did not differ significantly over the years (One-way Repeated Measures ANOVA), nor by mining impact (pooled t-test). Spring HCS was significantly lower in 2014 compared to 2018 and 2020-22; and lower in 2019 compared to 2021 ($p < 0.001$; One-way Repeated Measures ANOVA). In spring there was no significant difference in HCS by mining impact (pooled t-test). These scores show that all sites structurally provide good habitat for ground dwelling mammals and woodland birds, but only as food resources begin to return to the landscape.

[4] Catling P. C. and Burt R.J. (1995). Studies of the ground-dwelling mammals of eucalypt forests in south-eastern New South Wales: the effect of habitat variables on distribution and abundance. *Wildlife Research 22:* 271-288.

[5] Lothian, A.J., Denny, M.J.S. and Tong, N.W. (2022). Mammalian responses to fire on Newnes Plateau: A yardstick for future recovery. *Australian Zoologist* 42(2): 278-303.

Table 4-2: Habitat Complexity Scores for autumn (A) and spring (S) over time

Site	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
A North	-	12	13	12	13	13	13	14	12	12	13	12	12	12	13	14	13	13
B South	-	11	11	13	13	14	14	13	13	13	14	12	12	14	14	14	14	13
Overall mean	**-**	**11.5**	**12.0**	**12.5**	**13.0**	**13.5**	**13.5**	**13.5**	**12.5**	**12.5**	**13.5**	**12.0**	**12.0**	**13.0**	**13.5**	**14.0**	**13.5**	**13.0**

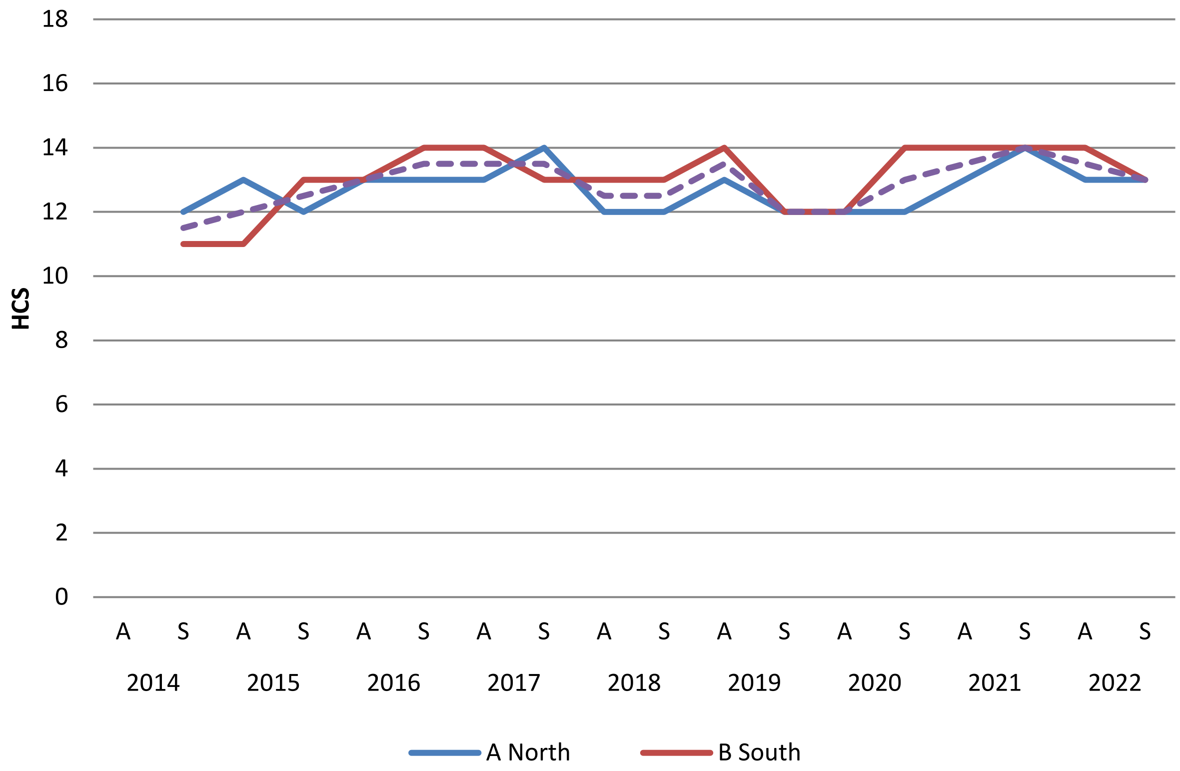

Figure 4-3: Changes in Habitat Complexity Scores over time

5.0 Results - fauna located

Eleven native mammal (plus two introduced), 45 bird, six reptile and three amphibian species were recorded from the 900 Area. **Tables 5-1** to **5-5** provide a list of species located within the 900 Area during the 2022 surveys. Calculations of diversity indices were undertaken where possible and presented in **Table 5-6**.

P – Protected species V – Vulnerable species U – Introduced species

Threatened species highlighted in green

Table 5-1: Mammals located within Clarence Colliery 900 Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Dasyuridae			
Antechinus agilis	Agile Antechinus	P	
Antechinus stuartii	Brown Antechinus	P	
Vombatidae			
Vombatus ursinus	Bare-nosed Wombat	P	
Macropodidae			
Macropus rufogriseus	Red-necked Wallaby	P	
Molossidae			
Austronomus australis	White-striped Freetail-bat	P	
Vespertilionidae			
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	
Vespadelus darlingtoni	Large Forest Bat	P	
Vespadelus regulus	Southern Forest Bat	P	
Muridae			
Rattus fuscipes	Bush Rat	P	
Rattus lutreolus	Swamp Rat	P	
Canidae			
Canis lupus	Dingo, domestic dog	U	
Vulpes vulpes	Fox	U	

Table 5-2: Birds located within Clarence Colliery 900 Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Anatidae			
Chenonetta jubata	Australian Wood Duck	P	
Podargidae			
Podargus strigoides	Tawny Frogmouth	P	
Aegothelidae			
Aegotheles cristatus	Australian Owlet-nightjar	P	
Accipitridae			
Accipiter cirrocephalus	Collared Sparrowhawk	P	
Turnicidae			
Turnix varius	Painted Button-quail	P	
Cacatuidae			
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	P	
Psittacidae			
Platycercus elegans	Crimson Rosella	P	
Cuculidae			
Cacomantis flabelliformis	Fan-tailed Cuckoo	P	
Strigidae			
Ninox novaeseelandiae	Southern Boobook	P	
Alcedinidae			
Dacelo novaeguineae	Laughing Kookaburra	P	
Menuridae			
Menura novaehollandiae	Superb Lyrebird	P	
Climacteridae			
Cormobates leucophaea	White-throated Treecreeper	P	
Ptilonorhynchidae			
Ptilonorhynchus violaceus	Satin Bowerbird	P	
Maluridae			
Malurus cyaneus	Superb Fairy-wren	P	
Dasyornithidae			
Pycnoptilus floccosus	Pilotbird	P	V
Acanthizidae			
Acanthiza lineata	Striated Thornbill	P	
Acanthiza pusilla	Brown Thornbill	P	
Acanthiza reguloides	Buff-rumped Thornbill	P	
Gerygone olivacea	White-throated Gerygone	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Sericornis frontalis	White-browed Scrubwren	P	
Pardalotidae			
Pardalotus punctatus	Spotted Pardalote	P	
Pardalotus striatus	Striated Pardalote	P	
Meliphagidae			
Acanthorhynchus tenuirostris	Eastern Spinebill	P	
Anthochaera carunculata	Red Wattlebird	P	
Caligavis chrysops	Yellow-faced Honeyeater	P	
Melithreptus lunatus	White-naped Honeyeater	P	
Nesoptilotis leucotis	White-eared Honeyeater	P	
Philemon corniculatus	Noisy Friarbird	P	
Phylidonyris novaehollandiae	New Holland Honeyeater	P	
Psophodidae			
Psophodes olivaceus	Eastern Whipbird	P	
Campephagidae			
Coracina novaehollandiae	Black-faced Cuckoo-shrike	P	
Pachycephalidae			
Colluricincla harmonica	Grey Shrike-thrush	P	
Pachycephala rufiventris	Rufous Whistler	P	
Artamidae			
Cracticus torquatus	Grey Butcherbird	P	
Strepera graculina	Pied Currawong	P	
Strepera versicolor	Grey Currawong	P	
Rhipiduridae			
Rhipidura albiscapa	Grey Fantail	P	
Corvidae			
Corvus coronoides	Australian Raven	P	
Monarchidae			
Myiagra rubecula	Leaden Flycatcher	P	
Petroicidae			
Eopsaltria australis	Eastern Yellow Robin	P	
Petroica boodang	Scarlet Robin	V	
Petroica phoenicea	Flame Robin	V	
Timaliidae			
Zosterops lateralis	Silvereye	P	
Estrildidae			
Neochmia temporalis	Red-browed Finch	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Stagonopleura bella	Beautiful Firetail	P	

Table 5-3: Amphibians located within Clarence Colliery 900 Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Myobatrachidae			
Crinia signifera	Common Eastern Froglet	P	
Pseudophryne bibronii	Bibron's Toadlet	P	
Hylidae			
Litoria citropa	Blue Mountains Tree Frog	P	

Table 5-4: Reptiles located within Clarence Colliery 900 Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Gekkonidae			
Amalosia lesueurii	Lesueur's Velvet Gecko	P	
Scincidae			
Acritoscincus platynota	Red-throated Skink	P	
Ctenotus taeniolatus	Copper-tailed Skink	P	
Eulamprus leuraensis	Blue Mountains Water skink	E1	E
Lampropholis guichenoti	Pale-flecked Garden Sunskink	P	
Elapidae			
Cryptophis nigrescens	Eastern Small-eyed Snake	P	

Table 5-5: Invertebrates located within Clarence Colliery 900 Area

Scientific Name	Common Name	NSW Status	Cwlth Status
None found*			

Table 5-6: Biodiversity indices for fauna in 900 Area

Site	Evenness	Simpson's Index of Diversity	Abundance	Species Richness
BIRDS				
900 Area	0.888	0.953	325	45
A North	0.934	0.961	140	35
B South	0.888	0.938	141	29
NATIVE MAMMALS (non-bat)				
900 Area	0.816	0.731	60	6
A North	0.703	0.629	15	5
B South	0.748	0.701	40	6
REPTILES				
900 Area	0.689	0.638	24	6
A North	0.000	0.000	2	1
B South	0.699	0.400	5	2
AMPHIBIANS				
900 Area	0.314	0.184	41	3
A North	0.000	0.000	11	1
B South	0.514	0.228	24	2

The fauna assemblage is similar to that recorded from other areas within Clarence Colliery and Newnes Plateau, with similar species richness values and similar species located. However, the overall diversity and population numbers appear to be lower in this area, possibly due to the smaller size of the area. A list of species located within the 900 Area from 2014 to 2022 is given in **Table 5-7**. The cumulative number of new species located each year is given in **Figure 5-1**. It is expected that the number of new species located each year will level out and the final maximum species richness for the area can be estimated from the value of the asymptote. By 2022, 82 bird, 27 native mammal, 19 reptile, six amphibian and one invertebrate species have been located within the 900 Area.

Table 5-7: Species located in 900 Area from the results of surveys since 2014 (threatened species highlighted in green)

Common Name	2014	2015	2016	2017	2018	2019	2020	2021	2022
MAMMALS									
Agile Antechinus				X	X	X	X	X	X
Bare-nosed Wombat	X	X	X	X	X	X	X	X	X
Brown Antechinus				X		X		X	X
Bush Rat	X	X	X	X	X	X	X	X	X
Cat							X		
Chocolate Wattled Bat		X	X	X		X	X	X	
Common Brushtail Possum			X	X		X			
Common Dunnart								X	
Common Ringtail Possum				X	X				
Dingo, domestic dog		X		X	X	X	X	X	X
Eastern False Pipistrelle		X	X	X	X	X	X	X	X
Eastern Free-tailed Bat					X		X		
Eastern Grey Kangaroo	X	X	X	X		X	X	X	
Eastern Horseshoe-bat				X	X	X		X	
Eastern Pygmy-possum		X	X				X		
Fox		X		X	X	X	X	X	X
Gould's Long-eared Bat			X						
Gould's Wattled Bat		X	X	X	X	X	X	X	
Greater Glider				X		X			
House Mouse		X	X					X	
Large Bent-winged Bat		X	X	X	X	X	X	X	X
Large Forest Bat			X	X	X	X	X	X	X
Large-eared Pied Bat		X		X	X	X	X	X	
Long-eared Bat sp.				X		X	X	X	
Rabbit		X					X	X	
Red-necked Wallaby	X	X		X	X	X	X	X	X
Southern Forest Bat			X	X	X	X	X	X	X
Sugar Glider				X					
Swamp Rat		X	X	X	X	X			X
Swamp Wallaby	X	X	X	X		X		X	
White-striped Freetail-bat	X	X	X	X	X	X	X	X	X
Yellow-bellied Sheath-tailed Bat				X	X				

Common Name	2014	2015	2016	2017	2018	2019	2020	2021	2022
BIRDS									
Australian Crake		X							
Australian King-Parrot		X	X		X		X		
Australian Magpie	X	X	X	X	X	X	X	X	
Australian Owlet-nightjar		X		X	X				X
Australian Raven	X	X	X	X	X	X	X	X	X
Australian Wood Duck							X		X
Bassian Thrush			X						
Beautiful Firetail			X		X				X
Black-faced Cuckoo-shrike	X	X	X	X	X	X	X	X	X
Brown Thornbill	X	X	X	X	X	X	X	X	X
Brown-headed Honeyeater	X	X	X	X	X	X	X		
Brush Cuckoo			X						
Buff-rumped Thornbill		X		X	X	X	X	X	X
Channel-billed Cuckoo		X							
Chestnut-rumped Heathwren				X		X			
Cicadabird		X		X	X		X		
Collared Sparrowhawk							X		X
Common Bronzewing								X	
Crescent Honeyeater				X	X				
Crimson Rosella	X	X	X	X	X	X	X	X	X
Dusky Woodswallow					X				
Eastern Rosella		X		X			X	X	
Eastern Shrike-tit	X	X	X	X	X	X	X	X	
Eastern Spinebill	X	X	X	X	X	X	X	X	X
Eastern Whipbird		X	X	X	X	X	X	X	X
Eastern Yellow Robin	X	X	X	X	X	X	X	X	X
Fan-tailed Cuckoo	X	X	X	X	X	X	X	X	X
Flame Robin	X	X	X	X	X	X	X		X
Gang-gang Cockatoo	X	X	X	X	X	X	X	X	
Golden Whistler	X	X	X	X	X	X	X	X	
Grey Butcherbird			X	X	X		X	X	X
Grey Currawong	X	X	X	X	X	X	X	X	X
Grey Fantail	X	X	X	X	X	X	X	X	X
Grey Shrike-thrush	X	X	X	X	X	X	X	X	X
Horsfield's Bronze-Cuckoo			X						

Common Name	2014	2015	2016	2017	2018	2019	2020	2021	2022
Laughing Kookaburra	X	X	X	X	X	X	X	X	X
Leaden Flycatcher		X	X	X	X				X
Masked Woodswallow		X							
New Holland Honeyeater	X	X	X	X	X	X		X	X
Noisy Friarbird				X	X	X	X	X	X
Olive-backed oriole			X		X				
Painted Button-quail				X			X	X	X
Pallid Cuckoo							X		
Pied Currawong	X	X	X	X	X	X	X	X	X
Pilotbird					X	X		X	X
Powerful Owl				X	X				
Red Wattlebird	X	X	X	X	X	X	X	X	X
Red-browed Finch		X			X				X
Red-browed Treecreeper	X	X	X	X	X	X	X	X	
Red-capped Robin		X		X					
Rufous Fantail				X					
Rufous Whistler	X	X	X	X	X	X	X	X	X
Sacred Kingfisher	X	X	X	X	X	X	X	X	
Satin Bowerbird	X				X	X			X
Satin Flycatcher	X			X		X	X	X	
Scarlet Robin		X	X	X	X	X	X	X	X
Shining Bronze-Cuckoo				X	X	X			
Silvereye	X	X	X	X	X	X		X	X
Southern Boobook	X		X	X	X	X	X	X	X
Southern Emu-wren			X		X	X			
Spotted Pardalote	X	X	X	X	X	X	X	X	X
Spotted Quail-thrush				X	X	X	X		
Striated Pardalote	X	X	X	X	X	X	X	X	X
Striated Thornbill	X	X	X	X	X	X	X	X	X
Sulphur-crested Cockatoo						X			
Superb Fairy-wren	X	X	X	X	X	X		X	X
Superb Lyrebird		X		X	X	X	X	X	X
Tawny Frogmouth			X				X	X	X
Tree Martin	X	X	X		X	X			
Varied Sittella		X			X	X		X	
Variegated Fairy-wren				X	X				

Common Name	2014	2015	2016	2017	2018	2019	2020	2021	2022
Wedge-tailed Eagle	X		X	X					
Welcome Swallow					X				
White-browed Scrubwren	X	X	X	X	X	X	X	X	X
White-eared Honeyeater	X	X	X	X	X	X	X	X	X
White-naped Honeyeater	X		X	X	X	X	X	X	X
White-throated Gerygone	X	X	X	X	X				X
White-throated Treecreeper	X	X	X	X	X	X	X	X	X
White-winged Chough				X	X	X	X	X	
White-winged Triller		X							
Yellow-faced Honeyeater	X	X	X	X	X	X	X	X	X
Yellow-tailed Black-Cockatoo	X	X	X	X	X	X	X	X	X
REPTILES									
Blue Mountains Water Skink							X	X	X
Blotched Blue-tongue						X			
Common Scaly-foot		X							
Copper-tailed Skink		X		X	X	X	X	X	X
Cunningham's Skink				X					
Dark-flecked Garden Sunskink		X	X	X	X	X	X	X	
Eastern Brown Snake						X			
Eastern Small-eyed Snake				X		X			X
Eastern Water Dragon		X	X						
Highland Copperhead								X	
Lesueur's Velvet Gecko				X					X
Mountain Dragon				X		X	X		
Pale-flecked Garden Sunskink		X	X	X	X	X	X	X	X
Red-bellied Black Snake				X					
Red-throated Skink		X				X		X	X
Tussock Skink								X	
Weasel Skink					X		X		
White's Skink		X							
Yellow-bellied Water-skink	X		X	X	X	X	X	X	
AMPHIBIANS									
Bibron's Toadlet				X	X		X	X	X
Blue Mountains Tree Frog							X	X	X
Common Eastern Froglet	X	X	X	X	X	X	X	X	X

Common Name	2014	2015	2016	2017	2018	2019	2020	2021	2022
Eastern Banjo Frog		X	X		X				
Peron's Tree Frog								X	
Verreaux's Frog					X				
INVERTEBRATES									
Giant Dragonfly	X	X	X	X			X		

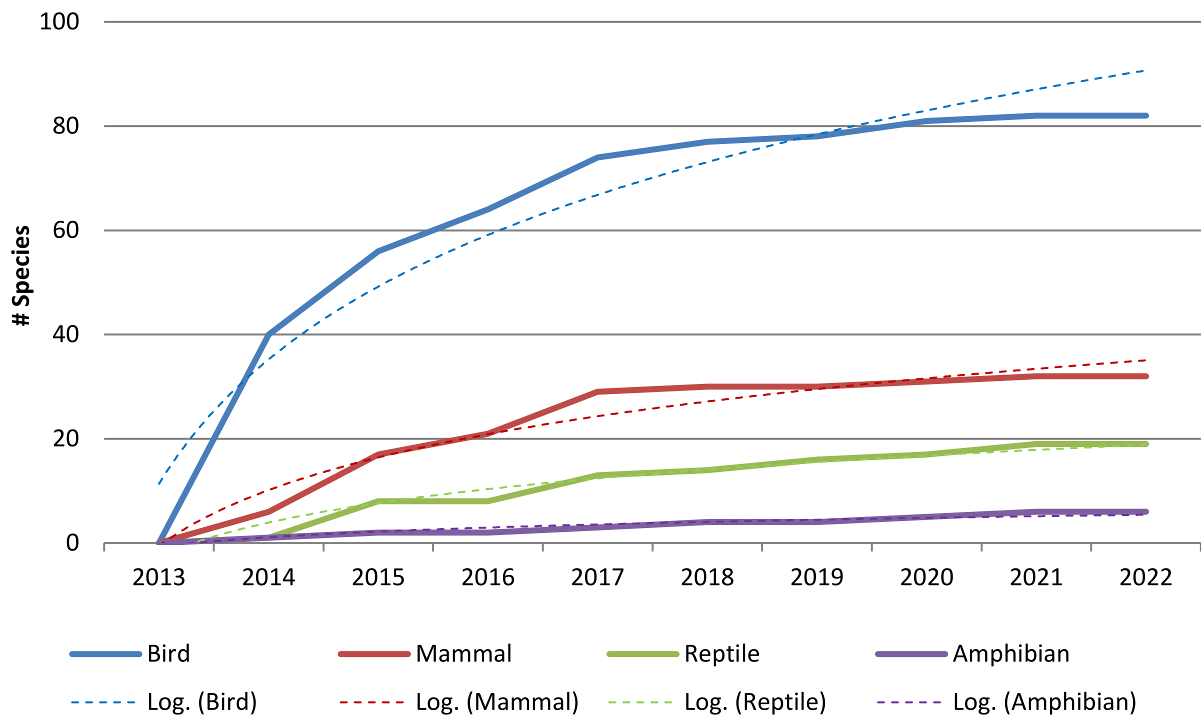

Figure 5-1: Cumulative new species in the 900 Area (including exotic species)

In terms of cumulative species curves, the trends for all groups are starting to level off, which is to be expected with nine years of surveys. It will be a while until the curves level out completely, as there are many Newnes Plateau species yet to be discovered in the area. The accumulation of new species is slowing, with no new species recorded in 2022.

CRITERIA USED TO MONITOR FAUNA

Most fauna monitoring surveys produce a species list that shows what animals were found within a specified area. Lists alone however do not provide the necessary criteria to determine whether an activity is affecting fauna populations through time. Consequently, it is important to provide a set of criteria that can be used to compare fauna populations within an area over time. The criteria must be relatively simple, easy to interpret and the processes required to develop each criterion must be consistent and repeatable.

To ensure such criteria are used in the long-term monitoring of fauna within the 900 Area, a set of quantifiable indices have been developed and adopted for this project.
The detailed surveys now provide sufficient information to establish a series of 'monitoring trigger points' i.e. single values that can be used to determine whether any significant changes have occurred in fauna populations over time. Monitoring trigger points being developed are:

- Species richness of faunal groups
- Diversity indices of faunal groups
- Population status of individual species
- Capture rates of individual species
- Population status of faunal groups
- Contribution to the faunal assemblages by threatened species, species dependent upon woodland and by species declining in the Central West of NSW
- Habitat complexity scores

Species richness of faunal groups

The number of species within each faunal group provides an index of its biodiversity. It is assumed that the higher the species richness, the higher the biodiversity. A high biodiversity index value indicates an area containing a complex variety of natural habitats in good condition. The species richness values for the surveys from 2014 to 2022 are given in **Table 5-8** and are graphed in **Figures 5-3** and **5-4**.

Simpson's diversity index of faunal groups

Simpson's diversity index combines species richness and species abundance to provide a better indication of biodiversity. The closer the Simpson's Index of Diversity is to one, the higher the biodiversity, and by implication, the better the area is for fauna. Simpson's Index of Diversity for the three main faunal groups over time are given in **Table 5-8** and the values of the diversity index are illustrated in **Figure 5-2**. This provides an indication of the productivity of each faunal group over time.

Temporal differences in autumn bird, mammal and reptile diversity measures were analysed using a series of One-way Repeated Measures ANOVAs, using just the two 900 Area sites. There were no significant differences over time. In spring, data from additional Clarence and Springvale sites was included. Spring bird abundance was significantly lower in 2022 compared to 2014 and 2017-19; and lower in 2020-21 compared to 2018 ($p < 0.001$). Bird species richness was significantly lower in 2022 compared to 2014-19; lower in 2021 compared to 2014 and 2017-18; and lower in 2020 compared to 2017-18 ($p < 0.0001$). Mammal abundance was significantly higher in 2019 compared to 2014-15 and 2020-22 ($p < 0.0001$). Reptile abundance was significantly higher in 2020 compared to 2015-16, 2018 and 2021-22; and higher in 2017 compared to 2015 and 2022 ($p < 0.001$). Reptile species richness was significantly higher in 2017 compared to 2015 ($p = 0.003$). It should be noted that some sites had reduced survey effort in 2022 compared to most other years.

Survey conditions have a large influence on survey success, and this year's conditions were generally wet and overcast. As reptiles rely directly on their environment for energy input, any survey conducted in wet or cold conditions is likely to result in low reptile activity. Reptile Simpson's declined from 2015, though 2019-21 saw an upturn in the trend. Conversely, reptile species richness has been increasing through time. This could be due to increased detectability post fire. Amphibian Simpson's and richness were increasing slowly through time, with 2022 falling off. 2020 was the highest amphibian Simpson's on record, but 2021 saw Simpson's fall, while richness was equal highest with 2018. Despite the wet weather, amphibian diversities saw little change from 2021 into 2022. Mammal species richness fluctuates and 2022 presented lower than average levels. Mammal Simpson's is starting to show a slight declining trend over the long term. Bird Simpson's is stable over time. Bird richness was increasing, but 2019-22 has seen a declining trend, with 2022 the second lowest on record. The increases in diversities are expected as the Area has only been surveyed for nine years. Drought conditions impacted amphibian and bird diversities in 2019, and the extensive fire that burned through in December 2019 has reset the post fire system again. Changes in abundance are probably due to climatic changes over time rather than impacts from mining, as none of the sites were undermined before spring 2022. Data from these sites were used as control data for other SMP area final reports, but from this report the statistics will be fixed to account for the undermining of 900 South in August 2022. Overall, the biodiversity indices are similar to that found elsewhere in Newnes Plateau and indicate a representative base-line sample to be used for on-going monitoring.

Table 5-8: Biodiversity indices for birds, mammals and reptiles over time

Group	Diversity index	2014	2015	2016	2017	2018	2019	2020	2021	2022
Birds	Simpson's	0.967	0.966	0.960	0.965	0.957	0.961	0.955	0.953	0.953
	Species richness	40	51	50	59	62	51	49	47	45
***Native Mammals**	Simpson's	0.786	0.856	0.729	0.799	0.747	0.704	0.763	0.775	0.731
	Species richness	5	7	7	12	6	10	6	8	6
Reptiles	Simpson's	NA	0.911	0.750	0.671	0.538	0.727	0.699	0.787	0.638
	Species richness	1	7	4	9	5	9	7	8	6
Amphibians	Simpson's	NA	0.167	0.333	0.286	0.417	0	0.479	0.187	0.184
	Species Richness	1	2	2	2	4	1	3	4	3

*Bats not included

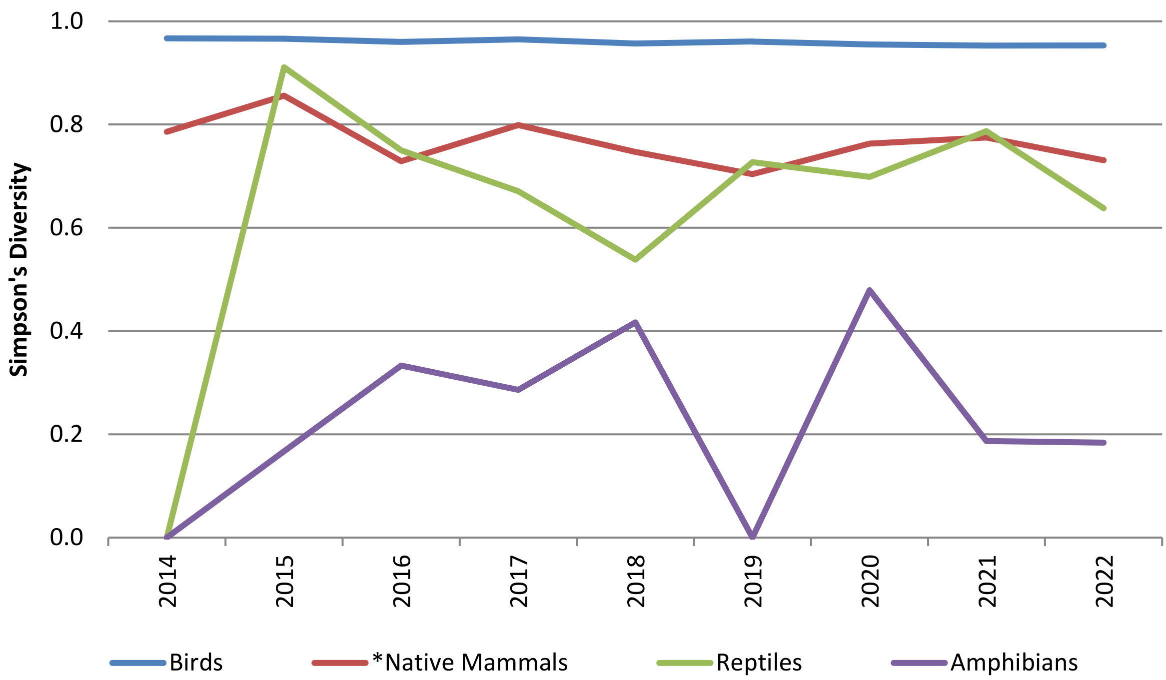

Figure 5-2: Simpson's Diversity for the 900 Area over time

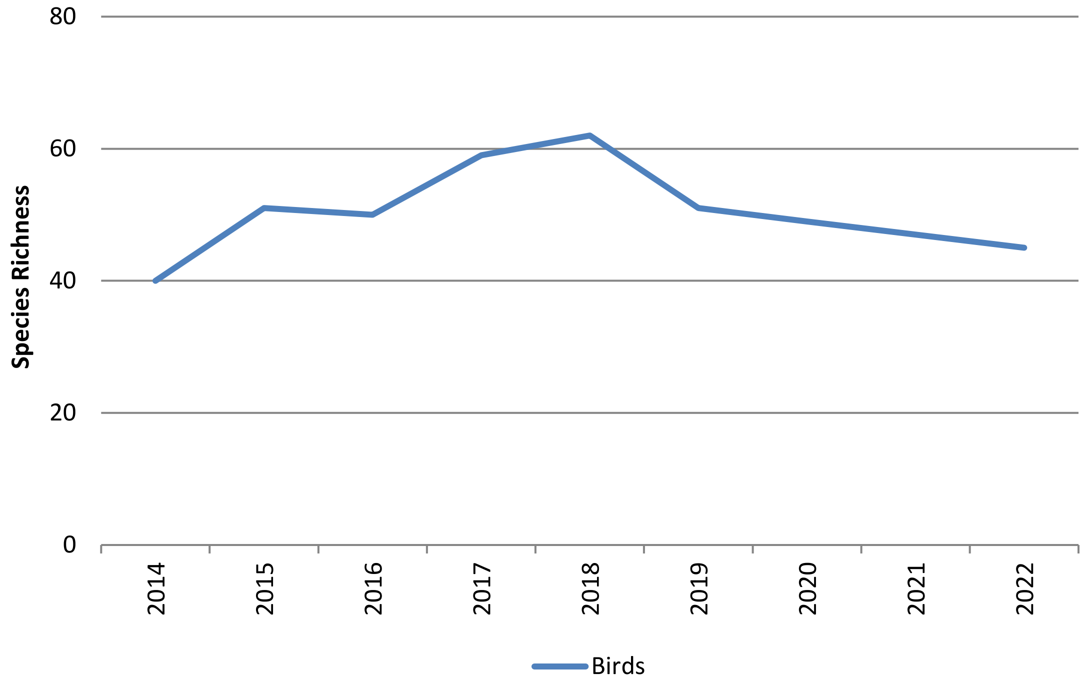

Figure 5-3: Species Richness for birds of the 900 Area over time

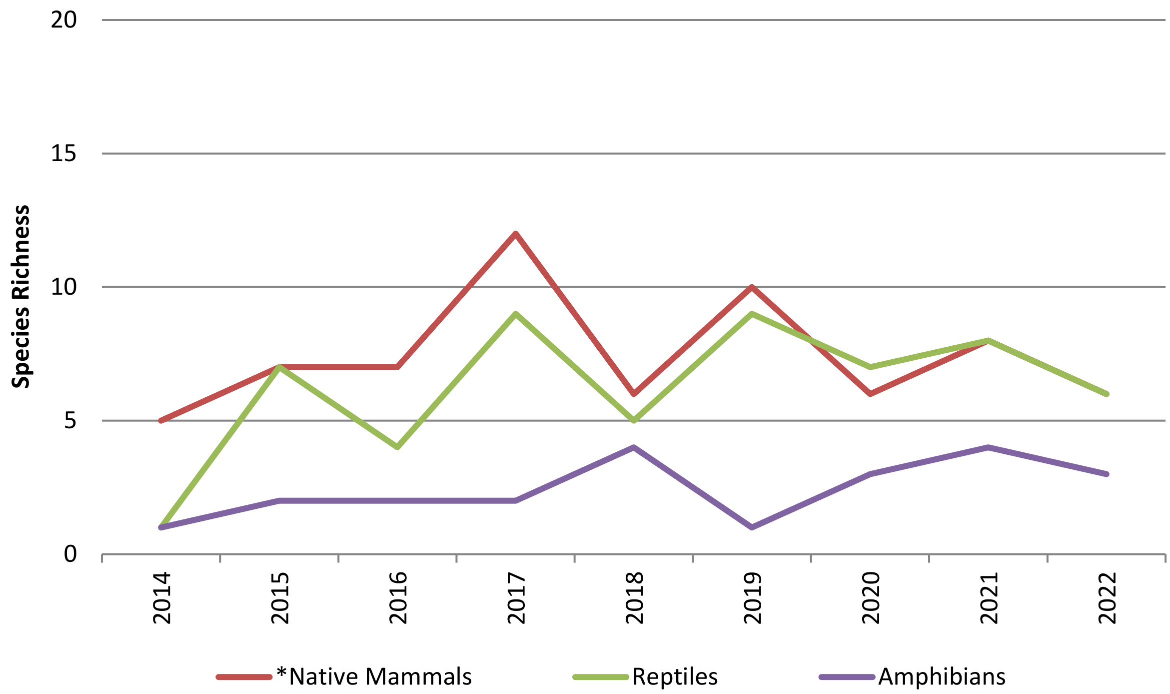

Figure 5-4: Species Richness for mammals, reptile and amphibians of the 900 Area over time

Capture rates of individual species

It is possible to calculate the trapping rates for small ground mammals within the 900 Area. Such values can be used as a surrogate for population size of each species captured and is important for long-term monitoring. Trapping rates for all small mammals captured in 2014 to 2022 are given in **Table 5-9** and shown in **Figure 5-5**.

The numbers of small mammals trapped in 2020 dropped to similar levels seen after the 2013 fire (**Figure 5-5**). Capture rates increased from 2014 as animals recolonised or bred up post fire, but the second fire in 2019 has reset the trend. Two years after the 2019 fire, levels are equal with those seen three years after the 2013 fire, however trapping rates declined again into spring 2022. Antechinus numbers did not look to be as impaired by the second fire as rodent numbers were. Dusky Antechinus have never been captured in the 900 Area, but are encountered in the nearby CLW Area. House Mice were captured in the 900 Area two years after the first fire, and 1.5 years after the second fire. This species is known to invade disturbed areas, but hasn't been captured here since autumn 2021. Also absent is the exotic Black Rat that has turned up in some other parts of the plateau.

Table 5-9: Mean trapping rates of small mammals in autumn and spring over time

Species	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Rattus fuscipes	-	0.5	1	1	2.5	9	7	11	7.5	12.5	18	17.5	1.5	0.5	0.5	8.5	2	7.5
Rattus lutreolus	-	0	0.5	2	2	5	3	4	4	7.5	4.5	10.5	0	0	0	0	1.5	1
Mus musculus	-	0	0	3	4	0	0	0	0	0	0	0	0	0	1	0	0	0
Antechinus agilis	-	0	0	0	0	0	2	0	6.5	1	6.5	2	4	2.5	7.5	4	8.5	1
Antechinus stuartii	-	0	0	0	0	0	1.5	0	0	0	2.5	1	0	0	1.5	0.5	1.5	0
Antechinus	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cercartetus nanus	-	0	0	0	0.5	0	0	0	0	0	0	0	0.5	0	0	0	0	0
Sminthopsis murina	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0
Total	**-**	**0.5**	**1.5**	**6**	**9**	**14**	**13.5**	**15**	**18**	**21**	**32**	**31**	**6**	**3**	**11**	**13**	**13.5**	**9.5**

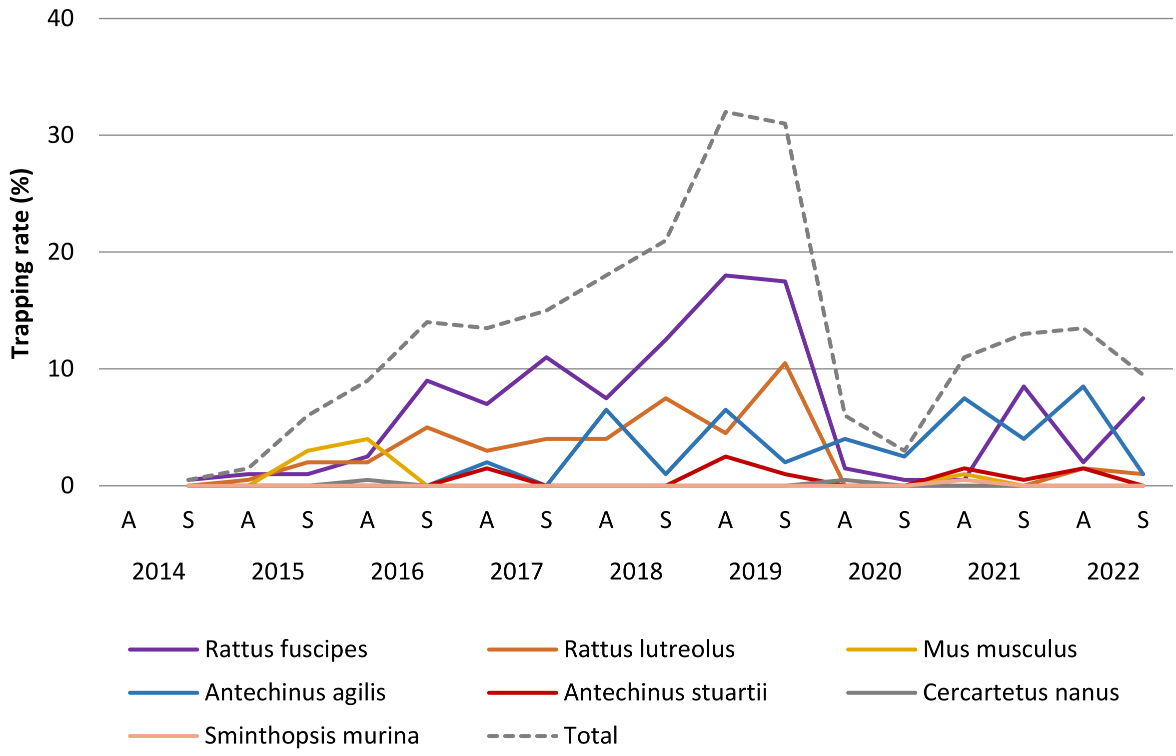

Figure 5-5: Trapping rates for small ground mammals over time

Population status of a species

Derivation of the local population status of species located at Clarence 900 Area requires a relatively large dataset. Population status is based upon the numbers and distribution of each species within the 900 Area. This data is still being collected and is part of an ongoing process to provide sufficient information to allow assignment of population status of species known to occur.

Contribution to the faunal assemblages by threatened species, species dependent upon woodland, and species declining in Central West NSW

Bird species have been classed by Reid (2000)[6] into woodland dependant and declining in the Central West. These lists were used to calculate the proportion of birds located within the 900 Area that are considered under threat. The higher the proportion, the greater the value that can be placed on the present habitat in the area.

[6] Reid J.R.W. (2000). *Threatened and Declining Birds in the New South Wales Sheep Wheat Belt2. Landscape relationships – Modelling bird atlas data against vegetation cover*. Consultancy Report to NSW National Parks and Wildlife Service. CSIRO Wildlife and Ecology, Canberra.

On inspection of the bird species list (**Table 5-2**), the following proportions calculated for the 900 Area over time are given in **Table 5-11** and **Figure 5-6**. The proportion of woodland-dependent and declining bird species has declined over the 2017-20 period. This is probably due to the dry conditions experienced followed by fire. Proportions of woodland birds experienced minor recovery in 2021-22, but proportion of declining bird species was the lowest on record in 2022. Significant changes to this figure may indicate changes to the condition of the woodland habitat.

The number of threatened species has varied over the years, but remains fairly stable over the long term (**Table 5-10** and **Figure 5-7**). Six threatened species were located during the 2022 surveys. These were the Eastern False Pipistrelle, Large Bent-winged Bat, Pilotbird, Scarlet Robin, Flame Robin and Blue Mountains Water Skink. Locations of threatened species are given in **Figure 5-8**. This is one of the few areas on the Plateau to record Blue Mountains Water Skink in 2022, with the species seen at both swamps in the 900 Area. Despite large numbers of Giant Dragonfly being seen in 2020, none were located across the Plateau this summer. Other areas show increases in numbers of threatened species over time, but this area has declined over the last two years, with 2022 wqual low with 2015 and 2021.

Habitat Complexity Scores

Data on Habitat Complexity Scores are covered in Section 4 (see **Table 4-2** and **Figure 4-3**). The main benefit from this approach is the production of a single number that can represent habitat values. By tracking such numbers over time some insight into changes in habitat values may be possible.

Table 5-10: Threatened species in 900 Area in autumn (A) and spring (S) over time

Category	2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Woodland-dependent bird species (%)	-	-	-	-	-	-	64.5	65.4	64.9	74.5	65.6	72.7	75.0	71.1	82.8	77.4	73.1	75.8
Declining bird species (%)	-	-	-	-	-	-	6.5	7.7	2.7	8.5	9.4	6.8	4.2	7.9	10.3	9.7	3.8	6.1
Threatened species	-	4	3	7	4	4	5	8	5	7	5	5	6	4	6	3	4	3

Table 5-11: Proportion of woodland-dependent or declining birds in 900 Area each year over time

Category	2014	2015	2016	2017	2018	2019	2020	2021	2022
Woodland-dependent	83.7	83	83.7	66.1	64.5	64.7	69.4	74.5	73.3
Declining	13.5	14.8	13.9	8.5	8.1	7.8	8.2	10.6	6.7

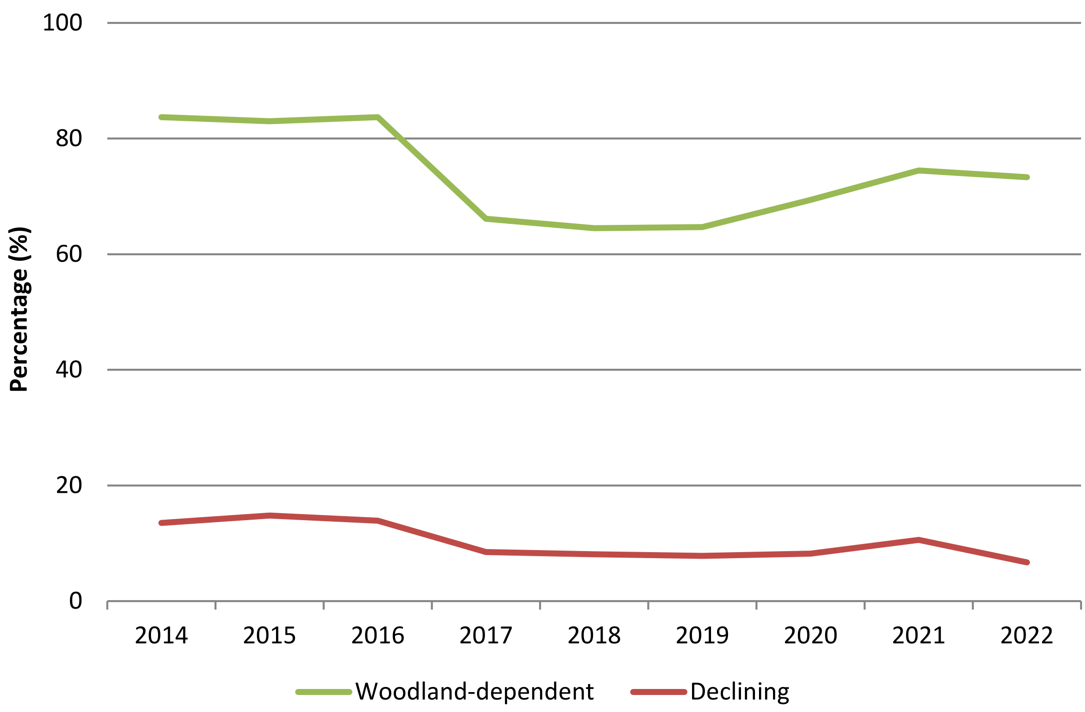

Figure 5-6: Proportion of woodland-dependent and declining bird species in 900 Area each year

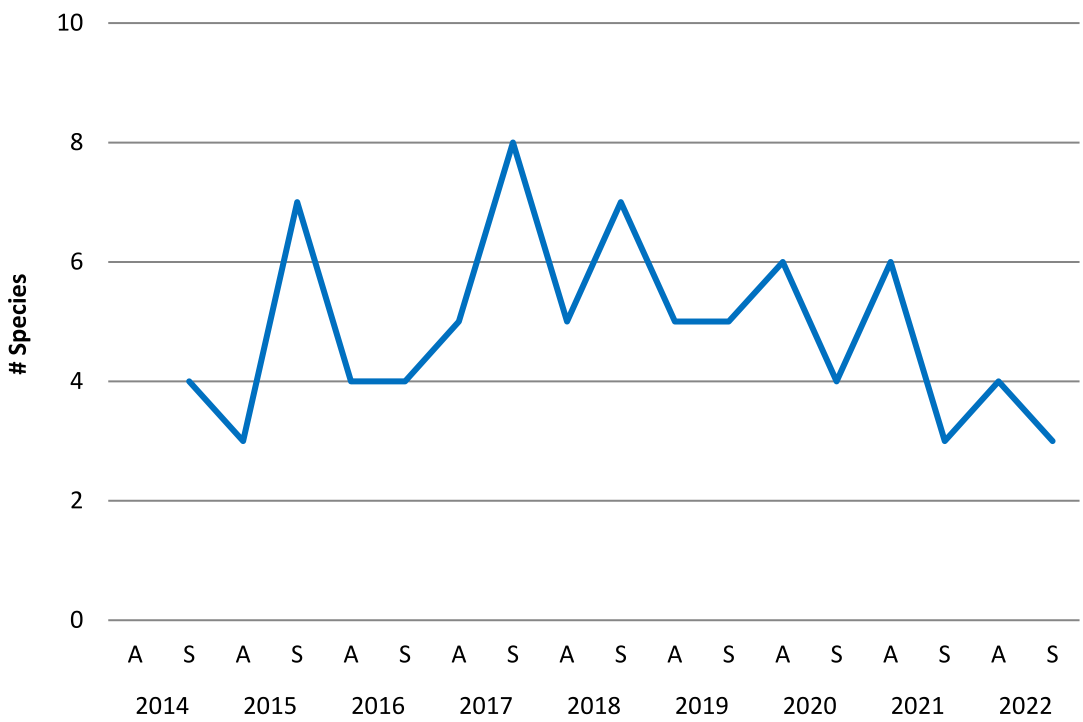

Figure 5-7: Number of threatened species in the 900 Area over time

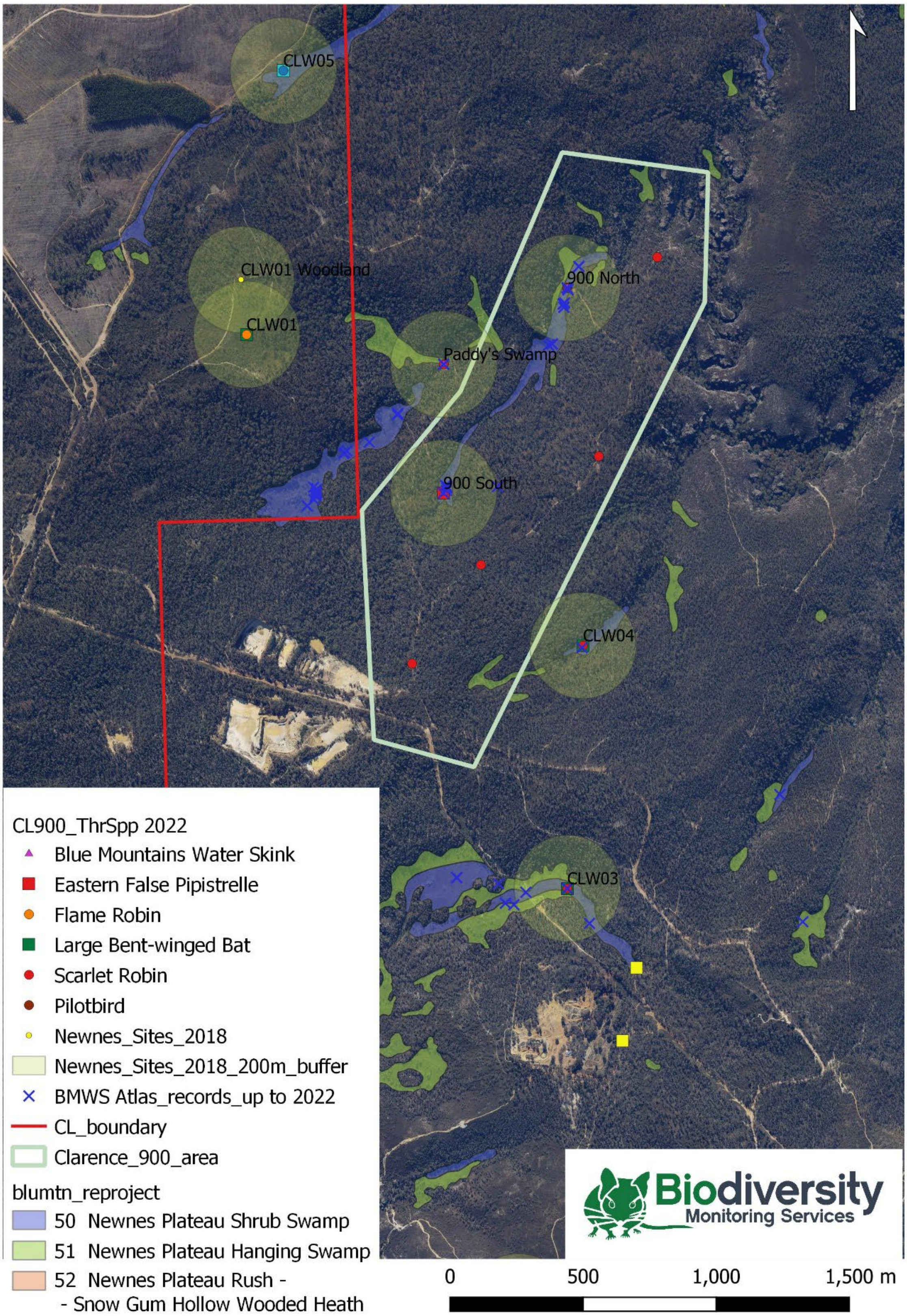

Figure 5-8: Threatened species located within Clarence 900 Area this year

Comparison between Treatment and Control sites

In December 2022, we discovered that 900 South had become undermined prior to the spring 2022 survey. The seasonal analyses in autumn still hold true, but those from spring used incorrect designation of sites. Diversity analyses are repeated here using the correct split of sites, with 900 South, CLW01 and CLW05 as treatment sites, and 900 North, Nine Mile and Paddy's as control sites. Note that 2023 will be the first complete year that 900 South is considered an "impact" site.

Treatment sites are CLW01 (undermined spring 2018), CLW05 (undermined spring 2018) and 900 South (undermined Aug 2022). Sites from the 900 Area (900 North) and Springvale New Area (Nine Mile and Paddy's Swamp) are used in the analysis as control sites. Further details on these sites are included in **Table 1-1** of this and the Clarence West 2022 Final Fauna Report. **Figure 5-9** to **5-11** show the control and impact fauna diversity values pooled for 2019-2022. **Figure 5-12** shows the HCS for control and impact sites pooled for 2019-2022. The following data is used in this comparison: bird, mammal, reptile and amphibian biodiversity indices, habitat cover characteristics and Habitat Complexity Scores. All sites burnt in both the 2013 and 2019 fires.

Pooled t-tests were conducted on all bird, native non-bat mammal, reptile and amphibian diversity measures to look for differences between control and impact sites in the fire recovery period. Bird Evenness, Simpson's and species richness were higher in control sites ($p = 0.028$, $p = 0.012$ and $p = 0.005$ respectively). Reptile richness was significantly higher in control sites ($p = 0.035$). Amphibian abundance was significantly higher in control sites ($p = 0.013$). T-tests from autumn and spring generally concur with these assumptions, though no differences in reptile diversity were observed seasonally.

There was no significant difference in HCS between control and impact sites over the CLW/900/control areas, in spring or autumn.

Overall, there is evidence to suggest reduced bird, reptile and frog diversity in undermined sites post fire, noting two of the sites used come from the CLW area. Results are inconsistent across taxa and season, so severe impact is unlikely. There is far greater variation in fauna diversities over time, which come from the effects of fire, drought and other climatic changes. Some changes are consistent with previous years findings, others are new. Monitoring for consistent differences going forward will be important.

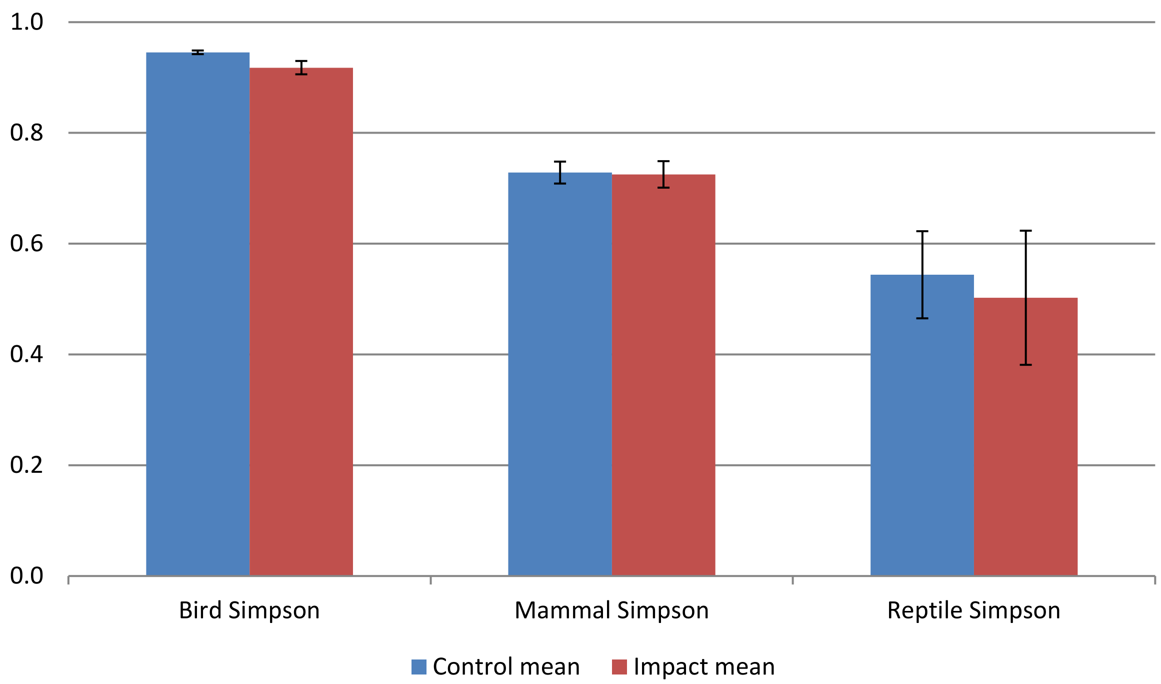

Figure 5-9: Simpson's Diversity Index for birds, mammals and reptiles in control and impact sites

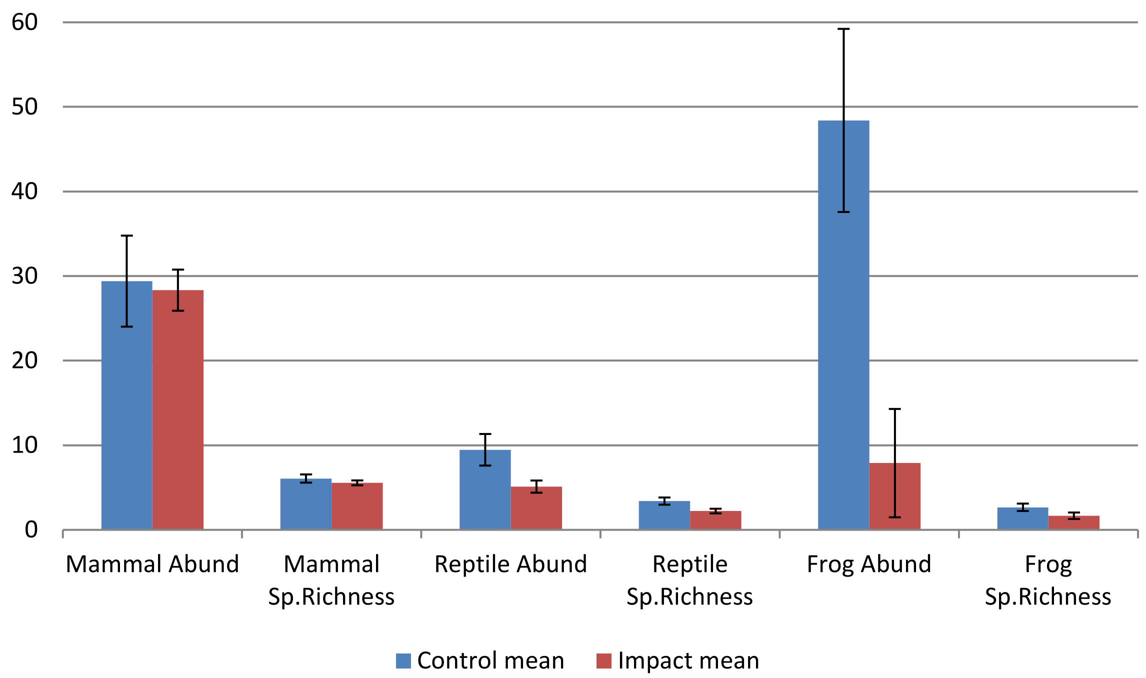

Figure 5-10: Abundance and Species Richness for mammals, reptiles and amphibians in control and impact sites

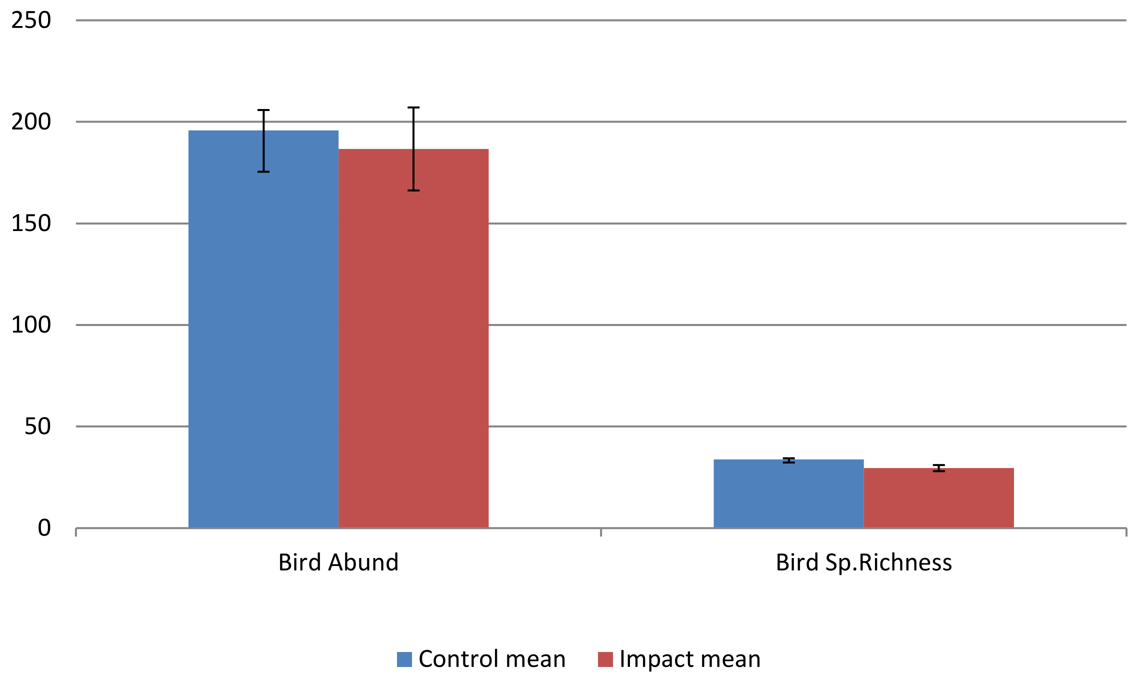

Figure 5-11: Abundance and Species Richness for birds in control and impact sites

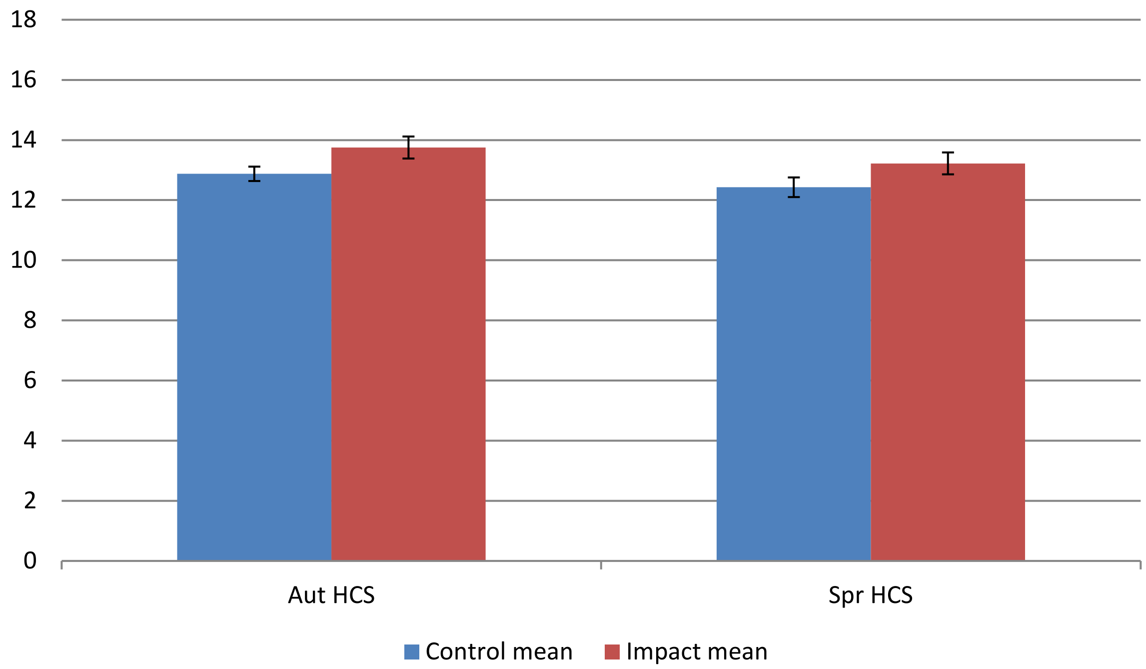

Figure 5-12: Autumn and spring Habitat Complexity Scores for control and impact sites

Bat Activity

Another index that can be derived from the survey data is the species richness and activity of bats over time. Ultrasonic recording with the Anabat device does not allow individual numbers of bats to be ascertained. It does however, let us get an idea of species richness and overall bat activity in an area. Results from the years bat surveys are presented in **Figure 5-13**.

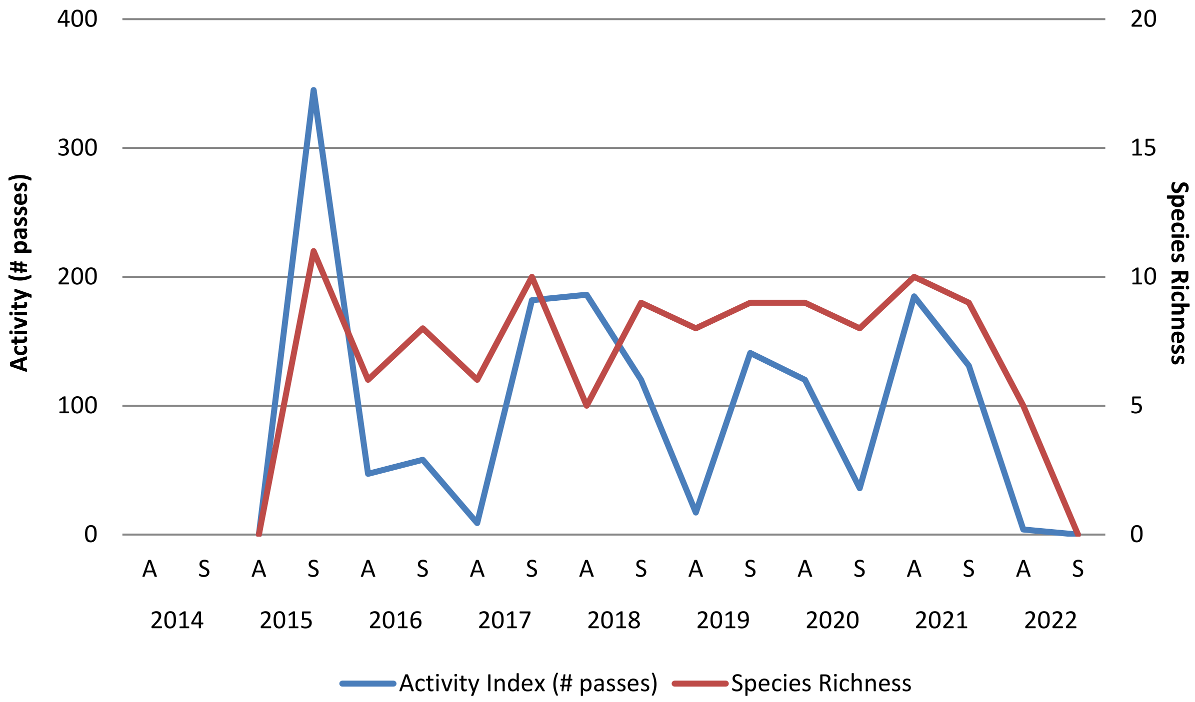

Figure 5-13: Bat species richness and activity index over time

6.0 Conclusion

The results from the survey of the Clarence Colliery 900 Area in 2022 show that the assemblages found are more typical of that found throughout Newnes Plateau than we would expect after extensive fires swept through the area in December 2019. The timing of the survey was successful, in terms of the number of individuals and diversity of species within the main fauna groups surveyed, though reduced survey efforts of some sites used in analyses were experienced in 2022 due to access issues. Species richness was on average for reptiles and amphibians, and on the lower side of average for birds and mammals. Richness for all four groups declined since last year. Bird and mammal Simpson's were stable, possibly showing the slightest decline over time. Mammal Simpson's and richness are relatively stable over the long term, but trapping rates declined sharply post fire. They had been tracking up since the State Mine fire, but the Gospers Mountain fire reset the system. Recovery of small mammal captures was tracking in advance of the previous fire, but stalled in 2022. Reptile Simpson's and richness were average, noting that wet survey conditions in 2021-22 did not favour this group. Low numbers in 2014 are due to the fact surveys only began in spring 2014, so survey effort was greatly reduced. Despite the wet conditions, amphibian diversity indices showed no growth in 2022. Reduced access/survey effort and cool conditions may explain this.

Swamps in this area had peat mostly consumed and canopy layers were fully burnt, so finding Blue Mountains Water Skink in 2021 was surprising. This species was found again in 2022, with three records across the two 900 Area swamps. The availability of rock outcropping near 900 North means refugia for small mammals allowed some to survive the fire, particularly Antechinus. Bat species richness and activity were very low in 2022, but this is expected with cold wet conditions. As is often the case with fire, once the vegetation and associated food source is wiped out, there is a delay in seeing return of species to the landscape. There were sufficient numbers and diversities of these fauna groups to be able to calculate a set of diversity indices that form part of the baseline monitoring database. Above average rainfall in most months since fire appears to have helped start the regeneration process on the Plateau. Fauna results have followed with overall abundance down, but most functional groups represented.

Six threatened species were located during 2022, as well several bird species dependent upon woodland habitats. Threatened species included the Eastern False Pipistrelle, Large Bent-winged Bat, Pilotbird, Scarlet Robin, Flame Robin and Blue Mountains Water Skink. Their locations are shown in **Figure 5-8**. Spring 2022 was the equal lowest number of threatened species recorded since surveys began. The swamps of the 900 Area have always contained suitable habitat for Blue Mountains Water Skink. Reptiles often have lower detection rates due to their cryptic nature and requirement for particular survey conditions, so it is good to record this species for the second year running. The Gospers Mountain fire affected the fauna and habitats within the 900 Area, with a number of measured parameters falling.

Now that 900 South has been undermined, we can start to look for potential impacts from undermining in the 900 Area. With only two sites, one undermined, one not, we cannot use statistics ot make this comparison. As such, sites from the surrounding Clarence West Area are added to the analysis. To date, the monitoring provides important baseline data for tracking the recovery of fauna from fire into the future. It also provides important data to compare the rates of recovery within areas that have been previously mined and those still to be mined or used as controls.

Given the low levels of subsidence from previous mining at Clarence Colliery, and the predicted low levels (30mm) of subsidence for 900 Area, the risk of adverse impacts on fauna within this area is considered to be low. The monitoring of recovery from fire within those sites mined and un-mined will be an important tool in the on-going assessment of mining activities.

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Fauna Report

Western SMP Application Area Terrestrial Fauna Monitoring Report (2022 Final)
for
Clarence Colliery Pty Ltd

Prepared for: Matt Ribas
Prepared by: Biodiversity Monitoring Services
Date: 27 January 2023

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FAUNA MONITORING WITHIN THE WESTERN SMP APPLICATION AREA AT CLARENCE COLLIERY

2022 FINAL

A report by Biodiversity Monitoring Services, January 2023

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Figures and tables

1.0 Background

Six long-term fauna monitoring sites have been established at Clarence Colliery to identify potential impacts of mining induced subsidence on native fauna within the Western Subsidence Management Plan (SMP) areas. The Western SMP areas now include the existing approved 700 SMP Area plus the proposed 700 West SMP application area. The 700 West SMP application area is an extension of the 700 Area and an application was submitted for approval in December 2011. For the purposes of this report, the existing 700 SMP Area and the proposed 700 West SMP Area will be collectively known the CLW Area.

The aim of the surveys to date has been to collect terrestrial fauna base-line data within the SMP area to be used to monitor changes (if any) in populations that may occur over time. Information regarding the presence of fauna, species diversity, population numbers and habitat characteristics were also obtained. This is the 16th year of these surveys.

Sites were chosen to ensure sampling of fauna within areas where underground mining (secondary extraction) has occurred (treatment sites), and areas where mining will not occur (control sites). The separation of control and treatment sites will provide comparative data to monitor any effects from underground mining within the CLW Area. The six sites surveyed were:

1) ***CLW01*** Located along the ridge to the east of the start of the (now cleared) pine plantation on Glowworm Tunnel Rd. The site covers the low heath of the pagoda complex and surrounding woodland. This site was affected by both the State Mine and Gospers Mountain fires. This site was undermined in spring 2018 so can now be used as a treatment site. <u>Not sampled in summer 2019</u>.

2) ***CLW02*** Located to the west of Old Bells Line of Rd where the powerline makes its second crossing, before the turnoff to the motorbike park. The site covers the shrub swamp, as well as the surrounding woodland. At the time of the survey there was no ground water in the swamp, though there was water in an old drillers pit. This site was affected by both the State Mine and Gospers Mountain fires. This site is subject to undermining so is considered as a treatment site. <u>Not sampled in spring-summer 2019. Only sampled for two nights/three days in autumn 2022</u>.

3) ***CLW03*** Located to the north of the motorbike park in Happy Valley Springs catchment. The site samples the shrub swamp, as well as the surrounding woodland. The site begins just beyond the big gate installed by Forestry Corporation. This site was affected by both the State Mine and Gospers Mountain fires. Burnt vegetation is recovering well. This site is subject to undermining so is considered as a treatment site. <u>Not sampled in spring-summer 2019</u>. <u>Only sampled for two nights/three days in autumn 2022</u>.

4) ***CLW04*** Located to the north of Old Bells Line of Rd to the south of Clarence 900 Area. The site samples shrub swamp and surrounding woodland. This site was affected by both the State Mine and Gospers Mountain fires. This site is subject to undermining so is considered as a treatment site. <u>Not sampled in spring-summer 2019</u>. <u>Only sampled for two nights/three days in autumn 2022</u>.

5) ***CLW05*** Located to the east of Bungleboori camping area downslope of the (now cleared and burnt) pine plantation. The site samples shrub swamp, as well as the surrounding woodland. Though the swamp has been through periods of drying and wetting over the years, it is currently in a dry state with no water pooling in any part of the site. The site only partially burnt in the 2013 State Mine fire and large patches of Leptospermum shrubs remained unburnt. It burnt in full during the 2019 Gospers Mountain fire. This site entered into the influence of drawdown in December 2018, so will be considered an impact site from autumn 2019. Not sampled in summer 2019.

6) ***CLW06*** Located on the ridge above the Lithgow water supply valley to the south of the motorbike park and west of Old Bells Line of Rd. The site samples hanging swamp/pagoda community, as well as surrounding woodland. This site was affected by both the State Mine and Gospers Mountain fires. Cages were set back up the track in the closest woodland. This site is subject to undermining so is considered as a treatment site. Not sampled in spring-summer 2019. Only sampled for two nights/three days in autumn 2022.

The Clarence West Area (CLW) is close to the 900 Area, and the two 900 sites (A North, B South) are currently suitable for inclusion as control sites in the CLW analyses as they have not yet been undermined. The use of CLW01 and CLW05 as controls has now ceased as late 2018 saw them undermined or under the influence of drawdown as part of Springvale ALA5 Southern Longwall Area. Through previous discussion with Catherine Suggate, Springvale have agreed to monitor two replacement control sites - Nine Mile Swamp and Paddy's Swamp. The results from the on-going monitoring surveys of the two additional sites will complement the data from the existing sites. Details for the two new control sites are as follows:

7) ***Nine Mile Swamp*** Located to the north east of Bungleboori camping area at the intersections of Nine Mile and Pine Swamps (down swamp of CLW05). The swamp is situated downslope of the (now cleared and burnt) pine plantation to the south and north. This site was affected by both the State Mine and Gospers Mountain fires, though the burn in 2013 could have been part of asset protection by Forestry Corp. The swamp is a good representative of Newnes Plateau Shrub Swamp and is to be used as a control site.

8) ***Paddy's Swamp*** Located at the eastern edge of Springvale Colliery near the Clarence 900 Area. The swamp is surrounded by native woodland. The swamp is surrounded by native woodland. This site was heavily affected by the State Mine and Gospers Mountain fires. Work started on the sand quarry upstream of the swamp in early 2020. The swamp is a good representative of Newnes Plateau Shrub Swamp and is to be used as a control site. Reduced sampling in spring 2022.

It is important to note that this baseline monitoring program has focussed on the Newnes Plateau Shrub Swamp and Hanging Swamp environments (albeit slightly different types) as they are considered to be the most sensitive habitat overlying the proposed mining area. It is also noted, that by virtue of the fauna monitoring methods, woodland habitats are also surveyed. The locations of the fauna monitoring sites are shown in **Figure 1-1**, with surrounding monitoring sites from Springvale and Clarence Collieries also included. The main roads and creeklines are shown along with the Clarence SMP Area boundary.

All of the sites in the CLW and CL900 Areas burnt in both the 2013 State Mine and 2019 Gospers Mountain fires. According to fire mapping it looks like all sites were burnt around the mid-late December 2019. Maps of the extents from each fire are shown in **Figure 1-2**. No summer surveys were conducted in 2019, with spring 2019 surveys for CLW02, CLW03, CLW04 and CLW06 also cancelled. Data used in the 2019 final report is pre fire, while all 2020-2021 data is post fire. CLW04, CLW05 and Paddy's swamps all had their peat layers almost fully consumed by the 2019 fire. Peat layers at CLW02, CLW03 and Nine Mile were only partially burnt. Most sites exhibited full canopy burn.

Due to the threatening snow conditions and subsequent State Conservation Area closure, sampling effort in autumn 2022 was reduced to two nights at four of the monitoring sites rather than the usual four night week. Approximately half of the usual sampling effort at sites CLW02/03/04/06 will be missing from the data, so comparative analyses over time should be wary of including the autumn 2022 data. High rainfall through 2022 meant the road to Paddy's swamp became impassable at the time of spring surveys. Physical trapping at Paddy's Swamp was not undertaken, so the restricted sampling effort must be considered when interpreting results for mammals. Bird surveys were undertaken over a reduced number of days (3 instead of 5).

Surveys were first undertaken during spring 2006, and were repeated in autumn, spring and summer thereafter to ensure a complete set of baseline data. The spring 2006 surveys used standardised methodology to establish baseline data for fauna populations to be used for on-going monitoring of the potential impacts from the development of the CLW Area. The methodology used is similar to that applied to long-term fauna monitoring surveys by Centennial Coal throughout Newnes Plateau. Surveys of the two new Springvale controls began in autumn 2018.

Table 1-1 provides information about each site, in terms of landscape characteristics and vegetation communities sampled. Vegetation communities were obtained from the Vegetation of the Western Blue Mountains mapping by Office of Environment and Heritage (OEH). In addition, habitat characteristics were measured at each site and these are provided in Section 4.

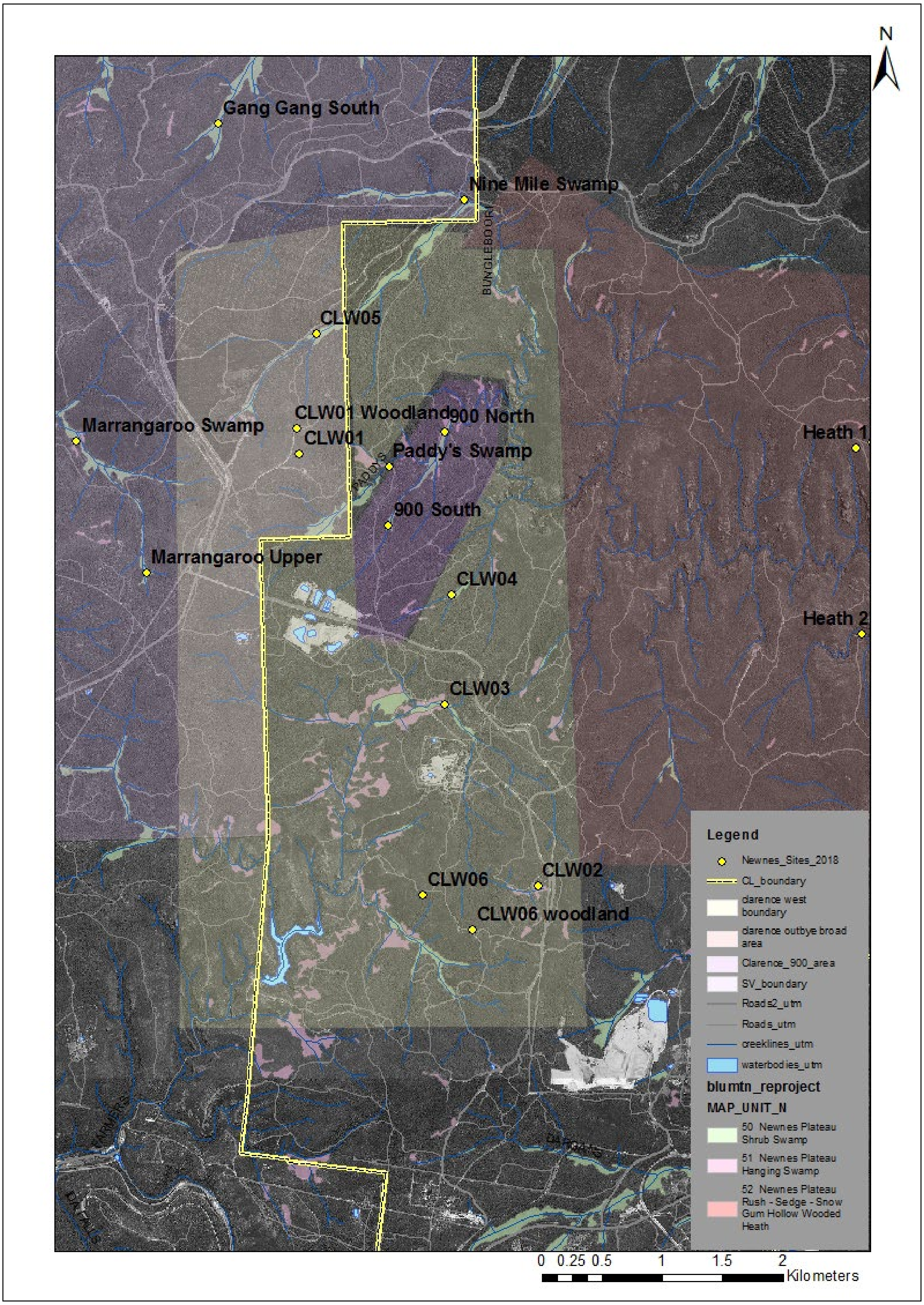

Figure 1-1: Locations of survey monitoring sites

Table 1-1: Locations of the monitoring sites at CLW Area

Site name	Easting	Northing	Landscape	Vegetation	Establishment date	Undermining date
CLW01	240634	6299166	Pagoda heath above steep-sided valley	Newnes Plateau Tea Tree – Banksia – Mallee Heath (high disturbance)	spring 2006	Mid 2018 (extraction)
CLW02	242610	6295587	Heath swamp within shallow-sided valley	Newnes Plateau Hanging Swamp (low disturbance), Newnes Plateau Gum Hollows variant: Brittle Gum – Mountain Gum, Scribbly Gum - Snow Gum Shrubby Open Forest (moderate disturbance)	spring 2006	March 2010 (extraction)
CLW03	241840	6297085	Heath swamp within steep-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance)	spring 2006	Sept 2010 (development), Dec 2010 (extraction)
CLW04	241899	6297998	Heath swamp within steep-sided valley	Newnes Plateau Shrub Swamp (low disturbance), Newnes Plateau Narrow-leaved Peppermint – Silver-top Ash Layered Open Forest (high disturbance)	spring 2006	April 2015 (development), November 2015 (extraction)
CLW05	240772	6300158	Heath swamp within steep-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance)	spring 2006	Dec 2018 (drawdown)
CLW06	241657	6295513	Pagoda heath above steep-sided valley	Newnes Plateau Dwarf Sheoak – Banksia Heath (high disturbance)	spring 2006	March 2011 (development), December 2011 (extraction)
Nine Mile Swamp	242000	6301270	Heath Swamp within steep-sided valley	Newnes Plateau Shrub Swamp (moderate disturbance)	autumn 2018	NA
Paddy's Swamp	241375	6299055	Heath Swamp within steep-sided valley	Newnes Plateau Shrub Swamp (low disturbance)	autumn 2018	NA

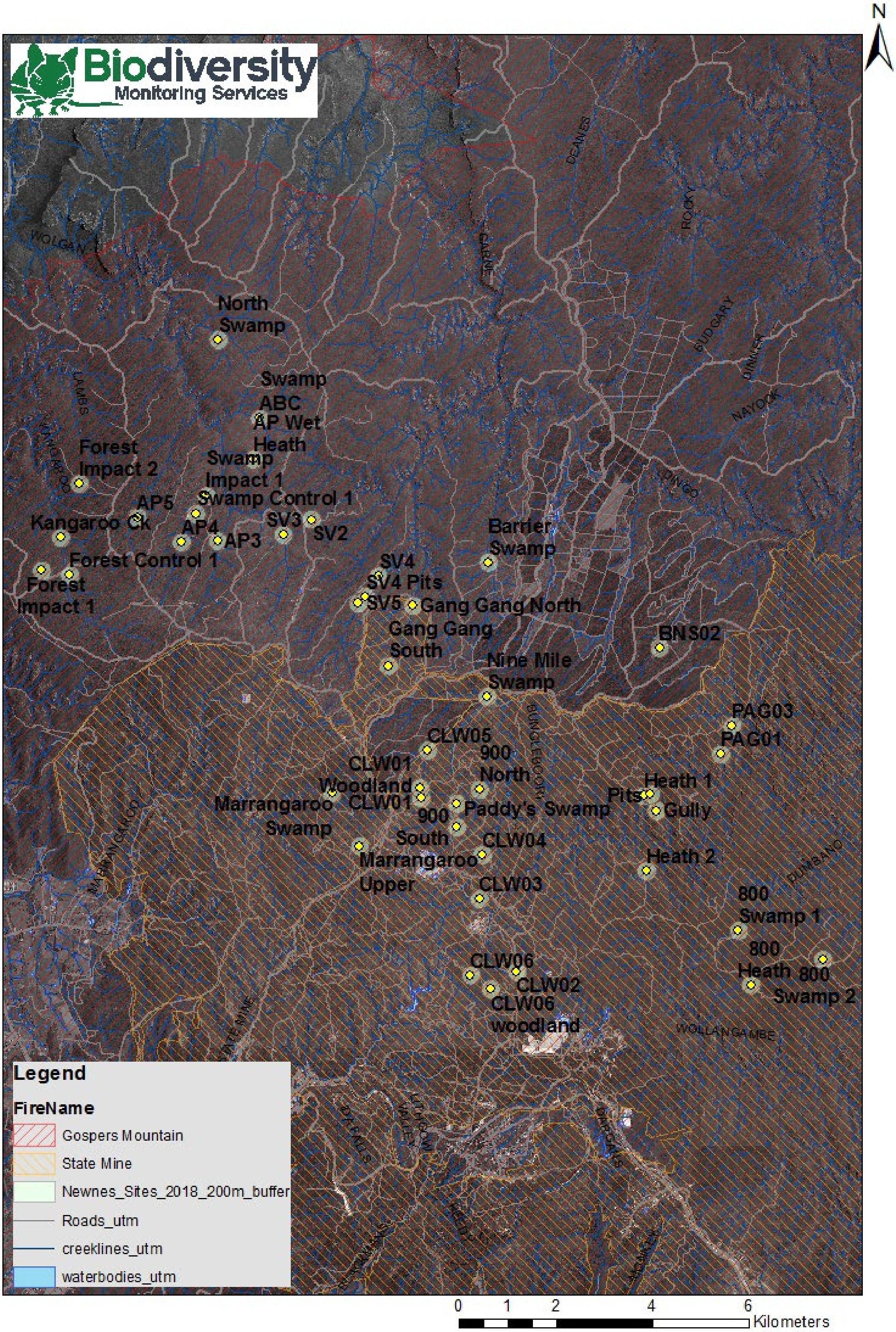

Figure 1-2: Extent of State Mine Fire in 2013 and Gospers Mountain Fire in 2019

2.0 Survey methodologies and survey efforts

The CLW sites were surveyed between the 9th May and 3rd June 2022, 10th October and 11th November 2022, and 28th November and 9th December 2022 by Andrew Lothian, Nicholas Tong and Rachel Moore using NPWS Scientific Licence No. SL101725 and DPI's Animal Research Authority No. 16/559. Autumn surveys focussed on small mammals (including bats) colonising new areas, reptiles and birds still active. Spring surveys targeted breeding activity by birds. Summer surveys targeted the activity period for reptiles (Blue Mountains Water Skink), bats, amphibians and Giant Dragonfly.

The methodology follows that established during surveys in previous years and other monitoring areas at Clarence, Angus Place and Springvale, to ensure consistency of approach and provide a basis for comparative studies. A summary of the survey effort at each site is given in **Tables 2-1** to **2-2**. A full description of the survey methodologies is provided below and in the BMS methods supplement[1]. The techniques used during the survey followed, as closely as possible, the draft working guidelines produced by DECC (2004)[2]. Although these guidelines are in draft form and still subject to review, they provide an important direction on survey methodology, including suggested survey effort. The survey techniques have remained constant over the years during the surveys undertaken at Newnes Plateau. This will continue into the future to ensure comparative data is obtained. The survey techniques are consistent with methodologies outlined in the *Clarence Colliery Subsidence Management Plan Application – Partial Extraction of Areas 700 West and 800*. Results from 18 years of surveys on Newnes Plateau have shown that little additional information about mammalian fauna is obtained during summer. Hence, summer surveys normally focus on threatened species likely to be active during this season (i.e. Giant Dragonfly and Blue Mountains Water Skink), as well as avifauna (particularly summer migrants), reptiles and amphibians.

Targeted surveys for each of the threatened species known from the locality were undertaken and **Table 2-3** summarises the methods used for each group of species.

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[1] BMS (2017). *Methodologies Supplement (2017)* - Methodologies Used to Conduct Terrestrial Fauna Surveys and Monitoring (2017).

[2] DECC (2004). *Threatened Species Survey & Assessment: Guidelines for Developments and Activities - Working Draft Report*, prepared by DECC.

Table 2-1: Different techniques used during the autumn and spring surveys

Survey technique	CLW01	CLW02	CLW03	CLW04	CLW05	CLW06	Nine Mile	Paddy's Swamp
Ground Elliott traps	25	25	25	25	25	25	25	25*
Tree-mounted Elliott traps	5	5	5	5	5	5	5	5*
Hair funnels	5	5	5	5	5	5	5	5*
Ground Tomahawk traps	3	3	3	3	3	3	3	3*
Tree-mounted Tomahawk traps	3	3	3	3	3	3	3	3*
Large Elliott traps	2	2	2	2	2	2	2	2*
Glider tubes	2	2	2	2	2	2	2	2*
Pit traps	4	4	5	-	3	-	-	3*
Remote IR cameras	2	2	2	2	2	2	2	2*
Anabat recording	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes*
Call broadcasting	-	-	Yes	-	-	-	Yes	-
Bird counts	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Litter searches	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Amphibian searches	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reptile walk	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Rock turning	50	-	-	-	-	100	-	-

**Note: due to lack of vehicle access, these traps were not deployed in spring 2022.*

Table 2-2: Number of trap nights undertaken during autumn and spring surveys

Survey technique	Autumn**	Spring	Total
Ground Elliott traps	600	700	1600
Tree-mounted Elliott traps	120	140	320
Hair funnels	120	140	320
Tomahawk traps	144	168	384
Large Elliott traps	48	56	128
Glider tubes	48	56	128
Pit traps	40	60	152
Remote IR cameras	64	56	108
Anabat recording	10	14	22
Rock/log turning	150	150	300
Spotlighting transects	31.0 km; 3.0 hr	27.2 km; 5.25 hr	58.2 km; 8.25 hr

***Note: half survey time for autumn at CLW02/03/04/06.*

Table 2-3: Methods used to target threatened species

Fauna group	Targeted survey methodology
Threatened amphibians	Searching preferred habitat, pit trapping, call analysis, reptile funnels
Threatened reptiles	Searching preferred habitat, searching under rocks, pit trapping, reptile funnels, tiles
Threatened diurnal birds	General observation, call recognition
Threatened nocturnal birds	General observation, spotlighting, call broadcasting
Threatened arboreal marsupials	General observation, tree traps, spotlighting, call broadcasting, hair tubes, pit trapping, detection of characteristic sap cuts and scratches on trunks, scat identification
Threatened large ground marsupials	General observation, ground traps, spotlighting, searching for characteristic diggings, hair tubes, recognition of tracks, scat identification
Threatened small ground mammals	Elliott trapping, pit trapping, hair tubes, recognition of tracks
Threatened bats	Ultrasonic call detection (Anabat)
Threatened invertebrates	Searches in preferred habitats

As each Elliott trap was laid, habitat description of the trap site was recorded. This included the upper, middle and lower storey vegetation, as well as the ground cover, within an area formed by a one metre radius around each trap. For example, if 10 trap sites out of a trap line of 25 Elliott traps contained a shrub, then it was estimated that the shrub cover in that survey site was 40%.

AUTUMN AND SPRING SURVEYS

Methodologies used in autumn and spring surveys are as follows:

a. Elliott Trapping
Twenty-five small (8x10x33cm) Elliott traps were laid in straight lines for five days through the habitats at each site. This is equivalent to 100 trap nights over four consecutive nights at each site. The traps were baited with a mixture of rolled oats, peanut butter and bacon fat, and a small piece of dacron was placed within each trap (as protection against the cold). A freezer bag was placed over the end of each trap to prevent the contents becoming wet from the rain. At each trap site a description of the physical characteristics of the habitat within a one metre radius was noted. This information was used in the analysis of habitat values.

To sample any small arboreal mammals, five small Elliott traps were mounted on trees at equal distances along each transect (20 trap nights over five consecutive days at each site). Aluminium tree mounts were attached to trees and a baited Elliott trap attached to the mount. The tree trunk and trap were sprayed with a honey-water mixture to assist in attracting any nectar or sap feeding arboreal mammals. Again, dacron and freezer bags were used to combat the cold and wet conditions.

b. Cage Traps
Three Tomahawk cage traps were laid on the ground and three Tomahawk traps were mounted on trees at each site (24 trap-nights). Two large Elliott traps were placed at each site (8 trap-nights). The large Elliott traps and the Tomahawk traps were baited with apple, muesli bar and chicken.

c. Spotlighting
Two forms of spotlighting transect were undertaken. Tracks within the CLW Area were spotlighted from a moving vehicle. In addition, spotlighting on foot was undertaken at the detailed fauna survey sites.

d. Hair Funnels
Hair funnels (from Faunatech) were used instead of large and small hair tubes. The design of the tapered hair funnels is such that both large and small animals can be detected by a single funnel. Five hair funnels were set out at each site for four nights and baited with a mixture of rolled oats, peanut butter and bacon fat. Where possible, some of the hair funnels were set onto 'habitat trees' (these were considered to be trees that showed signs of use by arboreal marsupials and had obvious hollows).

e. Glider Traps
Two vertical plastic tube traps were set up at each site and used as a tree-mounted pit-fall traps. These have been developed to trap small gliders (Squirrel and Sugar Gliders) and have been used successfully in coastal areas[3].

[3] Winning, G. and King, J. 2008. A new trap design for capturing squirrel gliders and sugar gliders. *Australian Mammalogy* **29**: 245-249.

f. Remote Cameras

Tree-mounted remote cameras (Scoutguard, Reconyx and Swann) were used at selected sites to capture images of any animal using the area, particularly near the traps.

g. Bird Surveys

In addition to the results obtained from general observations and spotlighting, listening and observing periods were undertaken at the six sites. Taking into consideration the discussion in the working draft on methods to survey diurnal birds (DECC 2006), an area-search method was used at each site. A 30 minute search was used where the observer walked around each site, as well as observing and listening for calls from a single point. At each site up to four periods of observation were undertaken (two in the morning and two in the late afternoon).

h. Call Broadcasting

Calls of several species of nocturnal bird were broadcast during the night in the general area. Calls were broadcast through a megaphone for approximately five minutes, with a ten minute listening time. Calls from the Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*), Sooty Owl (*Tyto tenebricosa*), Southern Boobook (*Ninox boobook*), Tawny Frogmouth (*Podargus strigoides*), Eastern Barn Owl (*Tyto javanica*) and the White-throated Nightjar (*Eurostopodus mystacalis*). Koala (*Phascolarctos cinereus*), Yellow-bellied Glider (*Petaurus australis*), Squirrel Glider (*Petaurus norfolcensis*) and Sugar Glider (*Petaurus breviceps*) were also broadcast.

i. Pitfall Traps

Pit traps were established at CLW01, CLW02, CLW03, CLW05 and Paddy's. The rocky ground associated with the heath at CLW06 and the steep valley around CLW04 prevented pitfalls being constructed in these locations. Nine Mile was flooded in 2021 so pits could not be installed.

j. Herpetological Searches

Systematic searches for reptiles and amphibians were undertaken within each habitat type at each survey site. Litter was raked and rocks and logs turned over. Loose bark was prised from the trunks of dead trees. Each search took approximately 30 minutes and was repeated at each site. Searches for amphibians took place at night using spotlights (particularly after rain) and recognition of characteristic calls. Spotlighting searches were also attempted for reptiles.

k. Bat Call Detection

An Anabat Express ultrasonic bat detector was placed at selected sites for two nights and any recorded bat calls analysed by Andrew Lothian and Glenn Hoye.

l. Animal Track Recognition

Areas of sand on tracks were inspected for evidence of animal movement. Paw prints and other animal signs were identified and recorded.

m. Opportunistic Observations

Any sightings of fauna were recorded whilst moving throughout the CLW Area and located using a Global Positioning System (GPS). Any scats were collected and their contents analysed.

n. Estimation of Diversity

Because of the accumulation of data under formal survey conditions (consistent survey effort and techniques at each survey site) it is possible to calculate some comparisons and relationships from the results of the survey.

Total numbers and species richness (number of species per site) are the simplest measures used to determine biodiversity of a site. However, these indices miss the information that some species may be rare and others common. The Simpson's Index of Dominance (D) takes into account both the abundance patterns and the species richness of a community. This index measures the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). It was possible to calculate Simpson's Index of Diversity for mammal, bird and sometimes reptile populations from each survey site for most survey periods.

An Evenness score was also calculated. Evenness is a measure of the relative abundance of different species making up the richness of an area. A low value for Evenness means that the sample is dominated by a large number of one or two species. A high Evenness value means that most species in the sample have a similar abundance.

SUMMER SURVEY

An area that included each survey site and a surrounding buffer of about 1km radius was searched over a period of three days for signs of fauna. In particular, searches targeted threatened species such as the Giant Dragonfly and Blue Mountains Water Skink. Both these species are associated with wet areas so the swamps and creeklines were searched at and around each site. Bird surveys were also undertaken. The census period was at least 30 minutes at each site. Spotlighting surveys were also undertaken at each site, mainly on foot using a 50 watt light. Whilst spotlighting each site, calls from nocturnal fauna were also recorded (i.e. frogs, gliders, owls etc.). Of particular interest were threatened species that would be more active during the warm summer period. Fauna results from this summer survey are presented below.

3.0 Weather during the trapping survey

Data from weather station at Cooerwull Lithgow (from Bureau of Meteorology) is given in **Table 3-1**. Total monthly rainfall at Mount Boyce (from BOM) is graphed against the long-term average from 1994 to 2022 in **Figure 3-1**.

Table 3-1: Weather records from Lithgow during 2022 surveys

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
07/05/2022	2.6	11.3	0
08/05/2022	1.0	13.7	0
09/05/2022	1.1	12.5	0
10/05/2022	9.8	12.8	2.0
11/05/2022	9.5	13.7	3.6
12/05/2022	11.6	14.8	13.2
13/05/2022	12.9	19.8	10.2
14/05/2022	11.1	21.2	0.2
15/05/2022	11.0	19.1	0.6
16/05/2022	8.7	16.6	0.2
17/05/2022	7.4	13.5	0
18/05/2022	5.2	12.5	0
19/05/2022	-1.7	12.2	0
20/05/2022	-1.0	9.5	0
28/05/2022	6.9	14.4	0.2
29/05/2022	0.6	9.4	0
30/05/2022	1.3	9.6	0
31/05/2022	3.4	7.9	10.8
01/06/2022	1.1	5.4	7.4
02/06/2022	-0.7	10.3	0.4
03/06/2022	-1.7	10.2	0
08/10/2022	11.5	16.2	9.0
09/10/2022	6.9	143	40.8
10/10/2022	20.0	14.4	0.2
11/10/2022	7.9	13.8	0.2
12/10/2022	6.0	15.3	0
13/10/2022	9.6	17.2	0

Date	Minimum temperature (°C)	Maximum temperature (°C)	Rainfall (mm)
14/10/2022	11.6	14.6	4.8
29/10/2022	8.4	15.7	0
30/10/2022	5.6	19.4	0
31/10/2022	10.9	20.5	0
01/11/2022	7.6	13.3	29.6
02/11/2022	1.6	9.2	14.6
03/11/2022	3.4	14.4	0.2
04/11/2022	6.3	14.3	0
05/11/2022	5.4	16.9	0
06/11/2022	5.8	18.6	2.0
07/11/2022	6.5	19.5	0.2
08/11/2022	7.6	19.3	0.8
09/11/2022	4.1	19.0	0
10/11/2022	7.3	20.2	0
11/11/2022	6.7	19.2	0
26/11/2022	4.6	21.8	0
27/11/2022	11.4	25.2	0
28/11/2022	8.8	19.5	7.8
29/11/2022	5.5	21.8	0
30/11/2022	8.7	19.9	0.4
01/12/2022	10.2	16.2	0
02/12/2022	10.0	16.7	0
03/12/2022	5.9	20.9	0
04/12/2022	7.0	23.6	0
05/12/2022	8.0	26.0	0
06/12/2022	730	22.4	3.4
07/12/2022	8.2	20.8	0
08/12/2022	10.1	16.9	2.2
09/12/2022	1.9	18.8	0

The extended dry periods of 2018-2019 were broken in 2020 with many months in 2020 and 2021 showing greater than average rainfall. Overall rainfall in 2022 was just over twice the long term average. Monthly rainfall was higher than the long-term average for nine of the 12 months, with considerable rainfall in March and July (**Figure 3-1**). Most of NSW has been in rainfall surplus over the last 36 months (**Figure 3-2**), particularly in the central tablelands/western slopes.

48.8mm of rain fell over the autumn survey period, hindering the effectiveness of some survey techniques (i.e. pitfall traps/Anabats not able to be utilised at all sites). Forecast snow conditions closed the SCA, resulting in reduced number of nights sampling at four sites. 102.4mm of rain fell during the spring survey period also impacting survey effort. One site could not be accessed via vehicle so was sampled on foot for three days only. There was considerably less rainfall over the summer survey period, though maximum and minimum temperatures were below average for summer. Wet/cloudy conditions led to generally lower maximum temperatures and higher minimum temperatures over the year. Cooler overnight temperatures resulted in few frogs seen or heard during summer surveys.

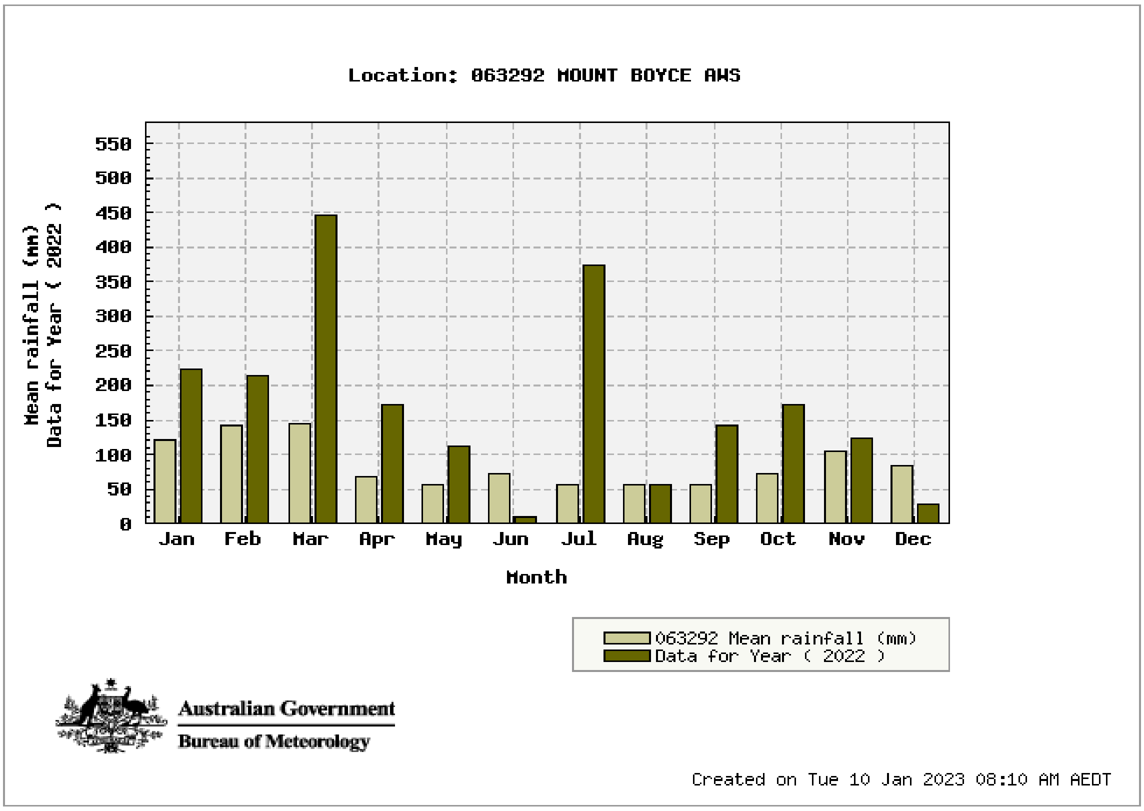

Figure 3-1: Total monthly rainfall in 2022 vs long-term mean monthly rainfall 1994-2022 (BOM, 2022)

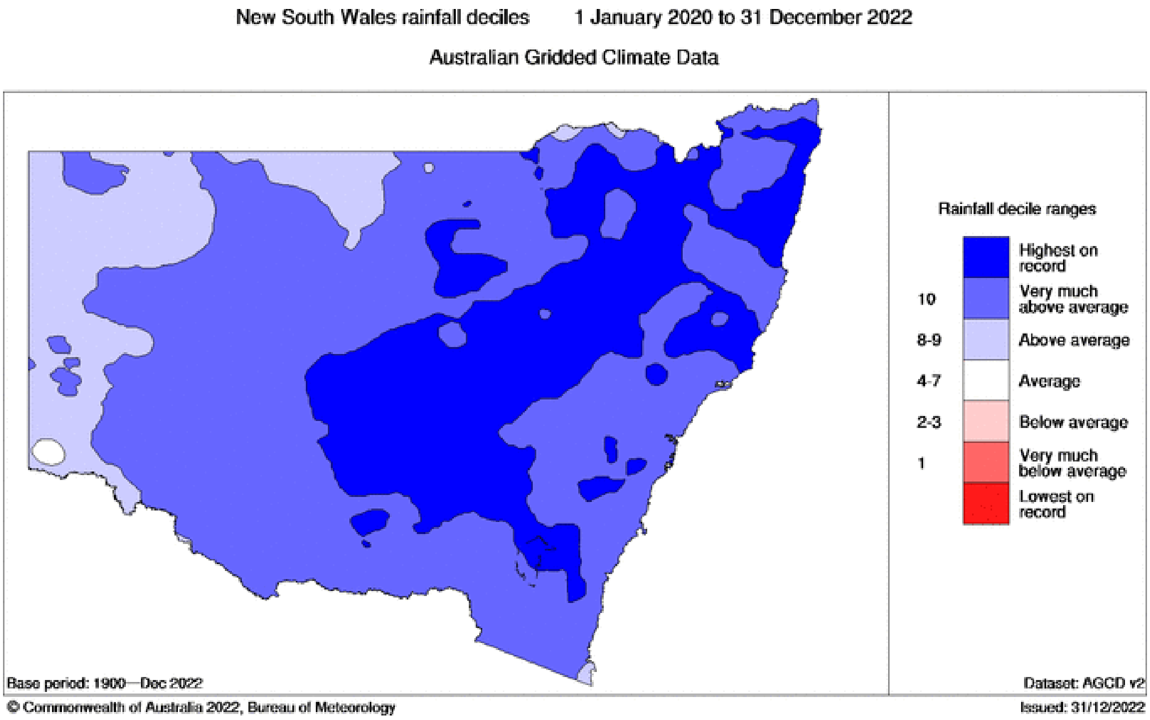

Figure 3-2: 12-month rainfall deficiency map (BOM, 2022)

4.0 Results - habitat measurement

Measurements from descriptions of each Elliott trap site were used to provide an index of habitat condition. It has been found that the use of walking transects to determine habitat condition in swamp and rocky areas did not provide an accurate picture of habitat characteristics. Consequently, information derived from the trap placement descriptions is now used. **Table 4-1** provides the data obtained from the autumn and spring surveys since 2009. Habitat assessment is illustrated in **Figures 4-1** and **4-2**.

CLW01, CLW02, CLW03, CLW04, CLW05 and CLW06 swamps are now all directly or indirectly affected by drawdown from the undermining. Therefore, they can be used as impact data for assessing the impacts from mining on swamp habitat. Paddy's, Nine Mile, 900 North and 900 South can be used as control sites as they remain outside the influence of potential drawdown.

Two-way Repeated Measures ANOVAs were conducted on autumn habitat characteristics over time by broad habitat type. Tall shrub cover was significantly lower from 2014-19 compared to 2007-13; and significantly lower in 2020-22 compared to 2007-2013 and 2019 ($p < 0.001$). Tall sapling cover was significantly lower in 2020 compared to 2018-19 and 2022 ($p = 0.002$). Low shrub cover was significantly lower in 2020 ($p < 0.001$). Grass cover was significantly lower 2014-16 and 2019 compared to 2007-13 and 2020-22; significantly lower in 2018 compared to 2007-13 and 2020-21; and significantly lower in 2020 compared to 2007-10; and significantly lower in 2017 compared to 2021 ($p < 0.001$). Cutting grass cover was significantly higher in 2014 compared to 2013, 2018 and 2020; 2021 was significantly higher than 2020 ($p < 0.001$). Reed cover was significantly lower in 2020-21 compared to 2015 and 2017-19; and significantly lower in 2013 compared to 2019 ($p < 0.001$). Litter cover was significantly lower in 2014 ($p < 0.001$). Log cover was significantly higher in 2020 compared to 2007 and 2019 ($p = 0.013$). Most of these changes reflect effects of the State Mine fire and Gospers Mountain fire.

Spring Two-way Repeated Measures ANOVAs conducted on habitat characteristics over time, by broad habitat type, showed differences in most cover characteristics over time. Most of these differences seem to be between the pre and post 2013 fire periods, reflecting the fact that habitat components were still recovering when the 2019 fires hit. Tall shrub cover was significantly lower from 2014-19 compared to 2007-13; and significantly lower in 2020-22 compared to 2007-2013 and 2019 ($p < 0.001$). Tall sapling cover was significantly lower in 2020 compared to 2018-19 and 2022 ($p = 0.002$). Low shrub cover was significantly lower in 2020 ($p < 0.001$). Grass cover was significantly lower 2014-16 and 2019 compared to 2007-13 and 2020-22; significantly lower in 2018 compared to 2007-13 and 2020-21; and significantly lower in 2020 compared to 2007-10; and significantly lower in 2017 compared to 2021 ($p < 0.001$). Cutting grass cover was significantly higher in 2014 compared to 2013, 2018 and 2020; 2021 was significantly higher than 2020 ($p < 0.001$). Reed cover was significantly lower in 2020-21 compared to 2015 and 2017-19; and significantly lower in 2013 compared to 2019 ($p < 0.001$). Litter cover was significantly lower in 2014 ($p < 0.001$). Log cover was significantly higher in 2020 compared to 2007 and 2019 ($p = 0.013$). Most of these changes reflect effects of the State Mine fire and Gospers Mountain fire.2012 compared to 2016-17 ($p < 0.0001$). Litter cover was significantly lower in 2014 ($p < 0.0001$).

Due to step wise changes in sites becoming classed as impact (differing years of undermining), we could not use Two-way Repeated Measures ANOVAs to analyse data by mining impact over the whole

2009-2022 survey period. A series of t-tests were run on autumn undermined and control habitat characteristics, pooled over years. Tall shrub and reed covers were significantly lower at undermined sites compared to control sites ($p = 0.002$ and $p = 0.027$ respectively). Tree hollow, low sapling and vine covers were significantly higher at undermined sites compared to control sites ($p = 0.002$, $p = 0.042$ and $p = 0.009$ respectively). These results are expected as the two pagoda heath sites, which typically exhibit more rock, are both undermined. With the undermining of CLW01 in 2018, there are no longer any control pagoda sites, so analyses comparing control and impact pagoda and swamp sites are no longer conducted. Pooled t-tests were also run on undermined and control spring habitat characteristics. Tall and low shrub covers were significantly lower at undermined sites compared to control sites ($p < 0.001$ and $p = 0.026$ respectively). Conversely low sapling and vine covers were significantly higher at undermined sites ($p = 0.033$ and $p = 0.022$ respectively).

The two fires led to obvious declines in shrub, fern and reed covers, with corresponding increases in low sapling, log and rock covers (as trap cover was sought post fire). A number of characteristics showed differing changes in response to the first and second fires (grass, forb, cutting grass and litter), probably demonstrating the limitation of this metric for monitoring change in vegetation over time, or nuances relating to fire intensity/response.

Most of the variation seen is over time. Six habitat characteristics varied by mining impact, but only three were consistent across seasons. Two were higher in undermined sites (low sapling and vine), and one lower in undermined sites (tall shrub). These results reflect the fact that two of the undermined sites are stunted pagoda heath communities which tend to have shorter mallee eucalypts and absence of a tall shrub layer. Results suggest that the variation in habitat characteristics are driven more by changes in environmental conditions on Newnes Plateau, particularly fire and drought.

Table 4-1: Overall mean habitat characteristics in autumn (A) and spring (S) each year

% Cover	2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Tree	29	30	37	33	45	29	21	21	18	30	20	15	19	22	15	23	17	10	13	14
Tree hollow	-	-	-	-	-	-	-	-	-	19	6	5	7	5	6	7	4	3	2	5
Tall shrub	61	67	66	55	35	53	43	45	45	28	5	3	4	5	7	7	16	19	29	27
Tall sapling	15	23	22	31	18	29	23	18	13	15	15	10	23	24	21	17	21	21	22	20
Low shrub	96	95	95	93	85	83	87	85	88	37	80	75	87	79	87	87	91	91	95	92
Low sapling	3	12	3	5	9	6	15	13	13	1	40	41	37	35	31	31	29	29	30	30
Grass	91	95	91	93	85	75	69	75	66	25	33	17	37	31	33	21	36	31	32	33
Fern	6	15	8	1	20	19	20	22	21	0	23	23	29	23	27	25	29	25	42	43
Forb	89	77	86	89	59	65	61	59	64	4	80	72	74	63	67	55	69	75	68	63
Cutting grass	-	-	-	-	14	7	51	61	57	32	79	79	69	78	69	57	64	58	53	58
Reed (sedge)	-	-	-	-	-	-	6	33	42	11	51	52	59	47	44	61	61	61	70	63
Vine	8	8	9	11	16	13	16	16	10	0	2	0	4	4	5	5	7	8	7	10
Litter	100	99	99	100	99	99	100	100	100	83	81	54	94	95	99	100	100	98	100	100
Log	15	11	15	18	17	20	16	13	15	27	15	13	21	11	15	14	15	17	19	13
Rock	11	6	7	4	11	8	11	9	11	22	18	14	13	11	10	15	12	8	9	4

% Cover	2019		2020		2021		2022	
	A	S	A	S	A	S	A	S
Tree	10	5	26	26	21	20	18	14
Tree hollow	3	1	8	5	6	3	6	4
Tall shrub	36	27	0	0	0	0	4	4
Tall sapling	24	20	2	10	25	28	29	22
Low shrub	84	96	43	59	71	70	84	80
Low sapling	24	13	66	76	74	71	61	46
Grass	32	32	56	60	67	57	61	57
Fern	47	53	18	28	24	27	29	23
Forb	62	50	65	85	79	74	86	77
Cutting grass	56	51	55	70	70	68	68	54
Reed (sedge)	71	62	28	24	32	26	36	35
Vine	6	3	0	4	4	11	8	8
Litter	100	100	100	100	100	100	100	100
Log	14	15	35	30	23	23	20	20
Rock	6	1	14	14	7.2	10	12	14

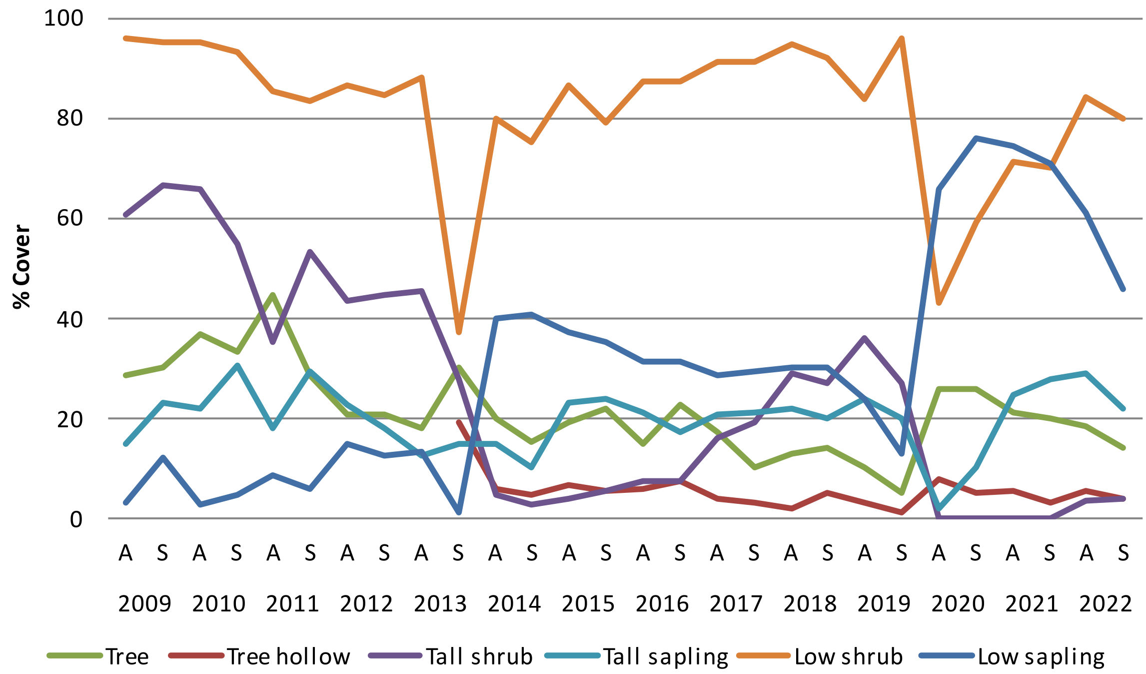

Figure 4-1: Overall mean habitat characteristics over time – upper and middle strata

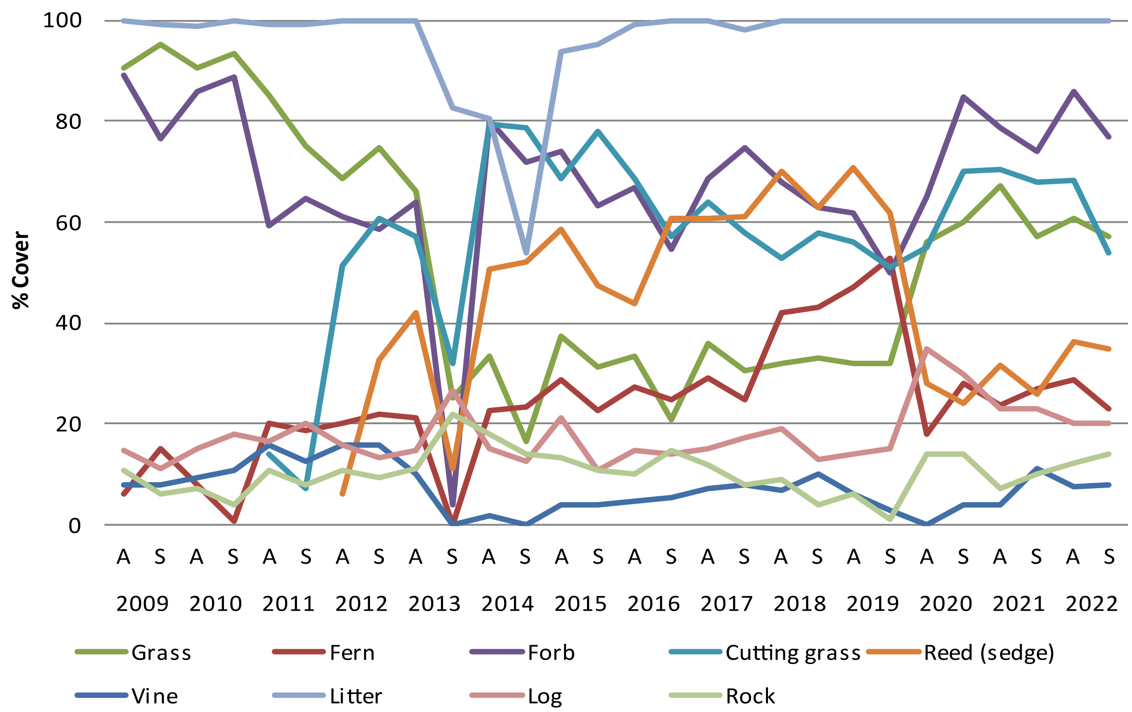

Figure 4-2: Overall mean habitat characteristics over time - lower strata and ground cover

Measurements of habitat characteristics derived from trap site descriptions have been used to provide an index of habitat complexity. This can then be used to determine changes in habitat through time in the study area. One index system used is that developed by Catling and Burt (1995[4]) called the Habitat Complexity Score. This system scores the following parameters: tree cover, tall and short shrub cover, ground cover, logs/rocks and litter cover. Parameter scores range from 0 to 3, hence the maximum score is 18 for a site overall. The Habitat Complexity Scores for each site are given in **Table 4-2** and **Figure 4-3.**

Despite the fire three years ago, the scores still indicate moderate habitat complexity. There are a number of reasons why this might be the case. As habitat features such as trees and logs are sought out for sheltering traps, structural complexity is artificially inflated. This system is a coarse method for assessing structural change in habitats. As it relies on presence/absence of cover components (rather than repeated cover estimates), and certain components can be biased by movements of the trap line, the scope to pick up changes from fire is limited if regrowth of certain components[5].

Autumn scores differed significantly over the years (Two-way Repeated Measures ANOVA), but not by habitat type (same) or undermining status (pooled t-test). 2014 HCS were significantly lower than 2009-11, and 2015 scores were lower than 2010 ($p < 0.001$). In spring, HCS were significantly lower in 2014 compared to 2008-12 and 2020-22; lower in 2019 compared to 2007-08 and 2011; lower in 2017 compared to 2008 and 2011; and lower in 2015-16 and 2018 compared to 2008 ($p < 0.001$; Two-way Repeated Measures ANOVA by time and habitat type). As with autumn, there were no significant differences in spring HCS by habitat or undermining status.

Complexity scores declined steeply after the State Mine fire, but showed partial recovery through the post fire period, albeit at a slightly lower level than before. There was no evidence of decline after the 2019 fire, with 2020 showing an increase from the dry year leading into the Gospers Mountain fire. Perhaps damage to complexity scores was done after the first fire, with minimal impact from the second fire during the recovery period. Also, good rainfall in the 2021-22 period has led to rapid vegetation growth, though HCS have still not returned to levels seen pre 2013. These scores show that all sites structurally provide moderate habitat for ground dwelling mammals and woodland birds, but only as food resources begin to return to the landscape.

[4] Catling P. C. and Burt R.J. (1995). Studies of the ground-dwelling mammals of eucalypt forests in south-eastern New South Wales: the effect of habitat variables on distribution and abundance. *Wildlife Research 22:* 271-288.

[5] Lothian, A.J., Denny, M.J.S. and Tong, N.W. (2022). Mammalian responses to fire on Newnes Plateau: A yardstick for future recovery. *Australian Zoologist* 42(2): 278-303.

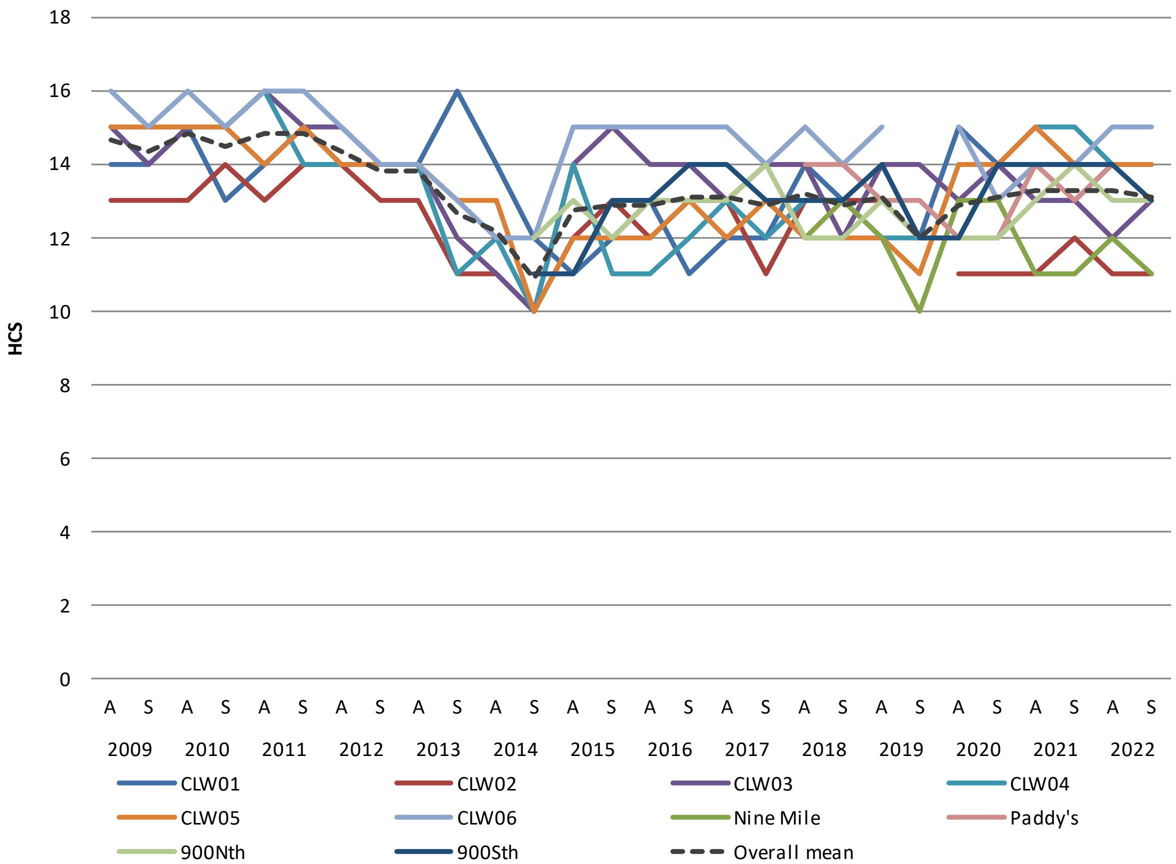

Figure 4-3: Changes in Habitat Complexity Scores over time

Table 4-2: Habitat Complexity Scores for autumn (A) and spring (S) over time

Site	2009		2010		2011		2012		2013		2014		2015		2016		2017		2018	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
CLW01	14	14	15	13	14	15	14	14	14	16	14	12	11	12	13	11	12	12	14	13
CLW02	13	13	13	14	13	14	14	13	13	11	11	10	12	13	12	13	13	11	13	13
CLW03	15	14	15	15	16	15	15	14	14	12	11	10	14	15	14	14	13	14	14	12
CLW04	15	15	15	15	16	14	14	14	14	11	12	10	14	11	11	12	13	12	13	13
CLW05	15	15	15	15	14	15	14	14	14	13	13	10	12	12	12	13	12	13	12	12
CLW06	16	15	16	15	16	16	15	14	14	13	12	12	15	15	15	15	15	14	15	14
Nine Mile	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	13
Paddy's	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14	14
900 North	-	-	-	-	-	-	-	-	-	-	-	12	13	12	13	13	13	14	12	12
900 South	-	-	-	-	-	-	-	-	-	-	-	11	11	13	13	14	14	13	13	13
Overall mean	**14.7**	**14.3**	**14.8**	**14.5**	**14.8**	**14.8**	**14.3**	**13.8**	**13.8**	**12.7**	**12.2**	**10.9**	**12.8**	**12.9**	**12.9**	**13.1**	**13.1**	**12.9**	**13.2**	**12.9**

Site	2019		2020		2021		2022	
	A	S	A	S	A	S	A	S
CLW01	13	12	15	14	13	13	14	14
CLW02	13	-	11	11	11	12	11	11
CLW03	14	14	13	14	13	13	12	13
CLW04	12	12	12	14	15	15	14	14
CLW05	12	11	14	14	15	14	14	14
CLW06	15	-	15	13	14	14	15	15
Nine Mile	12	10	13	13	11	11	12	11
Paddy's	13	13	12	12	14	13	14	-
900 North	13	12	12	12	13	14	13	13
900 South	14	12	12	14	14	14	14	13
Overall mean	**13.1**	**12.0**	**12.9**	**13.1**	**13.3**	**13.3**	**13.3**	**13.1**

5.0 Results - fauna located

Twenty-eight native mammal (plus five introduced), 62 bird, eight reptile and eight amphibian were recorded from the CLW Area. **Tables 5-1** to **5-5** provide a list of species located within the CLW Area during the 2022 surveys. Calculations of diversity indices were undertaken where possible and presented in **Table 5-6**.

P – Protected species V – Vulnerable species U – Introduced species
C/J/K – China/Japan/Korea Australia Migratory Bird Agreement

Threatened species highlighted in green

Table 5-1: Mammals located within CLW Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Dasyuridae			
Antechinus agilis	Agile Antechinus	P	
Antechinus stuartii	Brown Antechinus	P	
Sminthopsis murina	Common Dunnart	P	
Vombatidae			
Vombatus ursinus	Bare-nosed Wombat	P	
Burramyidae			
Cercartetus nanus	Eastern Pygmy-possum	V	
Petauridae			
Petaurus breviceps	Sugar Glider	P	
Pseudocheiridae			
Petauroides volans	Greater Glider	E	E
Pseudocheirus peregrinus	Common Ringtail Possum	P	
Phalangeridae			
Trichosurus vulpecula	Common Brushtail Possum	P	
Macropodidae			
Macropus giganteus	Eastern Grey Kangaroo	P	
Macropus rufogriseus	Red-necked Wallaby	P	
Wallabia bicolor	Swamp Wallaby	P	
Rhinolophidae			
Rhinolophus megaphyllus	Eastern Horseshoe-bat	P	
Molossidae			
Austronomus australis	White-striped Freetail-bat	P	
Ozimops planiceps	South-eastern Free-tailed Bat	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Ozimops ridei	Eastern Free-tailed Bat	P	
Vespertilionidae			
Chalinolobus dwyeri	Large-eared Pied Bat	V	V
Chalinolobus gouldii	Gould's Wattled Bat	P	
Chalinolobus morio	Chocolate Wattled Bat	P	
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	
Miniopterus orianae oceanensis	Large Bent-winged Bat	V	
Nyctophilus spp.	Long-eared Bat spp.	P	
Scoteanax rueppellii	Greater Broad-nosed Bat	V	
Scotorepens orion	Eastern Broad-nosed Bat	P	
Vespadelus darlingtoni	Large Forest Bat	P	
Vespadelus regulus	Southern Forest Bat	P	
Muridae			
Mus musculus	House Mouse	U	
Rattus fuscipes	Bush Rat	P	
Rattus lutreolus	Swamp Rat	P	
Rattus rattus	Black Rat	U	
Canidae			
Canis lupus	Dingo, domestic dog	U	
Vulpes vulpes	Fox	U	
Leporidae			
Oryctolagus cuniculus	Rabbit	U	

Table 5-2: Birds located within CLW Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Anatidae			
Chenonetta jubata	Australian Wood Duck	P	
Podargidae			
Podargus strigoides	Tawny Frogmouth	P	
Accipitridae			
Accipiter fasciatus	Brown Goshawk	P	
Falconidae			
Falco berigora	Brown Falcon	P	
Falco cenchroides	Nankeen Kestrel	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Turnicidae			
Turnix varius	Painted Button-quail	P	
Cacatuidae			
Cacatua galerita	Sulphur-crested Cockatoo	P	
Callocephalon fimbriatum	Gang-gang Cockatoo	V	E
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo	P	
Psittacidae			
Platycercus elegans	Crimson Rosella	P	
Platycercus eximius	Eastern Rosella	P	
Cuculidae			
Cacomantis flabelliformis	Fan-tailed Cuckoo	P	
Cacomantis variolosus	Brush Cuckoo	P	
Strigidae			
Ninox novaeseelandiae	Southern Boobook	P	
Alcedinidae			
Dacelo novaeguineae	Laughing Kookaburra	P	
Todiramphus sanctus	Sacred Kingfisher	P	
Menuridae			
Menura novaehollandiae	Superb Lyrebird	P	
Climacteridae			
Climacteris erythrops	Red-browed Treecreeper	P	
Cormobates leucophaea	White-throated Treecreeper	P	
Ptilonorhynchidae			
Ptilonorhynchus violaceus	Satin Bowerbird	P	
Maluridae			
Malurus cyaneus	Superb Fairy-wren	P	
Malurus lamberti	Variegated Fairy-wren	P	
Dasyornithidae			
Pycnoptilus floccosus	Pilotbird	P	V
Acanthizidae			
Acanthiza lineata	Striated Thornbill	P	
Acanthiza pusilla	Brown Thornbill	P	
Acanthiza reguloides	Buff-rumped Thornbill	P	
Sericornis frontalis	White-browed Scrubwren	P	
Pardalotidae			
Pardalotus punctatus	Spotted Pardalote	P	
Pardalotus striatus	Striated Pardalote	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Meliphagidae			
Acanthorhynchus tenuirostris	Eastern Spinebill	P	
Anthochaera carunculata	Red Wattlebird	P	
Caligavis chrysops	Yellow-faced Honeyeater	P	
Melithreptus lunatus	White-naped Honeyeater	P	
Nesoptilotis leucotis	White-eared Honeyeater	P	
Philemon corniculatus	Noisy Friarbird	P	
Phylidonyris novaehollandiae	New Holland Honeyeater	P	
Psophodidae			
Cinclosoma punctatum	Spotted Quail-thrush	P	
Psophodes olivaceus	Eastern Whipbird	P	
Neosittidae			
Daphoenositta chrysoptera	Varied Sittella	V	
Campephagidae			
Coracina novaehollandiae	Black-faced Cuckoo-shrike	P	
Pachycephalidae			
Colluricincla harmonica	Grey Shrike-thrush	P	
Pachycephala pectoralis	Golden Whistler	P	
Pachycephala rufiventris	Rufous Whistler	P	
Artamidae			
Artamus cyanopterus cyanopterus	Dusky Woodswallow	V	
Cracticus tibicen	Australian Magpie	P	
Cracticus torquatus	Grey Butcherbird	P	
Strepera graculina	Pied Currawong	P	
Strepera versicolor	Grey Currawong	P	
Rhipiduridae			
Rhipidura albiscapa	Grey Fantail	P	
Rhipidura leucophrys	Willie Wagtail	P	
Corvidae			
Corvus coronoides	Australian Raven	P	
Monarchidae			
Myiagra cyanoleuca	Satin Flycatcher	P	
Myiagra rubecula	Leaden Flycatcher	P	
Corcoracidae			
Corcorax melanorhamphos	White-winged Chough	P	
Petroicidae			
Eopsaltria australis	Eastern Yellow Robin	P	

Scientific Name	Common Name	NSW Status	Cwlth Status
Petroica boodang	Scarlet Robin	V	
Petroica phoenicea	Flame Robin	V	
Timaliidae			
Zosterops lateralis	Silvereye	P	
Hirundinidae			
Petrochelidon nigricans	Tree Martin	P	
Estrildidae			
Neochmia temporalis	Red-browed Finch	P	
Stagonopleura bella	Beautiful Firetail	P	
Motacillidae			
Anthus novaeseelandiae	Australian Pipit	P	

Table 5-3: Amphibians located within CLW Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Myobatrachidae			
Crinia parinsignifera	Eastern Sign-bearing Froglet	P	
Crinia signifera	Common Eastern Froglet	P	
Limnodynastes dumerilii	Eastern Banjo Frog	P	
Limnodynastes peronii	Brown-striped Frog	P	
Pseudophryne bibronii	Bibron's Toadlet	P	
Uperoleia laevigata	Smooth Toadlet	P	
Hylidae			
Litoria peronii	Peron's Tree Frog	P	
Litoria verreauxii verreauxii	Verreaux's Tree Frog	P	

Table 5-4: Reptiles located within CLW Area

Scientific Name	Common Name	NSW Status	Cwlth Status
Scincidae			
Acritoscincus platynota	Red-throated Skink	P	
Ctenotus taeniolatus	Copper-tailed Skink	P	
Eulamprus heatwolei	Yellow-bellied Water-skink	P	
Eulamprus leuraensis	Blue Mountains Water skink	E1	E
Lampropholis delicata	Dark-flecked Garden Sunskink	P	
Lampropholis guichenoti	Pale-flecked Garden Sunskink	P	
Tiliqua nigrolutea	Blotched Blue-tongue	P	
Agamidae			
Rankinia diemensis	Mountain Dragon	P	
Scincidae			
Acritoscincus platynota	Red-throated Skink	P	

Table 5-5: Invertebrates located within Angus Place SMP Area

Scientific Name	Common Name	NSW Status	Cwlth Status
None found			

Table 5-6: Biodiversity indices for fauna in CLW Area

Site	Evenness	Simpson's Index of Diversity	Abundance	Species Richness
		BIRDS		
CLW Area	0.831	0.950	1228	62
CLW01	0.870	0.911	81	21
CLW02	0.942	0.952	129	26
CLW03	0.904	0.951	162	33
CLW04	0.865	0.931	128	28
CLW05	0.877	0.933	185	31
CLW06	0.863	0.926	124	27
Nine Mile	0.907	0.949	153	35
Paddy's	0.879	0.935	142	29

Site	Evenness	Simpson's Index of Diversity	Abundance	Species Richness
NATIVE MAMMALS (non-bat)				
CLW Area	0.788	0.844	205	14
CLW01	0.760	0.559	17	3
CLW02	0.848	0.778	19	6
CLW03	0.769	0.709	29	6
CLW04	0.799	0.767	25	7
CLW05	0.751	0.726	26	7
CLW06	0.826	0.762	15	6
Nine Mile	0.899	0.849	27	8
Paddy's	0.907	0.792	16	5
REPTILES				
CLW Area	0.850	0.802	35	8
CLW01	0.000	0.000	1	1
CLW02	1.000	0.600	5	2
CLW03	0.890	0.806	9	5
CLW04	1.000	0.833	4	3
CLW05	1.000	0.667	3	2
CLW06	1.000	1.000	4	4
Nine Mile	0.000	0.000	2	1
Paddy's	1.000	0.667	4	2
AMPHIBIANS				
CLW Area	0.215	0.200	350	8
CLW01	0.000	0.000	1	1
CLW02	0.313	0.185	31	3
CLW03	0.309	0.265	109	6
CLW04	NA	NA	0	0
CLW05	0.530	0.237	23	2
CLW06	0.000	0.000	11	1
Nine Mile	0.245	0.188	148	5
Paddy's	0.000	0.000	25	1

The fauna assemblage is similar to that recorded from other areas within Clarence Colliery and Newnes Plateau, with similar species richness values and similar species located. A list of species located within the CLW Area from 2006 to 2022 is given in **Table 5-7**. The cumulative number of new species located each year is given in **Figure 5-1**. It is expected that the number of new species located each year will level out and the final maximum species richness for the area can be estimated from the value of the asymptote. By 2022, 134 bird, 36 native mammal, 26 reptile, 14 amphibian and one invertebrate species have been located within the CLW Area. In terms of cumulative species curves, the trend for all groups has mostly plateaued, with no new species added to any group in 2022. Reptiles and amphibians have been stable for three years, with birds and mammals two years.

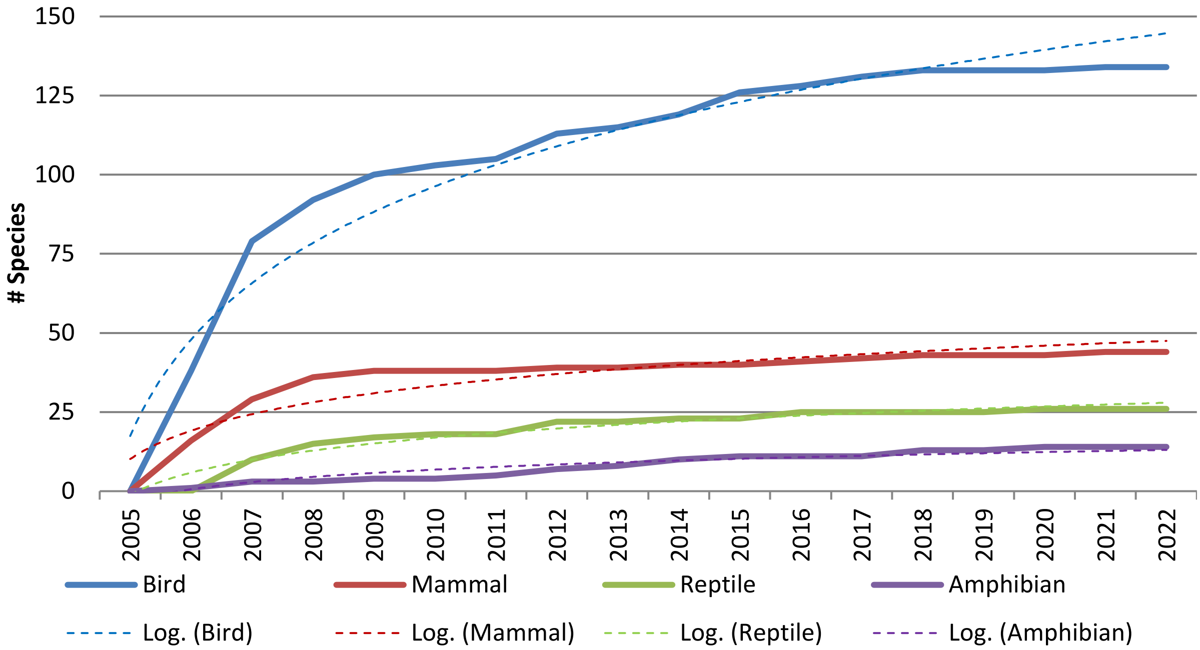

Figure 5-1: Cumulative new species in the CLW Area (including exotic species)

Table 5-7: Species located in CLW Area from the results of surveys since 2006 (threatened species highlighted in green)

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
MAMMALS																	
Agile Antechinus	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bare-nosed Wombat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black Rat																X	X
Brown Antechinus	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Bush Rat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Cat	X	X	X			X	X	X	X	X	X	X	X	X	X	X	
Chocolate Wattled Bat		X	X	X					X		X	X	X	X	X	X	X
Common Brushtail Possum	X				X		X	X	X	X	X		X	X	X	X	X
Common Dunnart			X	X	X					X	X		X	X		X	X
Common Ringtail Possum	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X
Dingo, domestic dog	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Broad-nosed Bat		X															X
Eastern False Pipistrelle		X		X					X		X	X	X		X	X	X
Eastern Free-tailed Bat		X											X			X	X
Eastern Grey Kangaroo	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Horseshoe-bat		X											X	X	X	X	X
Eastern Pygmy-possum		X				X		X	X	X			X			X	X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Feral Pig									X								
Fox	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Gould's Wattled Bat		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Greater Broad-nosed Bat				X													X
Greater Glider	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Horse												X		X	X	X	
House Mouse			X	X					X	X	X	X				X	X
Large Bent-winged Bat		X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Large Forest Bat		X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Large-eared Pied Bat			X	X			X		X		X	X	X	X	X	X	X
Little Forest Bat			X	X					X								
Long-eared Bat sp.			X	X		X					X	X	X	X	X	X	X
Long-nosed Bandicoot			X	X		X	X		X	X	X						
Mainland Dusky Antechinus	X			X	X	X	X	X	X	X			X				
Rabbit	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red-necked Wallaby	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Short-beaked Echidna		X	X														
South-eastern Free-tailed Bat			X									X			X	X	X
Southern Forest Bat		X	X	X		X			X			X	X	X	X	X	X
Southern Myotis				X													
Squirrel Glider		X		X													

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Sugar Glider											X	X	X	X	X	X	X
Swamp Rat	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Swamp Wallaby	X	X		X	X		X	X	X	X	X	X	X	X	X	X	X
Water Rat							X										
White-striped Freetail-bat		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Yellow-bellied Sheathtail-bat													X		X		
BIRDS																	
Australian Crake										X							
Australian Hobby		X															
Australian King-Parrot	X	X	X	X			X		X	X	X	X	X	X	X		
Australian Magpie	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Australian Owlet-nightjar								X		X	X	X					
Australian Pipit	X										X	X	X	X		X	X
Australian Raven	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Australian Wood Duck			X		X		X	X	X	X	X	X	X		X	X	X
Bar-shouldered Dove		X															
Bassian Thrush				X	X		X	X	X							X	
Beautiful Firetail		X	X			X	X	X	X		X	X	X	X			X
Black Kite				X													
Black-faced Cuckoo-shrike	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black-faced Woodswallow		X		X													

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black-shouldered Kite							X	X									
Brown Falcon							X								X	X	X
Brown Goshawk											X		X		X	X	X
Brown Thornbill		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brown Treecreeper	X	X	X	X	X												
Brown-headed Honeyeater		X		X			X		X	X	X	X	X	X	X	X	
Brush Cuckoo		X	X				X		X	X		X					X
Buff-rumped Thornbill					X		X	X	X	X	X	X	X	X	X	X	X
Channel-billed Cuckoo										X		X			X		
Chestnut-rumped Heathwren		X							X	X		X	X	X	X	X	
Cicadabird						X	X	X	X	X	X	X	X		X		
Collared Sparrowhawk							X									X	
Common Bronzewing	X	X	X	X	X	X				X	X	X	X				
Crescent Honeyeater													X	X			
Crimson Rosella	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Dollarbird		X												X			
Dusky Woodswallow		X					X	X	X	X	X	X	X	X		X	X
Eastern Rosella			X	X	X		X	X	X	X	X	X	X		X	X	X
Eastern Shrike-tit		X	X	X		X	X	X	X	X	X	X	X	X	X	X	
Eastern Spinebill	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Whipbird	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Eastern Yellow Robin	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fairy Martin		X															
Fan-tailed Cuckoo			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flame Robin	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Forest Kingfisher		X															
Galah		X	X														
Gang-gang Cockatoo	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glossy Black-Cockatoo		X	X														
Golden Whistler		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X
Green Catbird			X														
Grey Butcherbird			X	X	X		X	X	X	X			X		X	X	X
Grey Currawong	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Grey Fantail		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Grey Shrike-thrush	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hooded Robin		X	X														
Horsefield's Bronze-Cuckoo									X	X	X	X					
Jacky Winter	X	X															
Laughing Kookaburra	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Leaden Flycatcher		X			X		X	X	X	X	X	X	X		X		X
Lewin's Honeyeater					X												
Lewin's Rail							X	X			X						

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Little Eagle	X																
Little Friarbird			X														
Little Lorikeet												X	X				
Little Raven	X														X		
Magpie-lark												X					
Masked Lapwing		X						X	X	X			X	X		X	
Masked Owl			X														
Masked Woodswallow										X		X	X				
Mistletoebird													X				
Musk Lorikeet											X						
Nankeen Kestrel									X	X	X	X	X	X	X	X	X
New Holland Honeyeater	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Noisy Friarbird		X	X	X	X	X		X	X		X	X	X		X	X	X
Olive-backed oriole							X	X	X				X				
Pacific Black Duck				X								X					
Painted Button-quail										X					X	X	X
Pallid Cuckoo		X													X	X	
Peaceful Dove								X									
Peregrine Falcon					X		X				X	X					
Pied Butcherbird			X	X		X											
Pied Currawong	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Pilotbird							X										X
Powerful Owl			X														
Rainbow Bee-eater										X							
Red Wattlebird	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Red-backed Kingfisher		X															
Red-browed Finch			X	X		X	X	X	X	X	X		X	X	X	X	X
Red-browed Treecreeper	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red-capped Robin										X							
Restless Flycatcher																X	
Rose Robin							X			X							
Rufous Fantail			X										X				
Rufous Songlark												X				X	
Rufous Whistler		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sacred Kingfisher		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Satin Bowerbird		X	X		X	X	X		X	X	X	X	X	X	X		X
Satin Flycatcher		X					X	X	X		X	X	X	X	X		X
Scarlet Honeyeater				X													
Scarlet Robin	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Shining Bronze-Cuckoo							X		X	X		X	X	X			
Silvereye		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Southern Boobook		X	X	X			X	X	X	X	X	X	X	X	X	X	X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Southern Emu-wren		X			X		X		X	X	X	X	X				
Spiny-cheeked Honeyeater		X	X														
Spotted Pardalote	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spotted Quail-thrush	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X
Striated Pardalote		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Striated Thornbill	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sulphur-crested Cockatoo	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Superb Fairy-wren		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Superb Lyrebird	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Tawny Frogmouth	X	X		X	X	X	X	X		X		X	X	X		X	X
Tawny-crowned Honeyeater		X															
Tree Martin		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Turquoise Parrot									X	X	X						
Varied Sittella		X	X		X				X	X	X	X	X	X			X
Variegated Fairy-wren	X	X			X		X		X		X	X	X		X	X	X
Wedge-tailed Eagle	X	X	X				X	X	X	X	X	X	X	X	X	X	
Whistling Kite				X	X												
White-bellied Cuckoo-shrike						X											
White-browed Scrubwren		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
White-browed Woodswallow									X	X		X	X				
White-cheeked Honeyeater		X	X														

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
White-eared Honeyeater	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-naped Honeyeater	X		X	X	X		X	X	X	X	X	X	X	X	X	X	X
White-plumed Honeyeater		X															
White-throated Gerygone			X		X				X	X	X	X	X				
White-throated Needletail		X												X			
White-throated Nightjar				X													
White-throated Treecreeper	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-winged Chough	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
White-winged Triller										X			X				
Willie Wagtail				X					X			X		X		X	X
Wonga Pigeon				X	X				X		X						
Yellow Thornbill			X		X	X		X									
Yellow-faced Honeyeater	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Yellow-rumped Thornbill		X															
Yellow-tailed Black-Cockatoo	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
REPTILES																	
Black Rock-skink							X	X			X						
Blotched Blue-tongue		X	X	X	X	X	X	X	X	X	X	X	X	X		X	X
Blue Mountains Water Skink			X										X			X	X
Common Scaly-foot							X		X	X							
Copper-tailed Skink		X	X							X					X		X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Cunningham's Skink															X		
Dark-flecked Garden Sunskink			X	X	X	X	X		X	X		X	X	X	X	X	X
Eastern Blue-tongued Lizard		X							X		X						
Eastern Brown Snake		X	X														
Eastern Three-lined Skink					X	X			X			X	X	X			
Eastern Water Dragon							X			X	X						
Highland Copperhead		X		X		X					X	X			X	X	
Jacky Lizard		X	X														
Lace Monitor		X															
Litter Skink				X													
Mountain Dragon				X	X		X				X	X	X	X	X	X	X
Pale-flecked Garden Sunskink			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red-bellied Black Snake			X	X	X					X	X				X		
Red-throated Skink		X	X	X			X			X	X	X		X		X	X
South-eastern Morethia Skink		X															
Southern Rainbow Skink									X								
Tiger Snake											X					X	
Tussock Skink											X			X	X		
Weasel Skink							X		X						X		
White's Skink		X		X						X		X			X		
Yellow-bellied Water-skink			X	X			X		X		X	X	X	X	X	X	X

Common Name	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
AMPHIBIANS																	
Bibron's Toadlet										X	X	X	X	X	X	X	X
Bleating Tree Frog									X							X	
Blue Mountains Tree Frog													X		X		
Brown-striped Frog				X			X	X	X		X		X			X	X
Common Eastern Froglet	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eastern Banjo Frog		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
Eastern Sign-bearing Froglet															X		X
Giant Burrowing Frog						X											
Leaf-green Tree Frog													X		X	X	
Lesueur's Frog							X										
Peron's Tree Frog							X		X		X	X	X	X	X	X	X
Smooth Toadlet									X		X	X	X		X	X	X
Spotted Grass Frog		X	X	X					X			X					
Verreaux's Tree Frog								X	X	X	X	X	X	X	X	X	X
INVERTEBRATES																	
Giant Dragonfly							X	X	X	X	X	X			X		

CRITERIA USED TO MONITOR FAUNA

Most fauna monitoring surveys produce a species list that shows what animals were found within a specified area. Lists alone however do not provide the necessary criteria to determine whether an activity is affecting fauna populations through time. Consequently, it is important to provide a set of criteria that can be used to compare fauna populations within an area over time. The criteria must be relatively simple, easy to interpret and the processes required to develop each criterion must be consistent and repeatable.

To ensure such criteria are used in the long-term monitoring of fauna within the CLW Area, a set of quantifiable indices have been developed and adopted for this project.

The detailed surveys now provide sufficient information to establish a series of 'monitoring trigger points' i.e. single values that can be used to determine whether any significant changes have occurred in fauna populations over time. Monitoring trigger points being developed are:

- Species richness of faunal groups
- Diversity indices of faunal groups
- Population status of individual species
- Capture rates of individual species
- Population status of faunal groups
- Contribution to the faunal assemblages by threatened species, species dependent upon woodland and by species declining in the Central West of NSW
- Habitat complexity scores

Species richness of faunal groups

The number of species within each faunal group provides an index of its biodiversity. It is assumed that the higher the species richness, the higher the biodiversity. A high biodiversity index value indicates an area containing a complex variety of natural habitats in good condition. The species richness values for the surveys from 2006 to 2022 are given in **Table 5-8** and are graphed in **Figures 5-3** and **5-4**.

Simpson's diversity index of faunal groups

Simpson's diversity index combines species richness and species abundance to provide a better indication of biodiversity. The closer the Simpson's Index of Diversity is to one, the higher the biodiversity, and by implication, the better the area is for fauna. Simpson's Index of Diversity for the four main faunal groups over time are given in **Table 5-8** and the values of the diversity index are illustrated in **Figure 5-2**. This provides an indication of the productivity of each faunal group over time.

2018 saw the inclusion of a two new control sites, as Springvale moved longwall activity under two existing Clarence control sites. As such, sampling effort is greater in 2018-2022 compared to previous years. Abundance differences over time should be treated with caution, but other indices should not be greatly impacted by the increased sampling effort. Whilst the figures presented below are sourced from the overall value for the area, the statistical analyses work on the mean values between groups (year or impact), thus taking into account the increased sapling effort. The inclusion of CLW01 and CLW05 has been taken back to 2010 and data recalculated.

Autumn fauna diversities were analysed using Two-way Repeated Measures ANOVAs over time by habitat type. Bird Evenness was significantly lower in 2017-19 compared to 2011, 2015 and 2022 ($p < 0.001$). Bird Simpson's was significantly higher in 2011 compared to 2013 and 2018-19 ($p < 0.001$). Bird abundance was significantly higher in 2017 compared to 2011-16 and 2020-22 ($p < 0.001$). Bird species richness was significantly lower in 2022 compared to 2011 and 2017 ($p = 0.004$). Mammal Evenness was significantly lower in 2013 compared to 2016 and 2018-22 ($p = 0.041$). Mammal abundance was significantly higher in 2012-13 compared to all but 2019; and 2019 was higher than 2011, 2014-18 and 2021 ($p < 0.001$). Mammal species richness was significantly lower in 2011 and 2015-16 compared to 2012; as well as significantly lower in 2011 compared to 2019 ($p = 0.001$).

In spring, diversity indices were also analysed temporally using Two-way Repeated Measures ANOVAs over time by broad habitat type. Bird abundance was significantly lower in 2020-22 compared to 2014 ($p = 0.003$). Bird richness was significantly lower in 2022 compared to 2017-18; and lower in 2011 compared to 2017 ($p < 0.001$). Mammal Evenness was significantly higher in 2014 and 2021 compared to 2017 and 2020 ($p = 0.007$). Mammal abundance was significantly higher in 2012 compared with most years except 2011 and 2019; and higher in 2011 compared to 2013-15 and 2020 ($p <0.001$). Mammal species richness was significantly lower in 2020 compared to 2011 ($p = 0.015$). Reptile abundance was significantly higher in 2013 and 2020 compared to most other years ($p <0.001$).

A series of t-tests were conducted on pooled autumn diversity data from 2011 to 2022. Bird Simpson's and richness were significantly higher at control sites compared to undermined sites ($p = 0.017$ and $p = 0.021$ respectively). Mammal Evenness and Simpson's were significantly higher at undermined sites compared to control sites ($p = 0.006$ and $p = 0.009$ respectively). Amphibian abundance and richness were significantly lower at undermined sites compared to control sites ($p = 0.025$ and $p = 0.037$ respectively). Pooled t-tests on spring data showed bird Evenness, bird Simpson's diversity and mammal abundance were all significantly lower at undermined sites compared to control sites ($p = 0.033$, $p = 0.004$ and $p = 0.029$ respectively).

Bird diversity has increased slightly over time, with a reduction in species richness over the last four years. Even with the large fire in 2019, richness was lower in 2006 and 2011. Mammal diversity has remained relatively stable over time, with 2020 mammal species richness the lowest on record since surveys began. Mammal Simpson's was the highest on record in 2021. Though relatively stable over the long term, reptile Simpson's diversity declined in 2013 and 2020 to lower than average levels. Conversely, reptile species richness was comparatively high in 2020, with a slight increasing trend being confounded by high variability. Reptile diversities presented average levels in 2021-22. Amphibian Simpson's diversity is generally much lower than other groups, suggesting large numbers of one species often sways the results. Amphibian diversities appear to be trending upwards over time with the wet conditions in summer 2021 providing equal highest richness on record. This declined marginally with the drier conditions in December 2022.

Of the eight diversity indices that differ by undermining status, six are higher in control and two higher in undermined sites. Statistics suggest changes in diversity are predominantly due to climatic changes over time. There may be an indication of impacts from undermining, though they are inconsistent across seasons, with bird Simpson's diversity the only index to be lower in undermined sites in both seasons. Mammal indices were higher in undermined sites in autumn, but lower at undermined sites in spring. There may be differences in how habitats and fauna assemblages recover post fire in mined and non-mined sites. This will be investigated further as sites continue to recover from the Gospers Mountain fire. Overall, the biodiversity indices are similar to that found elsewhere in Newnes Plateau and indicate a representative base-line sample to be used for on-going monitoring.

Capture rates of individual species

It is possible to calculate the trapping rates for small ground mammals within the CLW Area. Such values can be used as a surrogate for population size of each species captured and is important for long-term monitoring. Trapping rates for all small mammals captured in 2012 to 2022 are given in **Table 5-9** and shown in **Figure 5-5**.

There was a large decrease in trapping rates from spring 2013. The decline is due to the loss of animals and habitat from the State Mine fire. Numbers started building in 2015, with numbers in 2019 almost back to levels seen pre fire (**Figure 5-5**). Post fire recovery of small mammals in the CLW Area took six years after the State Mine fire. Numbers in 2020 were the lowest on record, with potential cumulative impacts from two successive fires. Recovery post Gospers Mountain fire appears to be faster than the last fire, with trap rates in 2022 on par with five year post State Mine fire data. Bush Rat numbers generally drive trapping rates, though Swamp Rats increased their presence after the first fire. Antechinus numbers started to build in 2019 and exceeded rodent numbers for the first time in 2020, continuing to dominate through to 2022. House Mice were captured in the CLW Area from 2014 through 2017, and started being caught again in 2021. This species is known to invade disturbed areas. Trapping rates might be ahead of where we expect them to be three years post fire, but the composition of the small mammal community has changed. We will monitor Bush Rat numbers going forward to see whether successive fires has permanently impacted their population.

Table 5-8: Biodiversity indices for birds, mammals and reptiles over time

Group	Diversity index	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Birds	Simpson's	0.86	0.95	0.91	0.92	0.94	0.96	0.94	0.94	0.95	0.97
	Species richness	40	72	64	59	63	49	72	62	71	73
***Native**	Simpson's	0.70	0.71	0.70	0.82	0.82	0.79	0.77	0.76	0.84	0.86
	Species richness	12	13	11	12	14	12	15	13	14	15
Reptiles	Simpson's	NA	0.82	0.86	0.81	0.76	0.75	0.84	0.63	0.82	0.86
	Species richness	0	10	10	10	6	5	10	3	9	9
Amphibians	Simpson's	-	-	-	-	0.39	0.40	0.11	0.42	0.57	0.49
	Species richness	1	3	3	4	2	2	5	4	8	4

Group	Diversity index	2016	2017	2018	2019	2020	2021	2022
Birds	Simpson's	0.96	0.95	0.95	0.95	0.96	0.96	0.95
	Species richness	69	76	76	61	63	65	62
***Native**	Simpson's	0.82	0.81	0.85	0.81	0.84	0.87	0.84
	Species richness	13	11	15	12	10	14	14
Reptiles	Simpson's	0.93	0.73	0.82	0.85	0.67	0.80	0.8
	Species richness	12	9	7	8	11	9	8
Amphibians	Simpson's	0.74	0.78	0.57	0.50	0.56	0.44	0.2
	Species richness	7	7	9	5	9	9	8

*Bats not included

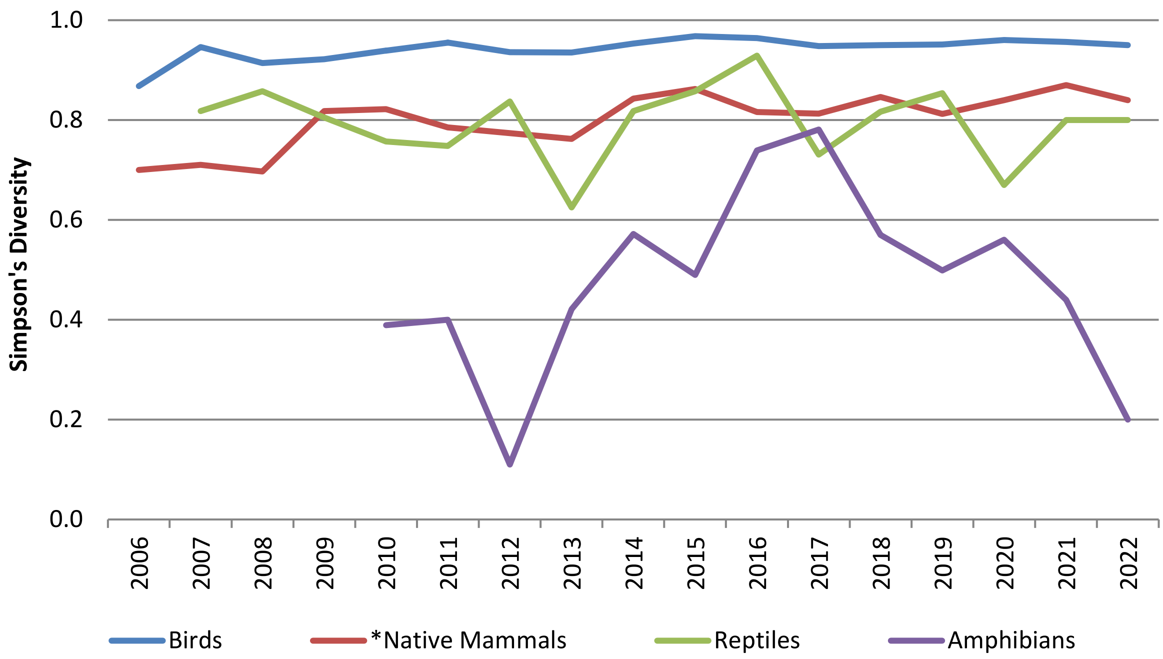

Figure 5-2: Simpson's Diversity for the CLW Area over time

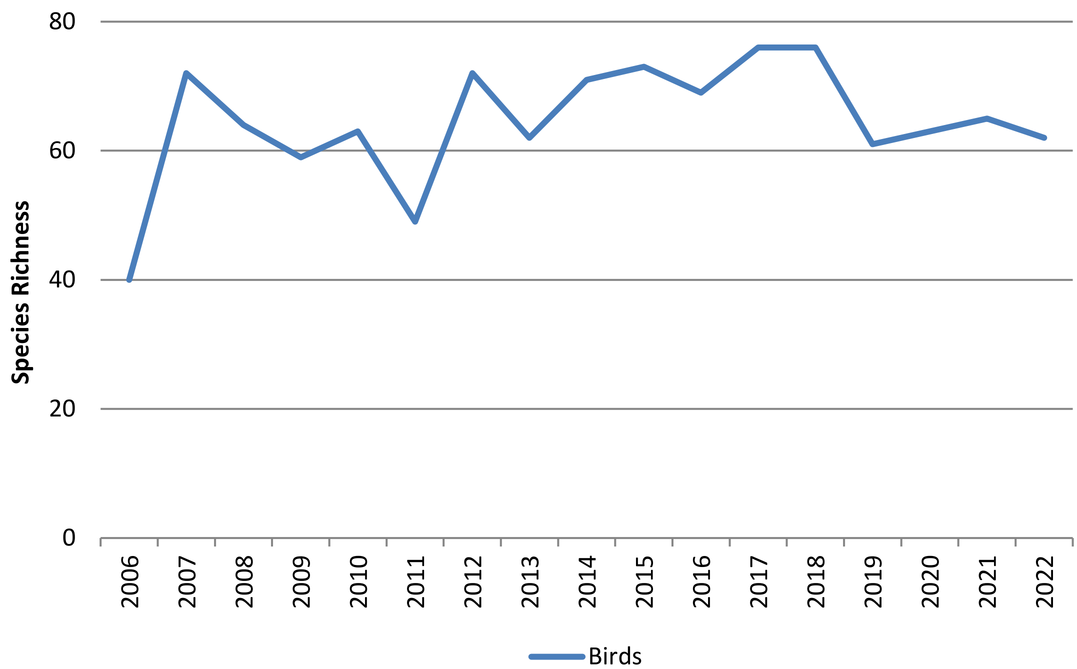

Figure 5-3: Species Richness for birds of the CLW Area over time

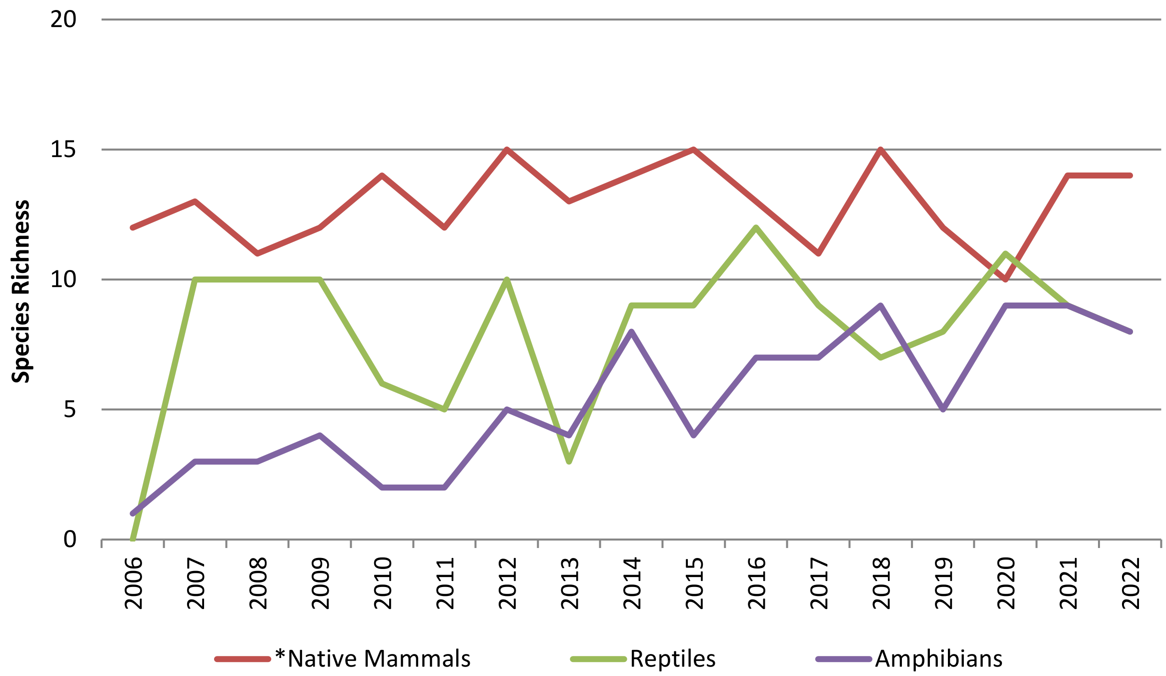

Figure 5-4: Species richness for mammals, reptiles and amphibians of the CLW Area over time

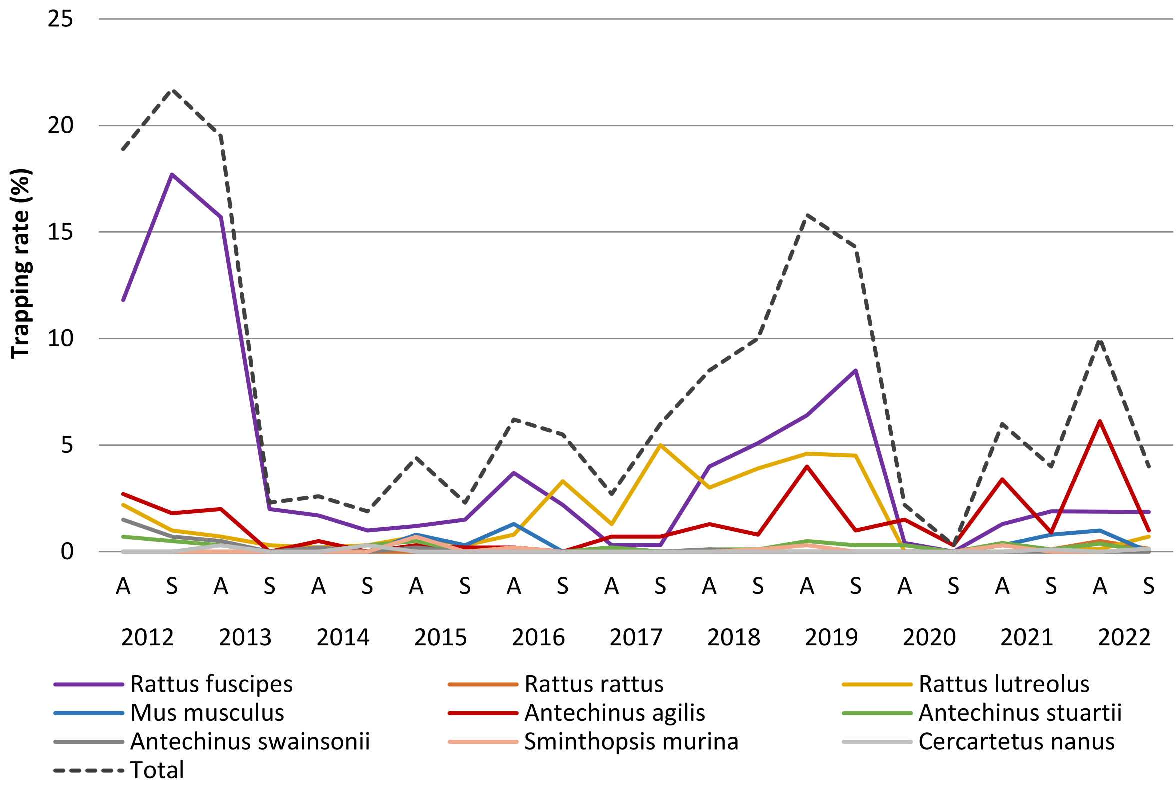

Figure 5-5: Trapping rates for small ground mammals over time

Table 5-9: Mean trapping rates of small mammals in autumn and spring over time

Species	2012		2013		2014		2015		2016		2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S*	A	S	A	S	A	S
Rattus fuscipes	11.8	17.7	15.7	2	1.7	1	1.2	1.5	3.7	2.2	0.3	0.3	4	5.1	6.4	8.5	0.4	0	1.3	1.9	1.9	1.9
Rattus rattus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.1	0.5	0.1
Rattus lutreolus	2.2	1	0.7	0.3	0.2	0.3	0.7	0.3	0.8	3.3	1.3	5	3	3.9	4.6	4.5	0	0	0	0.1	0.1	0.7
Mus musculus	0	0	0	0	0	0	0.8	0.3	1.3	0	0.2	0	0	0	0	0	0	0	0.3	0.8	1	0
Antechinus agilis	2.7	1.8	2	0	0.5	0	0.3	0.2	0.2	0	0.7	0.7	1.3	0.8	4	1	1.5	0.3	3.4	0.9	6.1	1
Antechinus stuartii	0.7	0.5	0.3	0	0	0.3	0.5	0	0	0	0.2	0	0.1	0.1	0.5	0.3	0.3	0	0.4	0.1	0.4	0
Antechinus swainsonii	1.5	0.7	0.5	0	0.2	0	0.2	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0
Sminthopsis murina	0	0	0	0	0	0	0.7	0	0.2	0	0	0	0	0.1	0.3	0	0	0	0.3	0	0	0.1
Cercartetus nanus	0	0	0.3	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0.1
Total	**18.9**	**21.7**	**19.5**	**2.3**	**2.6**	**1.9**	**4.4**	**2.3**	**6.2**	**5.5**	**2.7**	**6.0**	**8.5**	**10.0**	**15.8**	**14.3**	**2.2**	**0.3**	**6.0**	**4.0**	**10.0**	**4.0**

*only four of eight sites were surveyed in spring 2019 due to threatening fire conditions (two control, two impact)

** Paddy's not surveyed in spring 2022

Data based on 6 sites from 2012-2017, and eight sites from 2018 onwards.

Population status of a species

Derivation of the local population status of species located at CLW Area requires a relatively large dataset. Population status is based upon the numbers and distribution of each species within the CLW Area. This data is still being collected and is part of an ongoing process to provide sufficient information to allow assignment of population status of species known to occur.

Contribution to the faunal assemblages by threatened species, species dependent upon woodland, and species declining in Central West NSW

Bird species have been classed by Reid (2000)[6] into woodland dependant and declining in the Central West. These lists were used to calculate the proportion of birds located within the CLW Area that are considered under threat. The higher the proportion, the greater the value that can be placed on the present habitat in the area.

On inspection of the bird species list (**Table 5-2**), the following proportions calculated for the CLW Area over time are given in **Table 5-11** and **Figure 5-6**. The proportion of woodland-dependent and declining bird species is decreasing slowly over time, with drought and fire conditions leading to lower levels of both. It appears the data for this area supports the fact that these groups of species are in decline. After the 2013 fire the habitat may have become temporarily unsuitable for woodland birds, a situation which has not yet been rectified. Significant changes to this figure may indicate changes to the condition of the woodland habitat.

Conversely, the number of threatened species has been increasing over time, peaking in spring 2018 (**Table 5-10** and **Figure 5-7**). Thirteen threatened species were located during the 2022 surveys. These were the Eastern Pygmy-possum, Greater Glider, Large-eared Pied Bat, Eastern False Pipistrelle, Large Bent-winged Bat, Greater Broad-nosed Bat, Gang-gang Cockatoo, Pilotbird, Varied Sittella, Dusky Woodswallow, Scarlet Robin, Flame Robin and Blue Mountains Water Skink. Locations of threatened species are given in **Figure 5-8**. Despite searching preferred habitats during the warmer months, there was no evidence of the presence of Giant Dragonfly, Giant Burrowing Frog or Bathurst Copper Butterfly in the area. Traditionally the swamps of this area are good for Giant Dragonfly. 2020 saw a bumper year with 34 sightings across CLW02, CLW03, CLW04 and CLW06. CLW05 is normally a good site, but since it has been undermined it has dried out substantially, reducing the suitability of the habitat for the species. None were observed across the Plateau in 2022, suggesting climatic conditions may have been unsuitable for emergence this year.

[6] Reid J.R.W. (2000). *Threatened and Declining Birds in the New South Wales Sheep Wheat Belt2. Landscape relationships – Modelling bird atlas data against vegetation cover*. Consultancy Report to NSW National Parks and Wildlife Service. CSIRO Wildlife and Ecology, Canberra.

Table 5-10: Threatened species in CLW Area in autumn (A) and spring (S) over time

Category	2007		2008		2009		2010		2011		2012		2013		2014		2015		2016	
	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S	A	S
Woodland-dependent bird species (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Declining bird species (%)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Threatened species	1	3	5	7	6	7	3	2	6	4	2	3	4	3	4	5	3	6	3	6

Category	2017		2018		2019		2020		2021		2022	
	A	S	A	S	A	S	A	S	A	S	A	S
Woodland-dependent bird species (%)	65	59	59	63	63	64	61	60	70	66	64	62
Declining bird species (%)	5	7	7	9	8	8	3	7	10	8	8	6
Threatened species	7	7	9	11	6	6	8	7	7	9	7	10

Table 5-11: Proportion of woodland-dependent or declining birds in CLW Area each year over time

Category	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Woodland-dependent	83	67	72	77	82	84	74	79	72	79	77	58	62	59	59	62	61
Declining	13	14	12	15	14	12	13	13	15	14	13	8	8	8	6	9	8

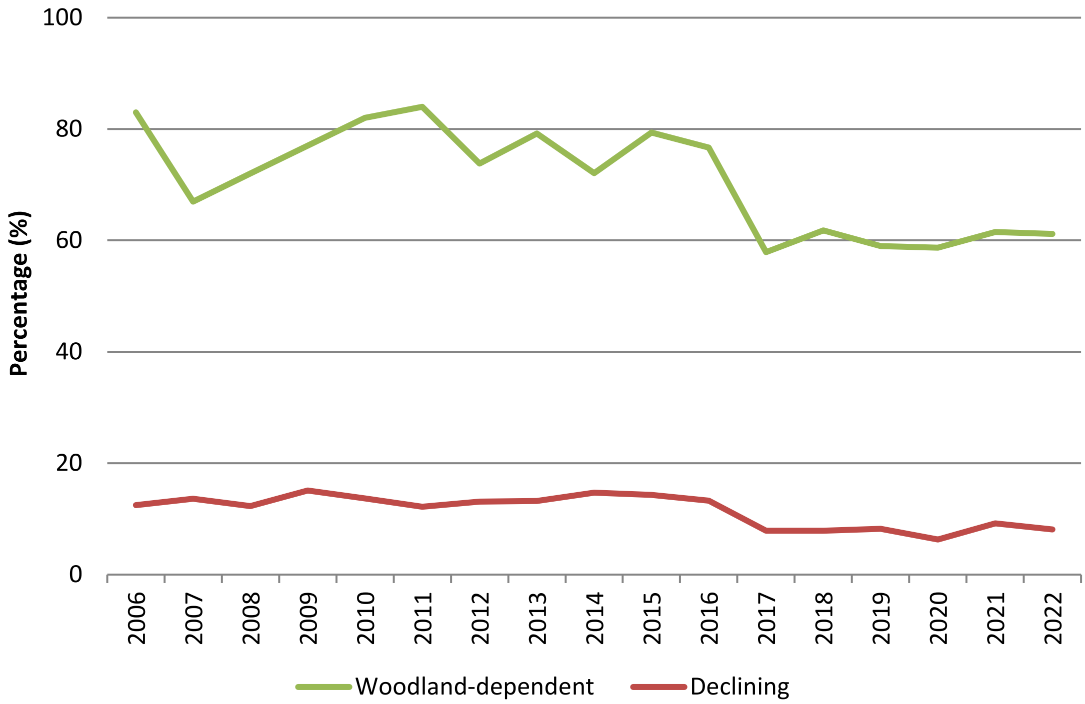

Figure 5-6: Proportion of woodland-dependent and declining bird species in CLW Area each year

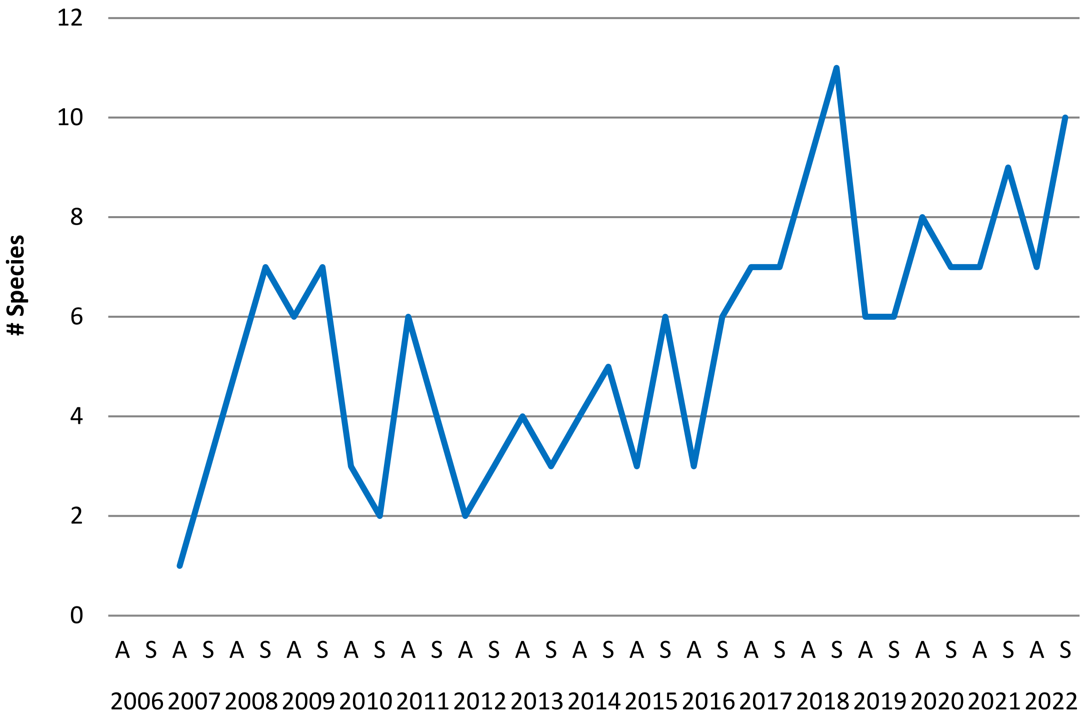

Figure 5-7: Number of threatened species in the CLW Area over time

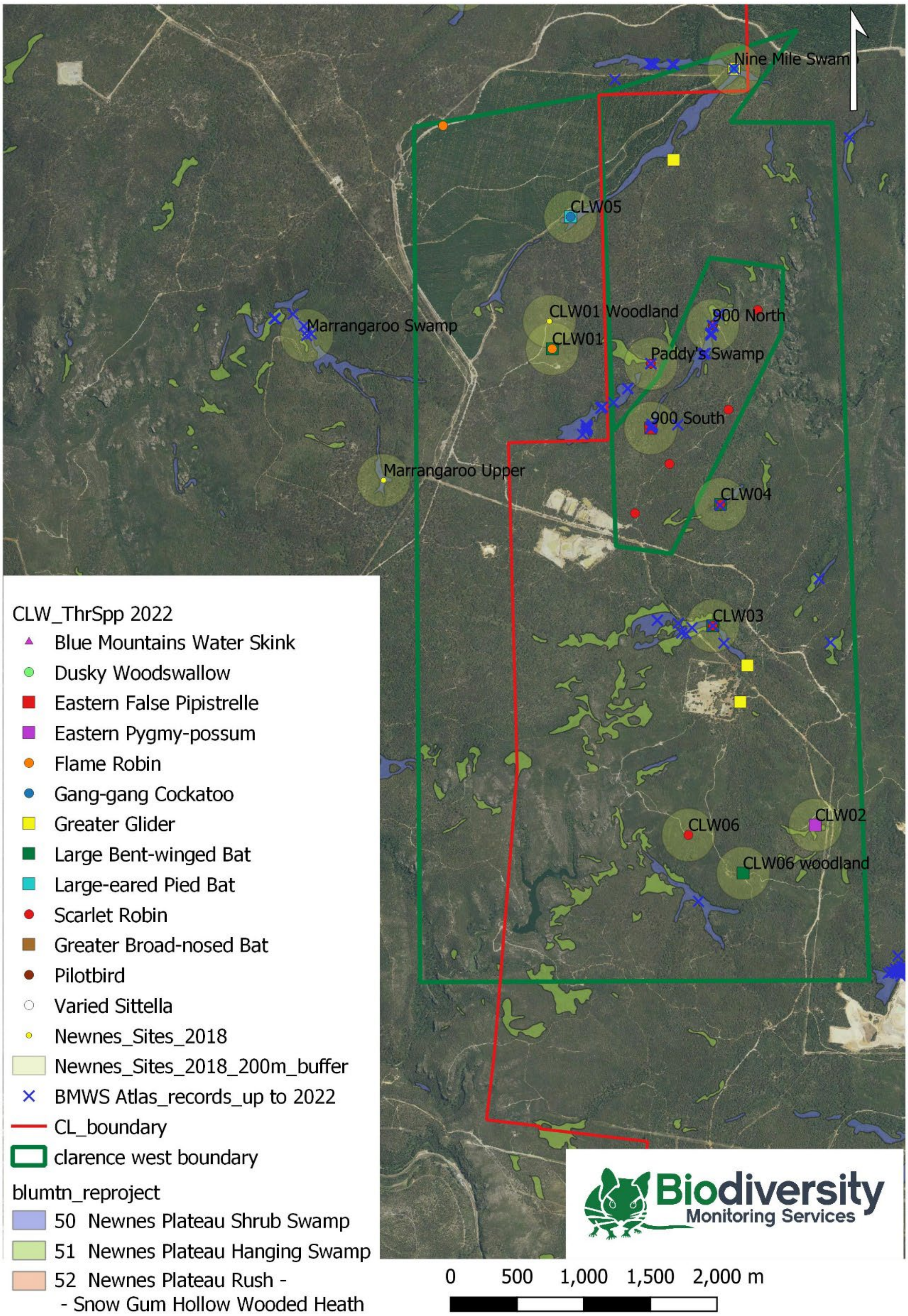

Figure 5-8: Threatened species located within CLW/900 Area this year

Habitat Complexity Scores

Data on Habitat Complexity Scores are covered in Section 4 (see **Table 4-2** and **Figure 4-3**). The main benefit from this approach is the production of a single number that can represent habitat values. By tracking such numbers over time some insight into changes in habitat values may be possible.

Comparison between Treatment and Control sites

The sites within the CLW and surrounding Area cover land where secondary extraction has occurred (treatment), and land where undermining has not occurred (control). Historical control sites are now undermined and included as treatment sites. Treatment sites are CLW01 (undermined spring 2018), CLW02 (undermined Nov 2009), CLW03 (undermined Oct 2010), CLW04 (undermined Nov 2015), CLW05 (undermined spring 2018) and CLW06 (undermined Nov 2011). Four additional sites from the 900 Area (900 North and 900 South) and Springvale New Area (Nine Mile and Paddy's Swamp) have been added to the analysis as control sites. Further details on these sites are included in **Table 1-1** of this and the Clarence 900 2022 Final Fauna Report. **Figure 5-9** to **5-11** show the control and impact fauna diversity values pooled for 2019-2022. **Figure 5-12** shows the HCS for control and impact sites pooled for 2019-2022. The following data is used in this comparison: bird, mammal, reptile and amphibian biodiversity indices, habitat cover characteristics and Habitat Complexity Scores. All sites burnt in both the 2013 and 2019 fires.

Pooled t-tests were conducted on all bird, native non-bat mammal, reptile and amphibian diversity measures to look for differences between control and impact sites in the fire recovery period. Bird Simpson's and species richness were higher in control sites ($p = 0.016$ and $p = 0.003$ respectively). Reptile abundance and richness were significantly higher in control sites ($p = 0.012$ and $p = 0.01$ respectively). Amphibian abundance was significantly higher in control sites ($p = 0.021$). T-tests from autumn and spring generally concur with these assumptions, though no differences in reptile diversity were observed seasonally, and seasonal mammal differences (higher at undermined sites) were not observed when looking at the yearly data.

There was no significant difference in HCS between control and impact sites over the CLW/900/control areas, in spring or autumn.

Overall, there is evidence to suggest reduced bird and reptile diversity in undermined sites post fire, yet there is also evidence for increased mammal diversity in undermined sites. Results are inconsistent across taxa and season, so severe impact is unlikely. There is far greater variation in fauna diversities over time, which come from the effects of fire, drought and other climatic changes. Some changes are consistent with previous years findings, others are new. Monitoring for consistent differences going forward will be important.

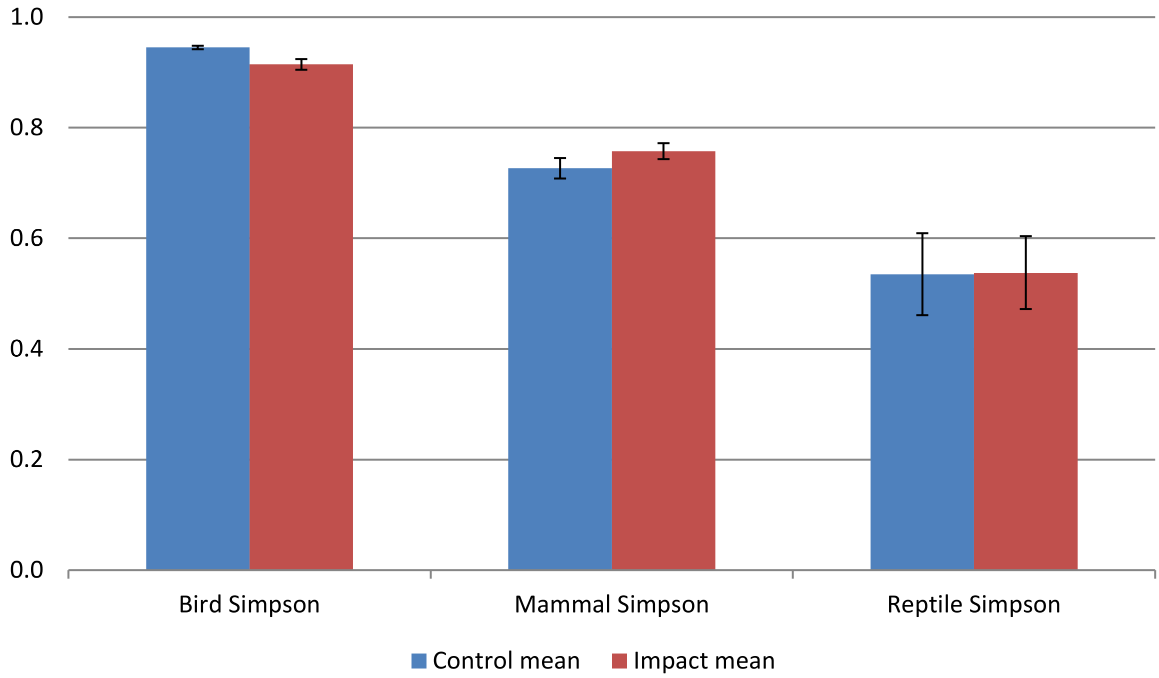

Figure 5-9: Simpson's Diversity Index for birds, mammals and reptiles in control and impact sites

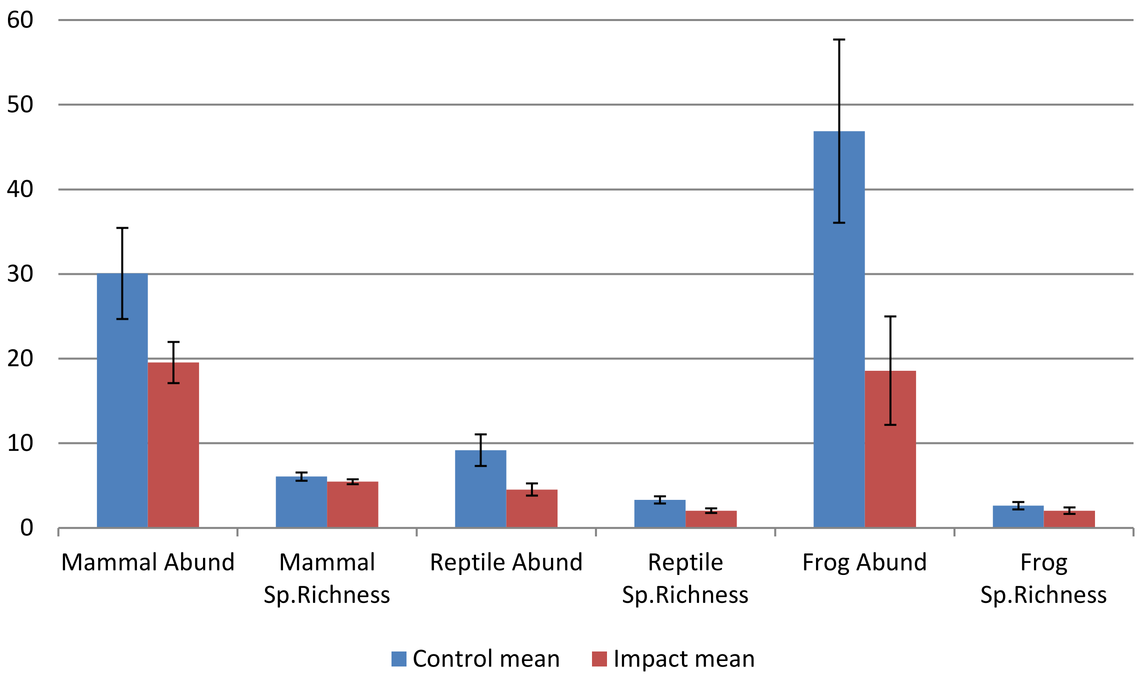

Figure 5-10: Abundance and Species Richness for mammals, reptiles and amphibians in control and impact sites

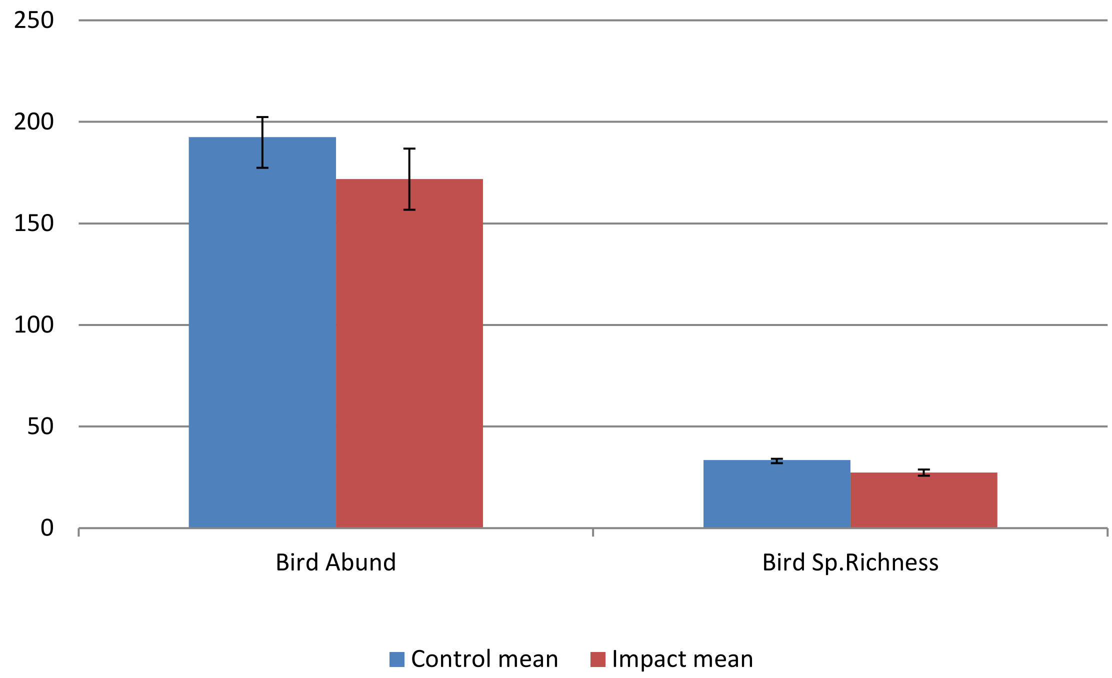

Figure 5-11: Abundance and Species Richness for birds in control and impact sites

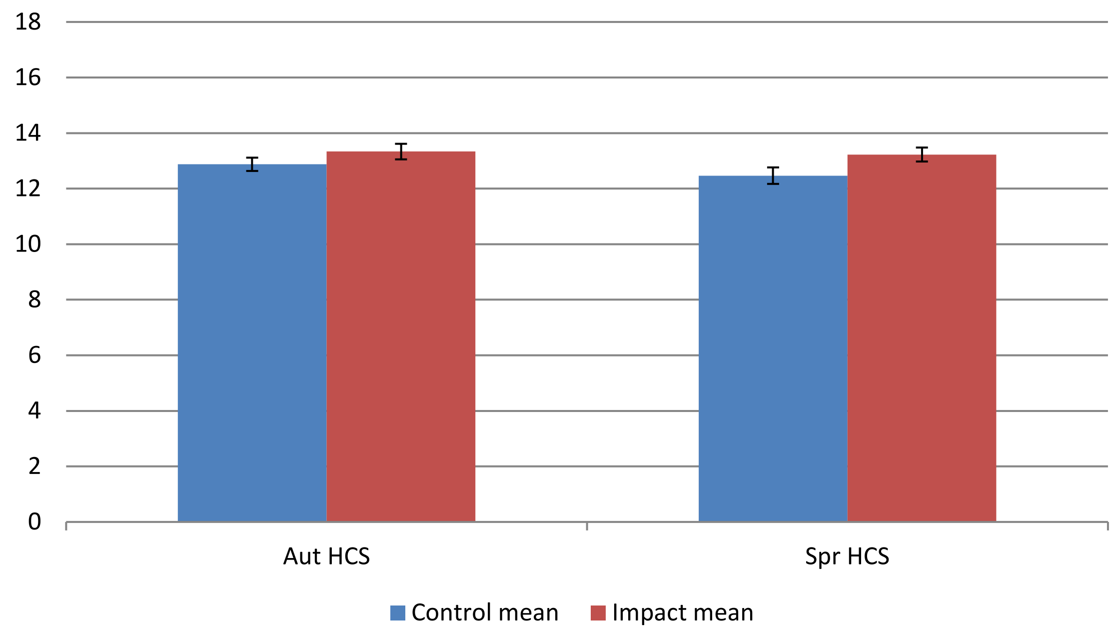

Figure 5-12: Autumn and spring Habitat Complexity Scores for control and impact sites

Bat Activity

Another index that can be derived from the survey data is the species richness and activity of bats over time. Ultrasonic recording with the Anabat device does not allow individual numbers of bats to be ascertained. It does however, let us get an idea of species richness and overall bat activity in an area. Results from the years bat surveys are presented in **Figure 5-13**.

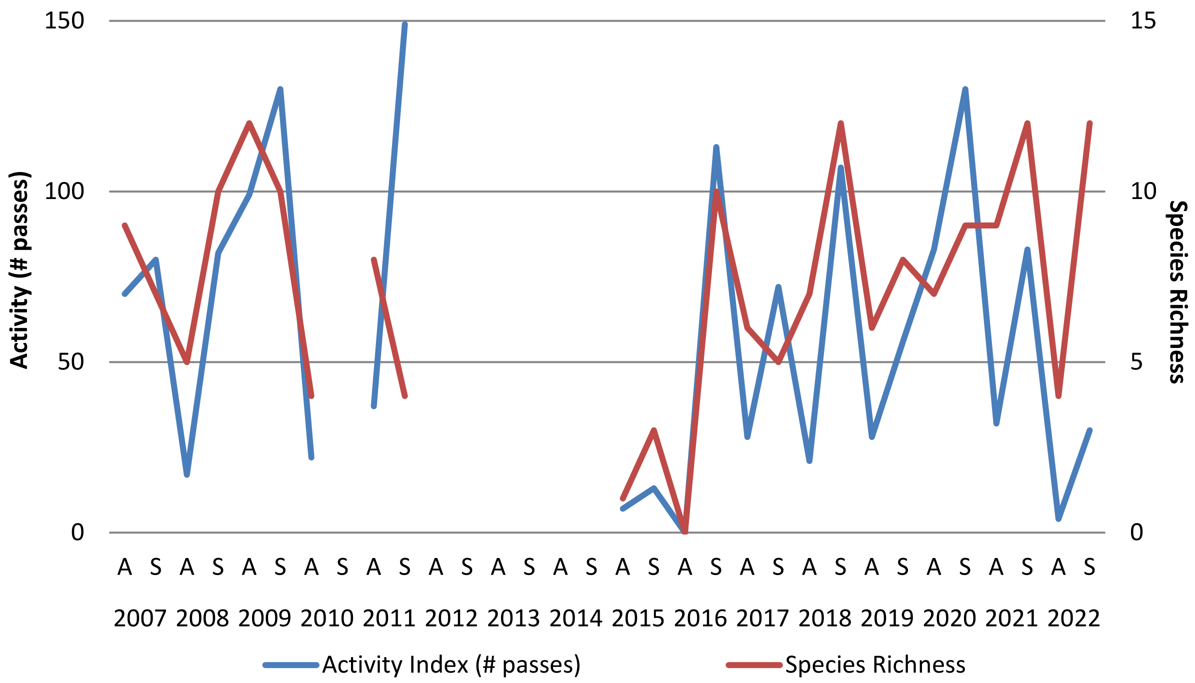

Figure 5-13: Bat species richness and activity index over time

6.0 Conclusion

The configuration of survey sites established in 2006 adequately samples the two major environments within Clarence Colliery Western SMP Application Area i.e. pagoda and wetland (swamp). These sites will provide the best possible data for the long-term monitoring of terrestrial vertebrates. The survey techniques used have been successful in locating a wide range of species, though no new species were found in the area this year. Pagoda habitat mainly comprises low heath that is characteristic of pagoda and hilltop environments on Newnes Plateau.

The Western SMP Area appears to be productive, in terms of fauna diversity values. At this stage 28 threatened species are known to occur within the area, and several species that have been located are considered as being of conservation concern in this region e.g. Beautiful Firetail, Rufous Fantail, Long-nosed Bandicoot. The area should be considered heavily disturbed by recreational activities, particularly trail bikes and 4WDs. This must be brought into consideration when assessing any changes.

The major influence upon the fauna populations (and vegetation) within Clarence West has been the 2013 State Mine and 2019 Gospers Mountain fires that burnt out all the sites in the area. Fire is a natural part of Australian ecosystems and both fires were typical of a high intensity burn. The frequency of fire is the issue here, as sufficient time is required for vegetation and fauna populations to recover before they can withstand another knock down. The data we have obtained over the years provides an important analysis of recovery from fire by fauna. Surveys from 2020 will likely focus on comparing rates of recovery within burnt areas that have been previously mined and those still to be mined or used as controls.

The results from the survey of the Clarence Colliery Western SMP Area in 2022 show that the assemblages found are more typical of that found throughout Newnes Plateau than we would expect after extensive fires swept through the area in December 2019. The timing of the survey was successful, in terms of the number of individuals and diversity of species within the main fauna groups surveyed, though park closure and weather conditions caused access issues for 5 sites across autumn and spring this year. Most diversity parameters have remained stable over the long term, except bird and amphibian species richness which have increased. Most diversity parameters that have remained within levels of expected variation still declined sometime in 2017-2019, with native non-bat mammal species richness the only measure to show an all time low in the drought/fire period (2020). Small mammal capture rates almost returned to pre fire levels in 2019, six years post fire, but crashed in 2020 to an all time low. This is likely due to the lack of rocky refugia proximal to the CLW sites, combined with the severity of the peat burning in many of the swamps and the frequency of fire. Bat activity was down in 2022, though species richness was still within the normal level of variation, suggesting the invertebrate food source that this group relies on may have experienced low activity due to cold/wet conditions. As is often the case with fire, once the vegetation and associated food source is wiped out, there is a delay in seeing return of species to the landscape. There were sufficient numbers and diversities of these fauna groups to be able to calculate a set of diversity indices that form part of the baseline monitoring database. Above average rainfall in most months since fire appears to have helped start the regeneration process on the Plateau. Fauna results have followed with overall abundance down, but most functional groups represented.

Thirteen threatened species were located during 2022, as well several bird species dependent upon woodland habitats. Threatened species included Eastern Pygmy-possum, Greater Glider, Large-eared Pied Bat, Eastern False Pipistrelle, Large Bent-winged Bat, Greater Broad-nosed Bat, Gang-gang Cockatoo, Pilotbird, Varied Sittella, Dusky Woodswallow, Scarlet Robin, Flame Robin and Blue Mountains Water Skink. Their locations are shown in **Figure 5-8**. This is about average, considering a number of species have been listed since surveys began. Woodland-dependant and declining birds have been dropping slowly over time, with the 2017-2022 period experiencing a lull. Both the State Mine and Gospers Mountain fires affected the fauna and habitats within the CLW area, with many measured parameters falling after each.

There are some differences between habitat characteristics in undermined and control areas, but differences are inconsistent across season and direction of change. Tall shrub was the only characteristic to be consistently low in undermined sites, two of which are stunted pagoda heath habitats that typically lack a tall shrub layer. Fauna diversities showed some difference by mining impact, but results were again inconsistent over season. Bird Simpson's, bird Evenness, bird richness, mammal abundance, and frog abundance and richness were lower in undermined sites (only bird Simpson's consistently). On the other hand, mammal Simpson's and Evenness were higher in undermined sites. Yearly analysis restricted to the period where new control sites were added and CLW previous controls were undermined, suggest bird Simpson's and species richness, reptile abundance and richness, and amphibian abundance are all significantly higher in control sites. There were more significant differences over time, suggesting the magnitude of change in habitat and fauna diversities is more dependent on climatic conditions or fire events. While the survey methodology and effort has not changed dramatically since 2010, the sites used in calculations have changed over time as some sites became undermined. Mining commenced in the CLW Area in November 2009, and is now affecting all of the impact survey sites. Undermining of the two control sites by Springvale began in November/December 2018, so these sites have also become impact sites.

Given the low levels of subsidence from previous mining at Clarence Colliery, the risk of adverse impacts on fauna within this area is considered to be low. Statistical analysis of fauna populations in the CLW areas suggest changes in diversities are primarily due to climatic changes, though some evidence of lower diversity measures in undermined sites is shown. The differences seen this year were similar to last year, but different to previous years (except bird Simpson's), so continued monitoring of these indices will tell whether we have evidence of ongoing change due to mining, or simply a temporal anomaly. At present, there appears to be little conclusive evidence of subsidence impacts upon the fauna diversity at CLW Area.

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27 January 2023

Appendix 5: Aquatic Monitoring Reports

Appendix	Report Name
Appendix 5A	Wollangambe River Aquatic Ecology – Autumn 2022 Data Report (Marine Pollution Research Pty Ltd, 2022a)
Appendix 5B	Wollangambe River Aquatic Ecology – Spring 2022 Data Report (Marine Pollution Research Pty Ltd, 2022b)
Appendix 5C	Bungleboori Creek Catchment Aquatic Ecology – Autumn 2022 Data Report (Marine Pollution Research Pty Ltd, 2022c)
Appendix 5D	Bungleboori Creek Catchment Aquatic Ecology – Spring 2022 Data Report (Marine Pollution Research Pty Ltd, 2022d)
Appendix 5E	Dingo Creek Catchment Aquatic Ecology – Autumn 2022 Data Report (Marine Pollution Research Pty Ltd, 2022e)
Appendix 5F	Dingo Creek Catchment Aquatic Ecology – Spring 2022 Data Report (Marine Pollution Research Pty Ltd, 2022f)
Appendix 5G	Wollangambe River Aquatic Ecology Monitoring – Annual 2022 Summary Report (Marine Pollution Research Pty Ltd, 2023)

CENTENNIAL COAL
CLARENCE COLLIERY

WOLLANGAMBE RIVER
AQUATIC ECOLOGY

AUTUMN 2022 DATA REPORT

Figure 1. Looking downstream through WGRdam.

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD
JULY 2022

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Marine Pollution Research Pty Ltd (MPR) has been re-commissioned by Clarence Colliery to undertake biannual (Autumn and Spring) streamhealth monitoring to assess the possible effects on aquatic ecology of Wollangambe River below the Clarence Colliery Licensed Discharge Point 2 (LDP2). The streamhealth surveys are being conducted using standardised methods applied to other Centennial Coal stream health studies in the Coxs and Wolgan River upper catchments.

This report provides the results of the nineteenth biannual streamhealth sampling program which was undertaken in autumn 2022 and follows on from the previous Wollangambe River streamhealth survey undertaken in spring 2021. MPR had previously been commissioned to undertake additional EMP seasonal monitoring in spring 2019, and as that program utilised three of the Streamhealth sampling program sites, the results were incorporated into the long-term streamhealth indices for this survey.

The mine is located within the 690 Ha upper Wollangambe River catchment, above the Blue Mountains National Park. The portions of the upper Wollangambe River catchment upstream and downstream of the mine comprise undeveloped native forest, and the upper catchment is bounded by Newnes State Forest to the north, Blue Mountains National Park to the east and Hansons' Sand Quarry to the west. The Wollangambe River below the mine Main Storage dam flows past several tributaries that contain hanging swamp endangered ecological communities (EECs) prior to reaching the National Park boundary.

The Clarence Colliery site includes a storm water and dirty water management scheme that separates clean and dirty water streams, bunding, stilling and filtration ponds plus a Mine Water Treatment Plant (MWTP). The discharge from the MWTP is licensed by the NSW Environment Protection Authority (EPA).

Discharge from the MWTP at LDP2 flows down a small western tributary of the Wollangambe River, with the combined discharge and river flow discharged into a 70ML dam (the Colliery Main Dam). The Colliery extracts water from the dam for use on site, and during dry weather periods, additional water can be extracted and piped to Farmers Creek to provide additional source water for the Lithgow City potable water supply plant.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims the Aquatic Ecology Sampling Program endeavoured to answer the following questions:

- Are there measurable differences in aquatic ecological habitat or riparian attributes between river or creek pools upstream and downstream of LDP2, and within reference sites?
- Are there measurable differences in aquatic macroinvertebrate assemblages at the AusRivAS level of taxonomic resolution between Wollangambe River Upstream and Downstream of Discharge sites?
- Can observed differences be attributable to spatial (between-site) differences and/or Colliery discharge?
- Do the survey sites provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Do the sites provide suitable fish passage?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in Spring and Autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June15 and 'spring' is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of basic water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

There were seven sites sampled for the autumn 2022 Clarence aquatic ecology survey (**Table 1**), all of which were sampled during the previous survey in spring 2021. In total there were four sampling sites in the Wollangambe River, one site in the Main Dam and two sites in unnamed reference creek tributaries (see **Figure 2**).

The autumn 2012 survey report (MPR 2012) provides detailed descriptions of the original sample sites, with additional descriptions for sites brought online over subsequent seasons provided in the corresponding reports; WGRXdown in autumn 2013 (MPR 2013b) and WGRtrib1 in spring 2014 (MPR 2015).

Table 1 Clarence LDP Aquatic Ecology Seasonal Sample Site Information

Site	Coordinates		Seasonal Surveys			Description
	E	N	Au 12 - Sp 12	Au 13 - Au 14	Sp 14 - Au 22	
			N=2	N=3	N=12	
WGR up	243889	6295015	x	x	x	Upstream Wollangambe River monitoring site located above LDP2 input.
WGR dam	244427	6294590	x	x	x	Site sampled at upper end of the Main Dam below the confluence of LDP2 and Wollangambe River.
WGR trib1	244568	6294840			x	Site sampled within lower limits of unnamed tributary, in 'backwaters' of discharge from Main Dam spillway.
WGR swamp	244871	6294619	x	x	x	Site located at the downstream end of the lower of two swamps in Wollangambe River, around 530m below the Main Dam weir.
WGR down	245070	6294799	x	x	x	Downstream monitoring site located in Wollangambe River around 950m below the Main Dam weir.
WGRX down	245452	6293646		x	x	Downstream monitoring site located in Wollangambe River around 2.6km downstream from the Main Dam weir.
WGR ref	245073	6294952	x	x	x	Reference tributary site which flows in a southerly direction to join Wollangambe River at WGRdown.

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b). The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.

Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum". However, "sampling riffles where the substratum consists predominantly of large boulders may be difficult and may not produce reliable results".
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

Site selection for sampling aquatic biota from the river is constrained by access from the road network through the forest to the river and by river access where the river flows through deep incised canyons or through boulder cascades. The river and reference tributary generally comprise narrow channels either with mobile sand or rock beds joined together by rock boulder cascades. There were few broader pools and few sand or log bar constraints.

Further, given the location of a number of the study sites in reaches of streams where there are known to be periods of little or no connecting flow between pools or where there are known to be limited riffle sections available for sampling, it was decided that only pool 'edge' samples would be sampled, as AusRivAS defined riffle samples could not be guaranteed for all (or possibly even for most) sites at all sample times.

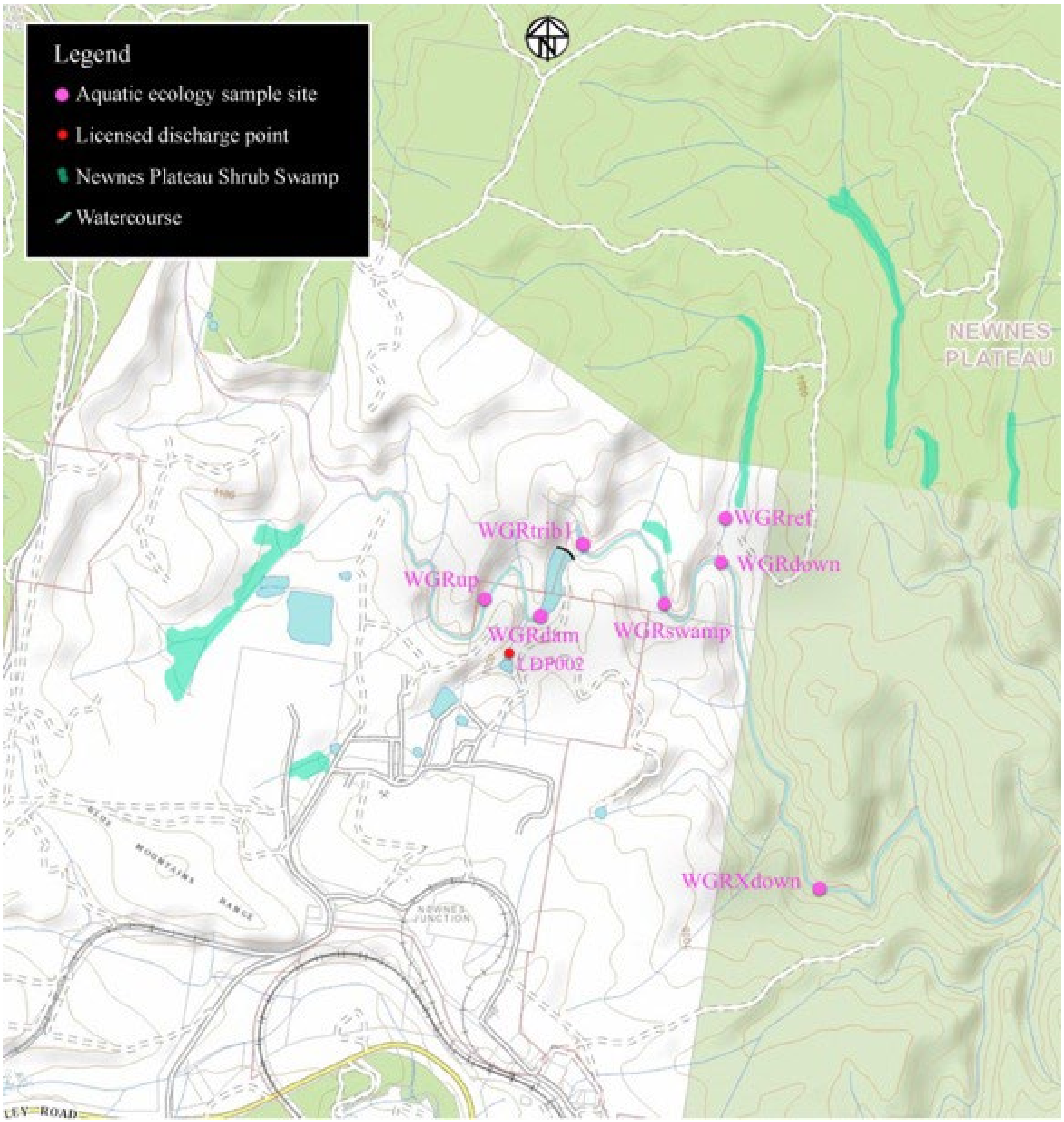

Figure 2: Clarence Aquatic Ecology Sample Sites Autumn 2022

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method. Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event. For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory.

Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae are kept for confirmation purposes.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars. Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant).

For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis. Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey. Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys.

As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised 'health' scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified.

For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the autumn 2022 aquatic ecology sampling are provided in **Appendix Table A3**. Sampling for the full autumn 2022 survey was undertaken over the 9^{th} and 10^{th} May 2022.

3.1 Sampling Conditions Spring 2021 to Autumn 2022

Appendix Tables A-1 & A-2 provide the daily rainfall and LDP discharge results for 2021-2022 and are shown graphically in **Figure 3**. Following on from the previous aquatic ecology spring survey in November 2021, the study area was subjected to consistent wet weather events:

- The combined rainfall total over the five-month period between December 2021 and April 2022 (848mm) was more than double the combined mean monthly total for the same months (381mm). Patterns of precipitation over the five-month period was characterised by regular rain events, with 78% of the days registering rainfall.
- March 2022 was the wettest month, recording the highest total rainfall with 317mm over 30 rainfall days, including 78% of the monthly total in the first eight days of the month (243mm).

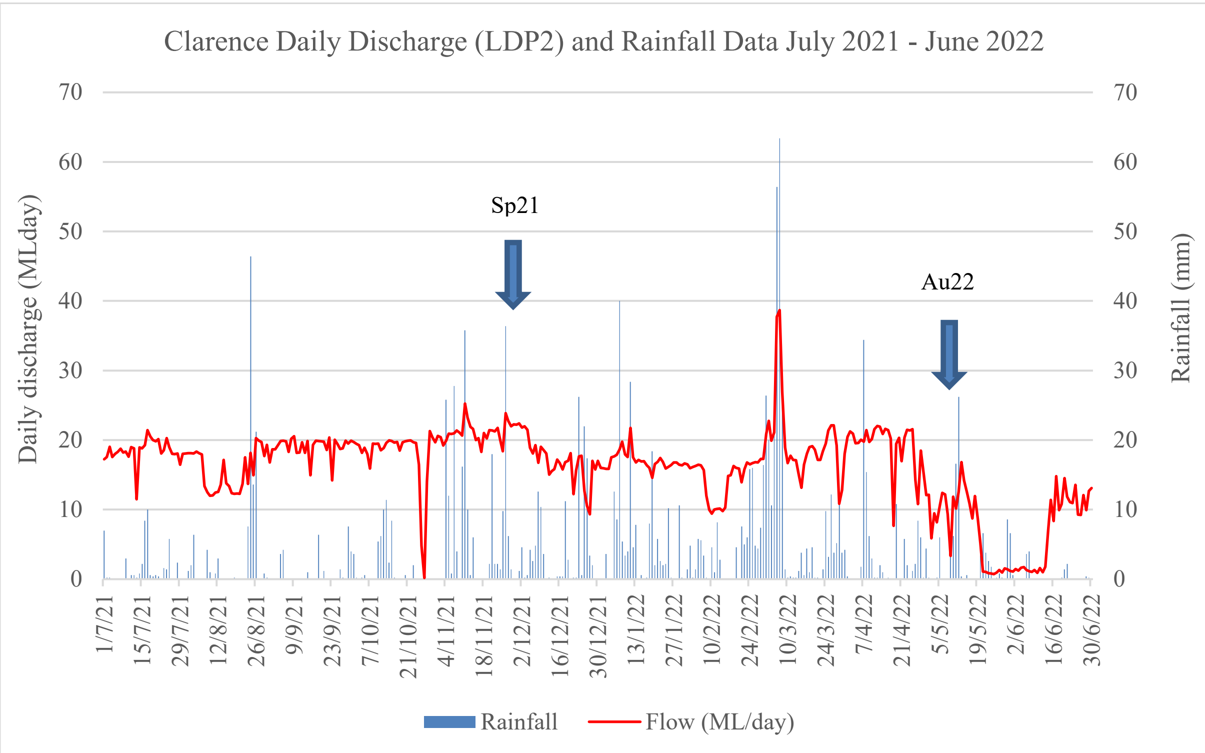

Figure 3 Monthly Rainfall & Monthly discharge between July 2021 – June 2022.

Daily discharges from LDP2 were for the most part, consistent between November 2021 and May 2022, maintaining flow rates between 15 and 22 ML/day. In response to 218mm rainfall over the preceding 7 days, daily discharges increased to a maximum of 39 ML/day on the 7th March, however this abated quickly with the easing of wet weather conditions.

3.2 Autumn 2022 Aquatic Ecology Survey Results

The Clarence autumn 2022 aquatic ecology survey was undertaken over 9th and 10th May 2022 following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. **Appendix Table A-3** provides site field notes for the autumn 2022 sampling program and site photos are also provided **Appendix A**. Summary tables for the autumn 2022 Appendix A data are provided in the following Sections.

3.3 Metered Water Quality Results

A water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling during the autumn 2022 aquatic ecology field sampling program.

Table 2 Site Field Water Quality Readings Autumn 2022

Site	Date	Time	Depth	Temp	Cond	DO	DO	pH	Turb
			m	°C	µS/cm	%sat	mg/L	Units	ntu
WGRup	10/05/22	10:26	0.1	11.39	7	61.0	6.68	5.12	0.4
LDP002	10/05/22	11:09	0.2	15.48	298	60.6	6.05	7.48	1.1
WGRdam	10/05/22	11:1	0.1	15.13	273	60.3	6.07	7.29	1.5
WGRtrib1	9/05/22	15:04	0.2	9.64	12	39.6	4.51	4.74	0.1
WGRswamp	9/05/22	13:34	0.1	12.61	214	60.5	6.44	6.53	0.1
WGRdown	9/05/22	11:02	0.2	12.12	215	62.3	6.70	6.70	0.2
WGRXdown	10/05/22	8:00	0.2	12.20	213	62.5	6.71	6.69	0.3
WGRref	9/05/22	11:17	0.1	10.37	5	60.6	6.79	5.50	0.1

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-3**) provide details of stream reach flows, pool dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-4** with summary provided in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the autumn 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results

Category	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	WGRref
Land-use pattern beyond immediate riparian zone	4	4	4	4	4	4	4
Width of riparian strip-of woody vegetation	4	4	4	4	4	4	4
Completeness of riparian strip of woody vegetation	2	4	4	2	2	2	2
Vegetation of riparian zone within 10 m of channel	4	4	4	4	4	4	4
Stream bank structure	1	4	4	2.5	2.5	2.5	1
Bank undercutting	2	3	3.5	1.5	2	2.5	2.5
Channel form	4	2.5	4	4	4	4	4
Riffle/pool sequence	4	0	3	3.5	4	4	4
Retention devices in stream	3	0.5	4	3	3	3.5	3.5
Channel sediment accumulations	3.5	1	2.5	2	2.5	2.5	2
Stream bottom	4	2	2.5	3	3	4	4
Stream detritus	1.5	2	3.5	3.5	3.5	3	3.5
Aquatic vegetation	4	2	1.5	4	4	4	4
Autumn 2022 RCE %age – this survey	78.8	63.5	85.6	78.8	81.7	84.6	81.7
Spring 2021 RCE %age - previous survey	77.9	63.5	86.5	78.8	81.7	84.6	80.8
Long-term Mean	88.3	66.2	88.1	80.9	85.7	89.0	88.5
Long-term SD	5.2	5.5	2.4	4.5	3.4	3.8	5.3
Long-term X-SD	83.1	60.7	85.8	76.4	82.3	85.1	83.1

Table 4 Clarence Aquatic Ecology Site Macrophyte Occurrence Autumn 2022

Season	Site	Rush *Baumea rubiginosa*	Pampas Grass *Cortaderia selloana*	Tall Spikerush *Eleocharis sphacelata*	Rush *Juncus sp.*	Sago Pondweed *Stuckenia pectinata*	Cumbungi *Typha spp*	Blunt Pondweed *Potamogeton ochreatus*	Charophytes
Autumn 2022	WGRup	1			1				1
	WGRdam	1	1	1	1		1	1	
	WGRtrib1	1	1	1	1	1	1	1	
	WGRswamp								1
	WGRdown				1				1
	WGRXdown								
	WGRref				1				

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-5 shows the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The table also provides site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

Tables 5 to 7 provide summary statistics for seasonal and site Diversity (taxa richness), SIGNAL and EPT scores, derived from the aquatic macroinvertebrate data in **Appendix Table A-4**. The Tables also provide a comparison of total and individual site results against the previous seasonal results and against site long term Mean (X) and Standard Deviation of the Mean (SD) statistics for each site:

- **Orange** highlight indicates results are below the X-SD value.
- **Yellow** highlight indicates results in the range X to X-SD.
- **Green** highlight indicates results in the range X to X+SD.
- **No highlight** indicated values > the X+SD value.
- Results in **Bold** are the site Minimum Value.

Table 5 Seasonal Site Diversity (No. Of Taxa)

Site / Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	**27**	**12**	15	14		8	15		
Sp12	35	19	17	14		8	20		
Au13	34	14	15	16		8	11	13	11
Sp13	31	17	14	14		11	15	**11**	**4**
Au14	36	14	14	18		8	**7**	16	9
Sp14	42	22	16	22	20	13	19	19	8
Au15	40	16	16	16	**15**	8	12	16	10
Sp15	38	14	**13**	16	18	5	14	14	12
Au16	42	17	15	16	19	11	14	16	8
Sp16	39	18	17	20	18	8	10	15	7
Au17	34	13	17	14	17	9	11	15	7
Sp17	36	13	17	16	17	**3**	8	16	9
Au18	36	18	16	15	18	10	7	14	11
Sp18	31	13	17	**12**	16	6	12	14	7
Au19	37	18	18	14	17	10	8	12	8
Sp19		15					7	19	11
Au20	34	15	16	13	17	10	12	13	11
Sp20	40	20	16	14	20	8	15	16	9
Au21	35	13	15	16	19	9	12	15	5
Sp21	35	11	12	17	20	7	14	13	6
Au22	37	13	17	16	16	11	17	14	6
Mean	35.9	15.6	15.6	15.6	17.9	8.4	12.2	14.8	8.5
SD	3.8	2.9	1.5	2.4	1.5	2.3	3.7	2.1	2.3
X-SD	32.1	12.7	14.0	13.2	16.4	6.2	8.4	12.7	6.2

Table 6 Seasonal Site SIGNAL Indices									
Site Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	5.44	5.92	6.07	4.14		4.50	5.73		
Sp12	4.71	5.35	5.29	2.86		4.25	4.55		
Au13	4.71	6.00	5.80	3.19		5.63	4.64	5.23	6.09
Sp13	4.97	5.67	5.79	3.36		5.00	4.87	4.09	5.50
Au14	5.05	6.14	5.21	3.94		4.13	4.50	4.13	4.67
Sp14	4.76	5.59	4.81	3.32	3.56	4.08	3.89	4.28	5.13
Au15	5.09	5.56	5.63	3.60	**3.14**	4.88	4.45	5.88	6.60
Sp15	4.62	5.08	4.77	3.73	3.47	4.60	4.15	4.29	5.00
Au16	4.44	5.00	5.00	3.13	3.72	4.09	4.62	4.65	6.25
Sp16	4.58	5.11	5.12	4.26	3.18	5.00	4.44	5.27	5.57
Au17	4.70	5.33	**4.59**	3.07	3.38	3.50	4.18	5.27	**3.86**
Sp17	4.20	5.08	5.35	3.53	3.63	**3.00**	4.75	4.12	5.56
Au18	4.54	4.71	5.53	3.00	3.41	4.20	**3.43**	3.79	6.09
Sp18	4.70	4.83	4.81	2.91	4.27	3.33	3.92	5.00	4.57
Au19	4.64	5.00	4.94	4.29	3.25	3.82	3.88	4.83	5.88
Sp19		5.43					3.86	5.11	5.82
Au20	**4.19**	**4.07**	4.64	**2.75**	3.47	5.22	4.36	**3.36**	5.91
Sp20	4.46	4.89	5.27	3.71	3.47	4.25	4.20	5.27	5.00
Au21	4.39	4.92	5.80	3.19	3.65	4.44	4.55	4.73	6.00
Sp21	4.36	5.09	5.58	4.13	3.61	4.57	3.62	5.23	4.33
Au22	4.58	5.23	4.88	4.31	3.60	4.36	5.00	5.50	4.88
Mean	4.66	5.24	5.26	3.48	3.51	4.34	4.33	4.69	5.43
SD	0.31	0.49	0.44	0.50	0.28	0.66	0.51	0.65	0.74
X-SD	4.35	4.75	4.82	2.98	3.24	3.69	3.82	4.04	4.69

Table 7 Seasonal Site EPT Indices									
Site Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	9	7	6	3		2	6		
Sp12	8	7	6	2		1	4		
Au13	8	8	5	1		3	3	3	3
Sp13	**5**	3	4	1		1	4	2	2
Au14	8	5	4	2		1	**0**	4	4
Sp14	8	7	5	3	2	2	4	5	4
Au15	9	7	**3**	3	**1**	1	2	6	5
Sp15	6	**3**	5	2	2	1	1	3	4
Au16	10	5	3	1	3	2	2	6	4
Sp16	10	6	5	4	2	2	1	5	4
Au17	9	4	6	1	3	2	2	5	2
Sp17	6	4	5	2	2	**0**	1	2	2
Au18	7	4	3	2	2	3	1	2	5
Sp18	6	3	4	**0**	3	1	2	5	**1**
Au19	10	6	3	4	2	1	1	3	5
Sp19		5					1	5	3
Au20	5	3	3	2	2	2	2	**1**	5
Sp20	13	6	5	1	3	2	2	6	3
Au21	7	4	5	2	2	3	2	4	4
Sp21	7	**2**	4	3	3	1	0	4	2
Au22	7	**4**	5	4	3	3	2	4	3
Mean	7.9	5.0	4.4	2.1	2.3	1.6	2.1	3.9	3.4
SD	2.0	1.7	1.1	1.1	0.6	0.8	1.5	1.6	1.2
X-SD	5.9	3.2	3.4	1.0	1.7	0.8	0.5	2.4	2.2

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

AUTUMN 2022

Appendix Table A-1 Clarence Site Daily Rainfall (mm) for 2021 to 2022

Year	2021						2022					
Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1st	7	1.2	0	3.6	0	1.2	0	1.4	16.4	0.4	0.2	0.6
2nd	0.2	2	0	0.2	0	4.6	3.6	4.8	26.4	0	0	0
3rd	0.2	6.4	0	0	0	0.2	0	0.2	20	0	0	0
4th	0	0	3.6	0.2	25.8	0.6	0	1.4	10.6	0	0.2	0
5th	0	0	4.2	0.6	12	4.2	12.6	5.8	24.8	0	6	0
6th	0	0	0	0	0.8	2.6	8.6	5.6	56.4	1.8	0	3.6
7th	0	0	0	0	27.8	4.8	40	3.4	63.4	34.4	0	4
8th	0	4.2	0	0	4	12.6	5.4	0.2	24.8	15.4	0	0
9th	3	1	0	0	0	10.4	3.4	0	1.4	6.2	6	0
10th	0	0	0	5.4	16.2	3.6	4	4.6	0.2	3	6.2	0
11th	0.6	0.8	0	6.2	35.8	0	28.4	1	0.4	0.2	16.6	0
12th	0.6	3	0	10	10	0.2	4.6	8.2	0.2	0.2	26.2	0
13th	0.2	0	0	11.4	0.6	0	7.8	2.8	0.2	2	0.4	0
14th	0.8	0	1	2.4	6	0	0	0	1.2	1	0	0
15th	2.2	0	0	8.4	0	0.4	0.6	0	3.8	0	0.6	0
16th	8.4	0	0	0.2	0	0.4	0	0	0.6	0.2	0	0
17th	10	0	0	0	0	0.4	0.2	0	4.4	0	0	0
18th	0.6	0.2	6.4	0	0	11.2	8	0	1	0	0	0
19th	0.4	0	0	0	0	2.8	18.4	4.6	4.6	10.8	0	0.2
20th	0.6	0	1.2	0.6	2.2	0	2	0	0.2	0	3.4	1.4
21st	0.4	0	0	0	18	0.2	5.8	7.6	0.2	0	6.6	2.2
22nd	0	0	0	0	2.2	0.2	2.6	5	0	5.8	3.8	0
23rd	1.6	7.6	0	2	2.2	26.2	2	6	1.4	2	2.6	0
24th	1.4	46.4	0	0	1.4	0.6	2.2	15.8	9.8	0	1.8	0
25th	5.8	13.6	0	0	9.8	22	10.2	16	3.2	1.2	0	0
26th	0	21.2	1.4	0	36.4	17.4	0.2	4.8	12.2	2.2	0.2	0
27th	0	0	0.2	0	6.2	3.4	0	4.4	3.8	8.4	0.8	0
28th	2.4	0	0	0	1.4	2	0	7.4	5.2	6	0.2	0.4
29th	0	0.8	7.6	0	0	0	10.6		12.6	0.2	0	0.2
30th	0	0.2	4	0	0	0	0.2		3.8	4.4	8.6	0
31st	0	0		0		0	0		4.2		6.6	
Monthly total	46.4	108.6	29.6	51.2	218.8	132.2	181.4	111.0	317.4	105.8	97.0	12.6
Monthly Average*	60.3	57.9	55.7	61.9	64.5	79.1	85.2	81.4	77.8	57.1	51.1	71.7

Note: Days sampled are highlighted in yellow. *Monthly average is the long-term average from BOM station 63226.

Appendix Table A-2 Daily Discharge (ML/Day) (LDP2) for July 2021 to June 2022												
Year	2021						2022					
Date	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1st	17.2	18.1	18.7	19.8	20.6	22.4	16.0	16.5	17.3	20.5	12.1	1.1
2nd	17.6	18.1	18.7	19.4	20.4	21.8	15.9	16.0	20.9	21.2	5.9	1.5
3rd	19.0	18.1	19.2	19.3	19.2	22.0	15.8	16.1	22.8	20.9	9.5	1.2
4th	17.6	18.3	19.9	18.2	19.9	21.5	17.5	16.3	19.9	19.5	8.2	1.7
5th	18.0	18.1	19.9	18.9	20.9	18.9	17.6	16.4	21.1	19.6	10.5	1.7
6th	18.3	18.0	19.8	18.0	20.9	18.1	17.9	16.4	37.7	20.0	12.4	1.3
7th	18.8	13.4	18.3	15.9	21.0	19.3	18.7	15.7	38.7	19.8	12.2	1.1
8th	18.2	12.5	20.2	19.5	21.4	16.7	19.8	12.0	26.9	21.4	9.3	1.1
9th	18.4	12.0	20.6	19.5	21.1	19.1	17.9	10.0	18.9	19.7	3.4	1.3
10th	17.6	12.0	18.2	19.5	20.7	18.5	17.6	9.4	16.7	20.2	11.8	0.9
11th	19.0	12.5	18.2	18.5	25.3	18.1	21.7	10.0	17.7	21.6	10.2	1.6
12th	18.8	12.6	19.7	18.9	23.2	15.1	17.5	10.1	17.2	22.1	12.5	1.0
13th	11.5	13.6	18.2	19.6	21.9	15.5	16.8	10.2	17.1	21.9	16.8	1.8
14th	19.0	17.1	19.9	20.0	21.6	15.8	17.2	9.8	15.2	20.9	14.2	7.1
15th	18.8	13.8	14.9	19.9	20.0	17.2	16.9	10.3	13.2	21.6	12.5	11.4
16th	19.3	13.4	19.3	19.6	20.3	16.7	17.0	14.9	16.5	21.4	10.9	8.4
17th	21.4	12.4	19.9	19.7	18.3	15.8	16.4	15.0	18.0	20.2	8.8	14.8
18th	20.5	12.3	19.9	18.5	21.0	16.9	16.0	16.3	19.0	7.7	11.9	9.9
19th	20.0	12.3	19.8	19.7	20.3	17.0	14.6	16.0	19.1	19.5	8.7	10.8
20th	19.8	12.3	19.8	19.8	21.4	18.1	16.6	15.9	18.6	20.3	5.2	14.5
21st	20.2	13.7	18.6	19.9	21.4	12.3	16.9	13.9	17.2	17.0	1.1	11.8
22nd	18.1	17.5	20.4	20.0	21.3	15.6	17.4	15.8	17.1	20.4	1.0	11.1
23rd	18.6	13.7	14.2	19.7	21.8	17.7	16.9	16.8	18.4	21.5	0.9	10.9
24th	20.3	18.2	20.0	19.6	20.0	17.8	15.9	16.5	19.5	21.4	0.8	13.6
25th	19.0	14.9	19.4	16.5	18.4	12.7	16.2	16.7	21.4	21.6	0.7	9.3
26th	18.0	20.3	18.7	4.8	23.9	10.6	16.4	16.9	22.1	14.3	0.9	9.3
27th	18.0	19.9	18.8	0.2	22.8	9.3	16.8	16.8	22.1	10.8	1.3	12.1
28th	18.1	19.7	19.9	14.0	22.0	17.0	16.8	17.3	19.2	18.5	1.0	9.9
29th	16.4	17.7	19.5	21.3	22.3	15.8	16.5		10.8	15.5	1.6	12.7
30th	18.0	19.3	19.9	20.4	22.2	17.0	16.4		12.8	12.1	1.4	13.1
31st	18.1	16.8		19.7		16.0	16.7		18.0		1.2	
Total	571.3	482.4	572.4	558.0	635.2	526.0	527.9	403.8	611.2	572.8	218.7	208.0
Average	18.4	15.6	19.1	18.0	21.2	17.0	17.0	14.4	19.7	19.1	7.1	6.9
Note: Days sampled are highlighted in yellow.												

Table A-3 Field Comments – Seasonal Aquatic Ecology Monitoring Sites		
Date	Site	Comments
10/05/22	WGRup	Water was clear with a moderate flow throughout. Maximum width was approximately 3.5m with an average width of 1m. Maximum depth was 0.5m with an average depth of 0.15m. Large amounts of sands have infilled some channel sections and the main pool. Changes in pool channel form due to damming caused by debris build up. Site was relatively channelised with little backflow or areas of low flow. Very little habitat complexity. Silt/algal biofilm smothering submerged surfaces. Habitats sampled consisted mainly of undercut banks and tiny amounts of trailing bank vegetation. Sediments were comprised mostly of bedrock and sands with small amounts of gravels and pebbles throughout. Filamentous green alga was absent.
10/05/22	WGRdam	Water was clear and flowing throughout the site. The LDP channel had a moderate to high flow. Evidence of flows approximately 1m higher than the current water levels. Large amounts of sandy sediments were coming out of the Wollangambe tributary and had accumulated in the channel downstream from the LDP2/ Wollangambe river junction. All substrates were smothered in a thick biofilm. Sands were extremely soft throughout, suggesting recent deposition. Habitats sampled included mostly macrophytes, some detritus and trailing bank vegetation.
9/05/22	WGRtrib1	Water was clear throughout with a low flow. Water was flowing into the site upstream, though the water levels had receded in the upper limits since the spring 2021 survey, approximately 200-300mm across the site. Sluggish flow throughout the main pool with less water coming from the dam spillway compared to former survey. Maximum depth appeared to be approximately 3-3.5m. Some submerged surfaces with silt/biofilm cover. Habitats sampled included trailing bank vegetation, and macrophytes (mostly *Eleocharis sp.* and Sago Pond weed). Filamentous green alga was abundant.
9/5/22	WGRswamp	Water was very clear with a low flow throughout. Water levels reduced by 0.3-0.4m since former survey with a maximum depth of approximately 1.2m. Evidence of flows to 2-3m above current water levels. Overland lateral flow contributions observed throughout site. Increased amounts of charophytes throughout. Habitats sampled included trailing bank vegetation, undercut banks, some detritus and charophytes. Sediments were comprised of mostly sands with lesser amounts of pebbles, gravels, cobbles and boulders. Filamentous green alga was absent.

9/05/22	WGRdown	Water was clear and flowing throughout the site length. Maximum width was approximately 5.5-6m with an average width of 1.8m. Maximum depth was 1.2m with an average depth of 0.5m. Water levels appeared to have receded since former survey. Evidence of flows 2.5-3m higher than current water levels. Areas of mud deposition on bank edges. No charophytes observed and very little detritus throughout. Habitats sampled included mostly trailing bank vegetation and undercut banks. Sediments were the same as the Sp21 survey, consisting mostly of sands, with some silts and lesser amounts of cobbles, pebbles gravels and boulders. Filamentous green alga was absent.
10/05/22	WGRXdown	Water was clear and had a medium to high flow throughout the site. Maximum width was 5-6m with an average width of 2m. Maximum depth of 1.1-1.2m with and average width of 0.4-0.5m. Not many areas of low flow or backwaters. Evidence of flows 1.5-2m higher than current water levels. Areas of new undercutting and tree slumping. Riffle sections appear to be cleaner compared to former surveys, though still algal matting observed in some areas. Habitats sampled included mostly undercut banks, riffle sections and some trailing bank vegetation. Little particulate or coarse detritus in riffle sections. Sediments were comprised of mostly sands, pebbles, gravels with lesser amounts of boulders and cobbles. Filamentous green alga was absent.
10/05/21	WGRref	Water was extremely clear with a low flow throughout the site. Maximum depth was 0.9m with an average depth of 0.3m, Evidence of flows greater than 1m above current water levels. Orange precipitate smothering all submerged substrates. Habitats sampled included undercut banks, detritus and trailing bank vegetation. Sediments were comprised of mostly sands with cobbles and boulders throughout. Filamentous green alga was absent

Appendix Table A-4

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor	Category	Value	Au22 WGRup	Au22 WGRdam	Au22 WGRtrib1	Au22 WGRswamp	Au22 WGRdown	Au22 WGRXdown	Au22 WGRref
1	Land-use pattern beyond immediate riparian zone								
	Undisturbed native vegetation	4	4	4	4	4	4	4	4
	Mixed native vegetation and pasture/exotics	3							
	Mainly pasture, crops or pine plantation	2							
	Urban, some vegetation	1							
	Industrial, little vegetation	0							
2	Width of riparian strip-of woody vegetation								
	More than 30 m	4	4	4	4	4	4	4	4
	Between 5 and 30 m	3							
	Less than 5 m	2							
	No woody vegetation	1							
	No Vegetation	0							
3	Completeness of riparian strip of woody vegetation								
	Riparian strip without breaks in vegetation	4		4	4				
	Breaks at intervals of more than 50 m	3							
	Breaks at intervals of 10-50 m	2	2			2	2	2	2
	Breaks at intervals of less than 10 m	1							
	No riparian strip at all	0							
4	Vegetation of riparian zone within 10 m of channel								
	Native tree and shrub species	4	4	4	4	4	4	4	4
	Mixed native and exotic trees and shrubs	3							
	Exotic trees and shrubs	2							
	Exotic grasses/weeds	1							
	No vegetation at all	0							
5	Stream bank structure								
	Banks fully stabilized by trees, shrubs, concrete	4		4	4				
	Banks firm but held mainly by grass and herbs	3							
	Banks loose, partly held by sparse grass, rubble	2				2.5	2.5	2.5	
	Banks unstable, mainly loose sand or soil	1	1						1
	Banks actively eroding	0							
6	Bank undercutting								
	None, or restricted by tree roots or man-made	4							
	Only on curves and at constrictions	3		3	3.5				
	Frequent along all parts of stream	2	2				2	2.5	2.5
	Severe; bank collapses common	1				1.5			
	Total bank collapse	0							
7	Channel form								
	Deep; width:depth ratio less than 8:1	4	4		4	4	4	4	4
	Medium; width:depth ratio 8:1 to 15:1	3							
	Shallow; width:depth ratio greater than 15:1	2		2.5					
	Artificial; concrete or excavated channel< 8:1	1							
	Artificial; concrete or excavated channel > 8:1	0							
8	Riffle/pool sequence								
	Frequent alternation of riffles and pools	4	4				4	4	4
	Long pools with infrequent short riffles	3			3	3.5			
	Natural channel without riffle/pool sequence	2							
	Artificial channel; some riffle/pool sequence	1							
	Artificial channel; no riffle/pool sequence	0		0					
9	Retention devices in stream								
	Many large boulders and/or debris dams	4			4				
	Rocks/logs present; limited damming effect	3	3			3	3	3.5	3.5
	Rocks/logs present but unstable; no damming	2							
	Stream or channel with few or no rocks/logs	1							
	Artificial channel; no retention devices	0		0.5					
10	Channel sediment accumulations								
	Little or no accumulation of loose sediments	4							
	Some gravel bars but little sand or silt	3	3.5						
	Bars of sand and silt common	2			2.5	2	2.5	2.5	2
	Braiding by loose sediment	1		1					
	Complete in-filled muddy channel	0							
11	Stream bottom								
	Mainly clean stones with obvious interstices	4	4					4	4
	Mainly stones with some cover of algae/silt	3				3	3		
	Bottom heavily silted but stable	2		2	2.5				
	Bottom mainly loose and mobile sandy sedimen	1							
	Bottom mainly loose and mobile muddy sedimer	0							
12	Stream detritus								
	Mainly unsilted wood, bark, leaves	4							
	Some wood, leaves, etc. with much fine detritus	3			3.5	3.5	3.5	3	3.5
	Mainly fine detritus mixed with sediment	2		2					
	Little or no organic detritus, mainly sandy	1	1.5						
	No organic detritus, mainly mud	0							
13	Aquatic vegetation								
	Little or no macrophyte or algal growth	4	4			4	4	4	4
	Substantial algal growth; few macrophytes	3							
	Substantial macrophyte growth; little algal grow	2		2	1.5				.
	Substantial macrophyte and algal growth	1							
	Total cover of macrophytes plus algae	0							
	RCE Score		41.0	33.0	44.5	41.0	42.5	44.0	42.5
	RCE %age		78.8	63.5	85.6	78.8	81.7	84.6	81.7

Appendix Table A-5												Sample Site and Sample Date								Occurrence	SIG-2
Wollangambe River Aquatic Ecology Survey Macroinvertebrate & Fish Results - Autumn 2022									Life Stage			10/05/22	10/05/22	09/05/22	09/05/22	09/05/22	10/05/22	10/05/22	09/05/22		
Phylum	Class	Sub-class	Order	Sub-Order	Family	Sub-Family	*Genus/spp*	Common Name	L	N	A	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	WGRXdownri	WGRref		
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles	x		x	1		1		1	1			4	2
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles	x		x	1	1	1	1	1	1		1	7	4
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles	x			1				1	1		1	4	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges	x			1	1	1	1	1			1	6	4
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms	x				1	1			1		1	4	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae		Bloodworms	x				1			1			1	3	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms	x				1	1	1		1		1	5	4
Arthropoda	Insecta		Diptera		Dixidae			Meniscus Midges								1			1	2	7
Arthropoda	Insecta		Diptera		Simuliidae			Black flies				1								1	5
Arthropoda	Insecta		Diptera		Tabanidae			March Flies	x							1		1		2	3
Arthropoda	Insecta		Diptera		Tipulidae			Crane Flies	x			1	1			1	1		1	5	5
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies		x		1	1	1		1	1		1	6	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Waterboatmen						1		1				2	2
Arthropoda	Insecta		Hemiptera		Notonectidae			Backswimmers						1						1	1
Arthropoda	Insecta		Hemiptera		Veliidae			Small Water Striders								1			1	2	3
Arthropoda	Insecta		Neuroptera		Nevrorthidae			Lacewings								1				1	6
Arthropoda	Insecta		Odonata	Epiproctophora	Aeshnidae			Dragonflies	x			1	1	1						3	4
Arthropoda	Insecta		Odonata	Epiproctophora	Libellulidae			Dragonflies						1	1					2	4
Arthropoda	Insecta		Odonata	Epiproctophora	Gomphidae			Dragonflies									1			1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Synthemistidae			Dragonflies	x			1	1		1		1		1	5	2
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae			Dragonflies	x							1	1	1		3	9
Arthropoda	Insecta		Odonata	Zygoptera	Lestidae			Damselflies	x				1	1						2	1
Arthropoda	Insecta		Odonata	Zygoptera	Argiolestidae			Damselflies	x				1	1		1			1	4	5
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies	x							1	1			2	7
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies		x		1			1	1	1	1	1	6	8
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies					1		1				1	3	4
Arthropoda	Insecta		Trichoptera		Hydropsychidae			Caddis Flies	x									1		1	6
Arthropoda	Insecta		Trichoptera		Hyrdoptilidae			Caddis Flies	x					1						1	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies	x			1	1	1	1		1	1	1	7	6
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies	x			1	1				1		1	4	8
Arthropoda	Crustacea	Copepoda						Copepods						1						1	*
Arthropoda	Crustacea		Decapoda		Parastacidae			Freshwater crayfish							1					1	4
Arthropoda	Arachnida		Acarina	Hydracarina				Freshwater Mites							1					1	6
Annelida	Oligochaeta							Freshwater Worms					1			1		1	1	4	2
Platyhelminthes			Tricladia		Dugesiidae			Flat worms						1	1					2	2
Mollusca	Bivalvia				Sphaeriidae			Pea Shells					1							1	5
Nematomorpha								Horse hair Worms				1								1	6
Chordata	Amphibia							Tadpoles													
Chordata	Osteichthyes				Galaxiidae		*Galaxias olidus*	Mountain Galaxias											1	1	*
								number of invertebrate taxa per site:				13	16	16	11	17	14	6	17	37	
Notes:	*Represents taxa for which SIGNAL grades do not apply.							Site SIGNAL2 scores:				5.23	4.31	3.60	4.36	5.00	5.50	5.67	4.88		4.58
								Number of EPT taxa:				4	4	3	3	2	4	3	5	7	

Plate 1: Looking across site WGRup plunge pool in autumn 2022.

Plate 2: Looking downstream at WGRup.

Plate 3: Portion of Site WGRup looking downstream.

Plate 4: Looking downstream through the LDP channel to WGRdam.

Plate 5: Looking downstream at WGRdam in autumn 2022.

Plate 6: Looking upstream through the LDP channel.

Plate 7: Looking upstream at tributary channel at upstream end of WGRtrib1 in autumn 2022.

Plate 8: Looking upstream at WGRtrib1.


Plate 9: Looking Downstream at WGRtrib1 towards the dam spillway.


Plate 10: Looking downstream at WGRswamp in autumn 2022.


Plate 11: Looking upstream at WGRswamp.


Plate 12: Looking upstream at WGRdown.

Plate 13: Looking upstream at WGRdown in autumn 2022.

Plate 14: Looking upstream at WGRXdown in autumn 2022.

Plate 15: Looking upstream at WGRXdown.

Plate 16: Looking upstream at WGRXdown.

Plate 17: Looking upstream at WGRref in autumn 2022.

Plate 18: Looking upstream at WGRref.


Plate 19: Looking downstream at WGRref.

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WOLLANGAMBE RIVER
AQUATIC ECOLOGY

SPRING 2022 DATA REPORT

Figure 1. Looking across the top of the dam spillway.

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD
FEBRUARY 2023

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Marine Pollution Research Pty Ltd (MPR) has been re-commissioned by Clarence Colliery to undertake biannual (Autumn and Spring) streamhealth monitoring to assess the possible effects on aquatic ecology of Wollangambe River below the Clarence Colliery Licensed Discharge Point 2 (LDP2). The streamhealth surveys are being conducted using standardised methods applied to other Centennial Coal stream health studies in the Coxs and Wolgan River upper catchments.

This report provides the results of the twentieth biannual streamhealth sampling program which was undertaken in spring 2022 and follows on from the previous Wollangambe River streamhealth survey undertaken in autumn 2022. MPR had previously been commissioned to undertake additional EMP seasonal monitoring in spring 2019, and as that program utilised three of the Streamhealth sampling program sites, the results were incorporated into the long-term streamhealth indices for this survey.

The mine is located within the 690 Ha upper Wollangambe River catchment, above the Blue Mountains National Park. The portions of the upper Wollangambe River catchment upstream and downstream of the mine comprise undeveloped native forest, and the upper catchment is bounded by Newnes State Forest to the north, Blue Mountains National Park to the east and Hansons' Sand Quarry to the west. The Wollangambe River below the mine Main Storage dam flows past several tributaries that contain hanging swamp endangered ecological communities (EECs) prior to reaching the National Park boundary.

The Clarence Colliery site includes a storm water and dirty water management scheme that separates clean and dirty water streams, bunding, stilling and filtration ponds plus a Mine Water Treatment Plant (MWTP). The discharge from the MWTP is licensed by the NSW Environment Protection Authority (EPA).

Discharge from the MWTP at LDP2 flows down a small western tributary of the Wollangambe River, with the combined discharge and river flow discharged into a 70ML dam (the Colliery Main Dam). The Colliery extracts water from the dam for use on site, and during dry weather periods, additional water can be extracted and piped to Farmers Creek to provide additional source water for the Lithgow City potable water supply plant.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims the Aquatic Ecology Sampling Program endeavoured to answer the following questions:

- Are there measurable differences in aquatic ecological habitat or riparian attributes between river or creek pools upstream and downstream of LDP2, and within reference sites?
- Are there measurable differences in aquatic macroinvertebrate assemblages at the AusRivAS level of taxonomic resolution between Wollangambe River Upstream and Downstream of Discharge sites?
- Can observed differences be attributable to spatial (between-site) differences and/or Colliery discharge?
- Do the survey sites provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Do the sites provide suitable fish passage?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in Spring and Autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the ‘autumn’ sample season is defined as March 15 to June15 and ‘spring’ is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of basic water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

There were seven sites sampled for the spring 2022 Clarence aquatic ecology survey (**Table 1**), all of which were sampled during the previous survey in autumn 2022. In total there were four sampling sites in the Wollangambe River, one site in the Main Dam and two sites in unnamed reference creek tributaries (see **Figure 2**).

The autumn 2012 survey report (MPR 2012) provides detailed descriptions of the original sample sites, with additional descriptions for sites brought online over subsequent seasons provided in the corresponding reports; WGRXdown in autumn 2013 (MPR 2013b) and WGRtrib1 in spring 2014 (MPR 2015).

Table 1 Clarence LDP Aquatic Ecology Seasonal Sample Site Information

Site	Coordinates		Seasonal Surveys			Description
	E	N	Au 12 - Sp 12	Au 13 - Au 14	Sp 14 - Sp 22	
			N=2	N=3	N=12	
WGR up	243889	6295015	x	x	x	Upstream Wollangambe River monitoring site located above LDP2 input.
WGR dam	244427	6294590	x	x	x	Site sampled at upper end of the Main Dam below the confluence of LDP2 and Wollangambe River.
WGR trib1	244568	6294840			x	Site sampled within lower limits of unnamed tributary, in 'backwaters' of discharge from Main Dam spillway.
WGR swamp	244871	6294619	x	x	x	Site located at the downstream end of the lower of two swamps in Wollangambe River, around 530m below the Main Dam weir.
WGR down	245070	6294799	x	x	x	Downstream monitoring site located in Wollangambe River around 950m below the Main Dam weir.
WGRX down	245452	6293646		x	x	Downstream monitoring site located in Wollangambe River around 2.6km downstream from the Main Dam weir.
WGR ref	245073	6294952	x	x	x	Reference tributary site which flows in a southerly direction to join Wollangambe River at WGRdown.

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b). The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.

Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum". However, "sampling riffles where the substratum consists predominantly of large boulders may be difficult and may not produce reliable results".
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

Site selection for sampling aquatic biota from the river is constrained by access from the road network through the forest to the river and by river access where the river flows through deep incised canyons or through boulder cascades. The river and reference tributary generally comprise narrow channels either with mobile sand or rock beds joined together by rock boulder cascades. There were few broader pools and few sand or log bar constraints.

Further, given the location of a number of the study sites in reaches of streams where there are known to be periods of little or no connecting flow between pools or where there are known to be limited riffle sections available for sampling, it was decided that only pool 'edge' samples would be sampled, as AusRivAS defined riffle samples could not be guaranteed for all (or possibly even for most) sites at all sample times.

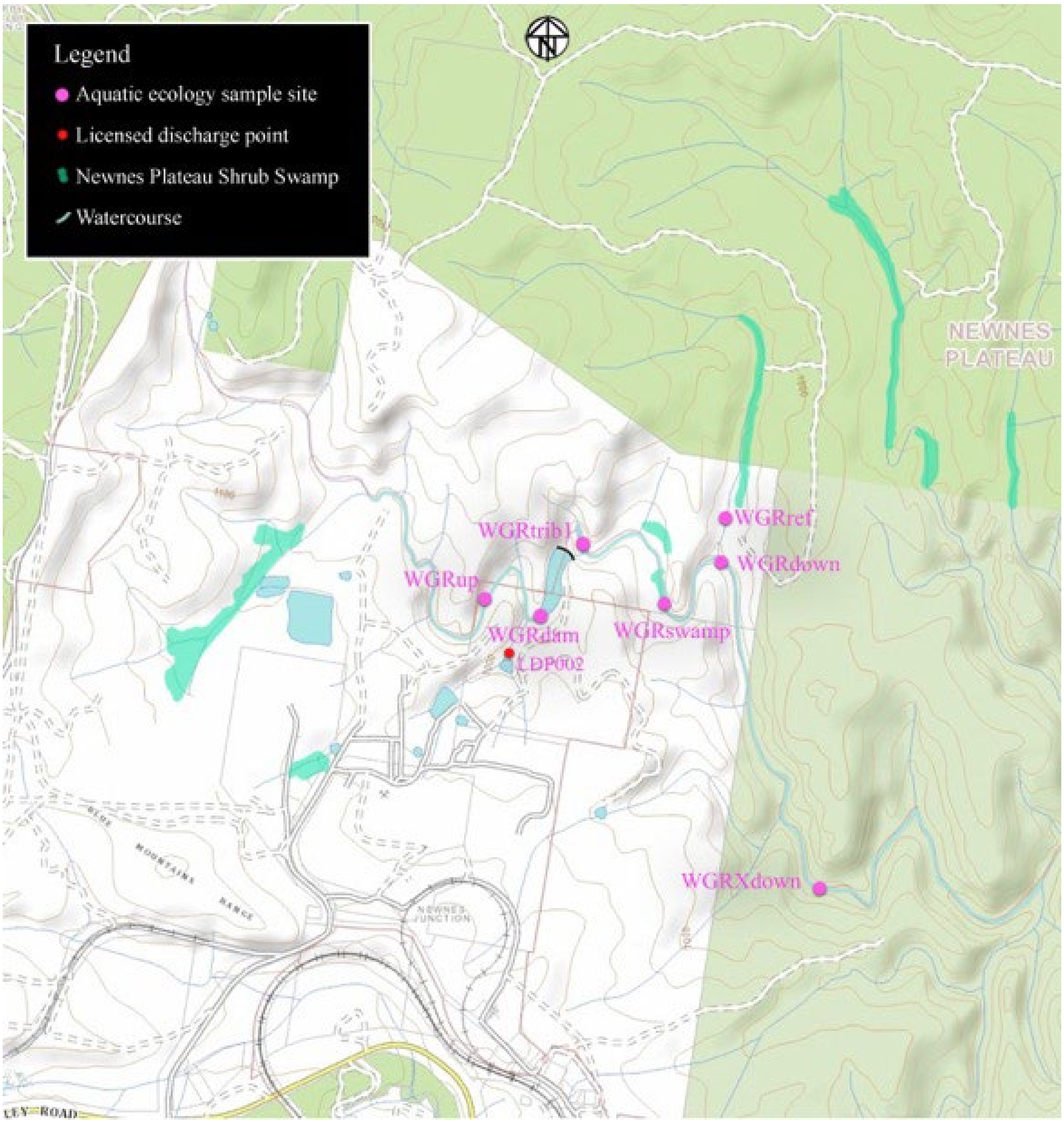

Figure 2: Clarence Aquatic Ecology Sample Sites Spring 2022

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method. Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event. For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory.

Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae are kept for confirmation purposes.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars. Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant).

For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis. Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey. Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys.

As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised 'health' scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified.

For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the spring 2022 aquatic ecology sampling are provided in **Appendix Table A3**. Sampling for the full spring 2022 survey was undertaken over the 4th and 5th October 2022.

3.1 Sampling Conditions Autumn 2022 to Spring 2022

Appendix Tables A-1 & A-2 provide the daily rainfall and LDP discharge results for 2022 and are shown graphically in **Figure 3**. Following on from the previous aquatic ecology spring survey in May 2022, the study area was subjected to consistent wet weather events:

- Monthly rainfall between the 2022 autumn and spring surveys was generally above or close to monthly averages, with several major contributing rain events.
- July was the wettest month totalling a near 250mm, where 80% (200mm) of this fell within the first week.
- Both August and September endured average rainfall with a couple of 30mm days throughout.
- Leading up to sampling in early October, 32mm fell within the week prior to sampling, where the sampling days themselves were dry.

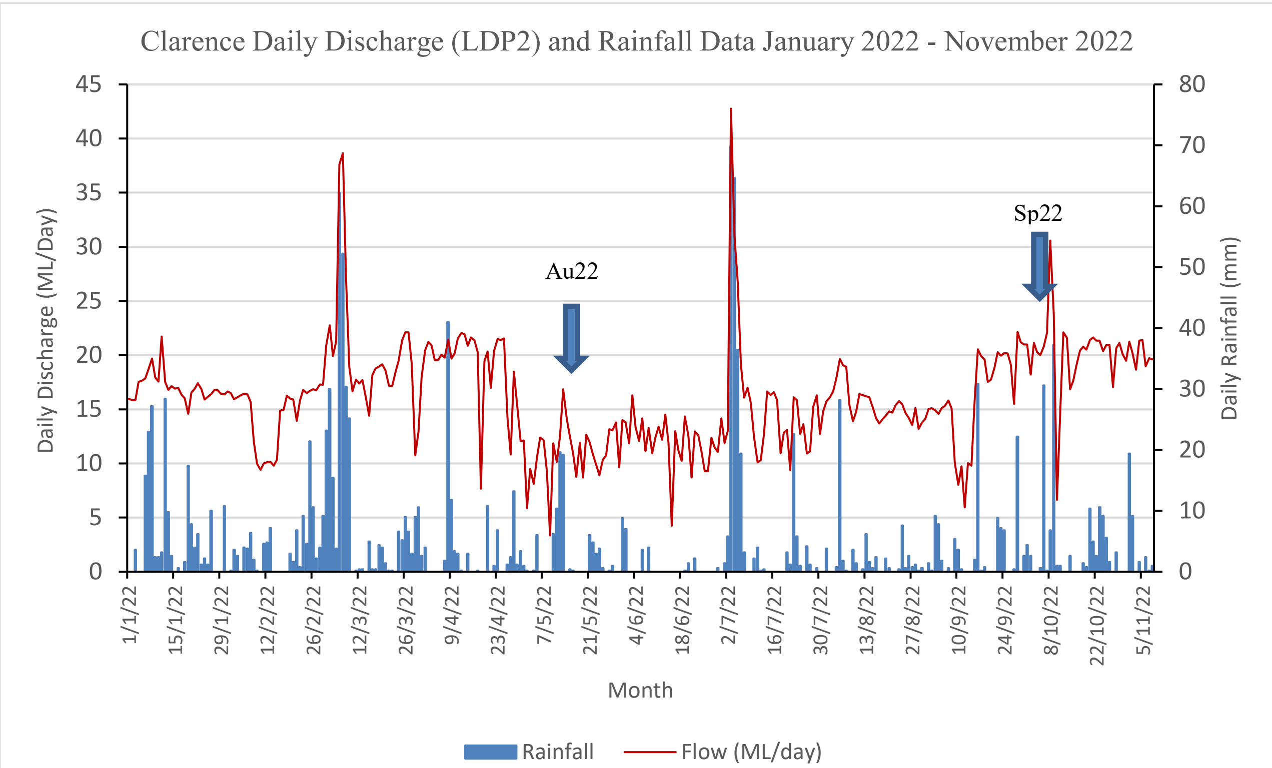

Figure 3 Monthly Rainfall & Monthly discharge between January 2022 – November 2022.

Daily discharge rates fluctuated between the autumn and spring 2022 surveys, ranging between 4 and 42 ML/day. Discharge rates spiked at 42 ML/day in early July in response to a three-day 170mm rain event. The period leading up to sampling in early October saw daily discharges ranging between 10 – 20ML/day however discharges were slightly higher (over 20 ML/day) the week prior to sampling.

3.2 Spring 2022 Aquatic Ecology Survey Results

The Clarence spring 2022 aquatic ecology survey was undertaken over 4th and 5th October 2022 following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. **Appendix Table A-3** provides site field notes for the spring 2022 sampling program and site photos are also provided **Appendix A**. Summary tables for the spring 2022 Appendix A data are provided in the following Sections.

3.3 Metered Water Quality Results

A water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling during the spring 2022 aquatic ecology field sampling program.

Table 2 Site Field Water Quality Readings Spring 2022

Site	Date	Time	Depth	Temp	Cond	DO	DO	pH	Turb
			m	°C	µS/cm	%sat	mg/L	Units	ntu
WGRup	5/10/22	10:00	0.1	10.14	5	82.0	9.27	5.27	0.1
LDP002	5/10/22	15:00	0.2	16.60	298	95.8	9.34	7.90	92.0
WGRdam	5/10/22	15:15	0.2	16.19	268	93.3	9.18	7.92	5.2
WGRtrib1	5/10/22	13:30	0.1	10.42	10	81.7	9.14	5.11	0.4
WGRswamp	4/10/22	14:35	0.1	15.36	249	96.1	9.62	7.19	1.2
WGRdown	4/10/22	11:00	0.1	14.18	250	98.8	10.15	7.45	3.1
WGRXdown	5/10/22	8:00	0.1	13.80	234	93.0	9.63	7.27	0.2
WGRref	4/10/22	12:15	0.1	9.72	3	91.7	10.44	4.99	0.1

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-3**) provide details of stream reach flows, pool dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-4** with summary provided in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the spring 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results

Category	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	WGRref
Land-use pattern beyond immediate riparian zone	4	4	4	4	4	4	4
Width of riparian strip-of woody vegetation	4	4	4	4	4	4	4
Completeness of riparian strip of woody vegetation	2	4	4	2	2	2	2
Vegetation of riparian zone within 10 m of channel	4	4	4	4	4	4	4
Stream bank structure	1	4	4	2.5	2.5	2.5	1
Bank undercutting	2	3	3.5	1.5	2	2.5	2.5
Channel form	4	2.5	4	4	4	4	4
Riffle/pool sequence	4	0	3	3.5	4	4	4
Retention devices in stream	3	0.5	4	3	3	3.5	3.5
Channel sediment accumulations	2.5	1	2.5	2	2.5	2.5	2
Stream bottom	4	2	2.5	3	3	4	4
Stream detritus	1.5	2	3.5	3.5	3.5	3	3.5
Aquatic vegetation	4	1.5	1.5	4	4	4	4
Spring 22 RCE %age – this survey	76.9	62.5	85.6	78.8	81.7	84.6	81.7
Autumn 22 RCE %age - previous survey	78.8	63.5	85.6	78.8	81.7	84.6	81.7
Long-term Mean	87.9	66.0	88.0	80.8	85.5	88.8	88.1
Long-term SD	5.5	5.4	2.4	4.4	3.4	3.9	5.4
Long-term X-SD	82.4	60.7	85.6	76.4	82.1	84.9	82.7

Table 4 Clarence Aquatic Ecology Site Macrophyte Occurrence Spring 2022

Site	Rush *Baumea rubiginosa*	Pampas Grass *Cortaderia selloana*	Tall Spikerush *Eleocharis sphacelata*	Rush *Juncus sp.*	Sago Pondweed *Stuckenia pectinata*	Cumbungi *Typha spp*	Blunt Pondweed *Potamogeton ochreatus*	Charophytes
WGRup	1			1				1
WGRdam	1		1	1		1		1
WGRtrib1	1	1	1	1	1	1	1	1
WGRswamp								1
WGRdown	1		1					1
WGRXdown								
WGRref				1				1

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-5 shows the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The table also provides site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

Tables 5 to 7 provide summary statistics for seasonal and site Diversity (taxa richness), SIGNAL and EPT scores, derived from the aquatic macroinvertebrate data in **Appendix Table A-4**. The Tables also provide a comparison of total and individual site results against the previous seasonal results and against site long term Mean (X) and Standard Deviation of the Mean (SD) statistics for each site:

- **Orange** highlight indicates results are below the X-SD value.
- **Yellow** highlight indicates results in the range X to X-SD.
- **Green** highlight indicates results in the range X to X+SD.
- **No highlight** indicated values > the X+SD value.
- Results in **Bold** are the site Minimum Value.

Table 5 Seasonal Site Diversity (No. Of Taxa)

Site / Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	**27**	**12**	15	14		8	15		
Sp12	35	19	17	14		8	20		
Au13	34	14	15	16		8	11	13	11
Sp13	31	17	14	14		11	15	**11**	**4**
Au14	36	14	14	18		8	**7**	16	9
Sp14	42	22	16	22	20	13	19	19	8
Au15	40	16	16	16	**15**	8	12	16	10
Sp15	38	14	**13**	16	18	5	14	14	12
Au16	42	17	15	16	19	11	14	16	8
Sp16	39	18	17	20	18	8	10	15	7
Au17	34	13	17	14	17	9	11	15	7
Sp17	36	13	17	16	17	**3**	8	16	9
Au18	36	18	16	15	18	10	7	14	11
Sp18	31	13	17	**12**	16	6	12	14	7
Au19	37	18	18	14	17	10	8	12	8
Sp19		15					7	19	11
Au20	34	15	16	13	17	10	12	13	11
Sp20	40	20	16	14	20	8	15	16	9
Au21	35	13	15	16	19	9	12	15	5
Sp21	35	11	12	17	20	7	14	13	6
Au22	37	13	17	16	16	11	17	14	6
Sp22	29	11	13	12	13	8	14	14	3
Mean	36.0	15.5	15.7	15.7	17.8	8.6	12.4	14.8	8.4
SD	3.7	2.9	1.5	2.3	1.6	2.3	3.8	2.1	2.3
X-SD	32.2	12.6	14.1	13.3	16.2	6.3	8.6	12.7	6.1

Table 6 Seasonal Site SIGNAL Indices

Site Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	5.44	5.92	6.07	4.14		4.50	5.73		
Sp12	4.71	5.35	5.29	2.86		4.25	4.55		
Au13	4.71	6.00	5.80	3.19		5.63	4.64	5.23	6.09
Sp13	4.97	5.67	5.79	3.36		5.00	4.87	4.09	5.50
Au14	5.05	6.14	5.21	3.94		4.13	4.50	4.13	4.67
Sp14	4.76	5.59	4.81	3.32	3.56	4.08	3.89	4.28	5.13
Au15	5.09	5.56	5.63	3.60	**3.14**	4.88	4.45	5.88	6.60
Sp15	4.62	5.08	4.77	3.73	3.47	4.60	4.15	4.29	5.00
Au16	4.44	5.00	5.00	3.13	3.72	4.09	4.62	4.65	6.25
Sp16	4.58	5.11	5.12	4.26	3.18	5.00	4.44	5.27	5.57
Au17	4.70	5.33	**4.59**	3.07	3.38	3.50	4.18	5.27	**3.86**
Sp17	4.20	5.08	5.35	3.53	3.63	**3.00**	4.75	4.12	5.56
Au18	4.54	4.71	5.53	3.00	3.41	4.20	**3.43**	3.79	6.09
Sp18	4.70	4.83	4.81	2.91	4.27	3.33	3.92	5.00	4.57
Au19	4.64	5.00	4.94	4.29	3.25	3.82	3.88	4.83	5.88
Sp19		5.43					3.86	5.11	5.82
Au20	**4.19**	**4.07**	4.64	**2.75**	3.47	5.22	4.36	**3.36**	5.91
Sp20	4.46	4.89	5.27	3.71	3.47	4.25	4.20	5.27	5.00
Au21	4.39	4.92	5.80	3.19	3.65	4.44	4.55	4.73	6.00
Sp21	4.36	5.09	5.58	4.13	3.61	4.57	3.62	5.23	4.33
Au22	4.58	5.23	4.88	4.31	3.60	4.36	5.00	5.50	4.88
Sp22	4.37	4.92	5.00	3.27	3.55	4.75	5.00	4.93	3.33
Mean	4.66	5.24	5.24	3.52	3.52	4.34	4.36	4.74	5.40
SD	0.31	0.48	0.44	0.52	0.27	0.64	0.52	0.66	0.73
X-SD	4.35	4.76	4.81	3.00	3.25	3.70	3.84	4.08	4.67

Table 7 Seasonal Site EPT Indices

Site Season	Comb sites Edge	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	9	7	6	3		2	6		
Sp12	8	7	6	2		1	4		
Au13	8	8	5	1		3	3	3	3
Sp13	**5**	3	4	1		1	4	2	2
Au14	8	5	4	2		1	**0**	4	4
Sp14	8	7	5	3	2	2	4	5	4
Au15	9	7	**3**	3	**1**	1	2	6	5
Sp15	6	**3**	5	2	2	1	1	3	4
Au16	10	5	3	1	3	2	2	6	4
Sp16	10	6	5	4	2	2	1	5	4
Au17	9	4	6	1	3	2	2	5	2
Sp17	6	4	5	2	2	**0**	1	2	2
Au18	7	4	3	2	2	3	1	2	5
Sp18	6	3	4	**0**	3	1	2	5	**1**
Au19	10	6	3	4	2	1	1	3	5
Sp19		5					1	5	3
Au20	5	3	3	2	2	2	2	**1**	5
Sp20	13	6	5	1	3	2	2	6	3
Au21	7	4	5	2	2	3	2	4	4
Sp21	7	**2**	4	3	3	1	0	4	2
Au22	7	**4**	5	4	3	3	2	4	3
Sp22	5	**3**	4	1	1	2	4	3	0
Mean	7.9	4.9	4.5	2.2	2.3	1.7	2.0	3.9	3.4
SD	2.0	1.7	1.1	1.1	0.6	0.9	1.5	1.5	1.2
X-SD	5.9	3.2	3.4	1.0	1.7	0.8	0.6	2.4	2.2

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

SPRING 2022

Appendix Table A-1 Daily Rainfall (mm) for 2022												
Date	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0.0	0.2	9.2	4.0	1.0	7.0	1.4	3.8	1.4	4.4	19.4	
2nd	0.0	3.6	23.2	0.0	0.2	0.0	5.8	0.0	0.2	2.6	9.2	
3rd	3.6	2.6	30.0	0.0	0.0	0.0	69.8	0.0	9.2	0.0	0.0	
4th	0.0	0.0	15.4	0.0	0.2	0.0	64.6	0.8	7.8	0.0	1.6	
5th	0.0	4.0	3.8	0.0	6.0	0.0	36.4	28.2	1.8	0.6	0.0	
6th	15.8	3.8	62.2	0.0	0.0	3.6	19.4	1.8	0.0	30.6	2.4	
7th	23.0	6.4	52.2	1.8	0.0	0.0	3.2	0.2	0.6	0.2	0.2	
8th	27.2	2.0	30.4	41.0	0.0	4.0	0.0	0.0	0.0	6.8	1.0	
9th	2.4	0.2	25.2	11.8	0.0	0.0	0.0	3.6	5.4	37.2		
10th	2.4	0.0	0.0	3.4	6.2	0.0	2.2	1.4	3.6	1.0		
11th	3.2	4.6	0.2	3.0	10.4	0.0	4.0	0.0	0.4	1.0		
12th	28.4	4.8	0.4	0.2	19.6	0.0	0.2	0.4	0.0	0.0		
13th	9.8	7.2	0.4	0.0	19.2	0.0	0.4	6.2	0.0	0.0		
14th	2.6	0.0	0.0	3.0	0.0	0.0	0.0	1.6	0.0	2.6		
15th	0.0	0.0	5.0	0.0	0.4	0.0	0.0	0.6	2.0	0.0		
16th	0.6	0.0	0.4	0.0	0.2	0.0	0.0	2.4	30.8	0.0		
17th	0.0	0.0	0.4	0.2	0.0	0.0	0.0	0.0	0.2	0.0		
18th	1.6	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.8	1.4		
19th	17.4	3.0	4.0	0.0	0.0	0.2	0.0	2.2	0.0	0.8		
20th	7.8	1.6	1.4	10.8	0.0	1.4	3.2	0.6	0.0	10.4		
21st	4.0	6.8	0.2	0.0	6.0	0.0	1.2	0.0	0.0	5.0		
22nd	6.2	0.8	0.2	1.0	4.8	2.2	22.6	0.0	8.8	2.6		
23rd	1.2	9.2	0.0	6.8	3.0	0.0	5.8	0.4	7.2	10.6		
24th	2.2	4.6	6.6	0.0	3.8	0.0	1.0	7.6	6.8	9.2		
25th	1.2	21.4	5.2	0.0	0.6	0.0	0.0	0.6	0.0	5.6		
26th	10.0	10.6	9.0	1.2	0.0	0.0	4.2	2.6	0.0	1.6		
27th	0.0	2.2	6.6	2.4	0.2	0.0	1.2	0.8	0.4	0.0		
28th	0.0	4.0	3.0	13.2	1.0	0.0	0.0	1.2	22.2	3.2		
29th	0.0		9.0	1.2	0.0	0.6	0.6	0.2	0.0	0.0		
30th	10.8		10.6	3.4	0.0	0.0	0.0	0.6	2.6	0.0		
31st	0.0		2.6		8.8		0.0	0.0		0.0		
Total	181.4	103.6	321.2	108.4	91.6	19.0	247.2	67.8	112.2	137.4		
Monthly Average*	236.7	70.8	238.8	78.2	64.8	20.6	211.0	71.6	115.6	123.2		
Note: Days sampled are highlighted in yellow. *Monthly average is the long-term average from BOM station 63226												

Appendix Table A-2 Daily Discharge (ML/Day) (LDP2) for 2022												
Date	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	16.0	16.5	17.3	20.4	12.1	13.8	11.9	15.7	15.0	21.0	21.3	
2nd	15.8	16.0	20.9	21.2	5.9	11.9	13.0	16.1	15.1	18.2	20.2	
3rd	15.8	16.1	22.8	20.9	9.5	16.3	42.8	16.6	14.9	21.1	18.7	
4th	17.5	16.3	19.9	19.5	8.1	13.4	31.0	17.9	14.6	20.3	21.3	
5th	17.7	16.4	21.3	19.6	10.5	12.1	26.8	19.7	15.1	20.0	21.4	
6th	17.9	16.4	37.6	20.0	12.4	14.2	19.2	19.1	15.3	20.8	19.0	
7th	18.7	15.7	38.7	19.8	12.2	11.1	16.1	18.9	15.8	22.1	19.7	
8th	19.7	12.0	26.9	21.4	9.3	13.3	17.0	15.4	15.1	30.6	19.6	
9th	17.9	10.0	18.9	19.7	3.4	10.9	15.6	13.9	10.1	23.8		
10th	17.6	9.4	16.7	20.2	11.8	12.4	12.4	14.8	8.0	6.6		
11th	21.7	10.0	17.7	21.6	10.2	13.4	10.1	16.4	9.7	14.6		
12th	17.5	10.1	17.4	22.1	12.5	12.2	10.3	16.3	6.0	22.1		
13th	16.8	10.2	17.7	21.9	16.9	14.5	12.7	16.2	10.0	21.6		
14th	17.1	9.8	16.0	20.9	14.2	11.9	16.7	16.1	9.8	16.9		
15th	16.9	10.3	14.4	21.6	12.5	4.2	16.3	15.3	15.9	17.6		
16th	17.0	14.9	18.1	21.4	10.9	13.0	16.6	14.2	20.6	19.2		
17th	16.4	15.0	18.8	20.3	8.8	11.2	15.8	13.7	19.9	20.4		
18th	16.0	16.3	19.0	7.7	11.9	10.2	11.0	14.1	19.6	20.8		
19th	14.6	16.0	19.1	19.5	8.7	14.3	12.8	14.4	17.5	20.5		
20th	16.6	15.9	18.6	20.3	12.7	12.6	13.1	14.8	17.7	21.4		
21st	16.9	13.9	17.2	17.0	12.0	8.7	9.4	14.7	18.9	21.7		
22nd	17.4	15.8	17.1	20.4	10.8	12.9	16.1	15.4	20.3	21.4		
23rd	16.9	16.8	18.4	21.5	9.9	12.6	15.9	15.8	19.9	21.4		
24th	15.9	16.5	19.5	21.4	8.9	11.1	12.7	15.5	20.2	20.4		
25th	16.2	16.7	21.4	21.6	10.3	9.3	13.6	14.7	20.2	20.9		
26th	16.4	16.8	22.1	14.2	10.7	9.3	10.9	14.2	19.1	21.0		
27th	16.8	16.8	22.1	10.8	13.2	12.4	11.1	13.5	15.5	17.1		
28th	16.8	17.3	19.2	18.5	13.1	11.5	15.3	15.1	22.1	20.6		
29th	16.4		10.8	15.5	13.8	11.1	16.3	13.2	21.2	21.1		
30th	16.4		12.9	12.1	9.6	14.2	12.7	13.8	21.0	20.1		
31st	16.7		18.0		14.0		14.8	14.1		19.5		
Total	527.9	403.8	616.5	572.8	340.8	359.9	490.0	479.5	484.2	624.7		
Average	17.0	14.4	19.9	19.1	11.0	12.0	15.8	15.5	16.1	20.2		
Note: Days sampled are highlighted in yellow.												

Table A-3 Field Comments – Seasonal Aquatic Ecology Monitoring Sites		
Date	Site	Comments
5/10/22	WGRup	Water clarity was very high with a moderate flow throughout. Maximum width was approximately 5m with an average width of 0.7m. The majority of the site had been exposed to rapid flows over bedrock, with some soft sand drifts present. However, sections of the stream had been incised and undercut. There was evidence of flows up to 1m above the current water levels at the time of sampling. Proper edge areas were isolated throughout the site with generally small amounts (approximately 0.5 to 4m in length) in locations. Edge areas were generally separated by rapid flows, with the majority of these present in the downstream pool area. This resulted in little habitat complexity. Therefore, the habitats sampled consisted mainly of undercut banks and minimal trailing bank vegetation. Bedrock and sand were the dominant sediments present with small amounts of gravels, pebbles and cobbles throughout. Filamentous green alga was absent.
4/10/22	WGRdam	The water clarity was average with a high flow throughout the site. The maximum depth was 0.8m and the average width was 0.4m. At the time of sampling water levels were elevated, resulting in the saturation of most low-lying areas. A thick dark algae/silt matrix along with particulate clumps presented difficult sampling with the net rapidly clogging up. The Cumbungi present downstream appeared to have increased in coverage since former survey. Clean mobile soft sands were present in the channel. Sands were the most dominant substrate with silts present.
4/10/22	WGRtrib1	Water was very clear throughout the site with a low to moderate flow. The width of the stream appeared to be similar to former survey, with a maximum depth of 3 - 3.5m. Water was slowly flowing into the site from the upstream, with what appeared to be a greater volume of water compared to former survey. Some submerged surfaces had a silt/biofilm layer. The habitats sampled included macrophytes (mostly *Eleocharis sp.* and Sago Pond weed), trailing bank vegetation, and detritus. The main macrophyte beds sampled appeared to be consistent with previous surveys, no obvious change. Substrates were the same as former survey. Filamentous green alga was moderate - abundant.
4/10/22	WGRswamp	Water was clear with a moderate to high flow throughout. The length and width of the sample site was the same as former survey. Maximum depth was approximately 1.4 - 1.5m with an average depth of 0.8m. Evidence suggested flows 1-2m above the current water level at the time of sampling. Some of the stick and log jams had been cleared and flushed downstream. Banks were heavily undercut with evidence of bank slumping. Edge areas were uncommon however isolated from flow. Edge areas were also relatively bare. Silt covered the majority of surfaces and substrates throughout. A large portion of sand banks were soft and unconsolidated, therefore suggesting recent deposition. Sand was the most dominant substrate, with small amounts of cobbles, gravel and pebbles. Filamentous green alga was absent.

4/10/22	WGRdown	Water was clear with a moderate flow throughout the site. Similar to the former survey, maximum width was approximately 5.5-6m with an average width of 1.8m. Maximum depth was 1.4m with an average depth of 0.7m. Conditions were similar to former survey. There was evidence of flows of at least 1.5m above current levels at the time of sampling. Some edge banks were bare. Channel areas in some spots had been scoured back to bare substrates however there were intermittent sand drifts. Submerged surfaces were covered by a silt and algal matrix. Substrates were comprised of mainly sand, with lesser amounts of cobbles and pebbles and minimal gravels. Filamentous green alga was absent.
5/10/22	WGRXdown	Water was clear with a moderate to high flow throughout the site. The maximum width was 6m with an average width of 1.5-1.8m. The maximum depth was 1.3m with an average depth of 0.5m. The riffle sections at this site had improved with less algal matting and slightly less unconsolidated material, making sampling easier. However, there was still high flows over riffle sections. The upstream end of this site had good edge habitat (3-4m long), with most other sections small (approximately 1m in length) and fragmented. Habitat sampled included undercut banks, trailing bank vegetation and detritus. Cobbles and sand were responsible for around 50% of substrate coverage, with gravels, bedrock, pebbles, and to a lesser extent boulders, contributing to the other half. Filamentous green alga was absent.
4/10/22	WGRref	The water clarity was extremely good with a low flow throughout the entire site. The maximum width was approximately 1.5m with an average width of 0.8-1m. The maximum depth was 0.7m with an average depth of 0.2m. The channel sampled appeared to be more channelised than former surveys. The broader channel bank was still undercut ad eroding in parts. There was a large volume of orange/brown flocculated material which was smothering submerged material. Habitats sampled were the same as former surveys, with trailing bank vegetation, undercut banks and detritus. The channels riparian vegetation was still relatively open, with easy access around the site. Substrates consisted of equal parts cobbles, gravels, pebbles and sands, with bedrock and boulders to a lesser extent. Filamentous green alga was absent.

Appendix Table A-4									
Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).									
Descriptor									
	Category		Sp22	Sp22	Sp22	Sp22	Sp22	Sp22	Sp22
		Value	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	WGRref
1	Land-use pattern beyond immediate riparian zone								
	Undisturbed native vegetation	4	4	4	4	4	4	4	4
	Mixed native vegetation and pasture/exotics	3							
	Mainly pasture, crops or pine plantation	2							
	Urban, some vegetation	1							
	Industrial, little vegetation	0							
2	Width of riparian strip-of woody vegetation								
	More than 30 m	4	4	4	4	4	4	4	4
	Between 5 and 30 m	3							
	Less than 5 m	2							
	No woody vegetation	1							
	No Vegetation	0							
3	Completeness of riparian strip of woody vegetation								
	Riparian strip without breaks in vegetation	4		4	4				
	Breaks at intervals of more than 50 m	3							
	Breaks at intervals of 10-50 m	2	2			2	2	2	2
	Breaks at intervals of less than 10 m	1							
	No riparian strip at all	0							
4	Vegetation of riparian zone within 10 m of channel								
	Native tree and shrub species	4	4	4	4	4	4	4	4
	Mixed native and exotic trees and shrubs	3							
	Exotic trees and shrubs	2							
	Exotic grasses/weeds	1							
	No vegetation at all	0							
5	Stream bank structure								
	Banks fully stabilized by trees, shrubs, concrete	4		4	4				
	Banks firm but held mainly by grass and herbs	3							
	Banks loose, partly held by sparse grass, rubble	2				2.5	2.5	2.5	
	Banks unstable, mainly loose sand or soil	1	1						1
	Banks actively eroding	0							
6	Bank undercutting								
	None, or restricted by tree roots or man-made	4							
	Only on curves and at constrictions	3		3	3.5				
	Frequent along all parts of stream	2	2				2	2.5	2.5
	Severe; bank collapses common	1				1.5			
	Total bank collapse	0							
7	Channel form								
	Deep; width:depth ratio less than 8:1	4	4		4	4	4	4	4
	Medium; width:depth ratio 8:1 to 15:1	3							
	Shallow; width:depth ratio greater than 15:1	2		2.5					
	Artificial; concrete or excavated channel< 8:1	1							
	Artificial; concrete or excavated channel > 8:1	0							
8	Riffle/pool sequence								
	Frequent alternation of riffles and pools	4	4				4	4	4
	Long pools with infrequent short riffles	3			3	3.5			
	Natural channel without riffle/pool sequence	2							
	Artificial channel; some riffle/pool sequence	1							
	Artificial channel; no riffle/pool sequence	0		0					
9	Retention devices in stream								
	Many large boulders and/or debris dams	4			4				
	Rocks/logs present; limited damming effect	3	3			3	3	3.5	3.5
	Rocks/logs present but unstable; no damming	2							
	Stream or channel with few or no rocks/logs	1							
	Artificial channel; no retention devices	0		0.5					
10	Channel sediment accumulations								
	Little or no accumulation of loose sediments	4							
	Some gravel bars but little sand or silt	3							
	Bars of sand and silt common	2	2.5		2.5	2	2.5	2.5	2
	Braiding by loose sediment	1		1					
	Complete in-filled muddy channel	0							
11	Stream bottom								
	Mainly clean stones with obvious interstices	4	4					4	4
	Mainly stones with some cover of algae/silt	3				3	3		
	Bottom heavily silted but stable	2		2	2.5				
	Bottom mainly loose and mobile sandy sedimen	1							
	Bottom mainly loose and mobile muddy sedimer	0							
12	Stream detritus								
	Mainly unsilted wood, bark, leaves	4							
	Some wood, leaves, etc. with much fine detritus	3			3.5	3.5	3.5	3	3.5
	Mainly fine detritus mixed with sediment	2		2					
	Little or no organic detritus, mainly sandy	1	1.5						
	No organic detritus, mainly mud	0							
13	Aquatic vegetation								
	Little or no macrophyte or algal growth	4	4			4	4	4	4
	Substantial algal growth; few macrophytes	3							
	Substantial macrophyte growth; little algal grow	2		1.5	1.5				.
	Substantial macrophyte and algal growth	1							
	Total cover of macrophytes plus algae	0							
	RCE Score		40.0	32.5	44.5	41.0	42.5	44.0	42.5
	RCE %age		76.9	62.5	85.6	78.8	81.7	84.6	81.7

Appendix Table A-5												Sample Site and Sample Date								Occurrence	SIG-2
Wollangambe River Aquatic Ecology Survey Macroinvertebrate & Fish Results - Spring 2022									Life Stage			5/10/2022	4/10/2022	4/10/2022	4/10/2022	4/10/2022	5/10/2022	5/10/2022	4/10/2022		
Phylum	Class	Sub-class	Order	Sub-Order	Family	Sub-Family	Genus/spp	Common Name	L	N	A	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	VGRXdownri	WGRref		
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles	x		x		1	1			1		1	4	2
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles	x		x	1		1	1	1	1		1	6	4
Arthropoda	Insecta		Coleoptera		Hydrophilidae			Scavanger Water Beetles								1	1			2	2
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles	x			1	1			1	1		1	5	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges	x				1	1	1	1	1		1	6	4
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms	x			1	1	1				1		4	3
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1	1	1	1		1		1	6	4
Arthropoda	Insecta		Diptera		Simuliidae			Black flies				1								1	5
Arthropoda	Insecta		Diptera		Tabanidae			March Flies	x				1							1	3
Arthropoda	Insecta		Diptera		Tipulidae			Crane Flies	x			1			1	1	1	1		5	5
Arthropoda	Insecta		Ephemoptera		Leptophlebiidae			Mayflies		x				1	1	1	1		1	5	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Waterboatmen				1		1						2	2
Arthropoda	Insecta		Hemiptera		Veliidae			Small Water Striders					1			1			1	3	3
Arthropoda	Insecta		Odonata	Epiproctopho	Aeshnidae			Dragonflies	x				1	1						2	4
Arthropoda	Insecta		Odonata	Epiproctopho	Corduliidae			Dragonflies	x					1						1	5
Arthropoda	Insecta		Odonata	Epiproctopho	Synthemistidae			Dragonflies	x							1	1		1	3	2
Arthropoda	Insecta		Odonata	Epiproctopho	Telephlebiidae			Dragonflies	x							1	1		1	3	9
Arthropoda	Insecta		Odonata	Zygoptera	Lestidae			Damselflies	x				1	1						2	1
Arthropoda	Insecta		Odonata	Zygoptera	Argiolestidae			Damselflies	x										1	1	5
Arthropoda	Insecta		Odonata	Zygoptera	Coenagrionidae			Damselflies	x					1						1	2
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies	x						1		1			2	7
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies		x		1				1	1		1	4	8
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies					1		1	1			1	4	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies	x			1				1	1		1	4	6
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies	x			1								1	8
Arthropoda	Crustacea	Copepoda						Copepods						1		1				2	*
Arthropoda	Crustacea		Podocopida					Seed Shrimp					1	1						2	*
Arthropoda	Crustacea		Decapoda		Parastacidae			Freshwater crayfish								1				1	4
Annelida	Oligochaeta							Freshwater Worms				1	1		1		1	1		5	2
Chordata	Amphibia							Tadpoles													
Chordata	Osteichthyes				Galaxiidae		*Galaxias olidus*	Mountain Galaxias				1		1	1	1			1	5	*
								Total number of invertebrate taxa				11	12	13	8	14	14	3	13	29	
Notes:	* represents taxa for which SIGNAL grades do not ap							Site SIGNAL2 scores:				4.92	3.27	3.55	4.75	5.00	4.93	3.33	5.00		4.37
								Number of EPT taxa				3	1	1	2	4	3	0	4	5	

Plate 1: Looking across site WGRup plunge pool in spring 2022.

Plate 2: Portion of Site WGRup looking downstream.

Plate 3: Looking downstream through the LDP channel to WGRdam.

Plate 4: Looking downstream at WGRdam in spring 2022.

Plate 5: Looking upstream through the LDP channel.

Plate 6: Looking upstream at tributary channel at upstream end of WGRtrib1 in spring 2022.

Plate 7: Looking upstream at WGRtrib1.

Plate 8: Looking Downstream at WGRtrib1 towards the dam spillway.

Plate 9: Looking downstream at WGRswamp in spring 2022.

Plate 10: Looking upstream at WGRswamp.

Plate 11: Looking upstream at WGRdown.

Plate 12: Looking upstream at WGRdown in spring 2022.

Plate 13: Looking downstream at WGRXdown in spring 2022.

Plate 14: Looking upstream at WGRXdown.

Plate 15: Looking upstream at WGRXdown.

Plate 16: Looking upstream at WGRref in spring 2022.


Plate 17: Looking upstream at WGRref.


Plate 18: Looking downstream at WGRref.

CENTENNIAL COAL
CLARENCE COLLIERY

BUNGLEBOORI CREEK CATCHMENT
AQUATIC ECOLOGY

AUTUMN 2022 DATA REPORT

Figure 1. Looking upstream at Bungleboori creek site BCDn1.

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD
SEPTEMBER 2022

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Clarence Colliery Pty Ltd owns and operates the existing Clarence Colliery underground coal mine near the village of Clarence in NSW and is applying for a mine expansion (portion EP 918/920), located within the upper Bungleboori Creek catchment, one of the major tributaries to the Wollangambe River. The study area catchments are contained within the Gardens of Stone State Conservation Area (SCA), with catchment areas upstream and downstream of the proposed mine footprint comprising mixed undeveloped native forest and former state forest pine plantation, Blue Mountains National Park and Hansons' Sand Quarry. The Bungleboori and Paddys Creek catchment drainage lines overlying and downstream from the proposed extraction area contain Newnes Plateau Shrub and Hanging Swamp endangered ecological communities (EECs).

As part of the Environmental assessment process, Clarence Colliery commissioned Marine Pollution Research Pty Ltd (MPR) to review existing aquatic ecological information and initiate a baseline aquatic ecology monitoring program to describe the existing aquatic environment of the EP 918/920 proposal footprint. The aims of the baseline aquatic ecology (streamhealth) monitoring program are as follows:

- To develop an understanding of the aquatic ecological attributes of the Newnes Plateau Shrub Swamps which overly the areas of proposed mining in order to enable impact assessment and provide suitable mitigation and offset measures where necessary or desirable.
- To provide additional aquatic site base-line data that can be utilised to monitor potential construction and operational impacts of continued and new mining and that can be used to develop suitable trigger, action and response plans (TARPS) to be incorporated into Construction and Operational Environmental Monitoring Plans (CEMP and OEMP) that would be required as part of an EIS consent.

This data report provides the results for the second consecutive aquatic ecology baseline monitoring survey for Clarence EP 918/920 undertaken in autumn 2022, and follows on from the initial baseline monitoring spring 2021 survey reported in MPR (2022)

1.1 Description of Locality and Existing Information

The proposed mine expansion area is located in the upper Bungleboori Creek catchment including a tributary of Paddys Creek (**Figure 2**). Several sub-catchments support Newnes Plateau Shrub Swamp (NPSS) habitats dominated by shrubs and sedges that occur on sites with impeded drainage in low slope headwater valleys on the Newnes Plateau in the upper Blue Mountains (Web Reference 1).

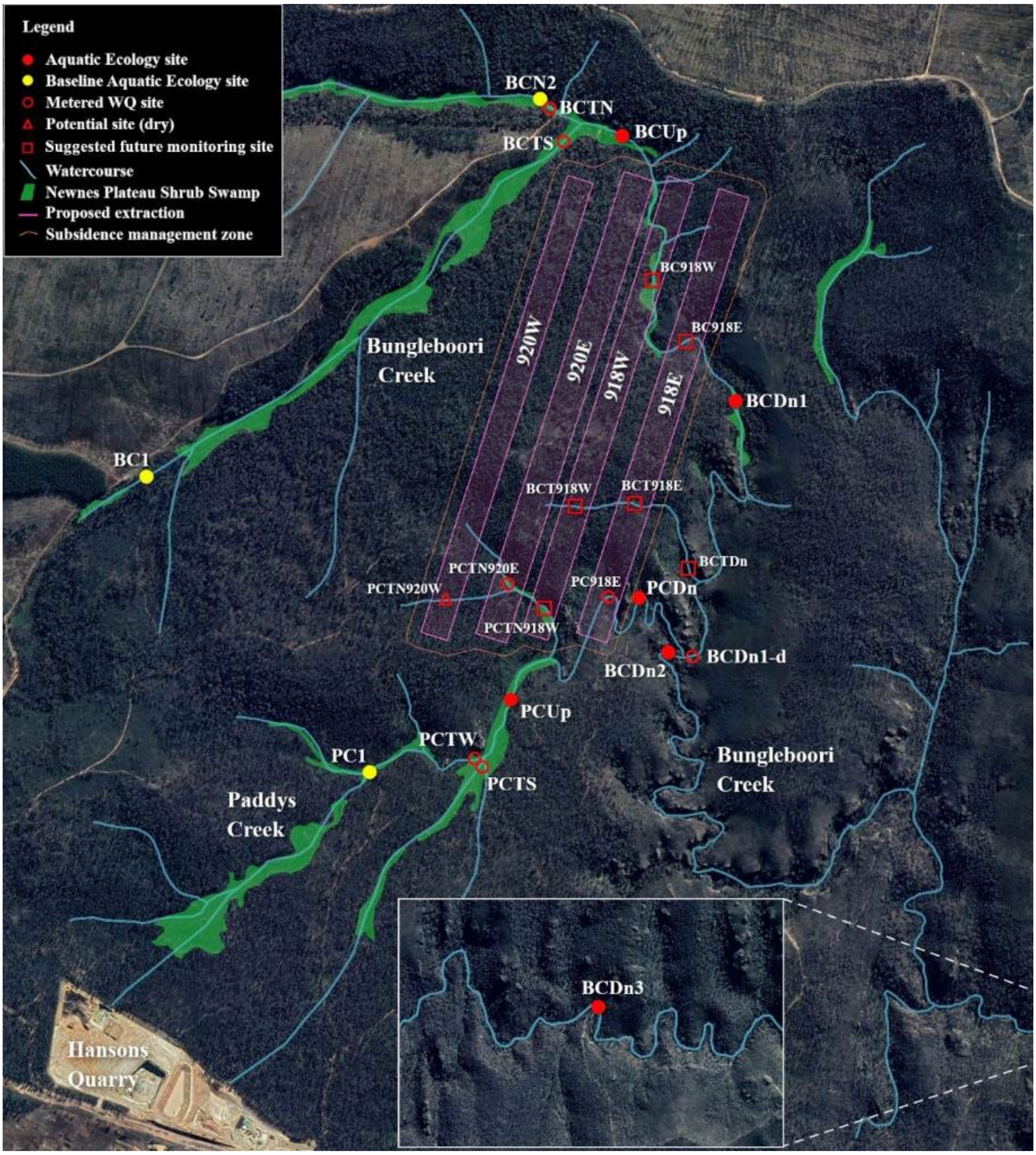

Figure 2 Clarence EP 918/920 autumn 2022 aquatic ecology survey sites.

The NPSSs are listed as Endangered Ecological Communities (EECs) under the NSW *Biodiversity Conservation Act 2016* (BCA) and are also listed as part of the Temperate Highland Peat Swamps on Sandstone (TPHSS) under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Bungleboori Creek originates on the Newnes Plateau in the Blue Mountains Range at elevations reaching 1170m Australian Height Datum (AHD) and has an average annual rainfall of 1092mm. From the headwaters the creek flows in a north easterly direction for 3km where it meets Waratah Ridgeline, turns to the south for 4km flowing through narrow escarpment ridgelines, whereby it changes direction to flow in a general easterly direction before discharging into the Colo River.

The Bungleboori Creek study area is situated in Newnes State Forest, around 11km upstream from the western boundary of the Blue Mountains National Park. The upper headwaters to the south of Waratah Ridge are divided into two separate drainages of equal size, of which approximately half of the catchment area is occupied by plantation pine forest and the remainder comprises native bushland. The ridgelines bounding the drainages and bordering the adjacent creek catchment boundaries contain a complex network of access tracks, and both sub-catchment drainage channels contain NPSS's. The gradient of the entire southern drainage where the NPSS prevails is relatively shallow, decreasing 40m in height over the 2.6km length. Downstream of each NPSS in the study area sub-catchments, the channel valleys become more incised and bordered by steep sandstone escarpments, which increase in depth and frequency with increasing distance downstream.

The proposed EP 918/920 mining footprint underlies Bungleboori Creek for a distance of around 860m (**Figure 2**), which contains intermittently occurring shrub swamps and incised creek drainage channel throughout the length. There is one small 1st order unnamed sub-catchment tributary to Bungleboori Creek which overlies the mining footprint (BCT in **Figure 2**) and flows from the west to join Bungleboori Creek just above its confluence with Paddys Creek.

Paddys Creek originates on the Newnes Plateau in the Blue Mountains Range near State Mine Gully at elevations reaching 1190m AHD. The headwaters of Paddys Creek catchment border the upper Bungleboori Creek catchment to the south, and flow in a north easterly direction for a distance of around 4.1km before merging with Bungleboori Creek.

Whilst there are no pine plantation compartments within the Paddys Creek catchment area, the two main sub-catchment branches accommodate Hansons' Sand Quarry in their upper limits (**Figure 2**). The longer northern sub-catchment supports a NPSS upstream of the site that extends for approximately 1300m in length, and the smaller southern sub-catchment contains a NPSS that is around 660m in length, which continues further downstream from the confluence of the sub-catchments for a distance of 520m, after which the stream channel becomes incised and meandering through bedrock escarpment and gullies in its lower limits. A small tributary to Paddys Creek overlies the proposed underground footprint (PCTN in **Figure 2**) which merges with Paddys Creek at the downstream limits of the NPSS distribution in the main channel.

In terms of existing aquatic ecological sampling information for the study area, a previous Environmental Assessment for an adjoining Springvale Colliery mining lease area included a baseline aquatic ecology monitoring program that ran from 2010 to 2016. This study included three sites in the upper Bungleboori Creek and Paddys Creek catchments, and Springvale Colliery provided permission to incorporate these results as long-term streamhealth indices for this project which were provided in the first Clarence EP 918/920 monitoring report (MPR 2022).

1.2 Newnes Plateau Site Threatened Species Considerations

The NPSS provide habitat for several water related terrestrial species; the giant dragonfly (*Petalura gigantea*) and the Blue Mountains water skink (*Eulamprus leuraensis*) and possible habitat for one aquatic species, the Adams emerald dragonfly (*Archaeophya adamsi*). The giant dragonfly and water skink are listed as Endangered under the BCA with the latter also being listed as Endangered under the EPBC Act. The emerald dragonfly is listed as Endangered under the NSW *Fisheries Management Act 1994* (FMA).

The giant dragonfly is semi-aquatic, living in burrows in swamps and along stream edges. The larvae emerge from the terrestrial entrances at night and in wet weather in search of insects and other arthropods to eat, and larvae are not known to swim and avoid open water (Web Reference 2). Given their crepuscular habits of the larvae and the fact that adults only emerge between October and January, it would be unlikely to have observed or retained giant dragonflies during sampling for this autumn 2022 survey.

There is little information available on the ecology and biology of Blue Mountains water skink. The Blue Mountains water skink is restricted to sedge and shrub swamps that have boggy soils and appear to be permanently wet, and is semi-aquatic being active on warm, sunny days from September until late April (Web Reference 3). Although it is known from the Carne Creek swamps, no individuals were observed during this survey.

The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: Floods Creek in Brisbane Waters National Park near Gosford; Tunks Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 4). Considering these observations and owing to the generally poor level of knowledge of this species state-wide, the presence of *A. adamsi* in the Newnes Plateau study area (Bungleboori Creek and Paddys Creek) cannot be discounted entirely.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims, the Aquatic Ecology Sampling Program endeavours to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the study area aquatic habitats?
- Do the creeks provide suitable fish passage?
- Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June 15 and 'Spring' is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of basic water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

The adopted study design to achieve the objectives incorporated aquatic ecology sampling in autumn 2022 at six in-stream sampling sites located up and down-stream of the proposed extraction area in creek drainage channels and NPSS, with water quality metering was undertaken at a further eight locations.

Table 1 below presents the site descriptions and coordinates for all sites visited and **Figure 2** (above) shows sampling site locations in relation to the proposed underground mine, including the former Springvale Coal monitoring sites sampled between 2010 and 2016. Note that there are two sites shown as suggested possible future mining impact assessment sites that were not able to be visited for this survey. If access to these sites is possible and the sites are viable aquatic ecology monitoring locations, they could be sampled prior to under-mining and post mining to assess potential mine impacts.

Table 1 Clarence EP 918/920 Extraction Plan Aquatic Ecology Sample Site Information Spring 2021 and Autumn 2022

Catchment	Site	Site Coordinates		Metered WQ	Aq Eco
		E	N		
Bungleboori Ck	BCTS	241974	6301203	Sp21 & Au22	
	BCTN	241934	6301300	Sp21 & Au22	
	BCUp	242186	6301187		Sp21 & Au22
	BCDn1	242563	6300328		Sp21 & Au22
	BC918W	242302	6300754		
	BC918E	242405	6300547	Au22	
	BCT918W	242014	6299966	Au22	
	BCT918E	242249	6299983	Au22	
	BCTDn	242422	6299775		
	BCDn1-d	242464	6299495	Sp21 & Au22	
	BCDn2	242333	6299501		Sp21 & Au22
	BCDn3	244522	6298422		Sp21 & Au22
Paddys Creek	PCTW	241675	6299121	Sp21 & Au22	
	PCTS	241769	6299127	Sp21 & Au22	
	PCUp	241848	6299318		Sp21 & Au22
	PCTN920W	241630	6299674	Sp21 (dry)	
	PCTN920E	241835	6299709	Sp21	
	PCTN918W	241951	6299627		
	PC918E	242154	6299684	Sp21	
	PCDn	242255	6299651		Sp21 & Au22
Note:	Sites in red represent suggested future mining impact assessment sites. Aq Eco includes metered WQ, macroinvertebrate and fish sampling and RCE.				

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b).

The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.
Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum", and riffle samples collected from broken waters with only pebble, gravel, sand or bedrock substratum may not produce reliable results.
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

While many of the upper catchment tributary creek and swamp sites are readily accessible, site selection for sampling aquatic biota from some of the incised catchment sites is constrained by access from the road network through the forest to the drainages where the creek flows through deeply incised canyons bordered by escarpment.

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method.

Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event.

For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae or exuviae of other threatened species are kept for confirmation purposes.

Targeted searches were also made for giant dragonfly adults and exuviae (shells cast larval in the process of emergence) among suitable Newnes Plateau Shrub swamp habitats and along ridgelines.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars.

Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant). For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis.

Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey. Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys.

As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised ‘health’ scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate.

Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified. For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A calibrated submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE EP 918/920 AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the autumn 2022 aquatic ecology sampling are provided in **Appendix Table A2**. Sampling for the full autumn 2022 survey was undertaken between the 7th and 10th June 2022. Note that for sampling purposes the AusRivAS 'autumn' season is defined as March 15th to June 15th.

3.1 Sampling Conditions Leading into Autumn 2022

Rainfall measurements are recorded at Clarence Mine Meteorological Station, with long-term mean monthly totals acquired from Bureau of Meteorology (BOM) Lithgow (Cooerwull) Gauge 63226 (recorded from 1878 to current). **Appendix Tables A-1** provides the daily rainfall records for July 2021 to June 2022 and are shown graphically in **Figure 3**. Following on from the previous spring aquatic ecology survey in December 2021, the study area was subjected to consistent wet weather with heavy rainfall events in March 2022:

- March 2022 was the wettest month, recording the highest total rainfall with 317mm over 30 rainfall days, including 78% of the monthly total in the first eight days of the month (243mm).
- The combined rainfall total over the six-month period between December 2021 and May 2022 (945mm) was more than double the combined mean monthly total for the same months (432mm). Patterns of precipitation over the six-month period was characterised by regular rain events, with 75% of the days registering rainfall.

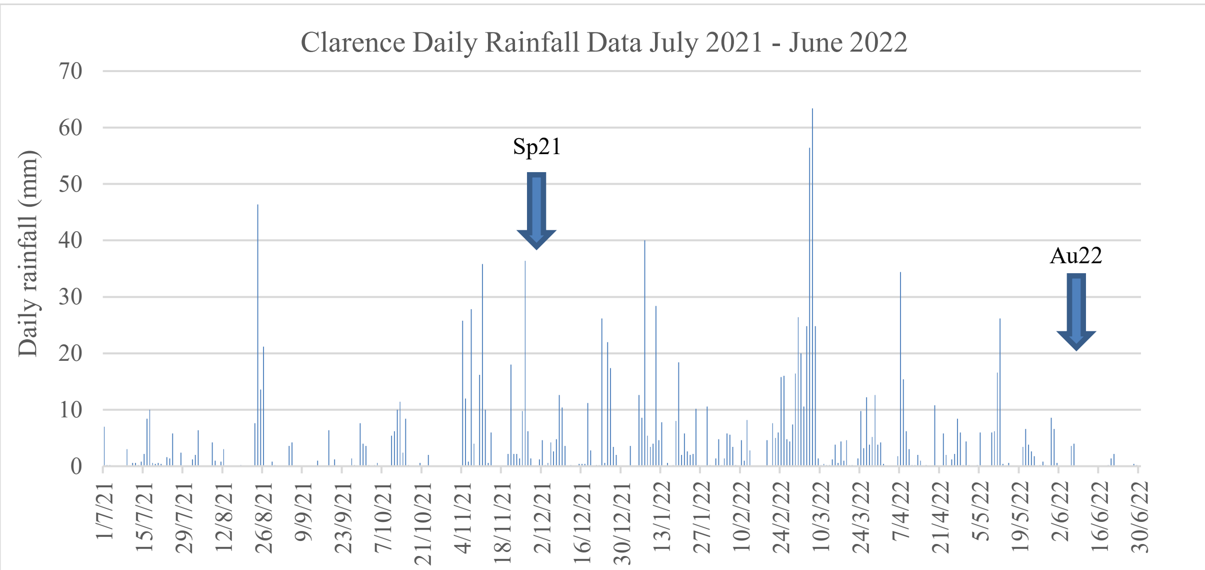

Figure 3 Clarence mine site daily rainfall July 2021 to June 2022.

3.2 Autumn 2022 Aquatic Ecology Survey Results

The Clarence EP 918/920 autumn 2022 aquatic ecology monitoring survey was undertaken between the 7th and 10th June 2022 2021following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. Site photos are also provided **Appendix A**. Summary tables for the autumn 2022 Appendix A data are provided in the following sections and include the spring 2021 survey results.

3.3 Autumn 2022 Metered Water Quality Results

A calibrated water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling during the autumn 2022 aquatic ecology field sampling program.

Table 2 EP 918/920 Extraction Area Water Quality Results Autumn 2022

Site	Date	Time	Temp	Cond	DO	DO	pH	Turb
			°C	µS/cm	% sat	mg/L	Units	ntu
BCTN	7/6/22	15:57	5.35	11	79.1	10.03	5.49	0.1
BCTS	7/6/22	16:03	5.85	12	72.0	9.02	4.88	0.3
BCUp	7/6/22	15:50	5.49	11	77.8	9.83	5.52	0.1
BC918E	10/6/22	8:52	5.89	12	81.9	10.24	5.46	0.1
BCDn1	10/6/22	8:26	5.96	12	87.9	10.98	5.64	0.1
BCDn1d	8/6/22	11:09	5.30	11	85.3	10.83	5.89	0.1
BCDn2	8/6/22	11:03	5.22	11	86.3	10.99	5.87	0.1
BCDn3	7/6/22	12:10	6.74	13	89.9	11.01	5.42	0.7
BCT918W	9/6/22	9:21	6.35	12	70.0	8.65	5.51	0.1
BCT918E	9/6/22	8:37	8.59	28	76.7	8.97	4.93	0.1
PCTS	8/6/22	9:10	5.08	11	82.2	10.50	5.58	0.1
PCTW	8/6/22	9:20	5.21	11	84.2	10.72	5.61	0.1
PCUp	8/6/22	8:52	5.27	12	89.6	11.39	5.10	2.3
PCDn	8/6/22	13:50	6.65	11	86.0	10.55	5.39	0.1

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-2**) provide details of stream reach flows, pool and channel dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-3** with summary provided below in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the autumn 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results Autumn 2022

Category	BCUp	BCDn1	BCDn2	BCDn3	PCUp	PCDn
Land-use pattern beyond immediate riparian zone	3.5	4	4	4	4	4
Width of riparian strip-of woody vegetation	4	4	4	4	4	4
Completeness of riparian strip of woody vegetation	4	4	4	4	4	4
Vegetation of riparian zone within 10 m of channel	4	4	4	4	4	4
Stream bank structure	4	4	4	4	4	4
Bank undercutting	3	2	2	2	2	2
Channel form	4	4	4	4	4	4
Riffle/pool sequence	3	4	4	4	4	4
Retention devices in stream	3	4	4	4	4	4
Channel sediment accumulations	3	3	3	2.5	3	3
Stream bottom	3	4	4	4	3	4
Stream detritus	4	4	4	4	4	4
Aquatic vegetation	4	4	4	4	4	4
Autumn 2022 Site RCE Score (%)	89.4	94.2	94.2	93.3	92.3	94.2
Spring 2021 Site RCE Score (%)	90.4	94.2	94.2	94.2	92.3	94.2

Table 4 Macrophyte Occurrence Autumn 2022

Site	Rush *Baumea rubiginosa*	Grass *Carex gaudichaundiana*	Jointed Rush *Juncus articulatus*	Bulbous Rush *Juncus bulbosus*	Rush *Juncus sp*	Tufted Algae *Batrochospermum sp*	Charophytes
BCUp				1			1
BCDn1	1	1		1		1	1
BCDn2						1	1
BCDn3				1		1	1
PCUp	1		1	1	1		1
PCDn			1	1		1	

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-4 provides the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The tables also provide site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

The individual site macroinvertebrate edge sample Diversity (taxa richness), SIGNAL and EPT diversity results recorded in spring 2021 and autumn 2022 are provided in **Figures 4** to **6** below. Note that riffle samples are named with a -R (e.g., BCDn2-R).

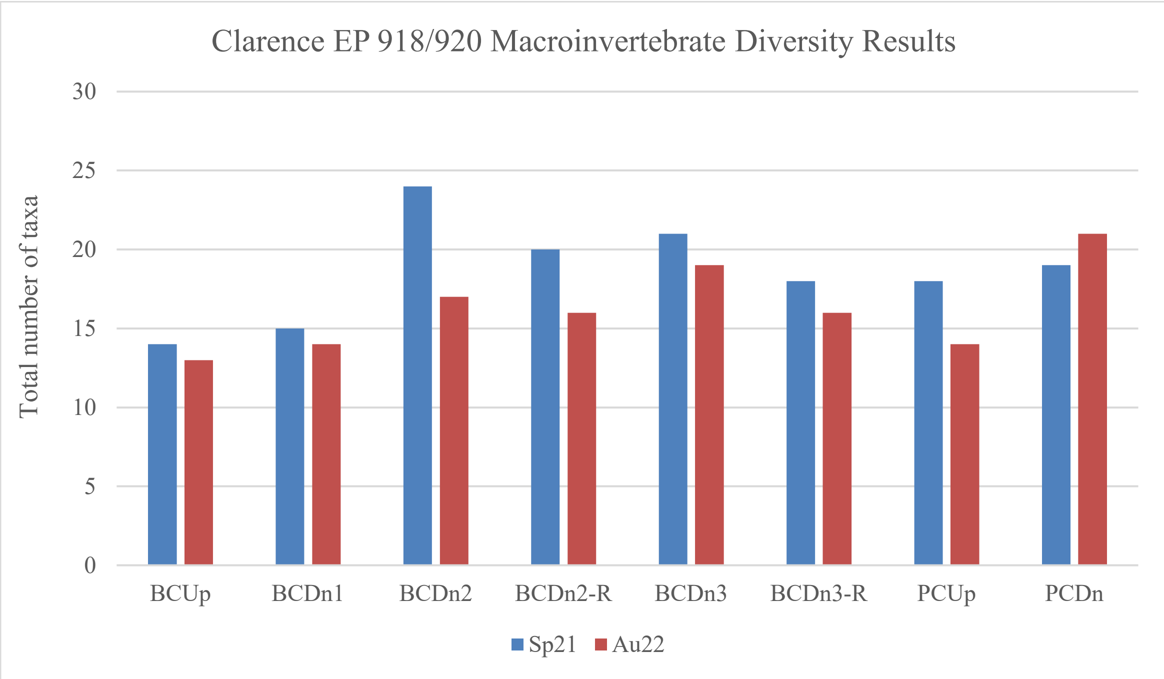

Figure 4 Clarence EP 918/920 spring 2021 and autumn 2022 survey macroinvertebrate taxa diversity.

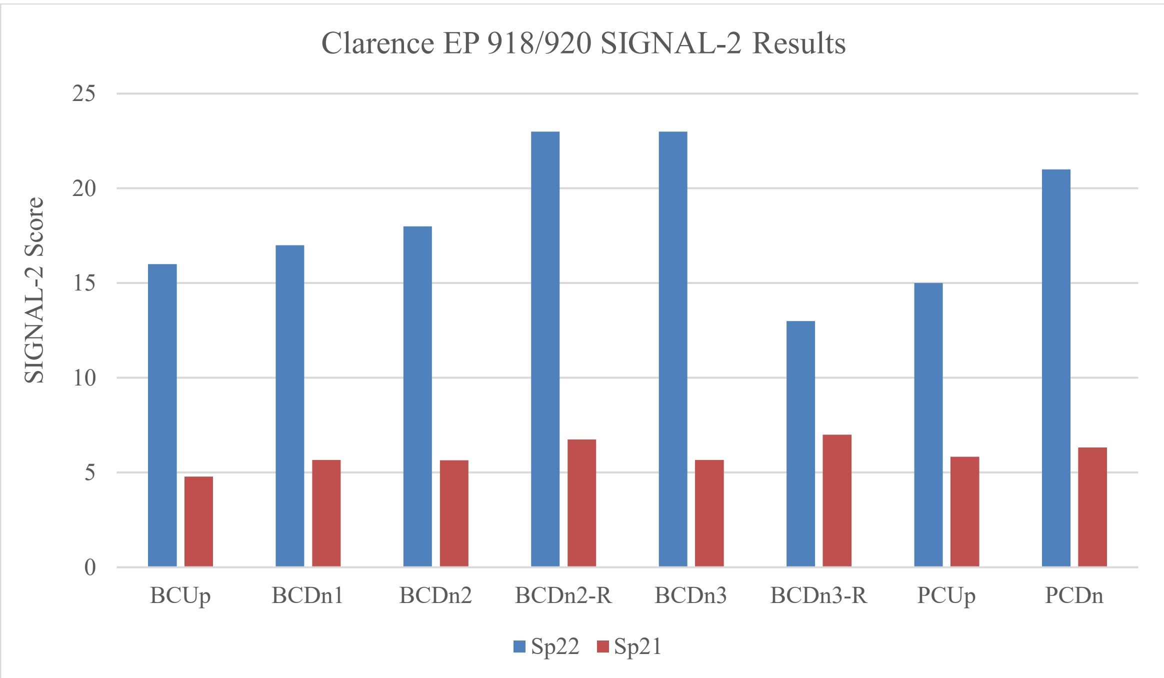

Figure 5 Clarence EP 918/920 spring 2021 and autumn 2022 survey SIGNAL-2 scores.

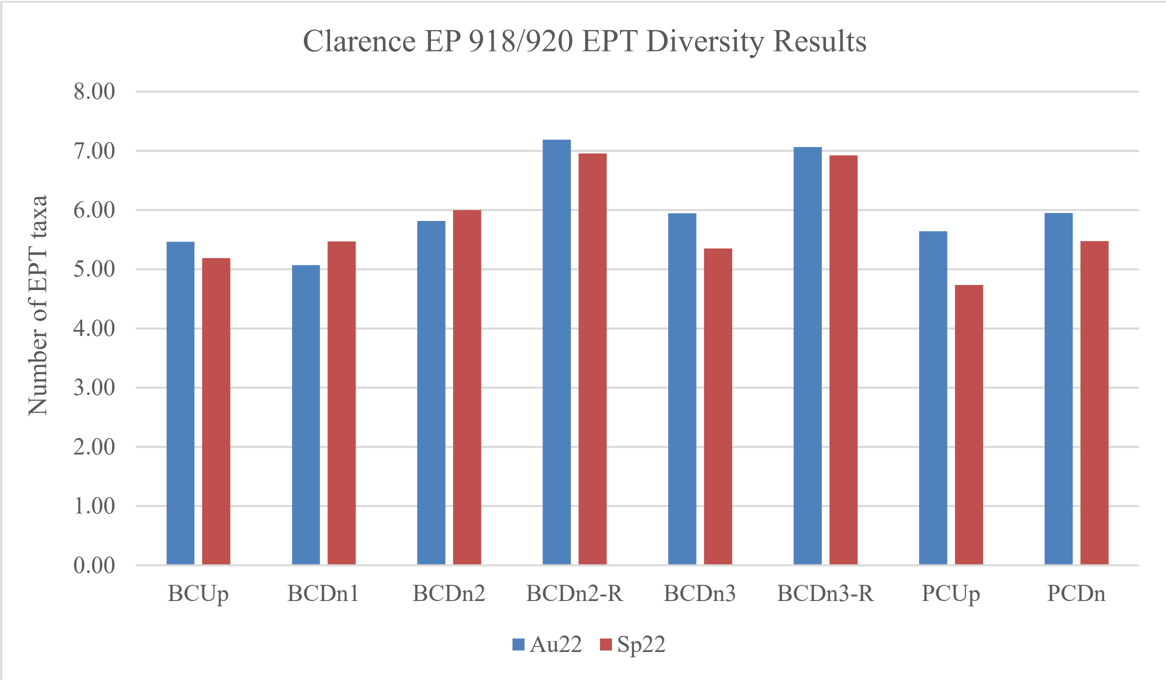

Figure 6 Clarence EP 918/920 spring 2021 and autumn 2022 survey EPT taxa diversity.

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

AUTUMN 2022

Appendix Table A-1 Clarence Site Daily Rainfall (mm) for July 2021 to June 2022												
Date	2021						2022					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1st	7	1.2	0	3.6	0	1.2	0	1.4	16.4	0.4	0.2	0.6
2nd	0.2	2	0	0.2	0	4.6	3.6	4.8	26.4	0	0	0
3rd	0.2	6.4	0	0	0	0.2	0	0.2	20	0	0	0
4th	0	0	3.6	0.2	25.8	0.6	0	1.4	10.6	0	0.2	0
5th	0	0	4.2	0.6	12	4.2	12.6	5.8	24.8	0	6	0
6th	0	0	0	0	0.8	2.6	8.6	5.6	56.4	1.8	0	3.6
7th	0	0	0	0	27.8	4.8	40	3.4	63.4	34.4	0	4
8th	0	4.2	0	0	4	12.6	5.4	0.2	24.8	15.4	0	0
9th	3	1	0	0	0	10.4	3.4	0	1.4	6.2	6	0
10th	0	0	0	5.4	16.2	3.6	4	4.6	0.2	3	6.2	0
11th	0.6	0.8	0	6.2	35.8	0	28.4	1	0.4	0.2	16.6	0
12th	0.6	3	0	10	10	0.2	4.6	8.2	0.2	0.2	26.2	0
13th	0.2	0	0	11.4	0.6	0	7.8	2.8	0.2	2	0.4	0
14th	0.8	0	1	2.4	6	0	0	0	1.2	1	0	
15th	2.2	0	0	8.4	0	0.4	0.6	0	3.8	0	0.6	
16th	8.4	0	0	0.2	0	0.4	0	0	0.6	0.2	0	
17th	10	0	0	0	0	0.4	0.2	0	4.4	0	0	
18th	0.6	0.2	6.4	0	0	11.2	8	0	1	0	0	
19th	0.4	0	0	0	0	2.8	18.4	4.6	4.6	10.8	0	
20th	0.6	0	1.2	0.6	2.2	0	2	0	0.2	0	3.4	
21st	0.4	0	0	0	18	0.2	5.8	7.6	0.2	0	6.6	
22nd	0	0	0	0	2.2	0.2	2.6	5	0	5.8	3.8	
23rd	1.6	7.6	0	2	2.2	26.2	2	6	1.4	2	2.6	
24th	1.4	46.4	0	0	1.4	0.6	2.2	15.8	9.8	0	1.8	
25th	5.8	13.6	0	0	9.8	22	10.2	16	3.2	1.2	0	
26th	0	21.2	1.4	0	36.4	17.4	0.2	4.8	12.2	2.2	0.2	
27th	0	0	0.2	0	6.2	3.4	0	4.4	3.8	8.4	0.8	
28th	2.4	0	0	0	1.4	2	0	7.4	5.2	6	0.2	
29th	0	0.8	7.6	0	0	0	10.6		12.6	0.2	0	
30th	0	0.2	4	0	0	0	0.2		3.8	4.4	8.6	
31st	0	0		0		0	0		4.2		6.6	
Total	46.4	108.6	29.6	51.2	218.8	132.2	181.4	111	317.4	105.8	97	8.2
Monthly Average*	60.3	57.9	55.7	61.9	64.5	79.1	85.2	81.4	77.8	57.1	51.1	71.7
Note: EP 918/920 study area Aquatic Ecology sample days are highlighted in yellow. *Monthly average is the long-term average from BOM station 63226.												

Table A-2 Field Comments – Autumn 2022 Aquatic Ecology Monitoring Sites		
Site	Date	Comments
BCUp	7/6/22	Evidence of high flow water levels reaching around 1m above baseflow water levels and at least 15m in width, as indicated by debris accumulations and slanted vegetation, increased channelisation and openness of the pool habitats. Bank adjacent creek has been scoured free of loose material. Water clear and flowing through site length. Maximum pool with around 1.5m and average width 0.8, maximum depth ~1.4m and average depth 0.5m. Brown silt and orange precipitate prevalent throughout site channel on submerged surfaces. The aquatic edge habitats sampled included trailing bank vegetation, macrophytes, detritus and undercut banks. The channel substrates were made up of generally equal proportions of cobbles, gravelly sands and pebble sized rocks, with small quantities of boulders. No filamentous green alga observed.
BC918E	10/6/22	Channel incised and box shaped, with gradual meanders among a mostly straight channel. While much of the site was exposed to flows, there were sufficient areas isolated from flows (pool edge areas with little to no flows) that could be sampled (as per the AusRivAS definition). Evidence of high flow scouring to 1m above baseflow water levels, as indicated by debris accumulations, slanted riparian vegetation and some uprooted vegetation clumps. Newnes Plateau shrub swamps occurring along creek edges on both banks in section, contributing water to channel. Similar riparian and instream vegetation to other Bungleboori Creek sites (bulbous rush (*Juncus bulbosus*), rush (*Baumea rubiginosa*) and charophytes, coral ferns (*Gleichenia sp*), Lomandra). A series of deeper pools occur just upstream from the water metering location (at 242355/6300507), with a section of hanging swamp along the creek bend.
BCDn1	10/6/22	Some section of the site exposed to scouring high flows at least 2m above baseflow water levels, with some section of the site hammered; banks free of detritus, channel edge banks incised, clean-cut and box shaped, large sections of bank have been removed since the spring 2021 survey with new log jams present, new flow paths. Lateral seepage and trickling contributions present all through site. Water clear and flowing through site length. Maximum pool width to 8m, average width around 1.4m, maximum depth 0.8m and average depth 0.4m. Bank undercutting was prevalent throughout the site however the banks appeared stable owing to consolidation by riparian (mostly swamp) vegetation. The aquatic edge habitats consistent with previous sample, comprising trailing bank vegetation, detritus, undercut banks, macrophytes (bulbous rush *Juncus bulbosus*) and charophytes. The channel substrates were made up of generally equal amounts of bedrock, gravelly sands and cobbles. No filamentous green alga observed.

BCDn2	8/6/22	Evidence of high energy high flow water levels to at least 2m above baseflow water levels. Large eucalypt on corner fallen over, some edge banks removed and re-shaped with bank vegetation having been scoured from banks. Undercut banks present throughout site length. Water clear and flowing through site. Maximum width around 8 to 10m and average width 2.5m, maximum depth 1.6 to 1.8m and average depth around 0.3 to 0.4m. The aquatic edge habitat sampled consisted of detritus, undercut banks and trailing bank vegetation, for the most part consistent with the previous survey. The channel substrates comprised generally equal quantities of cobbles and gravels and sandy pebble accumulations, with infrequent boulder and bedrock structures. No filamentous green alga observed.
BCDn3	7/6/22	Site been subjected to intense, scouring flows since spring 2021 survey, with re-distribution of instream banks and subsequent new flow paths, increased bank erosion on bend, new sandy sediment bank accumulations, and large debris accumulations. The riparian edge banks had been scoured free of debris. Water very clear and flowing through site length. Maximum width around 7m and average width around 3.5m, maximum depth around 1.4m. Seemingly lesser quantities of sample-able detritus in pool edge areas compared to previous survey. The sampled aquatic edge habitats included undercut banks, trailing bank vegetation and detrital accumulations. Mountain galaxias (*Galaxias olidus*) and native crayfish (*Euastacus spinifer*) observed. The site substrates were comprised mostly of sands with smaller quantities of cobbles, gravels and pebbles and boulders. No filamentous green alga observed.
PCUp	8/6/22	Evidence of recent high flow water level reaching 5 to 10m in width. Banks scoured free of detritus and localised debris accumulations present. Water clear and flowing through site length, lateral seepages and trickling flows entering site from adjacent swamp areas. Maximum width to 2.5m and average width around 0.8m, maximum pool depth to 1.4m and average depth 0.5m. The edge habitats were consistent with the previous survey, comprising trailing bank vegetation, undercut banks and aquatic vegetation; bulbous rush, jointed rush (*Juncus articulatus*), rush (*Baumea rubiginosa*) and charophytes. The site substrates were comprised of generally equal amounts of sloped bedrock benches (cascades), cobbles or gravelly sand accumulations. No filamentous green alga observed. Snow present on some logs.

PCDn	8/6/22	Evidence of flows to 1m above baseflow water levels, with impacts including new debris accumulations, scouring of riparian edge banks and stream channels (with increased incision), and scouring of log jams with subsequent loss of pool habitat. Water clear and flowing through site length. Pool dimensions generally consistent with previous sample occasion, maximum width around 3m and average width ~1.2m, maximum depth 1.3m and average depth 0.4m. The edge habitats sampled included trailing bank vegetation, detritus and undercut banks, and silts were smothering submerged surfaces in some isolated edge areas. The site substrates were comprised mostly of bedrock, with smaller and generally equal quantities of cobbles, pebbles and sandy gravels. No filamentous green alga observed.
BCT918W	9/6/22	Water metering location for BCT918W (242014/6299966) undertaken a little upstream of pre-identified middle of proposed shortwall GPS location (242049/6299990) which was dry. The broader section of catchment contains intermittently occurring surface water with very shallow (max pool depth around 5 to 10cm however mostly <1 to 2cm) runs and sections where water goes underground. Whilst there is some minor channel incision or indications of stormwater runoff (debris accumulations), the complexity of aquatic habitats is very low. Orange precipitation present on channel substrates.
BCT918E	9/6/22	Very shallow (<5cm) surface water flowing through narrow, straight run at GPS location (242239/6300003), location forested of moderate slope with open understorey. Water clear, with intense orange precipitation confined to flow path, and stream channel very shallow and contained within a shallow sloped swale, with only minor incision into surrounding valley floor. Just downstream the channel drops through a series of cascading plunge pools as the slope increases as does the broader bank slopes into a V-shaped valley supporting Newnes Plateau shrub swamp vegetation on both sides of the channel (sedges, *Gahnia sp*, coral ferns *Gleichenia sp*). The water metering location (242249/6299983) was undertaken in a plunge pool downstream of the GPS location. Overall, a pretty steep section. A large erosion hole exists just downstream of the water metering location, where a considerable head-cut exists instream, consolidated by swamp vegetation on the upstream side and exposed valley substrates, appears to be recent (as indicated by slumped banks with vegetation growing). Channel incision and steepness increases downstream. Overall, the aquatic habitat availability was confined to mostly shallow plunge pools connected by shallow runs, going underground in sections.

Appendix Table A-3

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor								
	Category		Au22	Au22	Au22	Au22	Au22	Au22
		Value	BCUp	BCDn1	BCDn2	BCDn3	PCUp	PCDn
1	Land-use pattern beyond immediate riparian zone							
	Undisturbed native vegetation	4		4	4	4	4	4
	Mixed native vegetation and pasture/exotics	3	3.5					
	Mainly pasture, crops or pine plantation	2						
	Urban, some vegetation	1						
	Industrial, little vegetation	0						
2	Width of riparian strip-of woody vegetation							
	More than 30 m	4	4	4	4	4	4	4
	Between 5 and 30 m	3						
	Less than 5 m	2						
	No woody vegetation	1						
	No Vegetation	0						
3	Completeness of riparian strip of woody vegetation							
	Riparian strip without breaks in vegetation	4	4	4	4	4	4	4
	Breaks at intervals of more than 50 m	3						
	Breaks at intervals of 10-50 m	2						
	Breaks at intervals of less than 10 m	1						
	No riparian strip at all	0						
4	Vegetation of riparian zone within 10 m of channel							
	Native tree and shrub species	4	4	4	4	4	4	4
	Mixed native and exotic trees and shrubs	3						
	Exotic trees and shrubs	2						
	Exotic grasses/weeds	1						
	No vegetation at all	0						
5	Stream bank structure							
	Banks fully stabilized by trees, shrubs, concrete	4	4	4	4	4	4	4
	Banks firm but held mainly by grass and herbs	3						
	Banks loose, partly held by sparse grass, rubble	2						
	Banks unstable, mainly loose sand or soil	1						
	Banks actively eroding	0						
6	Bank undercutting							
	None, or restricted by tree roots or man-made	4						
	Only on curves and at constrictions	3	3					
	Frequent along all parts of stream	2		2	2	2	2	2
	Severe; bank collapses common	1						
	Total bank collapse	0						
7	Channel form							
	Deep; width:depth ratio less than 8:1	4	4	4	4	4	4	4
	Medium; width:depth ratio 8:1 to 15:1	3						
	Shallow; width:depth ratio greater than 15:1	2						
	Artificial; concrete or excavated channel< 8:1	1						
	Artificial; concrete or excavated channel > 8:1	0						
8	Riffle/pool sequence							
	Frequent alternation of riffles and pools	4		4	4	4	4	4
	Long pools with infrequent short riffles	3	3					
	Natural channel without riffle/pool sequence	2						
	Artificial channel; some riffle/pool sequence	1						
	Artificial channel; no riffle/pool sequence	0						
9	Retention devices in stream							
	Many large boulders and/or debris dams	4		4	4	4	4	4
	Rocks/logs present; limited damming effect	3	3					
	Rocks/logs present but unstable; no damming	2						
	Stream or channel with few or no rocks/logs	1						
	Artificial channel; no retention devices	0						
10	Channel sediment accumulations							
	Little or no accumulation of loose sediments	4						
	Some gravel bars but little sand or silt	3	3	3	3		3	3
	Bars of sand and silt common	2				2.5		
	Braiding by loose sediment	1						
	Complete in-filled muddy channel	0						
11	Stream bottom							
	Mainly clean stones with obvious interstices	4		4	4	4		4
	Mainly stones with some cover of algae/silt	3	3				3	
	Bottom heavily silted but stable	2						
	Bottom mainly loose and mobile sandy sedimen	1						
	Bottom mainly loose and mobile muddy sedimer	0						
12	Stream detritus							
	Mainly unsilted wood, bark, leaves	4	4	4	4	4	4	4
	Some wood, leaves, etc. with much fine detritus	3						
	Mainly fine detritus mixed with sediment	2						
	Little or no organic detritus, mainly sandy	1						
	No organic detritus, mainly mud	0						
13	Aquatic vegetation							
	Little or no macrophyte or algal growth	4	4	4	4	4	4	4
	Substantial algal growth; few macrophytes	3						
	Substantial macrophyte growth; little algal grow	2						
	Substantial macrophyte and algal growth	1						
	Total cover of macrophytes plus algae	0						
	RCE Score		46.5	49.0	49.0	48.5	48.0	49.0
	RCE %age		89.4	94.2	94.2	93.3	92.3	94.2

Appendix Table A-4 Clarence 918/920 Extraction Plan Aquatic Ecology Monitoring Macroinvertebrate and Fish Results Autumn 2022												Sample Site and Sample Date									
									Life Stage			7/6/22	10/6/22	8/6/22	8/6/22	7/6/22	8/6/22	8/6/22	8/6/22		
Phylum	Class	Sub-Class	Order	Sub-Order	Family	Sub-Family	Genus/spp	Common name	L	N	A	BCUp	BCDn1	BCDn2-E	BCDn2-R	BCDn3-E	BCDn3-R	PCUp	PCDn	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae			Diving Beetles	x		x					1			1	2	2
Arthropoda	Insecta		Coleoptera		Elmidae			Riffle Beetles	x		x				1	1			1	3	7
Arthropoda	Insecta		Coleoptera		Gyrinidae			Whirligig Beetles	x		x	1	1	1		1			1	5	4
Arthropoda	Insecta		Coleoptera		Psephenidae			Water Pennies	x								1			1	6
Arthropoda	Insecta		Coleoptera		Scirtidae			Marsh Beetles	x			1	1	1	1	1	1	1	1	8	6
Arthropoda	Insecta		Diptera		Ceratopogonidae			Biting Midges	x				1	1						2	4
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae		Bloodworms	x			1	1	1		1		1		5	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae		Bloodworms	x								1		1	2	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1	1	1		1		1	1	6	4
Arthropoda	Insecta		Diptera		Simuliidae			Black Flies	x			1			1		1	1	1	5	5
Arthropoda	Insecta		Diptera		Tipulidae			Crane Flies	x					1	1	1	1		1	5	5
Arthropoda	Insecta		Ephemeroptera		Coloburiscidae			Mayflies		x		1			1		1		1	4	8
Arthropoda	Insecta		Ephemeroptera		Leptophlebiidae			Mayflies		x		1	1	1	1	1	1	1	1	8	8
Arthropoda	Insecta		Ephemeroptera		Oniscigastridae			Mayflies		x						1	1			2	8
Arthropoda	Insecta		Hemiptera		Corixidae			Lesser Water Boatmen					1							1	2
Arthropoda	Insecta		Mecoptera		Nannochoristidae			Scorpionflies	x						1			1		2	9
Arthropoda	Insecta		Megaloptera		Corydalidae			Dobsonflies	x									1		1	7
Arthropoda	Insecta		Neuroptera		Neurorthidae			Lacewings	x								1			1	9
Arthropoda	Insecta		Odonata	Epiproctophora	Corduliidae			Dragonflies	x				1							1	5
Arthropoda	Insecta		Odonata	Epiproctophora	Synthemistidae			Dragonflies	x			1	1	1		1		1	1	6	5
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae			Dragonflies	x					1	1		1		1	4	9
Arthropoda	Insecta		Odonata	Zygoptera	Synlestidae			Damselflies	x					1		1				2	7
Arthropoda	Insecta		Plecoptera		Eustheniidae			Stoneflies		x					1		1			2	10
Arthropoda	Insecta		Plecoptera		Gripopterygidae			Stoneflies		x			1	1	1	1	1	1	1	7	8
Arthropoda	Insecta		Plecoptera		Notonemouridae			Stoneflies		x		1								1	6
Arthropoda	Insecta		Trichoptera		Atriplectididae			Caddis Flies	x							1				1	7
Arthropoda	Insecta		Trichoptera		Conoesucidae			Caddis Flies	x						1		1			2	7
Arthropoda	Insecta		Trichoptera		Ecnomidae			Caddis Flies	x			1						1	1	3	4
Arthropoda	Insecta		Trichoptera		Helicophidae			Caddis Flies	x					1	1	1			1	4	10
Arthropoda	Insecta		Trichoptera		Helicopsychidae			Caddis Flies	x										1	1	8
Arthropoda	Insecta		Trichoptera		Hydrobiosidae			Caddis Flies	x			1			1		1			3	8
Arthropoda	Insecta		Trichoptera		Hydropsychidae			Caddis Flies	x						1		1		1	3	6
Arthropoda	Insecta		Trichoptera		Hydroptilidae			Caddis Flies	x				1	1		1				3	4
Arthropoda	Insecta		Trichoptera		Leptoceridae			Caddis Flies	x			1	1	1		1	1	1	1	7	6
Arthropoda	Insecta		Trichoptera		Odontoceridae			Caddis Flies	x						1	1				2	7
Arthropoda	Insecta		Trichoptera		Philorheithridae			Caddis Flies	x				1	1		1		1	1	5	8
Arthropoda	Crustacea	Copepoda	Cyclopoida		Cyclopidae			Copepods						1					1	2	*
Arthropoda	Crustacea		Decapoda		Parastacidae			Freshwater Crayfish								1				1	4
Arthropoda	Crustacea		Isopoda	Phreatoicidea	Phreatoicidae			Isopods				1	1					1		3	4
Annelida	Oligochaeta							Freshwater Worms						1	1			1	1	4	2
Chordata	Osteichthyes				Galaxiidae		*Galaxias olidus*	Mountain Galaxias					1	1		1		1	1	5	*
								Total number of invertebrate taxa per site:				13	14	17	16	19	16	14	21	40	
								Site SIGNAL2 Scores:				5.46	5.07	5.81	7.19	5.95	7.06	5.64	5.95		
Notes:	* represents those taxa for which SIGNAL-2 scores are not available							Number of EPT taxa:				6	5	6	9	9	9	5	9	17	

Plate 1: Looking upstream from the track crossing at Bungleboori Creek upstream northern swamp location BCTN.

Plate 2: Looking north across track crossing just upstream of Bungleboori Creek site BCUp in autumn 2022.

Plate 3: Looking downstream from the track crossing.

Plate 4: Looking downstream at Bungleboori Creek upstream site BCUp in autumn 2022.

Plate 5: Looking downstream in BCUp.

Plate 6: Looking upstream in BCUp.

Plate 7: Looking downstream along bend in Bunglenboori Creek just upstream from BC918E. Note the hanging swamp along the right hand side embankment.

Plate 8: Nice pool habitat just downstream from location shown in Plate 7.

Plate 9: Looking downstream at BC918E.

Plate 10: Looking upstream at BC918E.

Plate 11: Looking upstream through narrow incised channel just upstream from BCDn1.

Plate 12: Looking downstream at BCDn1.

Plate 13:Looking upstream through pool at upstream end of BCDn1.

Plate 14: Looking downstream at BCDn1.

Plate 15: Looking downstream through incised pool channel at BCDn1.

Plate 16: Looking upstream toward BCDn1.

Plate 17: Looking upstream at the confluence of Bungleboori Creek (right hand side) and Paddys Creek (left hand side).

Plate 18: Looking upstream through gorge at BCDn2 in spring 2021. Note the tea tree and ferns (circled) that are missing from Plate 19 below.

Plate 19: Looking upstream through gorge at BCDn2 in autumn 2022. Impacts from high flow events (most likely in March 2022) include scouring of channel banks and vegetation, including plants shown in Plate 18.

Plate 20: Looking upstream towards gorge at BCDn2.

Plate 21: Looking upstream at BCDn2.

Plate 22: Looking upstream through cobble riffle secion at BCDn2.


Plate 23: Looking upstream through riffle section at BCDn3.


Plate 24: Looking upstream toward one of the deeper pools at BCDn3.


Plate 25: Looking upstream through gravel/ cobble riffle section at BCDn3 in spring 2021.


Plate 26: Looking upstream at BCDn3 in autumn 2022 from same location as Plate 25. Note sand deposition in the riffle zone and redistribution of flow path due to sediment accumulation (circle).

Plate 27: Mountain galaxias *Galaxias olidus* from BCDn3.

Plate 28: Looking upstream at PCUp.

Plate 29: Looking upstream through contained pool area with macrophytes at PCUp.

Plate 30: Looking downstream through narrow bedrock confined cascade at PCUp.

Plate 31: Looking upstream PCUp.

Plate 32: Looking upstream through incised box-shaped channel at the upstream end of PCDn.

Plate 33: In spring 2021 this log jam had created one of the deeper pools encountered in the site due to backed up debris and sediment accumulations, however flow event scouring removed the debris and the pool was lost as a consequence.

Plate 34: Looking upstream at PCDn.

Plate 35: Looking downstream at PCDn.

Plate 36: Looking upstream at BCT918W water metering location.

Plate 37: Looking upstream at BCT918W GPS location. There was no surface water at this location with only minor channel incision.

Plate 38: Looking west (upslope) at BCT918E. There was shallow surface flow through the section and shallow pools were present just downstream at the water metering location (Plate 37).


Plate 39: Looking upstream at BCT918E water metering location.


Plate 40: Looking upstream at an instream erosion hole just downstream of BCT918E, incised and sunken swamp habitats just downstream from Plate 39.

Plate 41: Looking downstream through the steep, V-shaped channel just downstream of BCT918E.

CENTENNIAL COAL
CLARENCE COLLIERY

BUNGLEBOORI CREEK CATCHMENT AQUATIC ECOLOGY

SPRING 2022 DATA REPORT

Figure 1. Looking upstream at Bungleboori creek site BCDn3.

REPORT PREPARED FOR CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD

MARCH 2022

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Clarence Colliery Pty Ltd owns and operates the existing Clarence Colliery underground coal mine near the village of Clarence in NSW and is applying for a mine expansion (portion EP 918/920), located within the upper Bungleboori Creek catchment, one of the major tributaries to the Wollangambe River. The study area catchments are contained within the Gardens of Stone State Conservation Area (SCA), with catchment areas upstream and downstream of the proposed mine footprint comprising mixed undeveloped native forest and former state forest pine plantation, Blue Mountains National Park and Hansons' Sand Quarry. The Bungleboori and Paddys Creek catchment drainage lines overlying and downstream from the proposed extraction area contain Newnes Plateau Shrub and Hanging Swamp endangered ecological communities (EECs).

As part of the Environmental assessment process, Clarence Colliery commissioned Marine Pollution Research Pty Ltd (MPR) to review existing aquatic ecological information and initiate a baseline aquatic ecology monitoring program to describe the existing aquatic environment of the EP 918/920 proposal footprint. The aims of the baseline aquatic ecology (streamhealth) monitoring program are as follows:

- To develop an understanding of the aquatic ecological attributes of the Newnes Plateau Shrub Swamps which overly the areas of proposed mining in order to enable impact assessment and provide suitable mitigation and offset measures where necessary or desirable.
- To provide additional aquatic site base-line data that can be utilised to monitor potential construction and operational impacts of continued and new mining and that can be used to develop suitable trigger, action and response plans (TARPS) to be incorporated into Construction and Operational Environmental Monitoring Plans (CEMP and OEMP) that would be required as part of an EIS consent.

This data report provides the results for the third consecutive aquatic ecology baseline monitoring survey for Clarence EP 918/920 undertaken in spring 2022, and follows on from baseline monitoring survey reports for spring 2021 (MPR 2022a) and autumn 2022 (MPR 2022b).

1.1 Description of Locality and Existing Information

The proposed mine expansion area is located in the upper Bungleboori Creek catchment including a tributary of Paddys Creek (**Figure 2**). Several sub-catchments support Newnes Plateau Shrub Swamp (NPSS) habitats dominated by shrubs and sedges that occur on sites with impeded drainage in low slope headwater valleys on the Newnes Plateau in the upper Blue Mountains (Web Reference 1).

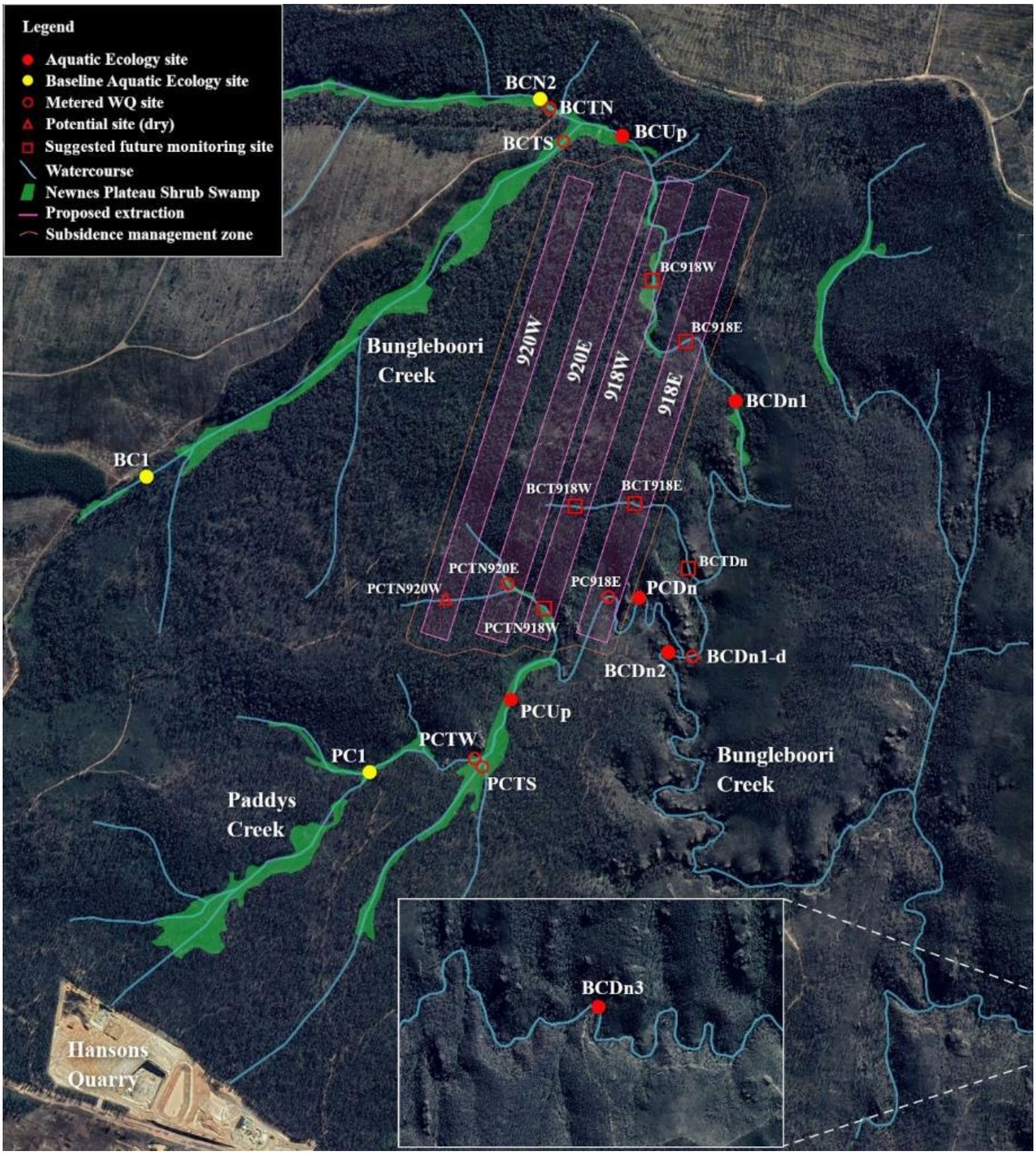

Figure 2: Clarence EP 918/920 aquatic ecology survey sites.

The NPSSs are listed as Endangered Ecological Communities (EECs) under the NSW *Biodiversity Conservation Act 2016* (BCA) and are also listed as part of the Temperate Highland Peat Swamps on Sandstone (TPHSS) under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Bungleboori Creek originates on the Newnes Plateau in the Blue Mountains Range at elevations reaching 1170m Australian Height Datum (AHD) and has an average annual rainfall of 1092mm. From the headwaters the creek flows in a north easterly direction for 3km where it meets Waratah Ridgeline, turns to the south for 4km flowing through narrow escarpment ridgelines, whereby it changes direction to flow in a general easterly direction before discharging into the Colo River.

The Bungleboori Creek study area is situated in Newnes State Forest, around 11km upstream from the western boundary of the Blue Mountains National Park. The upper headwaters to the south of Waratah Ridge are divided into two separate drainages of equal size, of which approximately half of the catchment area is occupied by plantation pine forest and the remainder comprises native bushland. The ridgelines bounding the drainages and bordering the adjacent creek catchment boundaries contain a complex network of access tracks, and both sub-catchment drainage channels contain NPSS's. The gradient of the entire southern drainage where the NPSS prevails is relatively shallow, decreasing 40m in height over the 2.6km length. Downstream of each NPSS in the study area sub-catchments, the channel valleys become more incised and bordered by steep sandstone escarpments, which increase in depth and frequency with increasing distance downstream.

The proposed EP 918/920 mining footprint underlies Bungleboori Creek for a distance of around 860m (**Figure 2**), which contains intermittently occurring shrub swamps and incised creek drainage channel throughout the length. There is one small 1st order unnamed sub-catchment tributary to Bungleboori Creek which overlies the mining footprint (BCT in **Figure 2**) and flows from the west to join Bungleboori Creek just above its confluence with Paddys Creek.

Paddys Creek originates on the Newnes Plateau in the Blue Mountains Range near State Mine Gully at elevations reaching 1190m AHD. The headwaters of Paddys Creek catchment border the upper Bungleboori Creek catchment to the south, and flow in a north easterly direction for a distance of around 4.1km before merging with Bungleboori Creek.

Whilst there are no pine plantation compartments within the Paddys Creek catchment area, the two main sub-catchment branches accommodate Hansons' Sand Quarry in their upper limits (**Figure 2**). The longer northern sub-catchment supports a NPSS upstream of the site that extends for approximately 1300m in length, and the smaller southern sub-catchment contains a NPSS that is around 660m in length, which continues further downstream from the confluence of the sub-catchments for a distance of 520m, after which the stream channel becomes incised and meandering through bedrock escarpment and gullies in its lower limits. A small tributary to Paddys Creek overlies the proposed underground footprint (PCTN in **Figure 2**) which merges with Paddys Creek at the downstream limits of the NPSS distribution in the main channel.

In terms of existing aquatic ecological sampling information for the study area, a previous Environmental Assessment for an adjoining Springvale Colliery mining lease area included a baseline aquatic ecology monitoring program that ran from 2010 to 2016. This study included three sites in the upper Bungleboori Creek and Paddys Creek catchments, and Springvale Colliery provided permission to incorporate these results as long-term streamhealth indices for this project which were provided in the first Clarence EP 918/920 monitoring report (MPR 2022a).

1.2 Newnes Plateau Site Threatened Species Considerations

The NPSS provide habitat for several water related terrestrial species; the giant dragonfly (*Petalura gigantea*) and the Blue Mountains water skink (*Eulamprus leuraensis*) and possible habitat for one aquatic species, the Adams emerald dragonfly (*Archaeophya adamsi*). The giant dragonfly and water skink are listed as Endangered under the BCA with the latter also being listed as Endangered under the EPBC Act. The emerald dragonfly is listed as Endangered under the NSW *Fisheries Management Act 1994* (FMA).

The giant dragonfly is semi-aquatic, living in burrows in swamps and along stream edges. The larvae emerge from the terrestrial entrances at night and in wet weather in search of insects and other arthropods to eat, and larvae are not known to swim and avoid open water (Web Reference 2). Given their crepuscular habits of the larvae it is unlikely that specimens would occur in routine samples. Adults emerge between October and January, and therefore targeted searches were undertaken for both exuviae (the larval skins shed in the process of metamorphosis into an adult) and adults in suitable swamp sites in spring 2022.

There is little information available on the ecology and biology of Blue Mountains water skink. The Blue Mountains water skink is restricted to sedge and shrub swamps that have boggy soils and appear to be permanently wet, and is semi-aquatic being active on warm, sunny days from September until late April (Web Reference 3). Although it is known from the Carne Creek swamps, no individuals were observed during this survey.

The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: Floods Creek in Brisbane Waters National Park near Gosford; Tunks Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 4). Considering these observations and owing to the generally poor level of knowledge of this species state-wide, the presence of *A. adamsi* in the Newnes Plateau study area (Bungleboori Creek and Paddys Creek) cannot be discounted entirely.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims, the Aquatic Ecology Sampling Program endeavours to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the study area aquatic habitats?
- Do the creeks provide suitable fish passage?
- Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June 15 and 'Spring' is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of basic water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

The adopted study design to achieve the objectives outlined above incorporated aquatic ecology sampling in spring 2022 at six in-stream sampling sites located up and down-stream of the proposed extraction area in creek drainage channels and NPSS, with water quality metering was undertaken at a further eight locations.

Table 1 below presents the site descriptions and coordinates for all sites visited between spring 2021 and spring 2022, and **Figure 2** (above) shows sampling site locations in relation to the proposed underground mine, including the former Springvale Coal monitoring sites sampled between 2010 and 2016. Note that there were three sites shown as suggested possible future mining impact assessment sites that were not able to be visited for this survey. If access to these sites is possible and the sites are viable aquatic ecology monitoring locations, they could be sampled prior to under-mining and post mining to assess potential mine impacts.

Table 1 Clarence EP 918/920 Extraction Plan Aquatic Ecology Seasonal Sample Site Information

Catchment	Site	Site Coordinates		Metered WQ	Aq Eco
		E	N		
Bungleboori Ck	BCTS	241974	6301203	Sp21, Au22 & Sp22	
	BCTN	241934	6301300	Sp21, Au22 & Sp22	
	BCUp	242186	6301187		Sp21, Au22 & Sp22
	BCDn1	242563	6300328		Sp21, Au22 & Sp22
	BC918W	242302	6300754		
	BC918E	242405	6300547	Au22	
	BCT918W	242014	6299966	Au22	
	BCT918E	242249	6299983	Au22	
	BCTDn	242422	6299775		
	BCDn1-d	242464	6299495	Sp21, Au22 & Sp22	
	BCDn2	242333	6299501		Sp21, Au22 & Sp22
	BCDn3	244522	6298422		Sp21, Au22 & Sp22
Paddys Creek	PCTW	241675	6299121	Sp21 & Au22	
	PCTS	241769	6299127	Sp21 & Au22	
	PCUp	241848	6299318		Sp21, Au22 & Sp22
	PCTN920W	241630	6299674	Sp21 (dry)	
	PCTN920E	241835	6299709	Sp21	
	PCTN918W	241951	6299627		
	PC918E	242154	6299684	Sp21	
	PCDn	242255	6299651		Sp21, Au22 & Sp22
Note:	Sites in red represent suggested future mining impact assessment sites. Aq Eco includes metered WQ, macroinvertebrate and fish sampling and RCE. Site coordinates are in MGA 56.				

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b).

The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.
Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum", and riffle samples collected from broken waters with only pebble, gravel, sand or bedrock substratum may not produce reliable results.
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

While many of the upper catchment tributary creek and swamp sites are readily accessible, site selection for sampling aquatic biota from some of the incised catchment sites is constrained by access from the road network through the forest to the drainages where the creek flows through deeply incised canyons bordered by escarpment.

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method.

Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event.

For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae or exuviae of other threatened species are kept for confirmation purposes.

Targeted searches were also made for giant dragonfly adults and exuviae (shells cast larval in the process of emergence) among suitable Newnes Plateau Shrub swamp habitats and along ridgelines.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars.

Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant). For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis.

Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey. Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys.

As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised ‘health’ scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate.

Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified. For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A calibrated submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE EP 918/920 AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the spring 2022 aquatic ecology sampling are provided in **Appendix Table A2**. Sampling for the full spring 2022 survey was undertaken over the 17th and 18th November 2022. Note that for sampling purposes the AusRivAS 'spring' season is defined as September 15th to December 15th.

3.1 Sampling Conditions Leading into Spring 2022

Rainfall measurements are recorded at Clarence Mine Meteorological Station, with long-term mean monthly totals acquired from Bureau of Meteorology (BOM) Lithgow (Cooerwull) Gauge 63226 (recorded from 1878 to current). **Appendix Tables A-1** provides the daily rainfall records for January to December 2022 and are shown graphically in **Figure 3** below. In 2022, the study area catchments were subjected to above average rainfall conditions with 60% of the days registering rain, and the annual total (1563mm) was the highest to date. The period between the autumn and spring 2022 surveys saw above average precipitation including heavy storm activity in July:

- Whilst June 2022 was relatively dry, July was very wet with 247mm rain, which included a single 4-day storm event early in the month which recorded 190mm.
- Patterns of precipitation from August to October were characterised by increasing intensity of storm events, and the combined monthly rainfall (317mm) was almost double the combined mean total (177mm).
- Leading into sampling for spring 2022, the study area received 92mm of rain over the first half of November, including 51mm three days prior to sampling.

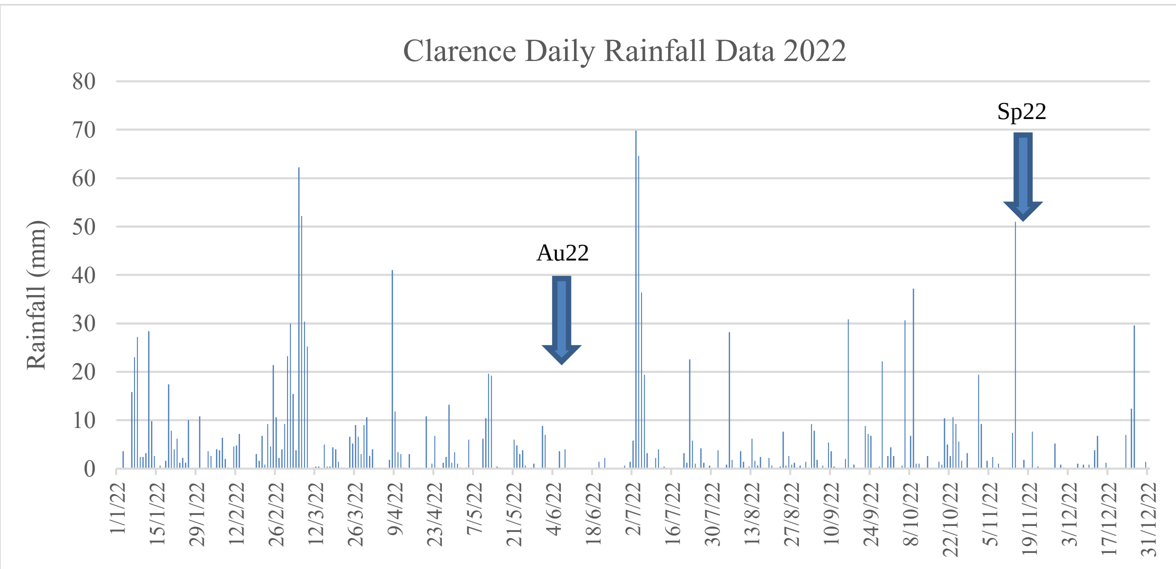

Figure 3 Clarence mine site daily rainfall 2022.

3.2 Spring 2022 Aquatic Ecology Survey Results

The Clarence EP 918/920 spring 2022 aquatic ecology monitoring survey was undertaken between the 17th and 18th November 2022 following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. Site photos are also provided **Appendix A**. Summary tables for the spring 2022 Appendix A data are provided in the following sections and include the results from previous baseline surveys (spring 2021 and autumn 2022).

3.3 Spring 2022 Metered Water Quality Results

A calibrated water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling during the spring 2022 aquatic ecology field sampling program.

Table 2 EP 918/920 Extraction Area Water Quality Results Spring 2022

Site	Date	Time	Temp	Cond	DO	DO	pH	Turb
			°C	µS/cm	% sat	mg/L	Units	ntu
BCTN	17/11/22	17:28	8.51	9	86.0	8.5	5.42	14.3
BCTS	17/11/22	17:43	7.05	11	69.8	7.1	4.86	3.4
BCUp	17/11/22	16:07	8.48	8	84.5	8.5	5.34	15.0
BCDn1	17/11/22	15:03	9.74	8	94.2	9.7	5.82	11.9
BCDn1	17/11/22	15:04	9.79	8	94.7	9.8	5.70	10.9
BCDn1d	17/11/22	10:19	11.14	13	99.9	11.1	5.37	5.9
BCDn2	17/11/22	10:00	11.30	16	100.2	11.3	5.53	4.6
BCDn3	18/11/22	11:26	10.46	11	99.8	10.5	5.39	8.1
PCUp	17/11/22	7:51	11.59	17	100.3	11.6	5.03	9.1
PCUp	17/11/22	7:51	11.28	16	97.6	11.3	5.05	11.6
PCUp	17/11/22	7:51	11.22	17	97.1	11.2	5.05	9.9
PCDn	17/11/22	12:24	10.29	10	98.3	10.3	5.14	8.7

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-2**) provide details of stream reach flows, pool and channel dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-3** with summary provided below in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the spring 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results Spring 2022

Category	BCUp	BCDn1	BCDn2	BCDn3	PCUp	PCDn
Land-use pattern beyond immediate riparian zone	3.5	4	4	4	4	4
Width of riparian strip-of woody vegetation	4	4	4	4	4	4
Completeness of riparian strip of woody vegetation	4	4	4	4	4	4
Vegetation of riparian zone within 10 m of channel	4	4	4	4	4	4
Stream bank structure	4	4	4	4	4	4
Bank undercutting	3	2	2	2	2	2
Channel form	4	4	4	4	4	4
Riffle/pool sequence	3	4	4	4	4	4
Retention devices in stream	3	4	4	4	4	4
Channel sediment accumulations	3	3	3	2.5	3	3
Stream bottom	3	4	4	4	4	4
Stream detritus	4	4	4	4	4	4
Aquatic vegetation	4	3.5	4	4	4	3.5
Spring 2022 Site RCE Score (%)	89.4	93.3	94.2	93.3	94.2	93.3
Autumn 2022 Site RCE Score (%)	89.4	94.2	94.2	93.3	92.3	94.2
Spring 2021 Site RCE Score (%)	90.4	94.2	94.2	94.2	92.3	94.2

Table 4 Macrophyte Occurrence Spring 2022

Site	Rush *Baumea rubiginosa*	Grass *Carex gaudichaundiana*	Jointed Rush *Juncus articulatus*	Bulbous Rush *Juncus bulbosus*	Rush *Juncus sp*	Tufted Algae *Batrochospermum sp*	Charophytes
BCUp		1		1			1
BCDn1	1	1		1		1	1
BCDn2						1	1
BCDn3				1		1	1
PCUp	1		1	1	1		1
PCDn			1	1		1	

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-4 provides the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The tables also provide site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

The individual site macroinvertebrate edge sample Diversity (taxa richness), SIGNAL and EPT diversity results recorded over the three baseline surveys are provided in **Figures 4** to **6** below. Note that riffle samples are named with a -R (e.g., BCDn2-R).

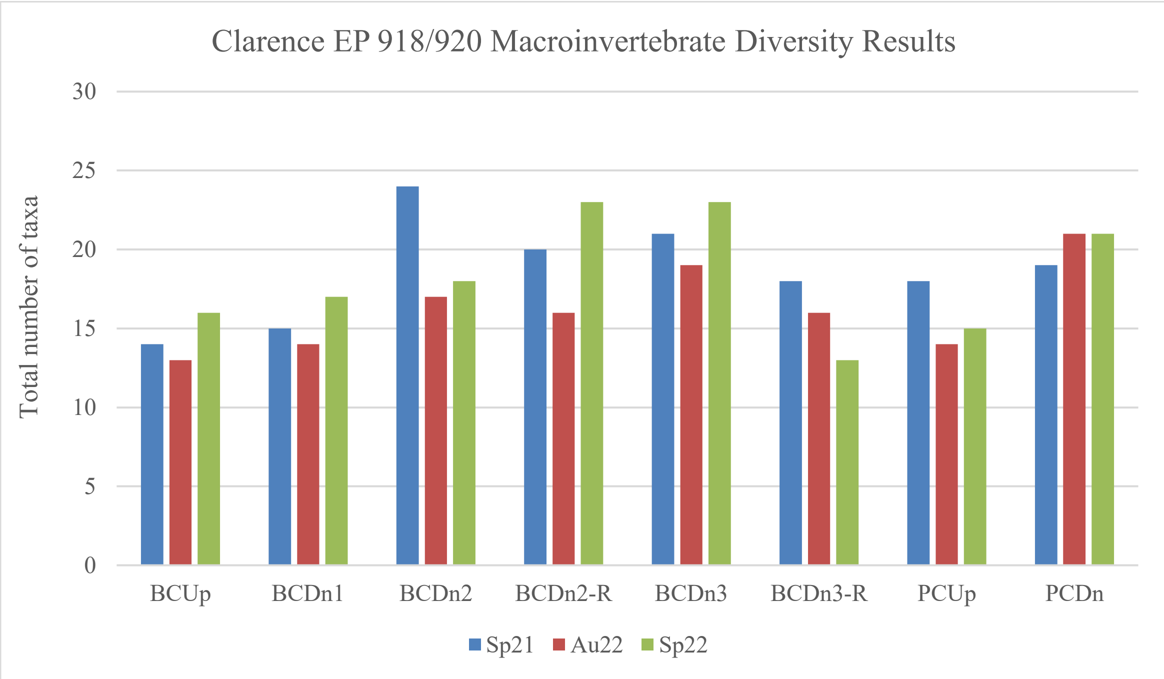

Figure 4 Clarence EP 918/920 spring 2021 to spring 2022 survey macroinvertebrate taxa diversity.

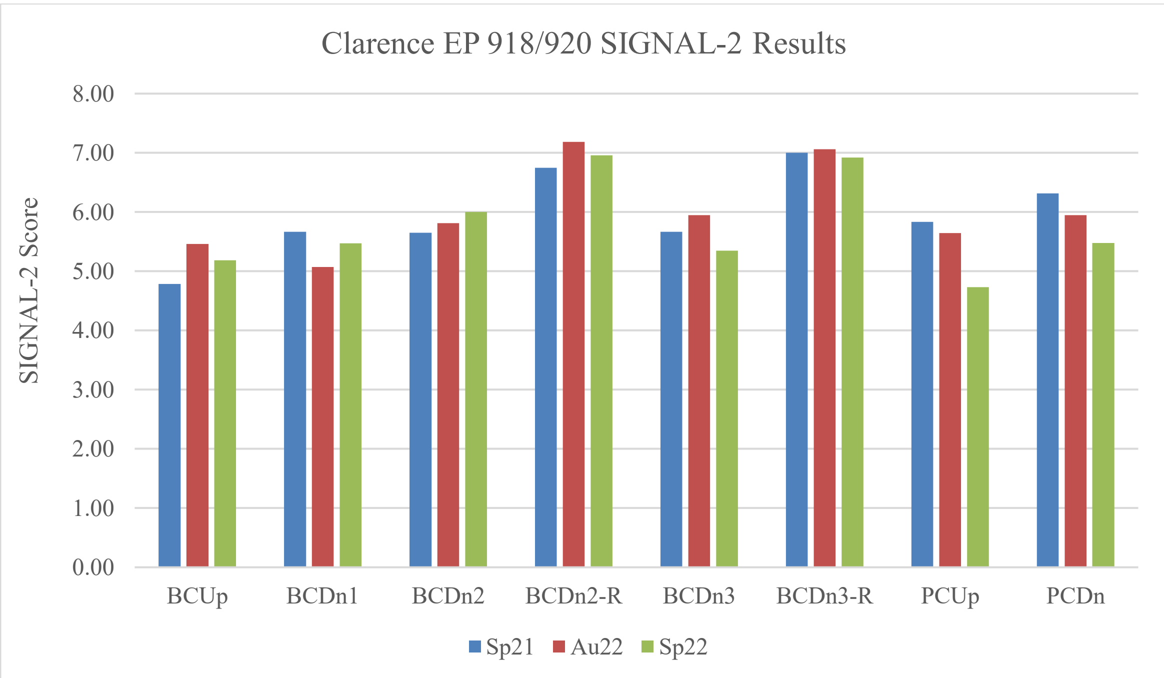

Figure 5 Clarence EP 918/920 spring 2021 to spring 2022 survey SIGNAL-2 scores.

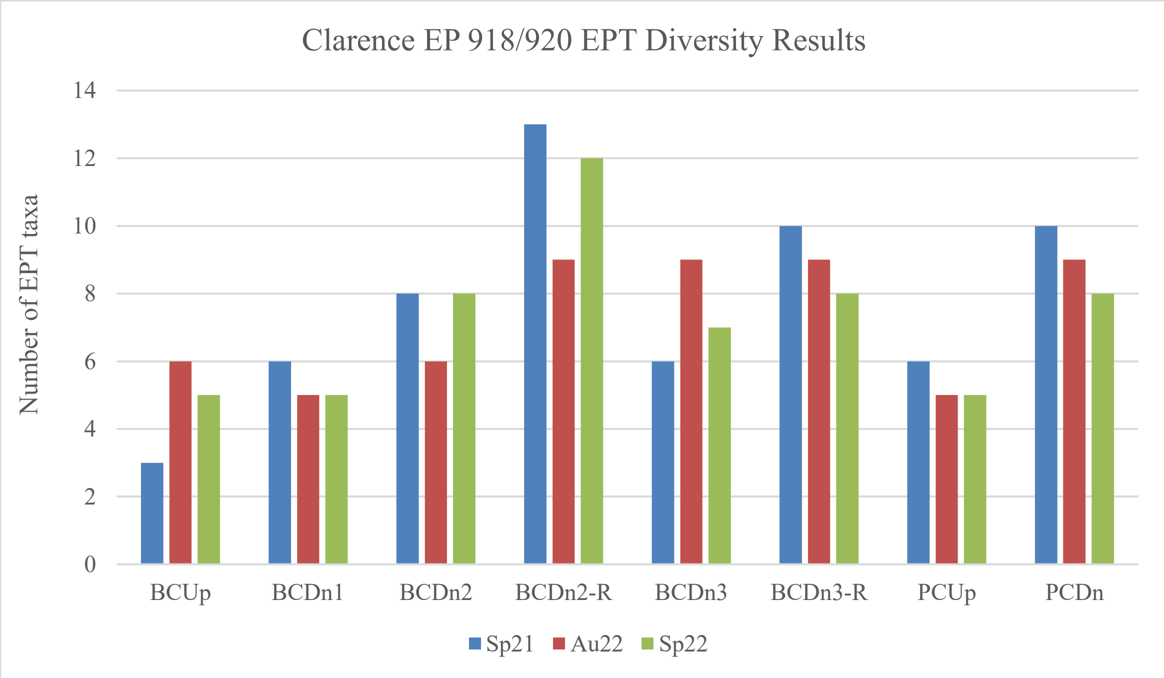

Figure 6 Clarence EP 918/920 spring 2021 to spring 2022 survey EPT taxa diversity.

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

SPRING 2022

Appendix Table A-1 Clarence Daily Rainfall (mm) for 2022

Date	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0.2	9.2	4	1	7	1.4	3.8	1.4	4.4	19.4	0.2
2nd	0	3.6	23.2	0	0.2	0	5.8	0	0.2	2.6	9.2	0
3rd	3.6	2.6	30	0	0	0	69.8	0	9.2	0	0	0
4th	0	0	15.4	0	0.2	0	64.6	0.8	7.8	0	1.6	0
5th	0	4	3.8	0	6	0	36.4	28.2	1.8	0.6	0	0
6th	15.8	3.8	62.2	0	0	3.6	19.4	1.8	0	30.6	2.4	1
7th	23	6.4	52.2	1.8	0	0	3.2	0.2	0.6	0.2	0.2	0
8th	27.2	2	30.4	41	0	4	0	0	0	6.8	1	0.8
9th	2.4	0.2	25.2	11.8	0	0	0	3.6	5.4	37.2	0	0
10th	2.4	0	0	3.4	6.2	0	2.2	1.4	3.6	1	0	0.8
11th	3.2	4.6	0.2	3	10.4	0	4	0	0.4	1	0	0.2
12th	28.4	4.8	0.4	0.2	19.6	0	0.2	0.4	0	0	0.2	3.8
13th	9.8	7.2	0.4	0	19.2	0	0.4	6.2	0	0	7.4	6.8
14th	2.6	0	0	3	0	0	0	1.6	0	2.6	51	0
15th	0	0	5	0	0.4	0	0	0.6	2	0	0	0
16th	0.6	0	0.4	0	0.2	0	0	2.4	30.8	0	0	1.2
17th	0	0	0.4	0.2	0	0	0	0	0.2	0	1.8	0.2
18th	1.6	0	4.4	0	0	0	0	0	0.8	1.4	0	0
19th	17.4	3	4	0	0	0.2	0	2.2	0	0.8	0	0
20th	7.8	1.6	1.4	10.8	0	1.4	3.2	0.6	0	10.4	7.6	0
21st	4	6.8	0.2	0	6	0	1.2	0	0	5	0	0
22nd	6.2	0.8	0.2	1	4.8	2.2	22.6	0	8.8	2.6	0.4	0
23rd	1.2	9.2	0	6.8	3	0	5.8	0.4	7.2	10.6	0	7
24th	2.2	4.6	6.6	0	3.8	0	1	7.6	6.8	9.2	0	0
25th	1.2	21.4	5.2	0	0.6	0	0	0.6	0	5.6	0	12.4
26th	10	10.6	9	1.2	0	0	4.2	2.6	0	1.6	0	29.6
27th	0	2.2	6.6	2.4	0.2	0	1.2	0.8	0.4	0	0	0
28th	0	4	3	13.2	1	0	0	1.2	22.2	3.2	5.2	0
29th	0		9	1.2	0	0.6	0.6	0.2	0	0	0	0
30th	10.8		10.6	3.4	0	0	0	0.6	2.6	0	0.8	1.4
31st	0		2.6		8.8		0	0		0		0.2
Total	181.4	103.6	321.2	108.4	91.6	19	247.2	67.8	112.2	137.4	108.2	65.6
Monthly Average*	85.7	81	77.8	57.1	51.1	71.7	61.7	58	56.2	62.5	65.2	79.1

Note: Sample dates are highlighted in yellow. *Monthly average is the long-term average from BOM Lithgow station 63226.

Appendix Table A-2 Field Comments – Spring 2022 Aquatic Ecology Monitoring Sites		
Site	Date	Comments
BCUp	17/11/22	Evidence of high flow event at 0.5m to 1m above current water levels. Riparian banks scoured free of fine detrital material; debris build up along edges. Water slightly turbid and flowing through site length, only a few isolated areas in site length with flow conditions meeting the edge habitat sample requirement for still or slow flowing pool edges. Channel dimensions and flow paths unchanged, comprising an incised and meandering box shaped channel. Maximum pool with around 1.5m and average width 0.8, maximum depth ~1m and average depth 0.5m. Very little detrital accumulations in stream channel area. The edge habitats sampled included undercut banks, macrophytes and trailing bank vegetation. The channel substrates were made up of generally equal proportions of cobbles, gravelly sands and pebble sized rocks, with small quantities of boulders. Filamentous green alga present in small amounts.
BCDn1	17/11/22	Evidence of recent scouring flow event to 2m above current water level, as indicated by increased channel incision and bank slumping (with slumped banks containing varying degrees of dying vegetation), newly exposed bedrock substrates. Water clear and flowing through site length. Maximum pool width to 8m, average width around 1.4m, maximum depth 1.3m and average depth 0.5m. Still adequate edge habitats available to sample, comprising trailing bank vegetation, detritus and undercut banks. The channel substrates were made up of generally equal amounts of bedrock, cobbles and gravelly sand. Filamentous green alga present in small to moderate amounts.
BCDn2	17/11/22	Evidence of flows to 1.5m above current water levels. Site appears to have been subjected to recent scouring flow event, comparatively lesser quantities of coarse and fine detrital accumulations compared to previous survey, however channel dimensions unchanged. Water very clear and flowing through site length. Maximum width around 8 to 10m and average width 2.5m, maximum depth 1.8m and average depth around 0.4m. The edge habitat availability was more limited than former surveys owing to lesser detrital habitats, with trailing bank vegetation and undercut banks comprising the main sampled habitat. The channel substrates contained smaller quantities of sand than autumn 2022, and the substrates were generally equal quantities of cobbles and gravelly sands with some boulders. Filamentous green alga present in small amounts.
BCDn3	18/11/22	Site has been subjected to scouring flow event since autumn 2022 survey, with impacts including new sediment bank formation and flow path on corner, recent and active bank erosion, debris accumulations along edge banks and instream, and increased proportions of sandy sediment. Not that much accumulated particulate detritus present. Water clear and flowing through site length. Maximum width to 8m, average width 3.5m, maximum depth around 1.6m and average depth 0.5m. The edge habitat availability was limited mostly to trailing bank vegetation and undercut banks, and coarse detritus. The site substrates were comprised of mobile sands, cobble and gravel banks. Filamentous green alga present in small amounts.

PCUp	17/11/22	Evidence of recent high flow scouring event to 0.5m above current water level. Water clear and flowing through site length, with most of the site channel accommodating swift flowing water through the (main) incised channel. Lateral flows entering creek channel from adjacent swamp areas. Maximum width to 2.5m and average width around 0.8m, maximum pool depth to 1.5m and average depth 0.5m (around half of the site averaging 0.1m and half site averaging 0.8m). The edge habitats sampled were consistent with the previous survey, comprising trailing bank vegetation, undercut banks and aquatic vegetation; bulbous rush, jointed rush (*Juncus articulatus*), rush (*Baumea rubiginosa*) and charophytes. The site substrates were dominated by sloped benched bedrock cascades in the downstream half of the site, and cobbles or gravelly sand accumulations in the upstream end. Filamentous green alga present in small amounts.
PCDn	17/11/22	Site seems to have been subjected to strong flow event since previous survey with evidence of water levels reaching 1.2m above current water levels, with some edge bank vegetation uprooted, not that much fine particulate detritus. Water clear and flowing through site length. Maximum width around 4m and average width ~1.0m, maximum depth 1.0m and average depth 0.4m. The extent and availability of aquatic habitats were mostly unchanged from the previous survey, comprising undercut banks, trailing bank vegetation and detritus (mostly coarse detritus). The channel substrates were dominated by bedrock, with small quantities of gravelly sands. Filamentous green alga present in small to moderate amounts.

Appendix Table A-3

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor								
	Category		Sp22	Sp22	Sp22	Sp22	Sp22	Sp22
		Value	BCUp	BCDn1	BCDn2	BCDn3	PCUp	PCDn
1	Land-use pattern beyond immediate riparian zone							
	Undisturbed native vegetation	4		4	4	4	4	4
	Mixed native vegetation and pasture/exotics	3	3.5					
	Mainly pasture, crops or pine plantation	2						
	Urban, some vegetation	1						
	Industrial, little vegetation	0						
2	Width of riparian strip-of woody vegetation							
	More than 30 m	4	4	4	4	4	4	4
	Between 5 and 30 m	3						
	Less than 5 m	2						
	No woody vegetation	1						
	No Vegetation	0						
3	Completeness of riparian strip of woody vegetation							
	Riparian strip without breaks in vegetation	4	4	4	4	4	4	4
	Breaks at intervals of more than 50 m	3						
	Breaks at intervals of 10-50 m	2						
	Breaks at intervals of less than 10 m	1						
	No riparian strip at all	0						
4	Vegetation of riparian zone within 10 m of channel							
	Native tree and shrub species	4	4	4	4	4	4	4
	Mixed native and exotic trees and shrubs	3						
	Exotic trees and shrubs	2						
	Exotic grasses/weeds	1						
	No vegetation at all	0						
5	Stream bank structure							
	Banks fully stabilized by trees, shrubs, concrete	4	4	4	4	4	4	4
	Banks firm but held mainly by grass and herbs	3						
	Banks loose, partly held by sparse grass, rubble	2						
	Banks unstable, mainly loose sand or soil	1						
	Banks actively eroding	0						
6	Bank undercutting							
	None, or restricted by tree roots or man-made	4						
	Only on curves and at constrictions	3	3					
	Frequent along all parts of stream	2		2	2	2	2	2
	Severe; bank collapses common	1						
	Total bank collapse	0						
7	Channel form							
	Deep; width:depth ratio less than 8:1	4	4	4	4	4	4	4
	Medium; width:depth ratio 8:1 to 15:1	3						
	Shallow; width:depth ratio greater than 15:1	2						
	Artificial; concrete or excavated channel< 8:1	1						
	Artificial; concrete or excavated channel > 8:1	0						
8	Riffle/pool sequence							
	Frequent alternation of riffles and pools	4		4	4	4	4	4
	Long pools with infrequent short riffles	3	3					
	Natural channel without riffle/pool sequence	2						
	Artificial channel; some riffle/pool sequence	1						
	Artificial channel; no riffle/pool sequence	0						
9	Retention devices in stream							
	Many large boulders and/or debris dams	4		4	4	4	4	4
	Rocks/logs present; limited damming effect	3	3					
	Rocks/logs present but unstable; no damming	2						
	Stream or channel with few or no rocks/logs	1						
	Artificial channel; no retention devices	0						
10	Channel sediment accumulations							
	Little or no accumulation of loose sediments	4						
	Some gravel bars but little sand or silt	3	3	3	3		3	3
	Bars of sand and silt common	2				2.5		
	Braiding by loose sediment	1						
	Complete in-filled muddy channel	0						
11	Stream bottom							
	Mainly clean stones with obvious interstices	4		4	4	4	4	4
	Mainly stones with some cover of algae/silt	3	3					
	Bottom heavily silted but stable	2						
	Bottom mainly loose and mobile sandy sediment	1						
	Bottom mainly loose and mobile muddy sedimen	0						
12	Stream detritus							
	Mainly unsilted wood, bark, leaves	4	4	4	4	4	4	4
	Some wood, leaves, etc. with much fine detritus	3						
	Mainly fine detritus mixed with sediment	2						
	Little or no organic detritus, mainly sandy	1						
	No organic detritus, mainly mud	0						
13	Aquatic vegetation							
	Little or no macrophyte or algal growth	4	4		4	4	4	
	Substantial algal growth; few macrophytes	3		3.5				3.5
	Substantial macrophyte growth; little algal grow	2						
	Substantial macrophyte and algal growth	1						
	Total cover of macrophytes plus algae	0						
	RCE Score		46.5	48.5	49.0	48.5	49.0	48.5
	RCE %age		89.4	93.3	94.2	93.3	94.2	93.3

Appendix Table A-4 Clarence EP 918/920 Aquatic Ecology Monitoring Macroinvertebrate and Fish Results Spring 2022											Sample Site and Sample Date									
								Life Stage			17/11/22	17/11/22	17/11/22	17/11/22	18/11/22	18/11/22	16/11/22	17/11/22		
Phylum	Class	Order	Sub-Order	Family	Sub-Family	Genus/spp	Common name	L	N	A	BCUp	BCDn1	BCDn2	BCDn2-R	BCDn3	BCDn3-R	PCUp	PCDn	Occurrence	SIG-2
Arthropoda	Insecta	Coleoptera		Dytiscidae			Diving Beetles	x		x					1			1	2	2
Arthropoda	Insecta	Coleoptera		Elmidae			Riffle Beetles	x		x			1	1	1	1			4	7
Arthropoda	Insecta	Coleoptera		Gyrinidae			Whirligig Beetles	x		x	1	1	1		1		1	1	6	4
Arthropoda	Insecta	Coleoptera		Scirtidae			Marsh Beetles	x				1	1	1	1	1	1		6	6
Arthropoda	Insecta	Diptera		Ceratopogonidae			Biting Midges	x			1	1			1		1	1	5	4
Arthropoda	Insecta	Diptera		Chironomidae	Chironominae		Bloodworms	x			1	1			1			1	4	3
Arthropoda	Insecta	Diptera		Chironomidae	Orthocladiinae		Bloodworms	x				1			1		1	1	4	4
Arthropoda	Insecta	Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1	1	1		1		1	1	6	4
Arthropoda	Insecta	Diptera		Dixidae			Mensicus Midges	x			1								1	7
Arthropoda	Insecta	Diptera		Simuliidae			Black Flies	x			1	1	1	1	1	1	1	1	8	5
Arthropoda	Insecta	Diptera		Tipulidae			Crane Flies	x			1		1	1	1			1	5	5
Arthropoda	Insecta	Ephemeroptera		Baetidae			Mayflies		x						1				1	5
Arthropoda	Insecta	Ephemeroptera		Coloburiscidae			Mayflies		x					1		1			2	8
Arthropoda	Insecta	Ephemeroptera		Leptophlebiidae			Mayflies		x		1	1	1	1	1	1	1	1	8	8
Arthropoda	Insecta	Ephemeroptera		Oniscigastridae			Mayflies		x						1				1	8
Arthropoda	Insecta	Hemiptera		Corixidae			Lesser Water Boatmen					1					1		2	2
Arthropoda	Insecta	Mecoptera		Nannochoristidae			Scorpionflies	x				1			1				2	9
Arthropoda	Insecta	Megaloptera		Corydalidae			Dobsonflies	x						1					1	7
Arthropoda	Insecta	Neuroptera		Neurorthidae			Lacewings	x						1					1	9
Arthropoda	Insecta	Odonata	Epiproctophora	Synthemistidae			Dragonflies	x			1	1	1	1	1		1	1	7	2
Arthropoda	Insecta	Odonata	Epiproctophora	Telephlebiidae			Dragonflies	x			1	1	1	1	1	1		1	7	9
Arthropoda	Insecta	Odonata	Zygoptera	Argiolestidae			Damselflies	x										1	1	5
Arthropoda	Insecta	Odonata	Zygoptera	Diphlebiidae			Damselflies	x						1					1	6
Arthropoda	Insecta	Odonata	Zygoptera	Synlestidae			Damselflies	x				1	1	1	1			1	5	7
Arthropoda	Insecta	Plecoptera		Austroperlidae			Stoneflies		x					1					1	10
Arthropoda	Insecta	Plecoptera		Eustheniidae			Stoneflies		x							1			1	10
Arthropoda	Insecta	Plecoptera		Gripopterygidae			Stoneflies		x		1	1	1	1	1	1	1	1	8	8
Arthropoda	Insecta	Trichoptera		Conoesucidae			Caddis Flies	x					1		1	1		1	4	7
Arthropoda	Insecta	Trichoptera		Ecnomidae			Caddis Flies	x					1				1		2	4
Arthropoda	Insecta	Trichoptera		Helicophidae			Caddis Flies	x					1	1				1	3	10
Arthropoda	Insecta	Trichoptera		Helicopsychidae			Caddis Flies	x						1					1	8
Arthropoda	Insecta	Trichoptera		Hydrobiosidae			Caddis Flies	x			1		1	1		1	1	1	6	8
Arthropoda	Insecta	Trichoptera		Hydropsychidae			Caddis Flies	x						1		1			2	6
Arthropoda	Insecta	Trichoptera		Hydroptilidae			Caddis Flies	x			1	1	1		1			1	5	4
Arthropoda	Insecta	Trichoptera		Leptoceridae			Caddis Flies	x			1	1	1	1	1	1	1	1	8	6
Arthropoda	Insecta	Trichoptera		Odontoceridae			Caddis Flies	x						1					1	7
Arthropoda	Insecta	Trichoptera		Philopotamidae			Caddis Flies	x						1					1	8
Arthropoda	Insecta	Trichoptera		Philorheithridae			Caddis Flies	x				1		1				1	3	8
Arthropoda	Crustacea	Decapoda		Parastacidae			Freshwater Crayfish						1		1				2	4
Arthropoda	Crustacea	Isopoda	Phreatoicidea	Phreatoicidae			Isopods				1						1		2	4
Annelida	Oligochaeta						Freshwater Worms				1			1	1	1	1	1	6	2
Chordata	Amphibia						Tadpoles										1		1	*
Chordata	Osteichthyes			Galaxiidae		*Galaxias olidus*	Mountain Galaxias					1	1		1		1	1	5	*
							Total number of invertebrate taxa per site:				16	17	18	23	23	13	15	21	41	
							Site SIGNAL2 Scores:				5.19	5.47	6.00	6.96	5.35	6.92	4.73	5.48		
Notes:	* represents those taxa for which SIGNAL-2 scores are not available									EPT:	5	5	8	12	7	8	5	8	18	

Plate 1: Looking north across track crossing just upstream of Bungleboori Creek site BCUp in spring 2022.

Plate 2: Looking downstream from the track crossing.

Plate 3: Looking downstream at Bungleboori Creek upstream site BCUp in spring 2022.

Plate 4: Looking downstream in BCUp.

Plate 5: Dragonfly larva (family Telephlebiidae) from BCUp.

Plate 6: Deploying fish traps at BCDn1.

Plate 7:Looking upstream through pool at upstream end of BCDn1.

Plate 8: Looking downstream at BCDn1.

Plate 9: Debris bank up and sediment deposition at BCDn1.

Plate 10: Looking downstream through incised pool channel at BCDn1.

Plate 11: Looking upstream toward BCDn1.

Plate 12: Looking upstream at the confluence of Bungleboori Creek (right hand side) and Paddys Creek (left hand side).


Plate 13: Looking upstream through gorge at BCDn2.


Plate 14: Looking upstream towards gorge at BCDn2.

Plate 15: Looking upstream at BCDn2.

Plate 16: Looking upstream through cobble riffle secion at BCDn2.

Plate 17: Looking upstream through riffle section at BCDn3.

Plate 18: Looking upstream toward one of the deeper pools at BCDn3.

Plate 19: Looking upstream through sand smothered riffle at BCDn3.

Plate 20: Large mountain galaxias *Galaxias olidus* from BCDn3.

Plate 21: Looking upstream at Paddys Creek site PCUp.

Plate 22: Looking upstream through contained pool area with macrophytes at PCUp.

Plate 23: Looking downstream through narrow bedrock confined cascade at PCUp.

Plate 24: Looking upstream PCUp.

Plate 25: Looking upstream through incised box-shaped channel at the upstream end of PCDn.

Plate 26: Looking upstream through bedrock run at PCDn.

Plate 27: Looking upstream at PCDn.

Plate 28: Looking downstream at PCDn.

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DINGO CREEK CATCHMENT
AQUATIC ECOLOGY

AUTUMN 2022 DATA REPORT

Figure 1. Looking upstream through swamp habitats at Dingo Creek site DCUp.

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD

AUGUST 2022

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Clarence Colliery Pty Ltd owns and operates the existing Clarence Colliery underground coal mine near the village of Clarence in NSW. Clarence Colliery is seeking to modify state significant development (SSD) consent DA 504-00 to synchronise operational and approval procedures of its existing mining operation in the northern extent of its mining lease area (Mod 8). The Mod 8 study area catchments are contained within the Gardens of Stone State Conservation Area (SCA) and landuse within the proposed mine footprint comprises mixed undeveloped native forest and former state forest pine plantations. Undeveloped native forests downstream of the proposed mine footprint are located in the Blue Mountains National Park. Each of the drainage lines overlying and downstream from the proposed Mod 8 extraction area contain *Newnes Plateau Shrub and Hanging Swamp* endangered ecological communities (EECs).

As part of the environmental assessment process associated with Mod 8, Clarence Colliery commissioned Marine Pollution Research Pty Ltd (MPR) to review existing aquatic ecological information and initiate a baseline aquatic ecology monitoring program to describe the existing aquatic environment of the Mod 8 proposal footprint. The aims of the baseline aquatic ecology (streamhealth) monitoring program are as follows:

- To develop an understanding of the aquatic ecological attributes of the Newnes Plateau Shrub Swamps and associated creeks which overly the areas of proposed mining in order to enable impact assessment and provide suitable mitigation and offset measures where necessary or desirable.
- To provide additional aquatic site base-line data that can be utilised to monitor potential construction and operational impacts of continued and new mining and that can be used to develop suitable trigger, action and response plans (TARPS) to be incorporated into Construction and Operational Environmental Monitoring Plans (CEMP and OEMP) that would be required as part of an EIS consent.

This data report provides the results for the second consecutive aquatic ecology baseline monitoring survey for Mod 8 undertaken in autumn 2022, and follows on from the initial baseline monitoring spring 2021 survey reported in MPR (2022).

1.1 Description of Locality and Existing Information

The proposed mining area is concentrated in the upper Carne and Dingo Creek catchments with a small portion situated in the upper limits of Bungleboori Creek in the southern limits of the Mod 8 boundary (**Figure 2**).

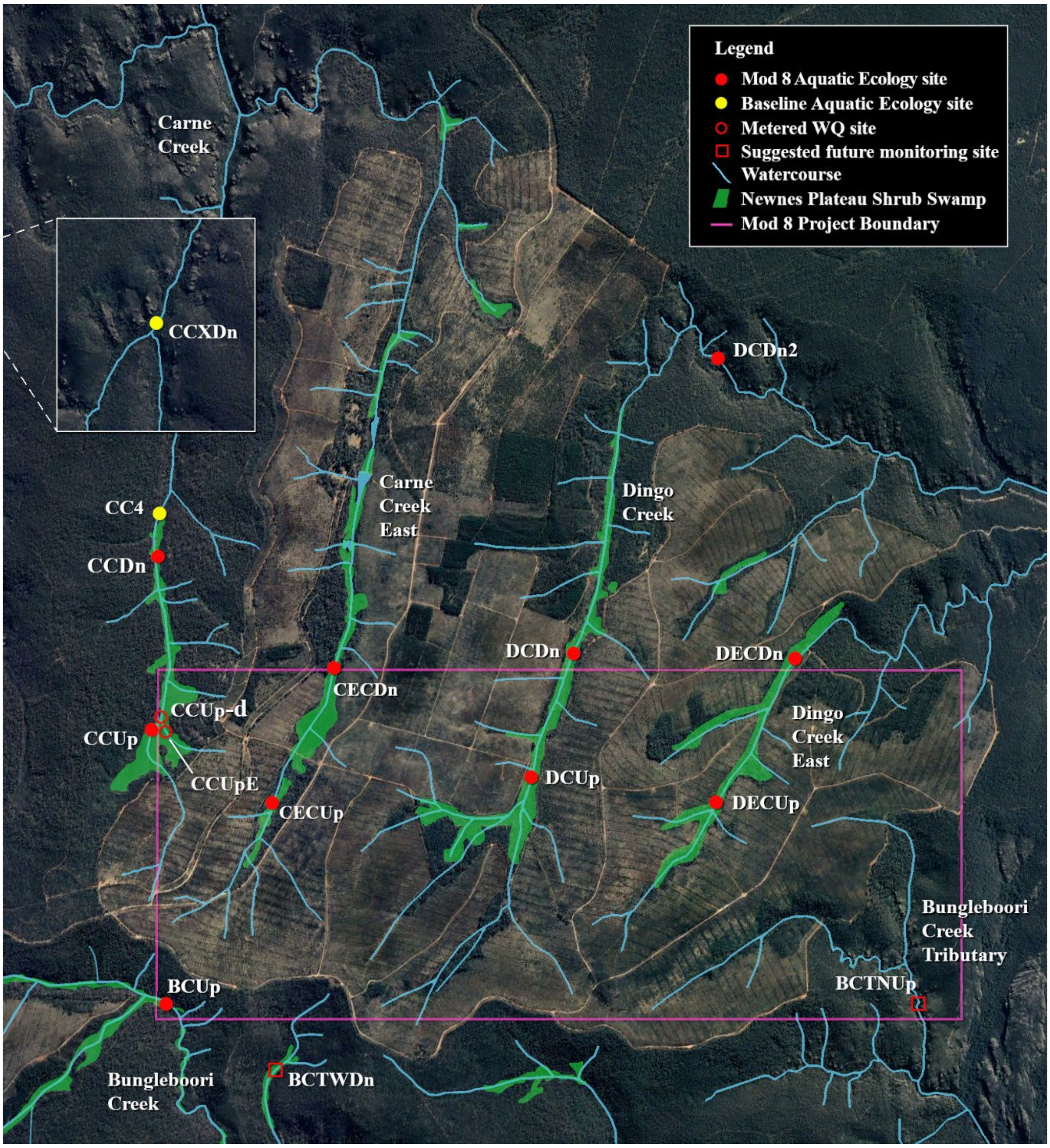

Figure 2 Clarence Mod 8 aquatic ecology survey sites.

Several of the sub-catchments support Newnes Plateau Shrub Swamp (NPSS) habitats dominated by shrubs and sedges that occur on sites with impeded drainage in low slope headwater valleys on the Newnes Plateau in the upper Blue Mountains (Web Reference 1), however the majority of the sub-catchments have been cleared for pine plantations.

The NPSSs are listed as Endangered Ecological Communities (EECs) under the NSW *Biodiversity Conservation Act 2016* (BCA) and are also listed as part of the Temperate Highland Peat Swamps on Sandstone (TPHSS) under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Carne Creek originates on Newnes Plateau at elevations reaching 1180m Australian Height Datum (AHD) and has an average annual rainfall of 1073mm. Carne Creek is considered pristine and from its headwaters, Carne Creek flows in a northerly direction for around 21km prior to joining the Wolgan River, a tributary of the Hawkesbury River. The headwaters of Carne Creek consist of at least six separate sub-catchments, with the two eastern most upper sub-catchments overlying the western extent of the Mod 8 boundary in areas of pine plantation (**Figure 2**). Whereas both sub-catchments support NPSS's along the low-profile main drainage arms, the channel valleys become more incised and bordered by steep sandstone escarpments downstream from the study area.

Dingo Creek lies to the east of Carne Creek on Newnes Plateau reaching altitudes of 1140m in its upper headwaters, and is bounded by Waratah Ridge Rd to the south. The headwaters of Dingo Creek are contained within two main branches which overlie the middle and eastern portion of the Mod 8 boundary. Dingo Creek flows in a northerly direction for around 5km before turning east for a further 16.5km to merge with Bungleboori Creek. The Blue Mountains National Park border lies 550m to the east of the eastern Mod 8 boundary. Whilst most of the Dingo Creek catchment area within the Mod 8 footprint has been cleared for pine plantation, the drainage lines accommodate considerable NPSS communities along the main creeks and lateral feeder tributaries (**Figure 2**). Pine plantations continue further north (downstream) from Mod 8, before the creek lines become heavily incised into the sandstone escarpment, which is generally continuous downstream to Bungleboori Creek.

In terms of existing aquatic ecological sampling information for the study area, a previous Environmental Assessment for an adjoining Springvale Colliery mining lease area included a baseline aquatic ecology monitoring program that ran from 2010 to 2016. This study included two sites in the eastern Carne Creek catchment (**Figure 2**), and Springvale Colliery provided permission to incorporate these results as long-term streamhealth indices for this project which were provided in the first Mod 8 monitoring report (MPR 2022).

1.2 Newnes Plateau Site Threatened Species Considerations

The NPSS provide habitat for several water related terrestrial species; the giant dragonfly (*Petalura gigantea*) and the Blue Mountains water skink (*Eulamprus leuraensis*) and possible habitat for one aquatic species, the Adams emerald dragonfly (*Archaeophya adamsi*). The giant dragonfly and water skink are listed as Endangered under the BCA with the latter also being listed as Endangered under the EPBC Act. The emerald dragonfly is listed as Endangered under the NSW *Fisheries Management Act 1994* (FMA).

The giant dragonfly is semi-aquatic, living in burrows in swamps and along stream edges. The larvae emerge from the terrestrial entrances at night and in wet weather in search of insects and other arthropods to eat, and larvae are not known to swim and avoid open water (Web Reference 2). Given their crepuscular habits and the fact that adults only emerge between October and January, it would be unlikely to have observed or retained larvae during sampling for this autumn 2022 survey.

There is little information available on the ecology and biology of Blue Mountains water skink. The Blue Mountains water skink is restricted to sedge and shrub swamps that have boggy soils and appear to be permanently wet, and is semi-aquatic being active on warm, sunny days from September until late April (Web Reference 3).

The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: Floods Creek in Brisbane Waters National Park near Gosford; Tunks Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 4). Considering these observations and owing to the generally poor level of knowledge of this species state-wide, the presence of *A. adamsi* in the Newnes Plateau study area (Carne Creek, Dingo Creek and Bungleboori Creek) cannot be discounted entirely.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims, the Aquatic Ecology Sampling Program endeavours to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the study area aquatic habitats?
- Do the creeks provide suitable fish passage?
- Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June 15 and 'Spring' is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of metered water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

The adopted study design to achieve the objectives outlined above incorporated aquatic ecology sampling at seven in-stream sampling sites in autumn 2022, located overlying and down-stream of the proposed extraction area in creek drainage channels and NPSS.

Table 1 below presents the site descriptions and coordinates for all sites visited for the Mod 8 baseline monitoring program (in spring 2021 and autumn 2022), and **Figure 2** (above) shows sampling site locations in relation to the proposed underground mine. Upper Carne Creek east site CECDn overlies the western portion of the proposed underground mine and was visited for the first time in autumn 2022. Note that there are two sites shown as suggested possible future mining impact assessment sites that were not able to be visited for this survey. If access to these sites is possible and the sites are viable aquatic ecology monitoring locations, they could be sampled prior to under-mining and post mining to assess potential mine impacts.

Table 1 Clarence Mod 8 Aquatic Ecology Sample Program Site Information Spring 2021 and Autumn 2022

Catchment	Site	Site Coordinates (MGA56)		Metered WQ	Aq Eco
		E	N		
Carne Creek	CCUp	242025	6302991		Sp21
	CCUpE	242095	6303089	Sp21	
	CCUp-d	242090	6303124	Sp21	
	CCDn	242028	6304172		Sp21
	CECUp	242852	6302574		Au22
	CECDn	243244	6303488		Sp21 & Au22
Dingo Creek	DCUp	244522	6302755		Sp21 & Au22
	DCDn	244801	6303631		Sp21 & Au22
	DCDn2	245688	6305553		Sp21
	DECUp	245774	6302620		Sp21 & Au22
	DECDn	246264	6303597		Sp21 & Au22
Bungleboori Ck	BCUp	242186	6301187		Sp21 & Au22
	BCTWDn	242842	6300708		
	BCTNUp	247156	6301379		
Note:	Sites in red represent suggested future mining impact assessment sites. Aq Eco includes metered WQ, macroinvertebrate and fish sampling and RCE.				

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b). The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.

Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum", and riffle samples collected from broken waters with only pebble, gravel, sand or bedrock substratum may not produce reliable results.
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

While many of the upper catchment tributary creek and swamp sites are readily accessible, site selection for sampling aquatic biota from some of the incised catchment sites is constrained by access from the road network through the forest to the drainages where the creek flows through deeply incised canyons bordered by escarpment.

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method. Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event.

For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae or exuviae of other threatened species are kept for confirmation purposes.

Targeted searches were also made for giant dragonfly adults and exuviae (shells cast larval in the process of emergence) among suitable Newnes Plateau Shrub swamp habitats and along ridgelines.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars.

Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant).

For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis. Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey.

Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys. As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised ‘health’ scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified. For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A calibrated submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE MOD 8 AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the autumn 2022 aquatic ecology sampling are provided in **Appendix Table A2**. Sampling for the full autumn 2022 survey was undertaken between the 7th and 10th June 2022. Note that for sampling purposes the AusRivAS 'autumn' season is defined as March 15th to June 15th.

3.1 Sampling Conditions Leading into Autumn 2022

Rainfall measurements are recorded at Clarence Mine Meteorological Station, with long-term mean monthly totals acquired from Bureau of Meteorology (BOM) Lithgow (Cooerwull) Gauge 63226 (recorded from 1878 to current). **Appendix Table A-1** provides the daily rainfall records for July 2021 to June 2022 and are shown graphically in **Figure 3**. Following on from the previous spring aquatic ecology survey in December 2021, the study area was subjected to consistent wet weather events:

- The combined rainfall total over the six-month period between December 2021 and May 2022 (945mm) was more than double the combined mean monthly total for the same months (432mm). Patterns of precipitation over the six-month period was characterised by regular rain events, with 75% of the days registering rainfall.
- March 2022 was the wettest month, recording the highest total rainfall with 317mm over 30 rainfall days, including 78% of the monthly total in the first eight days of the month (243mm).

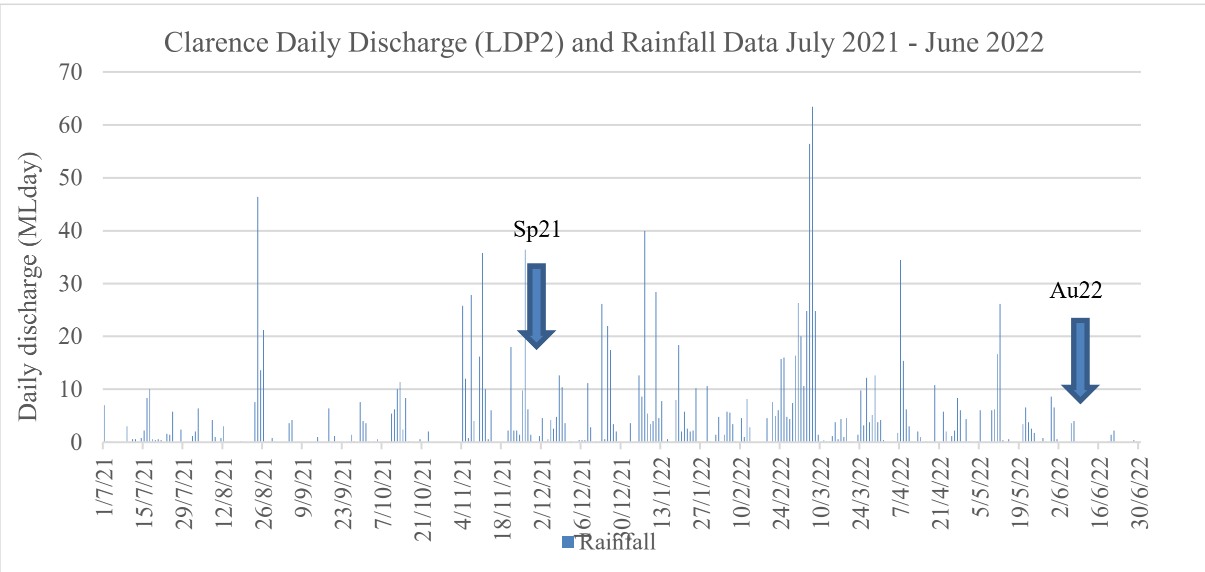

Figure 3 Clarence mine site daily rainfall July 2021 to June 2022.

3.2 Autumn 2022 Aquatic Ecology Survey Results

The Clarence Mod 8 autumn 2022 aquatic ecology survey was undertaken between the 7th and 10th June 2022 following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. Site photos are also provided **Appendix A**. Summary tables for the autumn 2022 Appendix A data are provided in the following Sections and include the spring 2021 survey results.

3.3 Autumn 2022 Metered Water Quality Results

A calibrated water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling (including depth profile readings) for the Clarence Mod 8 autumn 2022 aquatic ecology field sampling program.

Table 2 Mod 8 Water Quality Results Autumn 2022

Site	Date	Time	Depth	Temp	Cond	DO	DO	pH	Turb
			m	°C	µS/cm	%sat	mg/L	Units	ntu
CECUp	8/6/22	16:21	0.1	5.36	13	82.8	10.50	5.55	2.3
CECUp	8/6/22	16:21	0.4	5.35	13	82.8	10.50	5.55	2.3
CECDn	10/6/22	10:56	0.1	4.70	11	76.5	9.87	5.55	0.9
CECDn	10/6/22	10:56	0.3	4.70	11	76.6	9.88	5.54	2.4
CECDn	10/6/22	10:56	0.4	4.70	11	76.6	9.88	5.50	2.1
DCUp	9/6/22	10:28	0.1	4.33	14	78.8	10.26	5.01	0.4
DCUp	9/6/22	10:30	0.3	4.34	13	77.7	10.12	4.88	2.3
DCDn	9/6/22	15:46	0.1	5.75	14	82.6	10.37	4.63	8.4
DCDn	9/6/22	15:46	0.4	5.75	13	82.1	10.31	4.63	6.0
DECUp	9/6/22	12:29	0.1	6.64	11	82.2	10.09	5.06	0.1
DECDn	9/6/22	14:19	0.1	6.66	14	85.5	10.49	5.08	0.1
BCUp	7/6/22	15:50	0.1	5.49	11	77.8	9.83	5.52	0.1
BCUp	7/6/22	15:50	0.4	5.49	12	77.7	9.82	5.51	0.1

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-2**) provide details of stream reach flows, pool and channel dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-3** with summary provided below in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the autumn 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results Autumn 2022

Category	CECUp	CECDn	DCUp	DCDn	DECUp	DECDn	BCUp
Land-use pattern beyond immediate riparian zone	2	2	2	2	2	2	3.5
Width of riparian strip-of woody vegetation	3.5	3	3	2.5	2.5	3	4
Completeness of riparian strip of woody vegetation	3	3	2	2	2	2	4
Vegetation of riparian zone within 10 m of channel	3.5	3.5	3.5	3.5	3.5	3.5	4
Stream bank structure	3	3	3	3	3	2.5	4
Bank undercutting	3	3	4	4	4	4	3
Channel form	3	3	2	2	2	4	4
Riffle/pool sequence	2	2	2	2	2	3	3
Retention devices in stream	2	2	2	2	3	4	3
Channel sediment accumulations	2	2	2	2	2	2.5	3
Stream bottom	2	2	2	2	2	2.5	3
Stream detritus	3	3	3	3	3	3	4
Aquatic vegetation	4	4	4	4	4	4	4
Autumn 2022 Site RCE Score (%)	69.2	68.3	66.3	65.4	67.3	76.9	89.4
Spring 2021 Site RCE Score (%)		68.3	65.4	64.4	66.3	76.9	90.4

Table 4 Combined Macrophyte Occurrence Autumn 2022

Site	Rush *Baumea rubiginosa*	Grass *Carex gaudichaundiana*	Jointed Rush *Juncus articulatus*	Bulbous Rush *Juncus bulbosus*	Rush *Juncus sp*	Tufted Algae *Batrochospermum sp*	Charophytes
CECUp	1		1	1	1		1
CECDn	1		1	1			1
DCUp	1		1	1			1
DCDn							1
DECUp	1		1	1	1		
DECDn	1			1		1	
BCUp				1			1

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-4 provides the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The tables also provide site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

Individual site summary statistics for Diversity (taxa richness), SIGNAL and EPT scores for the spring 2021 and autumn 2022 Mod 8 aquatic ecology monitoring results are provided in **Figures 4** to **6** below.

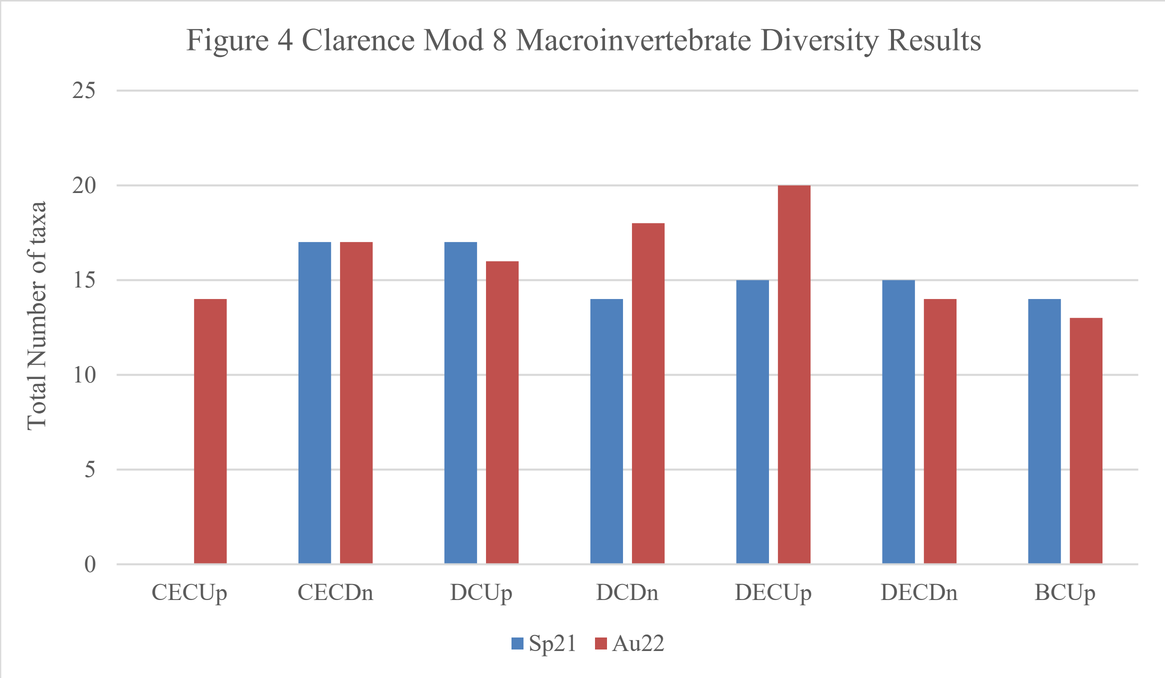

Figure 4 Mod 8 spring 2021 and autumn 2022 survey macroinvertebrate taxa diversity.

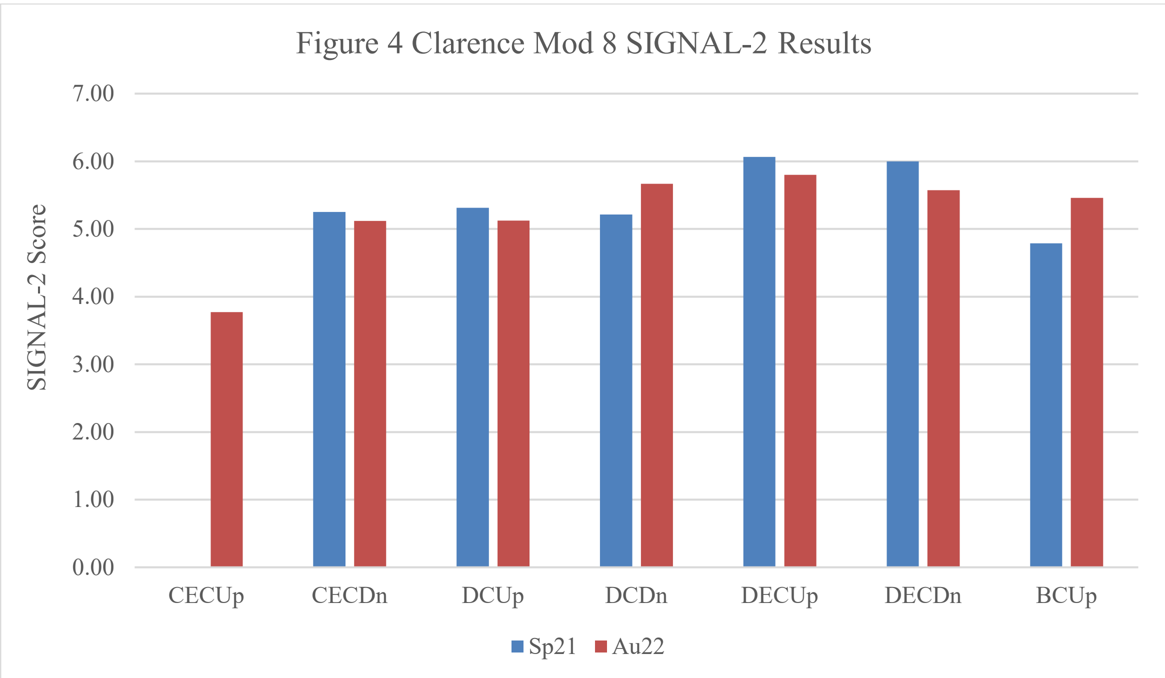

Figure 5 Mod 8 spring 2021 and autumn 2022 survey SIGNAL-2 scores.

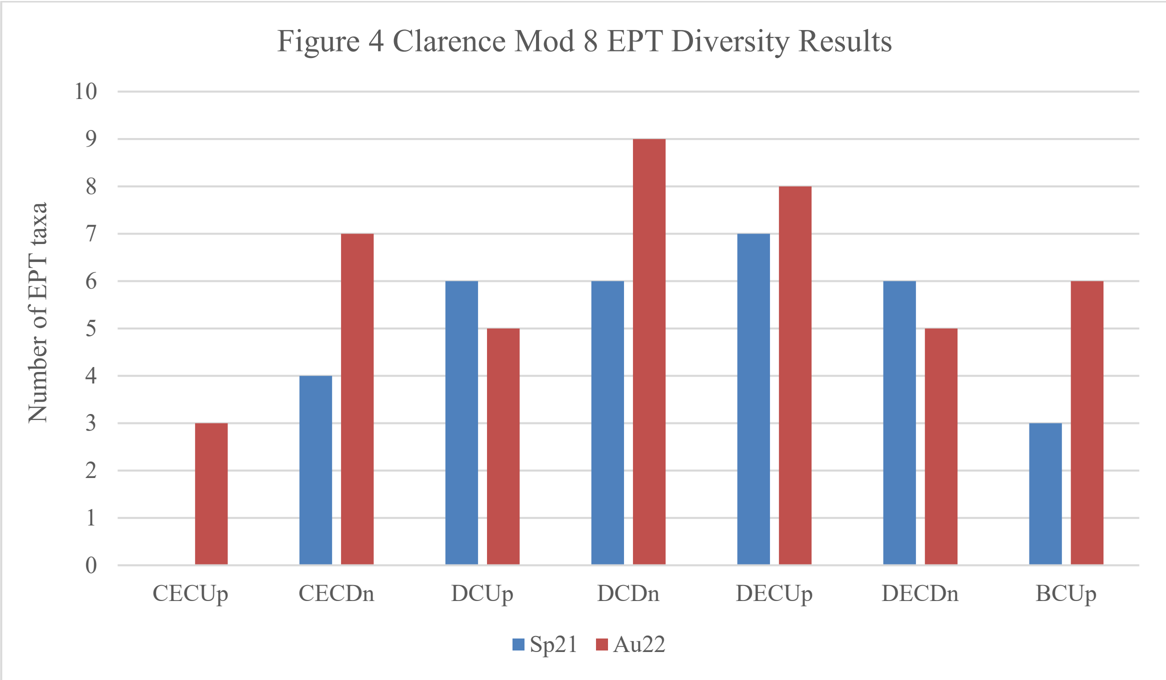

Figure 6 Mod 8 spring 2021 and autumn 2022 survey EPT taxa diversity.

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

AUTUMN 2022

Appendix Table A-1 Clarence Site Daily Rainfall (mm) for July 2021 to June 2022												
Date	2021						2022					
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
1st	7	1.2	0	3.6	0	1.2	0	1.4	16.4	0.4	0.2	0.6
2nd	0.2	2	0	0.2	0	4.6	3.6	4.8	26.4	0	0	0
3rd	0.2	6.4	0	0	0	0.2	0	0.2	20	0	0	0
4th	0	0	3.6	0.2	25.8	0.6	0	1.4	10.6	0	0.2	0
5th	0	0	4.2	0.6	12	4.2	12.6	5.8	24.8	0	6	0
6th	0	0	0	0	0.8	2.6	8.6	5.6	56.4	1.8	0	3.6
7th	0	0	0	0	27.8	4.8	40	3.4	63.4	34.4	0	4
8th	0	4.2	0	0	4	12.6	5.4	0.2	24.8	15.4	0	0
9th	3	1	0	0	0	10.4	3.4	0	1.4	6.2	6	0
10th	0	0	0	5.4	16.2	3.6	4	4.6	0.2	3	6.2	0
11th	0.6	0.8	0	6.2	35.8	0	28.4	1	0.4	0.2	16.6	0
12th	0.6	3	0	10	10	0.2	4.6	8.2	0.2	0.2	26.2	0
13th	0.2	0	0	11.4	0.6	0	7.8	2.8	0.2	2	0.4	0
14th	0.8	0	1	2.4	6	0	0	0	1.2	1	0	
15th	2.2	0	0	8.4	0	0.4	0.6	0	3.8	0	0.6	
16th	8.4	0	0	0.2	0	0.4	0	0	0.6	0.2	0	
17th	10	0	0	0	0	0.4	0.2	0	4.4	0	0	
18th	0.6	0.2	6.4	0	0	11.2	8	0	1	0	0	
19th	0.4	0	0	0	0	2.8	18.4	4.6	4.6	10.8	0	
20th	0.6	0	1.2	0.6	2.2	0	2	0	0.2	0	3.4	
21st	0.4	0	0	0	18	0.2	5.8	7.6	0.2	0	6.6	
22nd	0	0	0	0	2.2	0.2	2.6	5	0	5.8	3.8	
23rd	1.6	7.6	0	2	2.2	26.2	2	6	1.4	2	2.6	
24th	1.4	46.4	0	0	1.4	0.6	2.2	15.8	9.8	0	1.8	
25th	5.8	13.6	0	0	9.8	22	10.2	16	3.2	1.2	0	
26th	0	21.2	1.4	0	36.4	17.4	0.2	4.8	12.2	2.2	0.2	
27th	0	0	0.2	0	6.2	3.4	0	4.4	3.8	8.4	0.8	
28th	2.4	0	0	0	1.4	2	0	7.4	5.2	6	0.2	
29th	0	0.8	7.6	0	0	0	10.6		12.6	0.2	0	
30th	0	0.2	4	0	0	0	0.2		3.8	4.4	8.6	
31st	0	0		0		0	0		4.2		6.6	
Total	46.4	108.6	29.6	51.2	218.8	132.2	181.4	111	317.4	105.8	97	8.2
Monthly Average*	60.3	57.9	55.7	61.9	64.5	79.1	85.2	81.4	77.8	57.1	51.1	71.7
Note: Mod 8 Aquatic Ecology sample days are highlighted in yellow. *Monthly average is the long-term average from BOM station 63226.												

Table A-2 Field Comments – Autumn 2022 Aquatic Ecology Monitoring Sites		
Site	Date	Comments
CECUp	8/6/22	Site sampled in Carne Creek eastern tributary swamp around 1.1km upstream of CECDn. Water clear and flowing through site length, substrates and aquatic habitats smothered in silt or orange precipitation (floc-like). Lateral seepages entering site channel length. Maximum channel width at least 15m, maximum depth around 0.6m and average depth 0.2m. Swamp vegetation continuous and dense throughout site. The site riparian corridor continuous along site length, broader along the eastern bank, though most of the catchment area bounding the site and upstream comprises pine plantation. A couple of incised pools occurring adjacent to and in the main flow channel, with banks stabilised by established eucalypt trees. Dense charophytes and bulbous rush (*Juncus bulbosus*) throughout most of the site. The aquatic edge habitats sampled included macrophytes, charophytes, and small quantities of detritus and trailing bank vegetation. The site substrates were dominated by sandy sediments and muddy silts, with small amounts of pebbles and gravels. Filamentous green alga was present in small amounts.
CECDn	10/6/22	Site sampled in same location as previous survey. Overall conditions similar to previous survey. Evidence of high flow event to 1m above baseflow conditions, with impacts including increased channel incision within main pool area and downstream channel through swamp habitats, removal of large woody debris and localised uprooting of swamp vegetation and sediment deposits. Water clear and flowing through site length, brown silt smothering submerged surfaces and forming thick accumulations in some backwaters, smothering substrates. Maximum channel wetted width estimated around 15m to 20m, maximum pool width 4m, maximum depth 0.5m and average depth 0.3m. The edge habitats sampled consisted of limited trailing bank vegetation (mostly roots and trailing leaves), and detritus, plus small quantities of bulbous rush and charophytes, and the site substrates were comprised mostly of sands and pebbles. No filamentous green alga observed.
DCUp	9/6/22	Evidence of high flow event to at least 1m above baseflow water levels, some swamp sedges have been uprooted. Water clear and flowing through section. Lateral seepages entering site channel length. Maximum width estimated around 15 to 20m, maximum depth around 0.4m and average depth 20cm. Overall conditions (extent of water, habitats) similar to previous survey. The aquatic habitat availability consisted of detritus and trailing bank vegetation, small amounts of macrophytes (bulbous rush and rush *Baumea rubiginosa*). The channel substrates were smothered in dark silts, and was comprised mostly of muddy sandy sediments. Filamentous alga present in small amounts.

DCDn	9/6/22	Evidence of high flow water levels reaching around 1m above baseflow water levels. Some swamp vegetation had been uprooted and there increased channelisation along the main (deeper, more distinct) swamp flow channels. Water clear and flowing through site length. Brown silty material smothering most submerged surfaces, clogging net. Maximum wetted channel width estimated at 20m however maximum pool width to 3m, maximum depth around 0.6m and average depth 20cm. Overall good availability of edge habitats, comprising undercut banks, trailing bank vegetation (mostly roots and trailing leaves), aquatic vegetation and detritus. The site substrates were dominated by sandy sediments with mud. No filamentous green algae observed.
DECUp	8/6/22	Site conditions similar to previous survey, however evidence of high flow water levels with increased channelisation along the deeper main flow channels. Water clear and flowing through length. Lateral seepages entering site channel along length and upstream of site. Maximum (wetted) width estimated around 15 to 20m, maximum depth 0.5m and average depth 0.2m. The main aquatic edge habitats comprised detritus, trailing bank vegetation and undercut banks, and the channel substrates consisted mostly of muddy sand and localised gravels deposits, silt smothering most submerged surfaces. Filamentous green algae present in small amounts.
DECDn	9/6/22	Evidence of high flow water levels reaching around 1m above baseflow water levels, increased channel incision along main pool edges and pool habitats appears more open than previous survey (less overhanging vegetation coverage). Water clear and flowing through site length. Maximum pool width around 4m, maximum depth to 0.8 to 0.9m and average depth 0.4m. The edge habitats that were sampled included trailing bank vegetation, macrophytes, detritus and undercut banks, silt smothering submerged surfaces. The site substrates were made up mostly of muddy sand with smaller amounts of pebbles and gravels. No filamentous green alga observed.
BCUp	7/6/22	Evidence of high flow water levels reaching around 1m above baseflow water levels and at least 15m in width, as indicated by debris accumulations and slanted vegetation, increased channelisation and openness of the pool habitats. Bank adjacent creek has been scoured free of loose material. Water clear and flowing through site length. Maximum pool with around 1.5m and average width 0.8, maximum depth ~1.4m and average depth 0.5m. Brown silt and orange precipitate prevalent throughout site channel on submerged surfaces. The aquatic edge habitats sampled included trailing bank vegetation, macrophytes, detritus and undercut banks. The channel substrates were made up of generally equal proportions of cobbles, gravelly sands and pebble sized rocks, with small quantities of boulders. No filamentous green alga observed.

Appendix Table A-3

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor										
	Category			Au22	Au22	Au22	Au22	Au22	Au22	Au22
			Value	CECUp	CECDn	DCUp	DCDn	DECUp	DECDn	BCUp
1	Land-use pattern beyond immediate riparian zone									
		Undisturbed native vegetation	4							
		Mixed native vegetation and pasture/exotics	3							3.5
		Mainly pasture, crops or pine plantation	2	2	2	2	2	2	2	
		Urban, some vegetation	1							
		Industrial, little vegetation	0							
2	Width of riparian strip-of woody vegetation									
		More than 30 m	4							4
		Between 5 and 30 m	3	3.5	3	3			3	
		Less than 5 m	2				2.5	2.5		
		No woody vegetation	1							
		No Vegetation	0							
3	Completeness of riparian strip of woody vegetation									
		Riparian strip without breaks in vegetation	4							4
		Breaks at intervals of more than 50 m	3	3	3					
		Breaks at intervals of 10-50 m	2			2	2	2	2	
		Breaks at intervals of less than 10 m	1							
		No riparian strip at all	0							
4	Vegetation of riparian zone within 10 m of channel									
		Native tree and shrub species	4							4
		Mixed native and exotic trees and shrubs	3	3.5	3.5	3.5	3.5	3.5	3.5	
		Exotic trees and shrubs	2							
		Exotic grasses/weeds	1							
		No vegetation at all	0							
5	Stream bank structure									
		Banks fully stabilized by trees, shrubs, concrete	4							4
		Banks firm but held mainly by grass and herbs	3	3	3	3	3	3		
		Banks loose, partly held by sparse grass, rubble	2						2.5	
		Banks unstable, mainly loose sand or soil	1							
		Banks actively eroding	0							
6	Bank undercutting									
		None, or restricted by tree roots or man-made	4			4	4	4	4	
		Only on curves and at constrictions	3	3	3					3
		Frequent along all parts of stream	2							
		Severe; bank collapses common	1							
		Total bank collapse	0							
7	Channel form									
		Deep; width:depth ratio less than 8:1	4						4	4
		Medium; width:depth ratio 8:1 to 15:1	3	3	3					
		Shallow; width:depth ratio greater than 15:1	2			2	2	2		
		Artificial; concrete or excavated channel< 8:1	1							
		Artificial; concrete or excavated channel > 8:1	0							
8	Riffle/pool sequence									
		Frequent alternation of riffles and pools	4							
		Long pools with infrequent short riffles	3						3	3
		Natural channel without riffle/pool sequence	2	2	2	2	2	2		
		Artificial channel; some riffle/pool sequence	1							
		Artificial channel; no riffle/pool sequence	0							
9	Retention devices in stream									
		Many large boulders and/or debris dams	4						4	
		Rocks/logs present; limited damming effect	3					3		3
		Rocks/logs present but unstable; no damming	2	2	2	2	2			
		Stream or channel with few or no rocks/logs	1							
		Artificial channel; no retention devices	0							
10	Channel sediment accumulations									
		Little or no accumulation of loose sediments	4							
		Some gravel bars but little sand or silt	3							3
		Bars of sand and silt common	2	2	2	2	2	2	2.5	
		Braiding by loose sediment	1							
		Complete in-filled muddy channel	0							
11	Stream bottom									
		Mainly clean stones with obvious interstices	4							
		Mainly stones with some cover of algae/silt	3							3
		Bottom heavily silted but stable	2	2	2	2	2	2	2.5	
		Bottom mainly loose and mobile sandy sediment	1							
		Bottom mainly loose and mobile muddy sediment	0							
12	Stream detritus									
		Mainly unsilted wood, bark, leaves	4							4
		Some wood, leaves, etc. with much fine detritus	3	3	3	3	3	3	3	
		Mainly fine detritus mixed with sediment	2							
		Little or no organic detritus, mainly sandy	1							
		No organic detritus, mainly mud	0							
13	Aquatic vegetation									
		Little or no macrophyte or algal growth	4	4	4	4	4	4	4	4
		Substantial algal growth; few macrophytes	3							
		Substantial macrophyte growth; little algal growth	2							
		Substantial macrophyte and algal growth	1							
		Total cover of macrophytes plus algae	0							
		RCE Score		36.0	35.5	34.5	34.0	35.0	40.0	46.5
		RCE %age		69.2	68.3	66.3	65.4	67.3	76.9	89.4

Appendix Table A-4 Clarence Mod 8 Aquatic Ecology Monitoring Macroinvertebrate and Fish Results Autumn 2022											Sample Site and Sample Date								
								Life Stage			8/6/22	10/6/22	8/6/22	9/6/22	8/6/22	9/6/22	7/6/22		
Phylum	Class	Sub-Class	Order	Sub-Order	Family	Sub-Family	Common name	L	N	A	CECUp	CECDn	DCUp	DCDn	DECUp	DECDn	BCUp	Occurrence	SIG-2
Arthropoda	Insecta		Coleoptera		Dytiscidae		Diving Beetles	x		x	1							1	2
Arthropoda	Insecta		Coleoptera		Gyrinidae		Whirligig Beetles	x		x					1	1	1	3	4
Arthropoda	Insecta		Coleoptera		Scirtidae		Marsh Beetles	x					1	1	1	1	1	5	6
Arthropoda	Insecta		Diptera		Ceratopogonidae		Biting Midges	x				1			1			2	4
Arthropoda	Insecta		Diptera		Chironomidae	Chironominae	Bloodworms	x			1	1	1	1	1	1	1	7	3
Arthropoda	Insecta		Diptera		Chironomidae	Orthocladiinae	Bloodworms	x			1			1	1			3	4
Arthropoda	Insecta		Diptera		Chironomidae	Tanypodinae	Bloodworms	x			1	1	1	1		1	1	6	4
Arthropoda	Insecta		Diptera		Simuliidae		Black Flies	x			1	1	1	1	1	1	1	7	5
Arthropoda	Insecta		Diptera		Tipulidae		Crane Flies	x						1	1			2	5
Arthropoda	Insecta		Ephemeroptera		Baetidae		Mayflies		x		1							1	5
Arthropoda	Insecta		Ephemeroptera		Coloburiscidae		Mayflies		x								1	1	8
Arthropoda	Insecta		Ephemeroptera		Leptophlebiidae		Mayflies		x			1	1	1	1	1	1	6	8
Arthropoda	Insecta		Hemiptera		Corixidae		Lesser Water Boatmen				1	1						2	2
Arthropoda	Insecta		Hemiptera		Notonectidae		Backswimmers				1	1						2	1
Arthropoda	Insecta		Mecoptera		Nannochoristidae		Scorpionflies	x					1					1	9
Arthropoda	Insecta		Odonata	Epiproctophora	Aeshnidae		Dragonflies	x			1		1					2	4
Arthropoda	Insecta		Odonata	Epiproctophora	Corduliidae		Dragonflies	x			1		1		1			3	5
Arthropoda	Insecta		Odonata	Epiproctophora	Libellulidae		Dragonflies	x			1							1	4
Arthropoda	Insecta		Odonata	Epiproctophora	Synthemistidae		Dragonflies	x				1	1	1	1	1	1	6	5
Arthropoda	Insecta		Odonata	Epiproctophora	Telephlebiidae		Dragonflies	x							1	1		2	9
Arthropoda	Insecta		Odonata	Zygoptera	Argiolestidae		Damselflies	x				1	1					2	5
Arthropoda	Insecta		Plecoptera		Gripopterygidae		Stoneflies		x			1	1	1	1	1		5	8
Arthropoda	Insecta		Plecoptera		Notonemouridae		Stoneflies		x		1						1	2	6
Arthropoda	Insecta		Trichoptera		Ecnomidae		Caddis Flies	x				1	1	1	1	1	1	6	4
Arthropoda	Insecta		Trichoptera		Helicophidae		Caddis Flies	x				1		1	1	1		4	10
Arthropoda	Insecta		Trichoptera		Helicopsychidae		Caddis Flies	x						1	1			2	8
Arthropoda	Insecta		Trichoptera		Hydrobiosidae		Caddis Flies	x				1		1			1	3	8
Arthropoda	Insecta		Trichoptera		Hydroptilidae		Caddis Flies	x			1		1	1				3	4
Arthropoda	Insecta		Trichoptera		Leptoceridae		Caddis Flies	x				1	1	1	1	1	1	6	6
Arthropoda	Insecta		Trichoptera		Philopotamidae		Caddis Flies	x							1			1	8
Arthropoda	Insecta		Trichoptera		Philorheithridae		Caddis Flies	x				1		1	1			3	8
Arthropoda	Crustacea		Isopoda	Phreatoicidea	Phreatoicidae		Isopods					1	1	1	1	1	1	6	4
Arthropoda	Ostracoda						Seed Shrimps				1							1	*
Annelida	Oligochaeta						Freshwater Worms					1	1	1	1	1		5	2
Chordata	Amphibia						Tadpoles				1	1						2	*
							Total number of invertebrate taxa per site:				14	17	16	18	20	14	13	34	
							Site SIGNAL2 Scores:				3.77	5.12	5.13	5.67	5.80	5.57	5.46		
Notes:	* represents those taxa for which SIGNAL-2 scores are not available						Number of EPT taxa:				3	7	5	9	8	5	6	13	

Plate 1: Looking upstream at upper Carne Creek east monitoring site CECUp in autumn 2022.

Plate 2: Looking downstream at CECUp.

Plate 3: Looking upstream at CECUp.

Plate 4: Looking upstream at Carne Creek eastern tributary swamp site CECDn, from the upstream end of the site.

Plate 5: Looking downstream at CECDn.

Plate 6: Looking upstream at localised open pool section at CECDn.

Plate 7: Looking downstream at CECDn.

Plate 8: Looking downstream through swampy section at CECDn.

Plate 9: Looking upstream at Dingo Creek site DCUp.

Plate 10: Looking upstream through DCUp swamp.


Plate 11: Looking downstream through DCUp swamp.


Plate 12: Open pool area at DCUp swamp.

Plate 13: Looking upstream through one of the more incised pools in Dingo Creek downstream site DCDn.

Plate 14: Looking downstream through DCDn swamp.

Plate 15: Uprooted swamp vegetation at DCDn.

Plate 16: Looking upstream at section of incised channel at upstream eastern Dingo Creek tributary site DECUp.

Plate 17: Looking downstream at DECUp

Plate 18: Looking downstream through swamp habitat at DECUp.


Plate 19: Looking downstream at DECUp.


Plate 20: Looking upstream at Dingo Creek downstream site DECDn.

Plate 21: Looking upstream at DECDn.

Plate 22: Looking upstream at DECDn.


Plate 23: Looking downstream at DECDn.


Plate 24: Looking upstream from the track crossing at Bungleboori Creek upstream northern swamp location BCTN.

Plate 25: Looking north across track crossing just upstream of Bungleboori Creek site BCUp in autumn 2022.

Plate 26: Looking downstream from the track crossing.


Plate 27: Looking downstream at Bungleboori Creek upstream site BCUp in autumn 2022.


Plate 28: Looking downstream in BCUp.


Plate 29: Looking upstream in BCUp.

CENTENNIAL COAL
CLARENCE COLLIERY

DINGO CREEK CATCHMENT
AQUATIC ECOLOGY

SPRING 2022 DATA REPORT

Figure 1. *Euastacus* crayfish from CECDn with ectocommensal temnocephalans on its thorax.

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD

MARCH 2022

FIGURES

TABLES

APPENDIX

A FIELD NOTES, SITE PHOTOGRAPHS AND SAMPLING DATA

1 INTRODUCTION

Clarence Colliery Pty Ltd owns and operates the existing Clarence Colliery underground coal mine near the village of Clarence in NSW. Clarence Colliery is seeking to modify state significant development (SSD) consent DA 174-93 to synchronise operational and approval procedures of its existing mining operation in the northern extent of its mining lease area (Mod 2). The Mod 2 (formerly Mod 8) study area catchments are contained within the Gardens of Stone State Conservation Area (SCA) and landuse within the proposed mine footprint comprises mixed undeveloped native forest and former state forest pine plantations. Undeveloped native forests downstream of the proposed mine footprint are located in the Blue Mountains National Park. Each of the drainage lines overlying and downstream from the proposed Mod 2 extraction area contain *Newnes Plateau Shrub and Hanging Swamp* endangered ecological communities (EECs).

As part of the environmental assessment process associated with Mod 2, Clarence Colliery commissioned Marine Pollution Research Pty Ltd (MPR) to review existing aquatic ecological information and initiate a baseline aquatic ecology monitoring program to describe the existing aquatic environment of the Mod 2 proposal footprint. The aims of the baseline aquatic ecology (streamhealth) monitoring program are as follows:

- To develop an understanding of the aquatic ecological attributes of the Newnes Plateau Shrub Swamps and associated creeks which overly the areas of proposed mining in order to enable impact assessment and provide suitable mitigation and offset measures where necessary or desirable.
- To provide additional aquatic site base-line data that can be utilised to monitor potential construction and operational impacts of continued and new mining and that can be used to develop suitable trigger, action and response plans (TARPS) to be incorporated into Construction and Operational Environmental Monitoring Plans (CEMP and OEMP) that would be required as part of an EIS consent.

This data report provides the results for the third consecutive aquatic ecology baseline monitoring survey undertaken for Mod 2 in spring 2022, and follows on from baseline monitoring reports for survey work undertaken in spring 2021 (MPR 2022a) and autumn 2022 (MPR 2022b).

1.1 Description of Locality and Existing Information

The proposed mining area is concentrated in the upper Carne and Dingo Creek catchments with a small portion situated in the upper limits of Bungleboori Creek in the southern limits of the Mod 2 boundary (**Figure 2**).

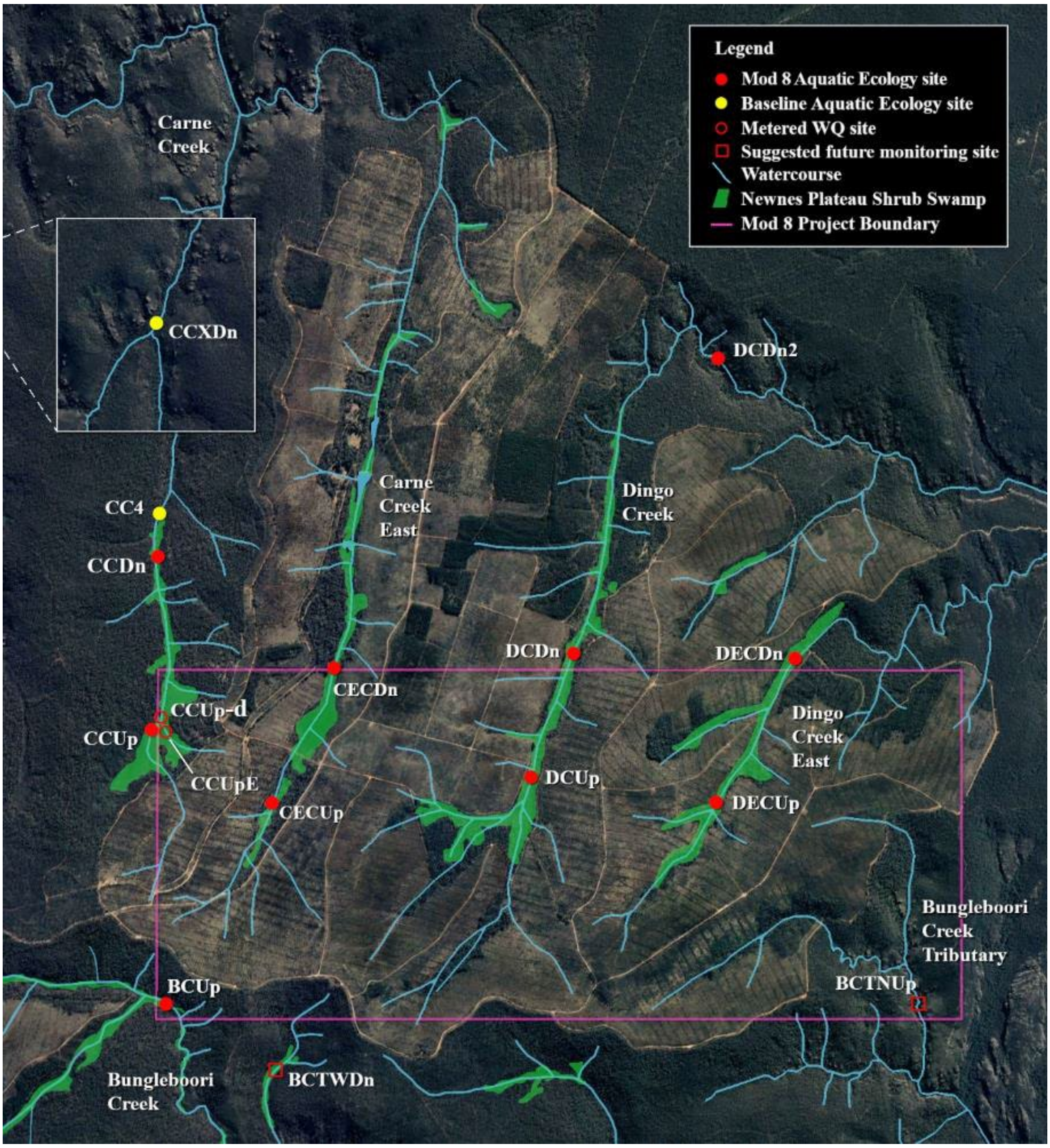

Figure 2 Clarence Mod 2 aquatic ecology survey sites.

Several of the sub-catchments support Newnes Plateau Shrub Swamp (NPSS) habitats dominated by shrubs and sedges that occur on sites with impeded drainage in low slope headwater valleys on the Newnes Plateau in the upper Blue Mountains (Web Reference 1), however the majority of the sub-catchments have been cleared for pine plantations.

The NPSSs are listed as Endangered Ecological Communities (EECs) under the NSW *Biodiversity Conservation Act 2016* (BCA) and are also listed as part of the Temperate Highland Peat Swamps on Sandstone (TPHSS) under the federal *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Carne Creek originates on Newnes Plateau at elevations reaching 1180m Australian Height Datum (AHD) and has an average annual rainfall of 1073mm. Carne Creek is considered pristine and from its headwaters, Carne Creek flows in a northerly direction for around 21km prior to joining the Wolgan River, a tributary of the Hawkesbury River. The headwaters of Carne Creek consist of at least six separate sub-catchments, with the two eastern most upper sub-catchments overlying the western extent of the Mod 2 boundary in areas of pine plantation (**Figure 2**). Whereas both sub-catchments support NPSS's along the low-profile main drainage arms, the channel valleys become more incised and bordered by steep sandstone escarpments downstream from the study area.

Dingo Creek lies to the east of Carne Creek on Newnes Plateau reaching altitudes of 1140m in its upper headwaters, and is bounded by Waratah Ridge Rd to the south. The headwaters of Dingo Creek are contained within two main branches which overlie the middle and eastern portion of the Mod 2 boundary. Dingo Creek flows in a northerly direction for around 5km before turning east for a further 16.5km to merge with Bungleboori Creek. The Blue Mountains National Park border lies 550m to the east of the eastern Mod 2 boundary. Whilst most of the Dingo Creek catchment area within the Mod 2 footprint has been cleared for pine plantation, the drainage lines accommodate considerable NPSS communities along the main creeks and lateral feeder tributaries (**Figure 2**). Pine plantations continue further north (downstream) from Mod 2, before the creek lines become heavily incised into the sandstone escarpment, which is generally continuous downstream to Bungleboori Creek.

In terms of existing aquatic ecological sampling information for the study area, a previous Environmental Assessment for an adjoining Springvale Colliery mining lease area included a baseline aquatic ecology monitoring program that ran from 2010 to 2016. This study included two sites in the eastern Carne Creek catchment (**Figure 2**), and Springvale Colliery provided permission to incorporate these results as long-term streamhealth indices for this project which were provided in the first Mod 2 monitoring report (MPR 2022a).

1.2 Newnes Plateau Site Threatened Species Considerations

The NPSS provide habitat for several water related terrestrial species; the giant dragonfly (*Petalura gigantea*) and the Blue Mountains water skink (*Eulamprus leuraensis*) and possible habitat for one aquatic species, the Adams emerald dragonfly (*Archaeophya adamsi*). The giant dragonfly and water skink are listed as Endangered under the BCA with the latter also being listed as Endangered under the EPBC Act. The emerald dragonfly is listed as Endangered under the NSW *Fisheries Management Act 1994* (FMA).

The giant dragonfly is semi-aquatic, living in burrows in swamps and along stream edges. The larvae emerge from the terrestrial entrances at night and in wet weather in search of insects and other arthropods to eat, and larvae are not known to swim and avoid open water (Web Reference 2). Given their crepuscular habits of the larvae it is unlikely that specimens would occur in routine samples. Adults emerge between October and January, and therefore targeted searches were undertaken for both exuviae (the larval skins shed in the process of metamorphosis into an adult) and adults in suitable swamp sites in spring 2022.

There is little information available on the ecology and biology of Blue Mountains water skink. The Blue Mountains water skink is restricted to sedge and shrub swamps that have boggy soils and appear to be permanently wet, and is semi-aquatic being active on warm, sunny days from September until late April (Web Reference 3). Although it is known from the Carne Creek swamps, no individuals were observed during this survey.

The Adams emerald dragonfly (*Archaeophya adamsi*) has been collected from 4 localities in NSW: Floods Creek in Brisbane Waters National Park near Gosford; Tunks Creek near Berowra and Hornsby; Bedford Creek in the Lower Blue Mountains and Hungry Way Creek in Wollemi National Park. Specimens of *A. adamsi* are extremely rare, and prior to 1998 only 5 adult specimens were known, indicating that this species has extremely low local population sizes. Habitats where larvae have been found include small creeks with gravel or sandy bottoms, in narrow shaded riffle zones with moss and rich riparian vegetation (Web Reference 4). Considering these observations and owing to the generally poor level of knowledge of this species state-wide, the presence of *A. adamsi* in the Newnes Plateau study area (Carne Creek, Dingo Creek and Bungleboori Creek) cannot be discounted entirely.

2 AQUATIC STUDY DESIGN

2.1 Aims and Objectives

In terms of study aims, the Aquatic Ecology Sampling Program endeavours to answer the following questions:

- Where are the aquatic habitat resources in the study area?
- What are the ecological and riparian attributes of the study area aquatic habitats?
- Do the creeks provide suitable fish passage?
- Do the aquatic resources provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Are there any protected or threatened aquatic species or communities residing within the study area, or any mammals such as platypus and Australian water rat that may utilise the aquatic resources of the study area?

To achieve these objectives the sampling program includes following features:

- Sampling the aquatic macroinvertebrate fauna twice a year (in spring and autumn) using the AusRivAS sampling, sorting and identification protocols (see Section 2.2 below). Note that for AusRivAS standardised sampling purposes the 'autumn' sample season is defined as March 15 to June 15 and 'Spring' is defined as September 15 to December 15.
- Estimation of fish occurrence by a combination of overnight and spot bait-trapping, dip netting and observation, with all captured fish identified in-situ and immediately released.
- Depth profiles of metered water quality parameters: Temperature, Electrical Conductivity (salinity), water acidity (pH), Dissolved Oxygen and Turbidity, at each site during each sampling run.
- Descriptions of creek riparian condition and aquatic plant communities within the study area.

The adopted study design to achieve the objectives outlined above incorporated aquatic ecology sampling at six in-stream sampling sites in spring 2022, located overlying and down-stream of the proposed extraction area in creek drainage channels and NPSS.

Table 1 below presents the site descriptions and coordinates for all sites visited for the three Mod 2 baseline monitoring program surveys between spring 2021 and spring 2022, and **Figure 2** (above) shows sampling site locations in relation to the proposed underground mine, including the former Springvale Coal monitoring sites sampled between 2010 and 2016. Note that there are two sites shown as suggested possible future mining impact assessment sites that were not able to be visited for this survey. If access to these sites is possible and the sites are viable aquatic ecology monitoring locations, they could be sampled prior to under-mining and post mining to assess potential mine impacts.

Table 1 Clarence Mod 2 Aquatic Ecology Seasonal Sample Program Site Information

Catchment	Site	Site Coordinates		Metered WQ	Aq Eco
		E	N		
Carne Creek	CCUp	242025	6302991		Sp21
	CCUpE	242095	6303089	Sp21	
	CCUp-d	242090	6303124	Sp21	
	CCDn	242028	6304172		Sp21
	CECUp	242852	6302574		Au22 & Sp22
	CECDn	243244	6303488		Sp21, Au22 & Sp22
Dingo Creek	DCUp	244522	6302755		Sp21, Au22 & Sp22
	DCDn	244801	6303631		Sp21, Au22 & Sp22
	DCDn2	245688	6305553		Sp21
	DECUp	245774	6302620		Sp21, Au22 & Sp22
	DECDn	246264	6303597		Sp21, Au22 & Sp22
Bungleboori Ck	BCUp	242186	6301187		Sp21, Au22 & Sp22
	BCTWDn	242842	6300708		
	BCTNUp	247156	6301379		
Note:	Sites in red represent suggested future mining impact assessment sites. Aq Eco includes metered WQ, macroinvertebrate and fish sampling and RCE. Site coordinates are in MGA 56.				

2.2 Macroinvertebrate Sampling Methods

The aquatic macroinvertebrate assemblages are determined using the standardised National River Process and Management Program River Bio-assessment Manual methods (NRPMP 1994) as adapted for the National River Health Program (the AusRivAS method (Turak et al 2004, Chessman 2003b). The AusRivAS protocol provides a number of definitions of sites and habitats within sites for selection of sampling locations and recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site.

Sampling has conformed to these definitions:

- A site is "a stream reach with a length of 100 m or 10 times the stream width, whichever is the greater".
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum", and riffle samples collected from broken waters with only pebble, gravel, sand or bedrock substratum may not produce reliable results.
- Edge habitat is "an area along the creek with little or no current".

Ideally, a particular reach within each of the sample locations is selected on the basis of it being (i) a reach with high drought resistance (generally based on pool size, depth and riparian cover) and (ii) a reach with high aquatic habitat diversity; ideally deep pools connected by gentle riffles, abundance of stream bed litter, presence of snags, presence of aquatic vegetation and good extent of cover of overhanging riparian vegetation.

While many of the upper catchment tributary creek and swamp sites are readily accessible, site selection for sampling aquatic biota from some of the incised catchment sites is constrained by access from the road network through the forest to the drainages where the creek flows through deeply incised canyons bordered by escarpment.

2.2.1 Field methods for macroinvertebrate sampling

Macroinvertebrate assemblages were sampled using a 250 µm mesh dip net over as many aquatic 'edge' habitat types as could be located within each of the pools along the defined stream reaches. Net samples were then placed into white sorting trays for in situ live sorting for up to 1 person-hour (with a minimum of 40 minutes), as per the AusRivAS protocol. Following cessation of live picking, further observations were made of the pool edge sample areas for surface aquatic macroinvertebrate taxa (e.g., water skaters and spiders) and any other taxa (such as freshwater crayfish) not collected by the dip netting process. Where possible (or necessary) representatives of these organisms were collected and added to the dip net samples.

Rarer specimens for which positive identification could be made in the field (e.g., water scorpions), were generally released. That is, for protection of the pool macroinvertebrate integrity we adopted a 'sampling with replacement' method. Notwithstanding this procedure, for all taxa that could be positively identified in the field, at least one of each of the field-identified taxa are retained as a representative of that taxa for that sampling event.

For all other macroinvertebrate taxa where field identifications were not definitive, specimens were retained for later detailed taxonomic analysis in the laboratory. Notes are also kept of the presence of burrows and holes that are present in the site aquatic habitats (i.e., as indications of yabbies or burrowing dragonflies). All retained specimens are placed in sample jars and preserved in 70% ethanol for subsequent laboratory identification. Each sample jar is labelled and paper laundry tags are inserted into the jars noting the sample site, sample date and sample collector/picker initials. Any giant dragonfly exuviae or exuviae of other threatened species are kept for confirmation purposes.

Targeted searches were also made for giant dragonfly adults and exuviae (shells cast larval in the process of emergence) among suitable Newnes Plateau Shrub swamp habitats and along ridgelines.

2.2.2 Laboratory methods for macroinvertebrate samples

In the laboratory, taxonomic identifications are generally facilitated using Maggy lights or binocular dissecting microscopes and taxonomic guides such as; CSIRO, Land and Water Resources & Environment Australia (1999), Hawking & Smith (1997), Hawking & Theischinger (1999), Theischinger (2009) and Williams (1980).

Organisms are identified (as a minimum) to the appropriate taxa level as per AusRivAS protocols. These are as follows; family level for all insect taxa except Chironomids which are taken to sub-family). Collembola arthropods (Springtails) are classified as a single class and the arachnid arthropods (spiders and mites) are classified as two orders. For the mites (Order Acarina) we have taken them to sub-order classification level where possible. Crustaceans were taken to Family level where suitable keys are available. Ostracoda were left at Class level. The worm-like taxa are shown at Phylum or Class level. For all taxa, where suitable keys were available, taxa were identified to lower levels of taxonomy.

The sorted specimens are then transferred to individual glass vials (one per family/sub-family) and paper laundry tags inserted into each glass vial with the sample site, sample date and initials of taxonomist noted on the tags. Glass vials are then topped up with 70 % alcohol, sealed with plastic lids and placed back into the original field sample jars.

Where there are any individual specimens where the collected material is too indistinct or fragmented to assign a definitive identification, the samples are dispatched to relevant Australian Museum specialists or other specialists, as recommended by EPA.

For all samples the following taxonomic QA/QC procedure is followed:

> At least ten percent of the samples/sites are selected at random and the individual retained taxa are identified without reference to the original identifications. A table is then made of the original identifications verses the second identifications, indicating where there were any anomalies in identification (if any). If there are no anomalies, the QA/QC sample protocol is accepted and no further QA/QC checking is undertaken. If there are differences in identifications, all the samples containing the related taxa are re-examined to clear up the anomalies.

Following this procedure, and if there have been anomalies, an additional 10 percent of the remaining samples are chosen and the QA/QC procedure re-applied. This process continues until there are no differences between original identifications and QA/QC identifications.

2.2.3 Site SIGNAL index & EPT Index calculations

The aquatic invertebrate assemblage for each sample site is described in terms of the site taxa diversity (number of individual AusRivAS taxa) and in terms of a site SIGNAL score. SIGNAL (Stream Invertebrate Grade Number Average Level) is a pollution tolerance index for stream macroinvertebrates. The indices are derived by correlation analysis of macroinvertebrate occurrence against water chemical analysis (Chessman 1995). The water chemistry attributes generally used are temperature, turbidity, conductivity, alkalinity, pH, dissolved oxygen, total nitrogen and total phosphorus (Chessman 2003a).

SIGNAL indices may be regionally specific (e.g. SIGNAL HU-97 developed for the Hunter Valley Catchment (Chessman 1997), or applicable Australia wide (e.g. SIGNAL-2, Chessman 2003a). Each macroinvertebrate Family has been assigned a SIGNAL score ranging from 10 (very pollution intolerant) to 1 (very pollution tolerant).

For the present study SIGNAL-2 scores are applied. Taxa with no published SIGNAL score are excluded from the site SIGNAL analysis. Once taxa SIGNAL indices have been applied individual site SIGNAL indices are calculated (as the mean) from all site taxa with SIGNAL scores. Creek SIGNAL scores are calculated as the mean of all taxa SIGNAL value occurrences recorded within each creek system for a survey.

Site and creek SIGNAL scores are then summarised and compared across each survey and between surveys. As a general guide site SIGNAL Indices are graded into the following categories (Chessman *et al.* 1997):

- SIGNAL Index > 6 = Healthy Unimpaired
- SIGNAL Index 5-6 = Mildly Impaired
- SIGNAL Index 4-5 = Moderately Impaired
- SIGNAL Index < 4 = Severely Impaired.

However, as the intent of this study is to assess site condition relative to other sites over time, the site scores are used for these comparison purposes rather than as overall study area condition indices. That is, the overall changes in site indices over time are of greater interest than the basic and generalised ‘health’ scores (as per Chessman et al 1997).

The combined number of Ephemoptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddis-fly) families present per site (the EPT index) is used to supplement the taxa richness (diversity) and SIGNAL index as an indicator of stream health.

2.3 Field Sampling Methods for Fish and Other Vertebrates

At each macroinvertebrate sampling site, four fish bait traps (dimensions 250 mm by 250 mm by 400 mm, 4 - 5 mm mesh size and 50 mm diameter entrance) are set at suitable locations. These are left in the stream either overnight, or for the duration of the combined macroinvertebrate sampling and live picking survey (minimum 1.5 hours) and then retrieved. Captured fish are identified i*n situ* using Allen *et. al*., (2002) and McDowall (1996).and immediately released. Fish caught or observed as part of the macroinvertebrate dip net sampling are also identified, noted and released.

Dead fish specimens and any fish that cannot be positively identified in the field are taken to the Australian Museum for confirmation of species identification. These specimens with capture details are then incorporated into the Australian Museum collection as appropriate. Following completion of the fish and macroinvertebrate sampling, any further observations of fish during the pool condition survey are also noted with fish species-name only noted if positively identified. For each survey, tadpoles (which are not macroinvertebrates but chordates) are noted in the results. Specimens are not kept or identified. The presence of birds, reptiles and turtles that utilise the aquatic habitats are noted, and notes are made of the potential for the study area habitats to support platypus or Australian water rats where appropriate.

2.4 Field Water Quality Sampling

A calibrated submersible Yeo-Kal 618 water quality data logger is used to record water depth, temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity at all aquatic ecology sampling sites. At some sites, depth profiles of water quality may also be made to test for layering/mixing. Physical observations are also taken in the field to highlight any aquatic habitat variations (e.g. recent rain, subsequent infilling, detritus in water column or on benthos, scum or flocculates in or on water body etc.) and the presence of fresh yabbie holes are also noted.

2.5 Aquatic Habitat Condition (RCE Index)

A standardised description of site aquatic habitat condition is used to compile a stream site condition index, based on a modified version of the River-Creek-Environment (RCE) method developed by Petersen (1992), as reported by Chessman *et al* (1997) for the greater Hunter River catchment. The index is compiled by giving each of the 13 RCE descriptors a score between 0 and 4, then summing the scores, to reach a maximum possible score of 52. Scores are then expressed as a percentage.

3 CLARENCE MOD 2 AQUATIC ECOLOGY SURVEY RESULTS

Full field sampling notes for the spring 2022 aquatic ecology sampling are provided in **Appendix Table A2**. Sampling for the full spring 2022 survey was undertaken between the 16th and 18th November 2022. Note that for sampling purposes the AusRivAS 'spring' season is defined as September 15th to December 15th.

3.1 Sampling Conditions Leading into Spring 2022

Rainfall measurements are recorded at Clarence Mine Meteorological Station, with long-term mean monthly totals acquired from Bureau of Meteorology (BOM) Lithgow (Cooerwull) Gauge 63226 (recorded from 1878 to current). **Appendix Table A-1** provides the daily rainfall records for July 2021 to June 2022 and are shown graphically in **Figure 3**. The study area catchments were subjected to above average rainfall conditions in 2022 with 60% of the days registering rain, and the annual total (1563mm) was the highest to date. The period between the autumn and spring 2022 surveys saw above average precipitation including heavy storm activity in July:

- Whilst June 2022 was relatively dry, July was very wet with 247mm rain, which included a single 4-day storm event early in the month which recorded 190mm.
- Patterns of precipitation from August to October were characterised by increasing intensity of storm events, and the combined monthly rainfall (317mm) was almost double the combined mean total (177mm).
- Leading into sampling for spring 2022, the study area received 92mm of rain over the first half of November, including 51mm three days prior to sampling.

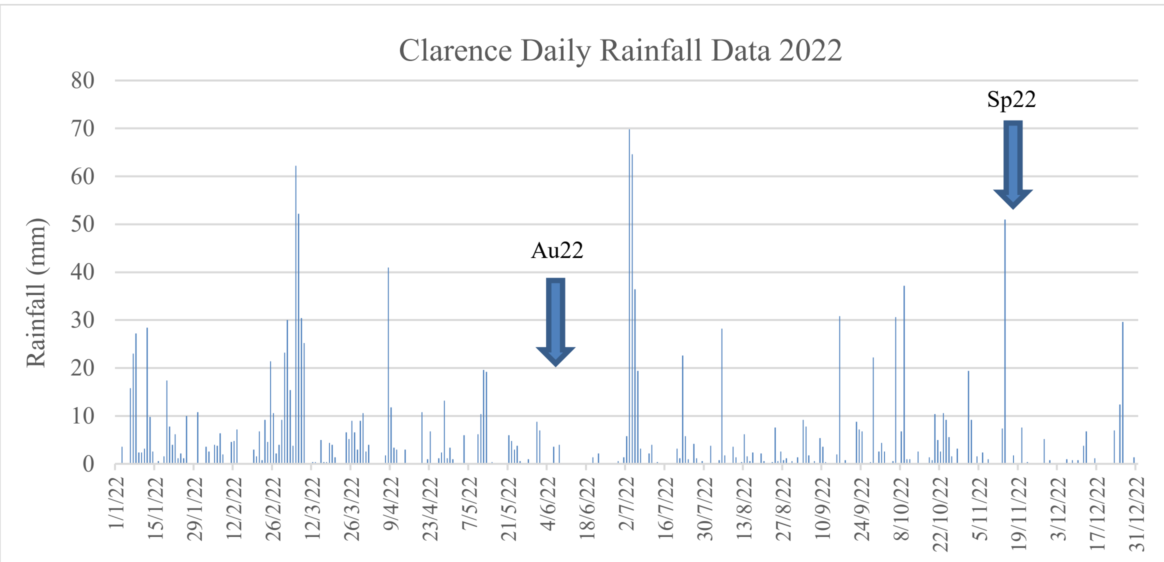

Figure 3 Clarence mine site daily rainfall 2022.

3.2 Spring 2022 Aquatic Ecology Survey Results

The Clarence Mod 2 spring 2022 aquatic ecology survey was undertaken between the 16th and 18th November 2022 following the sampling outline shown in **Table 1** and **Figure 2** above and using the methodology outlined in **Section 2**. Site photos are also provided **Appendix A**. Summary tables for the spring 2022 Appendix A data are provided in the following sections and include the results from previous baseline surveys (spring 2021 and autumn 2022).

3.3 Spring 2022 Metered Water Quality Results

A calibrated water quality meter is used at all aquatic ecology sampling sites plus at selected intermediary sites to record surface water quality - and where applicable, depth profiles of water temperature, dissolved oxygen concentration and saturation, pH, conductivity and turbidity. **Table 2** provides the results of metered water quality sampling for the Clarence Mod 2 spring 2022 aquatic ecology field sampling program.

Table 2 Mod 2 Water Quality Results Spring 2022

Site	Date	Time	Depth	Temp	Cond	DO	DO	pH	Turb
			m	°C	µS/cm	%sat	mg/L	Units	ntu
CECUp	18/11/22	8:03	0.1	10.53	14	94.7	10.5	5.68	4.2
CECDn	16/11/22	16:32	0.1	8.41	13	81.3	8.4	5.25	13.1
CECDn	16/11/22	16:33	0.3	7.96	13	76.9	8.0	5.28	13.7
DCUp	16/11/22	13:47	0.1	9.63	9	93.8	9.6	5.35	8.0
DCDn	16/11/22	12:57	0.1	9.13	13	84.9	9.1	5.23	**324.2**
DECUp	16/11/22	8:39	0.1	10.20	14	90.4	10.2	5.67	1.6
DECUp	16/11/22	8:40	0.3	10.19	14	90.4	10.2	5.60	1.6
DECDn	16/11/22	10:38	0.1	10.01	13	91.3	10.0	5.94	8.2
BCUp	17/11/22	16:07	0.1	8.48	8	84.5	8.5	5.34	15.0

Note: Turbidity reading in **bold** likely resulting from probe contacting the bottom and mobilising silt.

3.4 Aquatic & Riparian Habitat Condition

The field notes (**Appendix Table A-2**) provide details of stream reach flows, pool and channel dimensions and available aquatic habitats for the present survey. The overall Aquatic and Riparian Habitat condition - as estimated using the RCE Index - are provided in **Appendix Table A-3** with summary provided below in **Table 3**, and **Table 4** provides the results of aquatic macrophyte occurrences for the spring 2022 aquatic ecology sampling sites.

Table 3 Summary of RCE Results Spring 2022

Category	CECUp	CECDn	DCUp	DCDn	DECUp	DECDn	BCUp
Land-use pattern beyond immediate riparian zone	2	2	2	2	2	2	3.5
Width of riparian strip-of woody vegetation	3.5	3	3	2.5	2.5	3	4
Completeness of riparian strip of woody vegetation	3	3	2	2	2	2	4
Vegetation of riparian zone within 10 m of channel	3.5	3.5	3.5	3.5	3.5	3.5	4
Stream bank structure	3	3	3	3	3	2.5	4
Bank undercutting	3	3	4	4	4	4	3
Channel form	3	3	2	2	2	4	4
Riffle/pool sequence	2	2	2	2	2	3	3
Retention devices in stream	2	2	2	2	3	4	3
Channel sediment accumulations	2	2	2	2	2	2.5	3
Stream bottom	2	2	2	2	2	2.5	3
Stream detritus	3	3	3	3	3.5	3	4
Aquatic vegetation	3.5	3.5	3.5	3.5	3.5	3.5	4
Spring 2022 Site RCE Score (%)	68.3	67.3	65.4	64.4	67.3	76.0	89.4
Autumn 2022 Site RCE Score (%)	69.2	68.3	66.3	65.4	67.3	76.9	89.4
Spring 2021 Site RCE Score (%)	-	68.3	65.4	64.4	66.3	76.9	90.4

Table 4 Macrophyte Occurrence Spring 2022

Site	Rush *Baumea rubiginosa*	Grass *Carex gaudichaundiana*	Jointed Rush *Juncus articulatus*	Bulbous Rush *Juncus bulbosus*	Rush *Juncus sp*	Tufted Algae *Batrochospermum sp*	Charophytes
CECUp	1		1	1	1		1
CECDn	1		1	1			1
DCUp	1		1	1			1
DCDn							1
DECUp	1		1	1	1		
DECDn	1			1		1	
BCUp				1			1

3.5 Aquatic Macroinvertebrate and Fish Survey Results

Appendix Table A-4 provides the results of aquatic macroinvertebrate taxonomic identifications to the levels required by AusRivAS, plus occurrence data for all aquatic macroinvertebrates and fish. The tables also provide site SIGNAL and EPT scores (see **Section 2.2.3** for explanation of SIGNAL and EPT).

Individual site summary statistics for Diversity (taxa richness), SIGNAL and EPT diversity results for the spring 2021, autumn and spring 2022 Mod 2 aquatic ecology monitoring surveys are provided in **Figures 4** to **6** below.

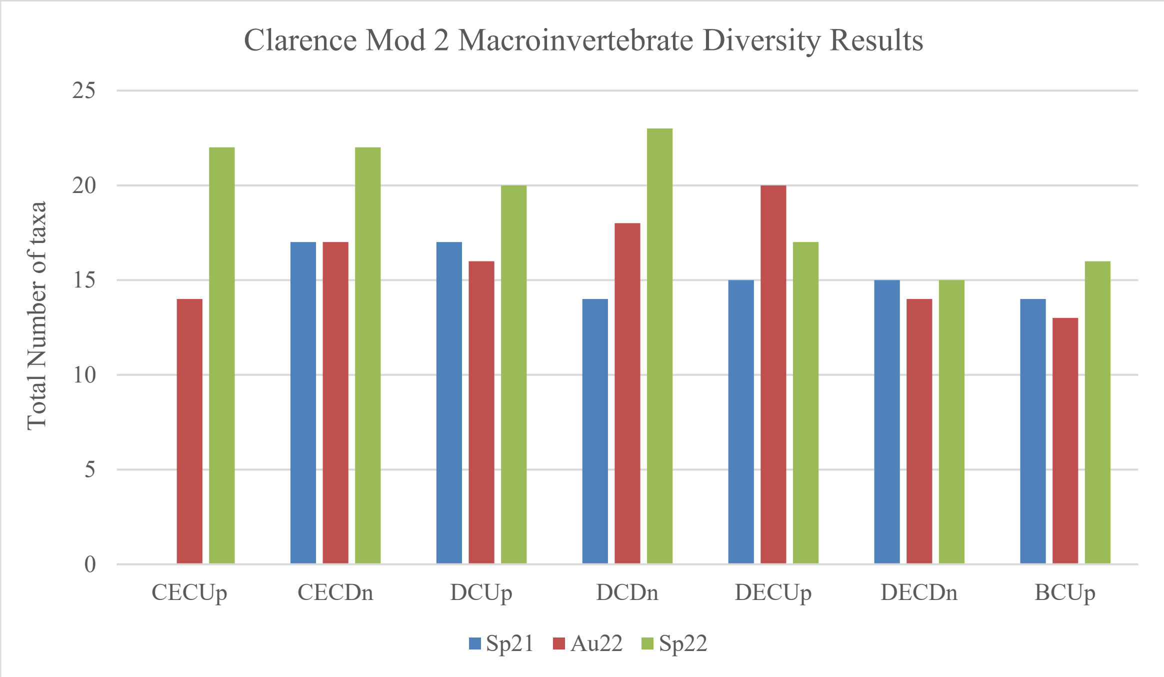

Figure 4 Mod 2 spring 2021 to spring 2022 survey macroinvertebrate taxa diversity.

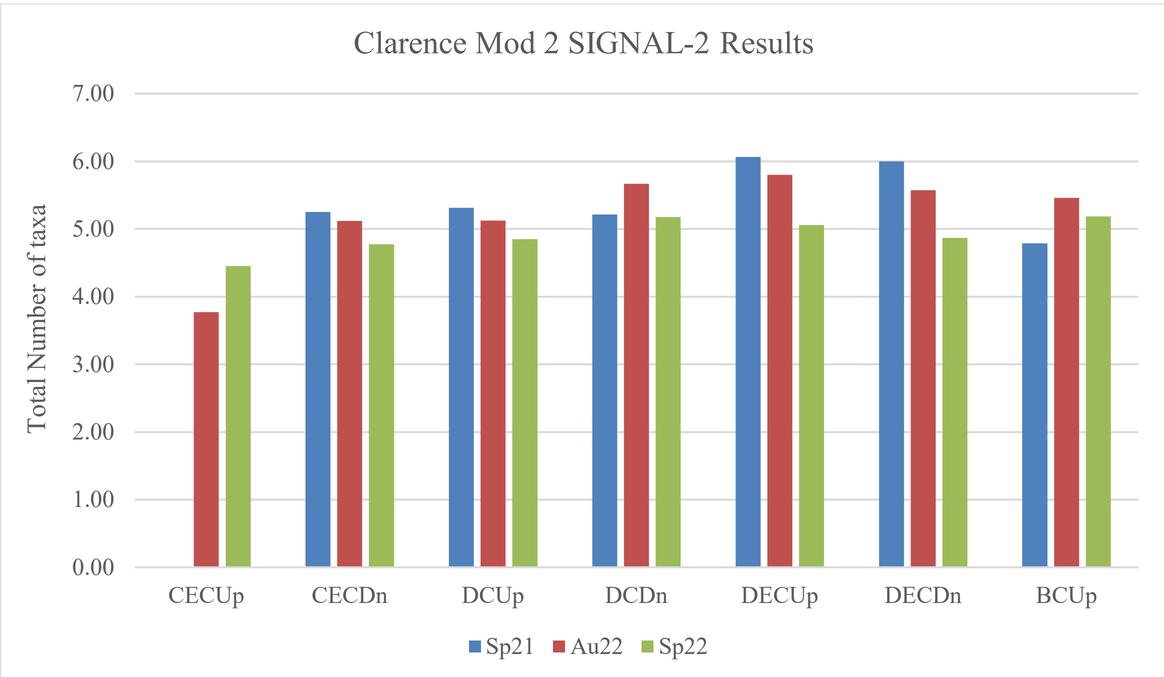

Figure 5 Mod 2 spring 2021 to spring 2022 survey SIGNAL-2 scores.

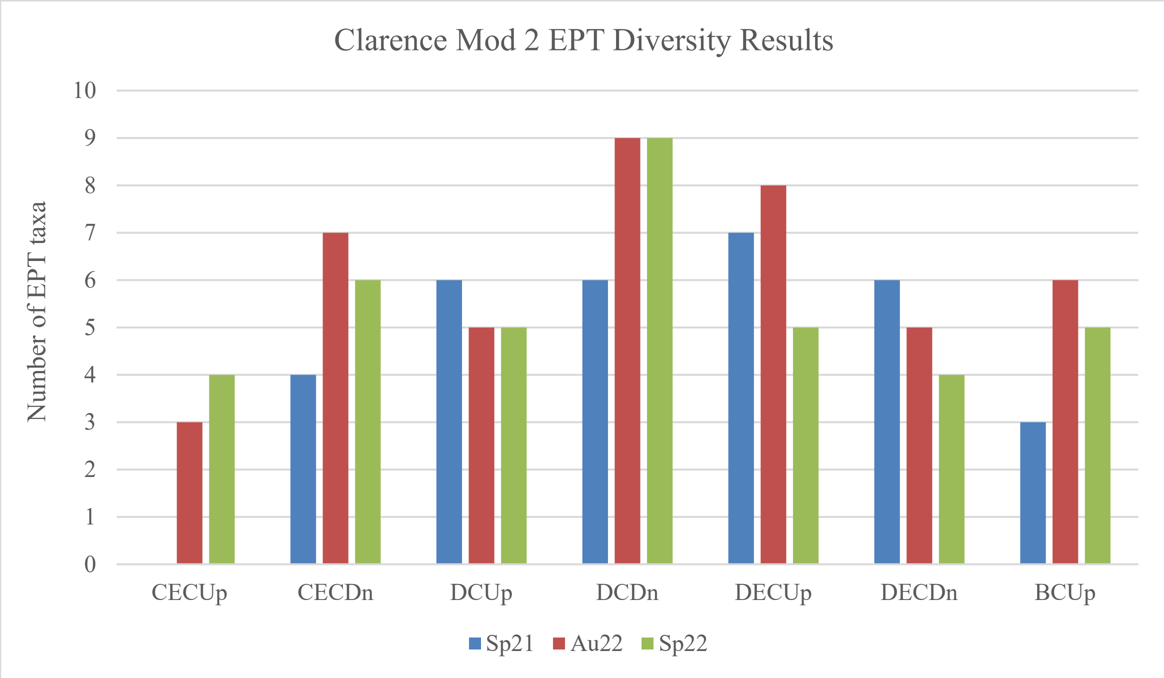

Figure 6 Mod 2 spring 2021 to spring 2022 survey EPT taxa diversity.

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APPENDIX A

FIELD NOTES,

SITE PHOTOGRAPHS

AND

SAMPLING DATA

SPRING 2022

Appendix Table A-1 Clarence 2022 Site Daily Rainfall (mm)												
Date	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1st	0	0.2	9.2	4	1	7	1.4	3.8	1.4	4.4	19.4	0.2
2nd	0	3.6	23.2	0	0.2	0	5.8	0	0.2	2.6	9.2	0
3rd	3.6	2.6	30	0	0	0	69.8	0	9.2	0	0	0
4th	0	0	15.4	0	0.2	0	64.6	0.8	7.8	0	1.6	0
5th	0	4	3.8	0	6	0	36.4	28.2	1.8	0.6	0	0
6th	15.8	3.8	62.2	0	0	3.6	19.4	1.8	0	30.6	2.4	1
7th	23	6.4	52.2	1.8	0	0	3.2	0.2	0.6	0.2	0.2	0
8th	27.2	2	30.4	41	0	4	0	0	0	6.8	1	0.8
9th	2.4	0.2	25.2	11.8	0	0	0	3.6	5.4	37.2	0	0
10th	2.4	0	0	3.4	6.2	0	2.2	1.4	3.6	1	0	0.8
11th	3.2	4.6	0.2	3	10.4	0	4	0	0.4	1	0	0.2
12th	28.4	4.8	0.4	0.2	19.6	0	0.2	0.4	0	0	0.2	3.8
13th	9.8	7.2	0.4	0	19.2	0	0.4	6.2	0	0	7.4	6.8
14th	2.6	0	0	3	0	0	0	1.6	0	2.6	51	0
15th	0	0	5	0	0.4	0	0	0.6	2	0	0	0
16th	0.6	0	0.4	0	0.2	0	0	2.4	30.8	0	0	1.2
17th	0	0	0.4	0.2	0	0	0	0	0.2	0	1.8	0.2
18th	1.6	0	4.4	0	0	0	0	0	0.8	1.4	0	0
19th	17.4	3	4	0	0	0.2	0	2.2	0	0.8	0	0
20th	7.8	1.6	1.4	10.8	0	1.4	3.2	0.6	0	10.4	7.6	0
21st	4	6.8	0.2	0	6	0	1.2	0	0	5	0	0
22nd	6.2	0.8	0.2	1	4.8	2.2	22.6	0	8.8	2.6	0.4	0
23rd	1.2	9.2	0	6.8	3	0	5.8	0.4	7.2	10.6	0	7
24th	2.2	4.6	6.6	0	3.8	0	1	7.6	6.8	9.2	0	0
25th	1.2	21.4	5.2	0	0.6	0	0	0.6	0	5.6	0	12.4
26th	10	10.6	9	1.2	0	0	4.2	2.6	0	1.6	0	29.6
27th	0	2.2	6.6	2.4	0.2	0	1.2	0.8	0.4	0	0	0
28th	0	4	3	13.2	1	0	0	1.2	22.2	3.2	5.2	0
29th	0		9	1.2	0	0.6	0.6	0.2	0	0	0	0
30th	10.8		10.6	3.4	0	0	0	0.6	2.6	0	0.8	1.4
31st	0		2.6		8.8		0	0		0		0.2
Total	181.4	103.6	321.2	108.4	91.6	19	247.2	67.8	112.2	137.4	108.2	65.6
Monthly Average*	85.7	81	77.8	57.1	51.1	71.7	61.7	58	56.2	62.5	65.2	79.1
Note: Mod 2 Aquatic Ecology sample days are highlighted in yellow. *Monthly average is the long-term average from BOM station 63226.												

Table A-2 Field Comments – Spring 2022 Aquatic Ecology Monitoring Sites		
Site	Date	Comments
CECUp	18/11/22	Site conditions similar to previous survey. Water clear and flowing through site length. Orange flocculant smothering submerged surfaces throughout site length. The channel form comprises a broad, flat soaked swamp channel with open, deeper pool areas in the downstream limits. Maximum channel width 15 to 20m, maximum depth around 0.6m and average depth 0.2m. Dense charophytes and bulbous rush (*Juncus bulbosus*) throughout most of the site. The aquatic edge habitats sampled included macrophytes, charophytes, detritus and trailing bank vegetation in the pool areas. The site substrates were dominated by sandy sediments with some gravels, and dark muddy overlying much of the substrates. Filamentous green alga was present in moderate amounts.
CECDn	16/11/22	Some minor indications of recent increased flow water levels however for the most part, site conditions similar to previous surveys. Localised areas of increased incision around main pools, isolated (new) sand deposits present, plus some of the dead (burnt) riparian pine trees had fallen over the site. Water slightly turbid and flowing through length. Maximum channel wetted width estimated around 20m, maximum pool width 4m, maximum depth 0.5m and average depth 0.3m. Edge habitat availability unchanged, comprising undercut banks, trailing bank vegetation, macrophytes and detritus. The site channel substrates were made up of gravelly sands with some fine sand accumulations, most submerged surface smothered in layer of dark silt. Filamentous green alga was present in moderate amounts.
DCUp	16/11/22	Water clear and flowing, surface flows mostly confined to western edge of swamp. Maximum overall wetted width around 20m, maximum depth 0.5m however average width only 20cm. Single blackberry plant observed along western bank. General site conditions similar to autumn 2022 survey, and the aquatic habitats sampled included trailing bank vegetation, macrophytes and detritus. The channel substrates were smothered in dark silts, and was comprised mostly of muddy sandy sediments with small quantities of pebbles. Filamentous green alga present in moderate amounts.
DCDn	16/11/22	Water clear and flowing through site length, comprising incised channel sections with localised flows and broader, shallower sheet flows through swampy areas with multiple, smaller channels. Maximum incised channel width reaching around 3.5m, average width 0.9m, maximum depth to 0.6m and average depth 0.3m. The edge habitat availability was unchanged from the previous surveys, consisting of trailing bank vegetation, undercut banks, detritus and macrophytes. The channel substrates were made up mostly of sands and gravels, with silty material smothering most submerged surfaces. Filamentous green alga present in moderate to abundant amounts.

DECUp	16/11/22	Evidence of recent raised water levels but no indications of flooding. Water clear and flowing through site, with sections of localised flow in incised channels and other swamp sections with broad shallow sheet flow. Maximum pool depth in incised channels to 0.5m and average depth around 25cm. Overall, the site conditions and habitat availability were consistent with the previous survey, with slightly lesser quantities of silt on submerged surfaces. The main aquatic edge habitats sampled included detritus, trailing bank vegetation and undercut banks, and the channel substrates consisted mostly of muddy sand with localised gravels deposits. Silt was smothering most submerged surfaces. Filamentous green algae present in moderate amounts.
DECDn	16/11/22	Evidence of recent high flows to 0.5m above current water levels. Water clear and flowing through site length. Maximum (incised creek sections) pool width to 2.2m and average width 1.1m, maximum depth to 1m and average depth 0.4m. The overall site conditions, substrates and available habitats were generally unchanged from the previous survey. The edge habitats sampled included trailing bank vegetation, macrophytes, detritus and undercut banks. The channel substrates were comprised mostly of sand (40%), gravels and pebbles, with smaller quantities cobbles, bedrock and boulders. Most of the submerged surfaces were smothered in dark silt. Filamentous green algae present in moderate amounts.
BCUp	17/11/22	Evidence of high flow event at 0.5m to 1m above current water levels. Riparian banks scoured free of fine detrital material; debris build up along edges. Water slightly turbid and flowing through site length, only a few isolated areas in site length with flow conditions meeting the edge habitat sample requirement for still or slow flowing pool edges. Channel dimensions and flow paths unchanged, comprising an incised and meandering box shaped channel. Maximum pool with around 1.5m and average width 0.8, maximum depth ~1m and average depth 0.5m. Very little detrital accumulations in stream channel area. The edge habitats sampled included undercut banks, macrophytes and trailing bank vegetation. The channel substrates were made up of generally equal proportions of cobbles, gravelly sands and pebble sized rocks, with small quantities of boulders. Filamentous green alga present in small amounts.

Appendix Table A-3

Modified Riparian, Channel and Environment (RCE) Inventory (after Chessman et al 1997).

Descriptor	Category	Value	Sp22 CECUp	Sp22 CECDn	Sp22 DCUp	Sp22 DCDn	Sp22 DECUp	Sp22 DECDn	Sp22 BCUp
1	Land-use pattern beyond immediate riparian zone								
	Undisturbed native vegetation	4							
	Mixed native vegetation and pasture/exotics	3							3.5
	Mainly pasture, crops or pine plantation	2	2	2	2	2	2	2	
	Urban, some vegetation	1							
	Industrial, little vegetation	0							
2	Width of riparian strip-of woody vegetation								
	More than 30 m	4							4
	Between 5 and 30 m	3	3.5	3	3			3	
	Less than 5 m	2				2.5	2.5		
	No woody vegetation	1							
	No Vegetation	0							
3	Completeness of riparian strip of woody vegetation								
	Riparian strip without breaks in vegetation	4							4
	Breaks at intervals of more than 50 m	3	3	3					
	Breaks at intervals of 10-50 m	2			2	2	2	2	
	Breaks at intervals of less than 10 m	1							
	No riparian strip at all	0							
4	Vegetation of riparian zone within 10 m of channel								
	Native tree and shrub species	4							4
	Mixed native and exotic trees and shrubs	3	3.5	3.5	3.5	3.5	3.5	3.5	
	Exotic trees and shrubs	2							
	Exotic grasses/weeds	1							
	No vegetation at all	0							
5	Stream bank structure								
	Banks fully stabilized by trees, shrubs, concrete	4							4
	Banks firm but held mainly by grass and herbs	3	3	3	3	3	3		
	Banks loose, partly held by sparse grass, rubble	2						2.5	
	Banks unstable, mainly loose sand or soil	1							
	Banks actively eroding	0							
6	Bank undercutting								
	None, or restricted by tree roots or man-made	4			4	4	4	4	
	Only on curves and at constrictions	3	3	3					3
	Frequent along all parts of stream	2							
	Severe; bank collapses common	1							
	Total bank collapse	0							
7	Channel form								
	Deep; width:depth ratio less than 8:1	4						4	4
	Medium; width:depth ratio 8:1 to 15:1	3	3	3					
	Shallow; width:depth ratio greater than 15:1	2			2	2	2		
	Artificial; concrete or excavated channel< 8:1	1							
	Artificial; concrete or excavated channel > 8:1	0							
8	Riffle/pool sequence								
	Frequent alternation of riffles and pools	4							
	Long pools with infrequent short riffles	3						3	3
	Natural channel without riffle/pool sequence	2	2	2	2	2	2		
	Artificial channel; some riffle/pool sequence	1							
	Artificial channel; no riffle/pool sequence	0							
9	Retention devices in stream								
	Many large boulders and/or debris dams	4						4	
	Rocks/logs present; limited damming effect	3					3		3
	Rocks/logs present but unstable; no damming	2	2	2	2	2			
	Stream or channel with few or no rocks/logs	1							
	Artificial channel; no retention devices	0							
10	Channel sediment accumulations								
	Little or no accumulation of loose sediments	4							
	Some gravel bars but little sand or silt	3							3
	Bars of sand and silt common	2	2	2	2	2	2	2.5	
	Braiding by loose sediment	1							
	Complete in-filled muddy channel	0							
11	Stream bottom								
	Mainly clean stones with obvious interstices	4							
	Mainly stones with some cover of algae/silt	3							3
	Bottom heavily silted but stable	2	2	2	2	2	2	2.5	
	Bottom mainly loose and mobile sandy sediment	1							
	Bottom mainly loose and mobile muddy sediment	0							
12	Stream detritus								
	Mainly unsilted wood, bark, leaves	4							4
	Some wood, leaves, etc. with much fine detritus	3	3	3	3	3	3.5	3	
	Mainly fine detritus mixed with sediment	2							
	Little or no organic detritus, mainly sandy	1							
	No organic detritus, mainly mud	0							
13	Aquatic vegetation								
	Little or no macrophyte or algal growth	4							4
	Substantial algal growth; few macrophytes	3	3.5	3.5	3.5	3.5	3.5	3.5	
	Substantial macrophyte growth; little algal growth	2							
	Substantial macrophyte and algal growth	1							
	Total cover of macrophytes plus algae	0							
	RCE Score		35.5	35.0	34.0	33.5	35.0	39.5	46.5
	RCE %age		68.3	67.3	65.4	64.4	67.3	76.0	89.4

Appendix Table A-4 Clarence Mod 2 Aquatic Ecology Monitoring Macroinvertebrate and Fish Results Spring 2022											Sample Site and Sample Date								
								Life Stage			18/11/22	16/11/22	16/11/22	16/11/22	16/11/22	16/11/22	17/11/22		
Phylum	Class	Order	Sub-Order	Family	Sub-Family	Genus/spp	Common name	L	N	A	CECUp	CECDn	DCUp	DCDn	DECUp	DECDn	BCUp	Occurrence	SIG-2
Arthropoda	Insecta	Coleoptera		Dytiscidae			Diving Beetles	x		x	1	1	1					3	2
Arthropoda	Insecta	Coleoptera		Gyrinidae			Whirligig Beetles	x		x			1	1	1	1	1	5	4
Arthropoda	Insecta	Coleoptera		Scirtidae			Marsh Beetles	x						1				1	6
Arthropoda	Insecta	Diptera		Ceratopogonidae			Biting Midges	x			1	1	1	1	1	1	1	7	4
Arthropoda	Insecta	Diptera		Chironomidae	Chironominae		Bloodworms	x			1	1	1	1	1	1	1	7	3
Arthropoda	Insecta	Diptera		Chironomidae	Orthocladiinae		Bloodworms	x						1	1			2	4
Arthropoda	Insecta	Diptera		Chironomidae	Tanypodinae		Bloodworms	x			1	1	1	1	1	1	1	7	4
Arthropoda	Insecta	Diptera		Dixidae			Mensicus Midges	x			1						1	2	7
Arthropoda	Insecta	Diptera		Simuliidae			Black Flies	x			1	1	1	1	1	1	1	7	5
Arthropoda	Insecta	Diptera		Tipulidae			Crane Flies	x			1		1	1	1	1	1	6	5
Arthropoda	Insecta	Ephemeroptera		Leptophlebiidae			Mayflies		x		1	1	1	1	1	1	1	7	8
Arthropoda	Insecta	Hemiptera		Corixidae			Lesser Water Boatmen				1	1						2	2
Arthropoda	Insecta	Hemiptera		Notonectidae			Backswimmers				1	1						2	1
Arthropoda	Insecta	Hemiptera		Veliidae			Small Water Striders				1		1	1				3	3
Arthropoda	Insecta	Mecoptera		Nannochoristidae			Scorpionflies	x			1		1					2	9
Arthropoda	Insecta	Odonata	Epiproctophora	Aeshnidae			Dragonflies	x			1		1					2	4
Arthropoda	Insecta	Odonata	Epiproctophora	Corduliidae			Dragonflies	x			1	1						2	5
Arthropoda	Insecta	Odonata	Epiproctophora	Libellulidae			Dragonflies	x			1							1	4
Arthropoda	Insecta	Odonata	Epiproctophora	Synthemistidae			Dragonflies	x			1	1	1	1	1	1	1	7	2
Arthropoda	Insecta	Odonata	Epiproctophora	Telephlebiidae			Dragonflies	x			1	1			1	1	1	5	9
Arthropoda	Insecta	Odonata	Zygoptera	Argiolestidae			Damselflies	x					1	1		1		3	5
Arthropoda	Insecta	Odonata	Zygoptera	Coenagrionidae			Damselflies	x			1							1	2
Arthropoda	Insecta	Odonata	Zygoptera	Lestidae			Damselflies	x			1							1	1
Arthropoda	Insecta	Odonata	Zygoptera	Synlestidae			Damselflies	x				1						1	7
Arthropoda	Insecta	Plecoptera		Gripopterygidae			Stoneflies		x			1	1	1	1	1	1	6	8
Arthropoda	Insecta	Plecoptera		Notonemouridae			Stoneflies		x		1							1	6
Arthropoda	Insecta	Trichoptera		Ecnomidae			Caddis Flies	x				1	1	1	1	1		5	4
Arthropoda	Insecta	Trichoptera		Helicophidae			Caddis Flies	x				1	1	1				3	10
Arthropoda	Insecta	Trichoptera		Hydrobiosidae			Caddis Flies	x			1			1			1	3	8
Arthropoda	Insecta	Trichoptera		Hydropsychidae			Caddis Flies	x						1				1	6
Arthropoda	Insecta	Trichoptera		Hydroptilidae			Caddis Flies	x			1	1		1			1	4	4
Arthropoda	Insecta	Trichoptera		Leptoceridae			Caddis Flies	x				1	1	1	1	1	1	6	6
Arthropoda	Insecta	Trichoptera		Philorheithridae			Caddis Flies	x						1	1			2	8
Arthropoda	Arachnida	Acarina	Hydracarina				Freshwater Mites					1		1	1			3	6
Arthropoda	Crustacea	Decapoda		Parastacidae			Freshwater Crayfish					1						1	4
Arthropoda	Crustacea	Isopoda	Phreatoicidea	Phreatoicidae			Isopods					1	1	1	1	1	1	6	4
Annelida	Oligochaeta						Freshwater Worms					1	1	1	1	1	1	6	2
Platyhelminthes	Turbellaria	Dalyellioida		Temnocephalidae			Temnocephalans					1	1					2	5
Chordata	Amphibia						Tadpoles				1							1	*
Chordata	Osteichthyes			Galaxiidae		*Galaxias olidus*	Mountain Galaxias						1	1				2	*
							Total number of invertebrate taxa per site:				22	22	20	23	17	15	16	38	
							Site SIGNAL2 Scores:				4.45	4.77	4.85	5.17	5.06	4.87	5.19		
Notes:	* represents those taxa for which SIGNAL-2 scores are not available									EPT:	4	6	5	9	5	4	5	10	

Plate 1: Looking upstream at upper Carne Creek east monitoring site CECUp in spring 2022.

Plate 2: Looking downstream at CECUp.


Plate 3: Looking upstream at CECUp.


Plate 4: Looking upstream at Carne Creek eastern tributary swamp site CECDn, from the upstream end of the site.


Plate 5: Looking downstream at CECDn.


Plate 6: Looking upstream at localised open pool section at CECDn.

Plate 7: Looking downstream at CECDn.

Plate 8: Looking downstream through swampy section at CECDn.

Plate 9: Looking upstream at Dingo Creek site DCUp.

Plate 10: Looking upstream through DCUp swamp.

Plate 11: Looking downstream through DCUp swamp.

Plate 12: Open pool area at DCUp swamp.

Plate 13: Looking upstream through one of the more incised pools in Dingo Creek downstream site DCDn.

Plate 14: Looking downstream through DCDn swamp.

Plate 15: Looking downstream through incised channel at DCDn.

Plate 16: Looking upstream at section of incised channel at upstream eastern Dingo Creek tributary site DECUp.

Plate 17: Looking downstream at DECUp

Plate 18: Looking downstream through swamp habitat at DECUp.

Plate 19: Looking downstream at DECUp.

Plate 20: Filamentous green algae at DECUp.

Plate 21: Looking upstream at Dingo Creek eastern tributary downstream site DECDn.

Plate 22: Looking upstream at DECDn.

Plate 23: Looking upstream at DECDn.

Plate 24: Looking downstream at DECDn.

Plate 25: Looking north across track crossing just upstream of Bungleboori Creek site BCUp in spring 2022.

Plate 26: Looking downstream from the track crossing.

Plate 27: Looking downstream at Bungleboori Creek upstream site BCUp in spring 2022.

Plate 28: Looking downstream in BCUp.

Plate 29: Dragonfly larva (family Telephlebiidae) from BCUp.

CENTENNIAL COAL
CLAENCE COLLIERY
ANNUAL 2022 SUMMARY REPORT

AQUATIC ECOLOGY MONITORING
WOLLANGAMBE RIVER

Looking upstream at Wollangambe River site WGRdown

REPORT PREPARED FOR
CLARENCE COLLIERY PTY LTD

MARINE POLLUTION RESEARCH PTY LTD

MARCH 2023

1 INTRODUCTION

Clarence Colliery has prepared a site-specific Water Management Plan (WMP) in accordance with the conditions of development consent DA504-00. The WMP provides, *inter alia*, the framework for assessing, managing, monitoring and mitigating impacts from the surface water system, and includes the requirement for monitoring of aquatic ecology under the Stream Health Monitoring Program.

This Annual Report summarises and compares the results of the 19th and 20th biannual stream health sampling surveys which were undertaken in autumn and spring 2022. Biannual aquatic ecology monitoring is undertaken to assess the possible effects of the Clarence Colliery Licensed Discharge Point 2 (LDP002) on the aquatic ecology of Wollangambe River downstream, and the aquatic ecology surveys are conducted using standardised methods also applied to other Centennial Coal stream health studies in the Coxs and Wolgan River upper catchments. The Aquatic Ecology Monitoring study considers the following questions:

- Are there measurable differences in aquatic ecological habitat or riparian attributes between river or creek pools upstream and downstream of LDP002, and within reference sites?
- Are there measurable differences in aquatic macroinvertebrate assemblages at the AusRivAS level of taxonomic resolution between Wollangambe River Upstream and Downstream of Discharge sites?
- Can observed differences be attributable to spatial (between-site) differences and/or Colliery discharge?
- Do the survey sites provide suitable and sustained aquatic habitat for fish and other aquatic biota?
- Do the sites provide suitable fish passage?

To be able to answer these questions and generate a holistic picture of stream health a number of monitoring tasks are undertaken including:

- Metered water quality profiling
- Fish trapping
- Aquatic macroinvertebrate assemblage analysis using macroinvertebrate Diversity, SIGNAL Index and EPT assessment.
- Aquatic habitat assessment using the Riparian Channel Environment (RCE) habitat scoring system.

1.1 Sampling Methods

Detailed sampling methodology is provided in the seasonal monitoring reports. In summary the study incorporates the AusRivAS aquatic macroinvertebrate sampling protocols (Turak *et al* 2003) which recommends that, wherever possible, two habitats (riffles and edges) be sampled at each site with the following definitions applicable:

- A site is "a stream reach length of 100 m or 10 times stream width, whichever is the greater"
- A riffle habitat is "an area of broken water with rapid current that has some cobble or boulder substratum". However, "sampling riffles where the substratum consists predominantly of large boulders or gravels may be difficult and may not produce reliable results".
- Edge habitat is "an area along the creek with little or no current".

As sampling has conformed to these definitions, the ‘riffle’ habitat criteria are only able to be met for the downstream site WGRXdown, there were seven sites sampled for both the autumn and spring 2021 Clarence aquatic ecology surveys (**Table 1**).

Table 1 Clarence LDP Aquatic Ecology Seasonal Sample Site Information			
Site	Coordinates		Description
	E	N	
WGR up	243889	6295015	Upstream Wollangambe River monitoring site located above LDP002 input.
WGR dam	244427	6294590	Site sampled at upper end of the Main Dam below the confluence of LDP002 and Wollangambe River.
WGR trib1	244568	6294840	Site sampled within lower limits of unnamed tributary, in ‘backwaters’ of discharge from Main Dam spillway.
WGR swamp	244871	6294619	Site located at the downstream end of the lower of two swamps in Wollangambe River, around 530m below the Main Dam weir.
WGR down	245070	6294799	Downstream monitoring site located in Wollangambe River around 950m below the Main Dam weir.
WGRX down	245452	6293646	Downstream monitoring site located in Wollangambe River around 2.6km downstream from the Main Dam weir.
WGR ref	245073	6294952	Reference tributary site which flows in a southerly direction to join Wollangambe River at WGRdown.

In total there were four sampling sites in the Wollangambe River, one site in the Main Dam and two sites in unnamed reference creek tributaries (see **Figure 2**). Site WGRup is now sampled approximately 400m upstream from its original location. The autumn 2012 survey report (MPR 2012) provides detailed descriptions of the original sample sites, with additional descriptions for sites brought online over subsequent seasons provided in the corresponding reports; WGRXdown in autumn 2013 (MPR 2013b) and WGRtrib1 in spring 2014 (MPR 2015).

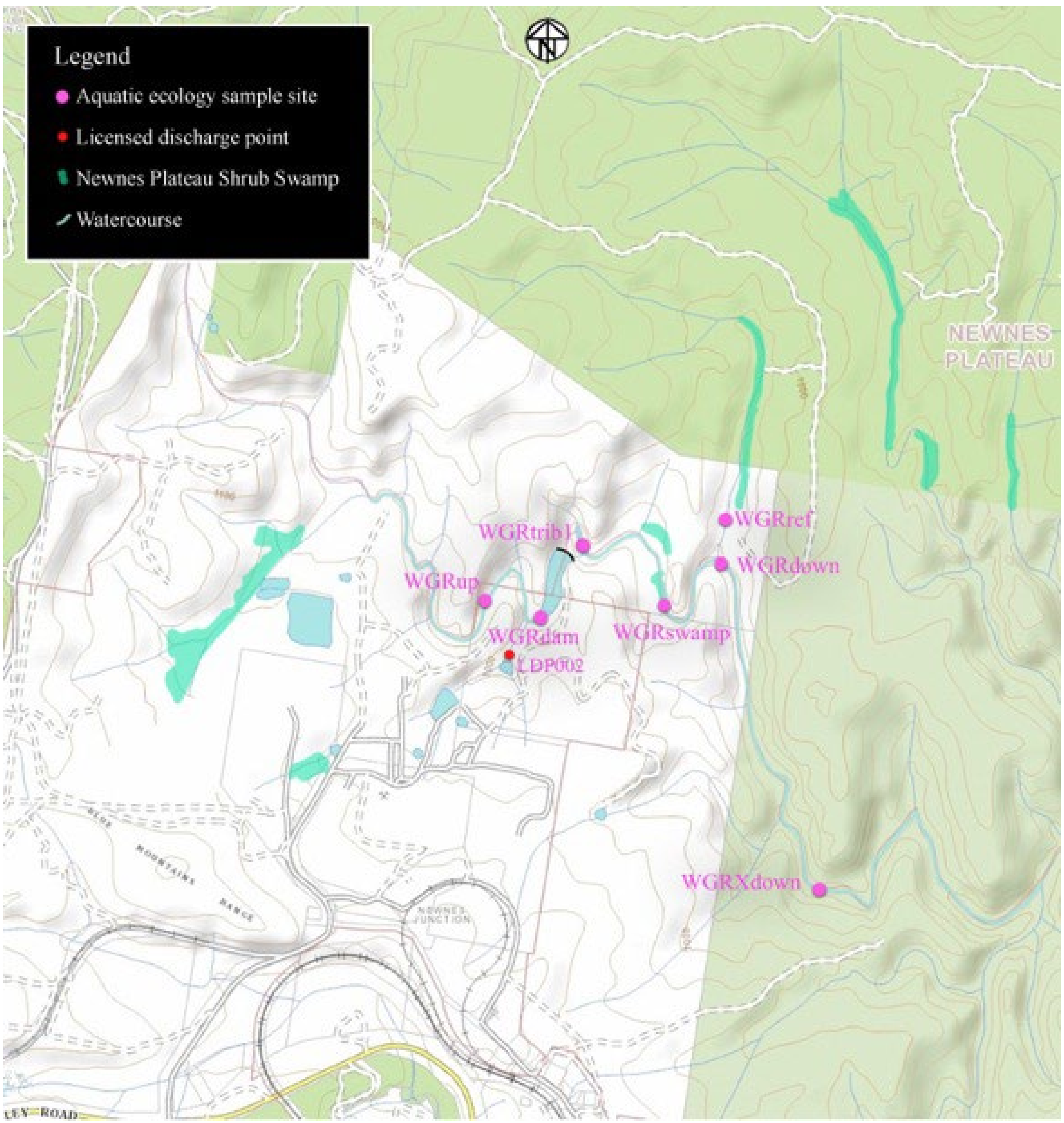

Figure 2. Clarence Aquatic Ecology Sample Sites 2022.

2 MONITORING RESULTS

2.1 Weather and Flow Leading Up to the Biannual Sampling Surveys

Table 2 below presents the monthly rainfall totals for 2021 and 2022, with the 2021 and 2022 autumn and spring sample months shaded grey. Rainfall measurements are recorded at Clarence Mine Meteorological Station, with long-term mean and median monthly totals acquired from Bureau of Meteorology (BOM) Lithgow, Cooerwull rainfall Gauge 63226. The LDP002 total and mean monthly discharge data for 2022 is provided in **Table 3** with autumn and spring sample months shaded in grey, and the daily rainfall and LDP discharge results for 2021 and are shown graphically in **Figure 3**.

Table 2 Clarence Monthly Rainfall Records 2021-2022

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	77.6	113.6	320.6	5.2	80.0	52.6	47.8	108.6	25.6	55.2	218.8	132
2022	181.4	103.6	321.2	108.4	91.6	19	247.2	67.8	112.2	137.4		
Median	79.1	62.2	60.3	47.8	37.6	56.6	47.2	53.2	48.7	58.7	52.0	67.7
Mean	85.7	81.0	77.8	57.1	51.1	71.7	61.7	58.0	56.2	62.5	65.2	79.1

Table 3 Clarence Monthly LDP002 Discharge Records 2022

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2022	527.9	403.8	616.5	572.8	340.8	359.9	490.0	479.5	484.2	624.7		
Mean	17.0	14.4	19.9	19.1	11.0	12.0	15.8	15.5	16.1	20.2		

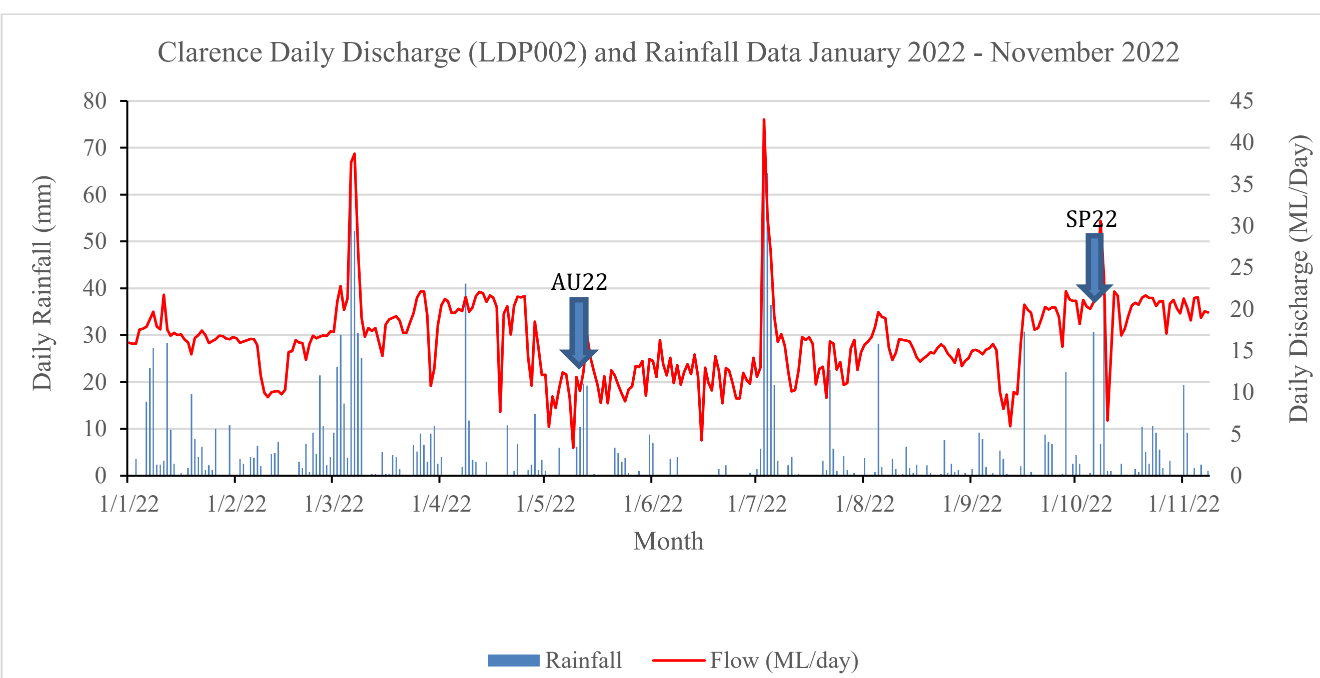

Figure 3 Monthly Rainfall & Monthly discharge between Jan 2022 – November 2022

Rainfall throughout 2022 has been well above average with some major flood events. Over the year of 2022 mean daily discharge from LDP002 ranged from 11 ML/day and 20 ML/day on a month-to-month basis with a few major peaks associated with large rainfall events, which in some cases peaked at over 70 ML/day.

2.1.1 Autumn survey 9 to 10 May 2022

The combined rainfall total over the five-month period between December 2021 and April 2022 (848mm) was more than double the combined mean monthly total for the same months (381mm). Patterns of precipitation over the five-month period was characterised by regular rain events, with 78% of the days registering rainfall. March 2022 was the wettest month, recording the highest total rainfall with 317mm over 30 rainfall days, including 78% of the monthly total in the first eight days of the month (243mm). Daily discharges from LDP002 were for the most part, consistent between November 2021 and May 2022, maintaining flow rates between 15 and 22 ML/day. However, in response to 218mm rainfall over the preceding 7 days, daily discharges during a single event increased to a maximum of 39 ML/day on the 7th March (**Figure 3**), and this abated quickly with the easing of wet weather conditions.

2.1.2 Spring survey 4 to 5 October 2022

Monthly rainfall between the 2022 autumn and spring surveys was generally above or close to monthly averages, with several major contributing rain events. July was the wettest month totalling almost 250mm, where 80% (200mm) of this fell within the first week. Both August and September endured average rainfall with a couple of 30mm days. Leading up to sampling in early October, 32mm fell within the week prior to sampling, where the sampling days themselves were dry. Daily discharge rates fluctuated between the autumn and spring 2022 surveys, ranging between 4 and 42 ML/day. Discharge in early July spiked at 42 ML/day in response to 170mm falling across three days. Leading up to sampling in early October, daily discharge ranged mostly between 10 – 20ML/day, where discharge was slightly above 20 ML/day the week prior to sampling.

2.2 Wollangambe Streamhealth Results

2.2.1 Wollangambe River Site Metered Water Quality

Full results of the metered water quality sampling for autumn and spring 2022 are provided in the respective Seasonal Data Reports and **Table 4** below provides a comparison of site water conductivity results for each of the monitoring locations sampled in autumn and spring 2022 against the long term-conductivity statistics for each site. Note that 'N' represents the number of samples prior to the spring 2022 survey from which the tabulated running Long Term Mean ± Standard Deviation (LTM ± SD) ranges are calculated. Note also that the autumn 2022 survey results are assessed against LTM ranges calculated up until spring 2021.

The autumn and spring 2022 survey water quality results showed patterns consistent with former survey results, with differences attributable to the influence of LDP waters on background Wollangambe River upstream and tributary runoff:

- All of the autumn and spring 2022 sites recorded electrical conductivity (EC) values within the ANZG (2018) default trigger value (DGV) range for slightly disturbed upland rivers (EC 30 to 350 µS/cm) with the exception of the upstream, reference and tributary sites which recorded conductivity values below the range (**Table 4**).
- Most site conductivity values were within their respective LTM ± SD range with the exception of WGRtrib (12 & 10 µS/cm), WGRswamp (214 & 249 µS/cm) during both autumn and spring surveys, and WGRdown (215 µS/cm) and WGRXdown during just the autumn 2022 survey.

Table 4 Clarence Site Conductivity Summary Statistics (µS/cm)

	WGR up	LDP002d	WGR dam	WGR trib1	WGR swamp	WGR down	WGRX down	WGR ref
Au22	7	298	273	12	214	215	213	5
Sp22	5	298	268	10	249	250	234	3
N	19	20	19	14	19	20	18	17
Min	1	169	118	6	220	217	178	0
Max	89	466	437	266	435	439	415	32
Mean	20.3	330.2	301.6	164.0	312.5	304.8	271.5	11.3
SD	19.2	67.8	81.3	93.3	56.0	59.0	50.7	9.9
X-SD	0.0	262.4	220.2	70.7	256.4	245.8	220.8	1.4
X+SD	39.5	398.0	382.9	257.3	368.5	363.7	322.2	21.2

- LDP conductivity (298 µS/cm) was the same for both the autumn and spring 2022 survey, though conductivity varied between surveys downstream with the autumn survey returning lower conductivity results. This is attributable to the lower discharge rates during the autumn 2022 sampling and the contribution of naturally low conductivity waters upstream of the LDP and from downstream tributaries.
- Water pH values for both autumn and spring 2022 were similar, and also in line with former surveys, however as noted for conductivity, pH was lower downstream of the LDP for the autumn survey due to a drop in discharge over the survey and increased (relative) proportion of runoff from upstream swamp areas.
- Sites within the Wollangambe River were within range for slightly disturbed upland rivers (6.5-8 pH units). Water pH values recorded in the upstream of LDP and Wollangambe River tributary sites (WGRup, WGRtrib and WGRref) were all below the ANZG DGV range (4.74 – 5.27 pH units) as a result of the upstream swamp areas producing naturally acidic runoff through these sites, plus these sites are not diluted with LDP water.

2.2.2 Wollangambe River Aquatic Habitat Conditions

Table 5 below provides seasonal summary data for the Aquatic and Riparian Habitat condition - as estimated using the RCE Index. The table also provides a comparison of individual site results against the previous seasonal results and against site long term Mean (LTM) and Standard Deviation of the Mean (SD) statistics for each site. The Riparian, Channel and Environment (RCE) Inventory indicates that most site riparian and channel conditions continue to remain in *good* condition (>70%). Most sites had similar RCE% values to previous surveys, with a few slight changes throughout (**Table 5)**.

The RCE values during both the 2022 autumn and spring surveys remained similar to 2021. Changes to the RCE scores were due changes in three categories: "Aquatic vegetation", "Channel sediment accumulation" and "Stream detritus". While changes in RCE values since 2021 have been slight, most of these changes can be attributed to the large rain events and flows that have occurred over the duration of 2022.

Between the autumn and spring 2022 surveys, sites WGRup and WGRdam were the only two sites that had changes in RCE values. WGRup slightly decreased as a result of higher sediment accumulations and deposits through the site and WGRdam also decreased as a consequence of minor increases in macrophyte growth.

Table 5 Seasonal Long Term RCE %

Season	WGRup	WGRdam	WGRtrib1	WGRswamp	WGRdown	WGRXdown	WGRref	WGRref2
Au12	95.2	67.3	95.2					
Sp12	94.2	87.5		67.3	91.3		95.2	
Au13	94.2	67.3		89.4	89.4	93.3	95.2	
Sp13	79.8	57.7		75.0	77.9	78.8	81.7	76.0
Au14	85.6	61.5		80.8	80.8	84.6	84.6	81.7
Sp14	90.4	66.3	88.5	84.6	85.6	89.4	90.4	87.5
Au15	90.4	67.3	89.4	85.6	86.5	91.3	91.3	87.5
Sp15	89.4	66.3	88.5	82.7	85.6	90.4	90.4	86.5
Au16	92.3	68.3	89.4	84.6	87.5	91.3	91.3	
Sp16	89.4	66.3	89.4	82.7	87.5	91.3	91.3	
Au17	90.4	68.3	89.4	84.6	87.5	91.3	90.4	
Sp17	90.4	67.3	89.4	80.8	87.5	91.3	91.3	
Au18	90.4	64.4	87.5	80.8	87.5	91.3	91.3	
Sp18	90.4	64.4	85.6	80.8	87.5	91.3	91.3	
Au18	90.4	64.4	85.6	80.8	87.5	91.3	91.3	
Sp18	90.4	64.4	85.6	80.8	87.5	91.3	91.3	
Au19	90.4	64.4	85.6	80.8	87.5	91.3	91.3	
Sp19	90.4				87.5	91.3		
Au20	78.8	64.4	87.5	78.8	81.7	84.6	77.9	
Sp20	79.8	64.4	87.5	78.8	81.7	84.6	80.8	
Au21	81.7	63.5	87.5	78.8	81.7	84.6	79.8	
Sp21	77.9	63.5	86.5	78.8	81.7	84.6	80.8	
Au22	78.8	63.5	85.6	78.8	81.7	84.6	81.7	
Sp22	76.9	62.5	85.6	78.8	81.7	84.6	81.7	
LTM	88.3	66.2	88.1	80.9	85.7	89.0	88.5	83.8
SD LTM	5.2	5.5	2.4	4.5	3.4	3.8	5.3	5.0

2.2.3 Wollangambe Macroinvertebrate and Fish Results

Tables 6 to 8 provide summary statistics for seasonal and site Diversity (taxa richness), SIGNAL and EPT scores, which are derived from the seasonal LDP monitoring program aquatic macroinvertebrate data.

The tables also provide a comparison of individual site results against the previous seasonal results and against site long term Mean (LTM) and Standard Deviation of the Mean (SD) statistics for each site.

While each of the autumn and spring 2022 results are assessed against the LTM ± SD ranges calculated from all surveys preceding each respective survey, the LTM and SD values provided in Tables 6 to 8 are calculated from all results preceding the spring 2022 survey:

- **Red** highlight indicates results are below the LTM - SD value.
- **Yellow** highlight indicates results in the range LTM to LTM - SD.
- **Green** highlight indicates results in the range LTM to LTM + SD.
- **No highlight** indicated values > the LTM + SD value.
- Results in **Bold** are the site Minimum Value.

The 2022 aquatic ecology results varied between the autumn and spring surveys, where the spring results had reduced compared to former surveys and had site values below the LTM ± SD:

- The Wollangambe River site macroinvertebrate edge sample diversity results reduced across all sites between the 2022 autumn and spring survey, with the majority of site diversities being below their LTM ± SD range (**Table 6**). Sites WGRswamp, WGRdown and WGRXdown-edge were the only sites that were within their respective LTM ± SD ranges in spring 2022, and sites WGRXdown-riffle and WGRtrib1 recorded new minimum values of 3 taxa & 13 taxa respectively during the spring 22 survey.
- Whilst Signal index results had slightly reduced for most sites between the autumn and spring 2022 surveys, mean values were still inline with former surveys and all sites were within their LTM ± SD range, with the exception of WGRXdown-riffle which was below (**Table 7**).

Table 6 Seasonal Long Term Site Diversity (No. Of Taxa)								
Site Season	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	**12**	15	14		8	15		
Sp12	19	17	14		8	20		
Au13	14	15	16		8	11	13	11
Sp13	17	14	14		11	15	**11**	4
Au14	14	14	18		8	**7**	16	9
Sp14	22	16	22	20	13	19	19	8
Au15	16	16	16	15	8	12	16	10
Sp15	14	13	16	18	5	14	14	12
Au16	17	15	16	19	11	14	16	8
Sp16	18	17	20	18	8	10	15	7
Au17	13	17	14	17	9	11	15	7
Sp17	13	17	16	17	**3**	8	16	9
Au18	18	16	15	18	10	7	14	11
Sp18	13	17	**12**	16	6	12	14	7
Au19	18	18	14	17	10	8	12	8
Sp19	15					7	19	11
Au20	15	16	13	17	10	12	13	11
Sp20	20	16	14	20	8	15	16	9
Au21	13	15	16	19	9	12	15	5
Sp21	**11**	**12**	17	20	7	14	13	6
Au22	13	17	16	16	11	17	14	6
Sp22	**11**	13	**12**	**13**	8	14	14	**3**
LTM	15.6	15.6	15.6	17.9	8.4	12.2	14.8	8.5
SD LTM	2.9	1.5	2.4	1.5	2.3	3.7	2.1	2.3

Table 7 Seasonal Long Term Signal Indices								
Site Season	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	5.92	6.07	4.14		4.50	5.73		
Sp12	5.35	5.29	2.86		4.25	4.55		
Au13	6.00	5.80	3.19		5.63	4.64	5.23	6.09
Sp13	5.67	5.79	3.36		5.00	4.87	4.09	5.50
Au14	6.14	5.21	3.94		4.13	4.50	4.13	4.67
Sp14	5.59	4.81	3.32	3.56	4.08	3.89	4.28	5.13
Au15	5.56	5.63	3.60	**3.14**	4.88	4.45	5.88	6.60
Sp15	5.08	4.77	3.73	3.47	4.60	4.15	4.29	5.00
Au16	5.00	5.00	3.13	3.72	4.09	4.62	4.65	6.25
Sp16	5.11	5.12	4.26	3.18	5.00	4.44	5.27	5.57
Au17	5.33	**4.59**	3.07	3.38	3.50	4.18	5.27	**3.86**
Sp17	5.08	5.35	3.53	3.63	**3.00**	4.75	4.12	5.56
Au18	4.71	5.53	3.00	3.41	4.20	**3.43**	3.79	6.09
Sp18	4.83	4.81	2.91	4.27	3.33	3.92	5.00	4.57
Au19	5.00	4.94	4.29	3.25	3.82	3.88	4.83	5.88
Sp19	5.43					3.86	5.11	5.82
Au20	**4.07**	4.64	**2.75**	3.47	5.22	4.36	**3.36**	5.91
Sp20	4.89	5.27	3.71	3.47	4.25	4.20	5.27	5.00
Au21	4.92	5.80	3.19	3.65	4.44	4.55	4.73	6.00
Sp21	5.09	5.58	4.13	3.61	4.57	3.62	5.23	4.33
Au22	5.23	4.88	4.31	3.60	4.36	5.00	5.50	4.88
Sp22	4.92	5.00	3.27	3.55	4.75	5.00	4.93	3.33
LTM	5.24	5.26	3.48	3.51	4.34	4.33	4.69	5.43
SD LTM	0.49	0.44	0.50	0.28	0.66	0.51	0.65	0.74

Table 8 Seasonal Long Term EPT Indices

Site Season	WGR up Edge	WGR ref Edge	WGR dam Edge	WGR trib1 Edge	WGR swamp Edge	WGR down Edge	WGRX down Edge	WGRX down Riffle
Au12	7	6	3		2	6		
Sp12	7	6	2		1	4		
Au13	8	5	1		3	3	3	3
Sp13	3	4	1		1	4	2	2
Au14	5	4	2		1	**0**	4	4
Sp14	7	5	3	2	2	4	5	4
Au15	7	**3**	3	**1**	1	2	6	5
Sp15	**3**	5	2	2	1	1	3	4
Au16	5	3	1	3	2	2	6	4
Sp16	6	5	4	2	2	1	5	4
Au17	4	6	1	3	2	2	5	2
Sp17	4	5	2	2	**0**	1	2	2
Au18	4	3	2	2	3	1	2	5
Sp18	3	4	**0**	3	1	2	5	**1**
Au19	6	3	4	2	1	1	3	5
Sp19	5					1	5	3
Au20	3	3	2	2	2	2	**1**	5
Sp20	6	5	1	3	2	2	6	3
Au21	4	5	2	2	3	2	4	4
Sp21	**2**	4	3	3	1	0	4	2
Au22	4	5	4	3	3	2	4	3
Sp22	3	4	1	1	2	4	3	0
LTM	5.0	4.4	2.1	2.3	1.6	2.1	3.9	3.4
SD LTM	1.7	1.1	1.1	0.6	0.8	1.5	1.6	1.2

- The autumn 2022 EPT values were all within or above their respective site LTM±SD range (**Table 8**). While the autumn 2022 EPT values were similar to or greater than the spring 2021 values, there were lower numbers of EPT taxa recorded for the spring 2022 survey across all sites except WGRdown, including three sites which recorded EPT values below their LTM-SD range; WGRup, WGRtrib1 and WGRXdown riffle.
- Compared to the autumn 2022 survey, the low EPT site WGRup for spring was due to the absence of a mayfly family Leptophlebiidae, which also contributed to the lower diversity and Signal score.
- WGRref recorded a reduced diversity and EPT, plus an increase in Signal score between surveys in 2022, this was due to the absence of a caddisfly family Philorheithridae, the absence of some lower Signal scoring taxa and the addition of the high scoring dragonfly family Telephlebiidae.
- WGRdam had reduced diversity, Signal and EPT for the spring survey with the absence of two caddisfly families (Leptoceridae and Philorheithridae).
- Whilst WGRtrib1 had a reduced diversity and EPT with the absence of two caddisfly families (Hydroptilidae and Leptoceridae), the Signal score remained

similar with the absence of a few lesser scoring taxa. This was also the case for WGRswamp where the spring survey did not have Leptoceridae or stoneflies (Gripopterygidae), though the Signal score increased slightly due to the addition of a mayfly (Leptophlebiidae), plus the absence of a few other lower scoring taxa.

- WGRdown decreased in diversity between the autumn and spring survey, however the Signal score remained the same and the EPT increased with the addition of two caddisfly families (Ecnomidae and Leptoceridae).
- WGRXdown edge sample recorded the same diversity for both autumn and spring, with a reduction in Signal score and EPT taxa (absence of Philorheithridae) for spring 2022.
- WGRXdown riffle recorded its lowest diversity, EPT and Signal score in spring 2022. No EPT taxa were recorded in spring, where the autumn 2022 survey recorded two caddisfly taxa (Hydropsychidae and Leptoceridae) and one stonefly family (Gripopterygidae).

With regard to fish species, mountain galaxias (*Galaxias olidus*) were only recorded at WGRref during autumn 2022 and WGRup, WGRtrib1, WGRswamp, WGRdown and WGRref in spring 2022.

3 CONCLUSIONS REGARDING CLARENCE AQUATIC ECOLOGY 2022

Leading up to both the autumn and spring 2022 aquatic ecology surveys, Clarence Colliery and the Wollangambe area was subject to above average rainfall with some major wet weather events causing large amounts of runoff and associated increases in LDP discharge. Discharge rates generally increased in times of greater rainfall and maintained more consistent rates of between 10-20 ML/day for most of 2022.

For five of the seven Clarence aquatic ecology monitoring sites, water quality in the Wollangambe River is influenced by the contribution of LDP002 discharges. For the most part, the 2022 seasonal survey water quality results were mostly within the ANZG (2018) default guideline values (DGVs) for *slightly disturbed upland rivers* and followed a similar pattern to that noted for previous years, however the upstream and reference sites produced values outside the DGV range owing to the naturally acidic, very low conductivity runoff from catchments containing swamps.

The 2022 macroinvertebrate indices results varied between sites; while the autumn 2022 macroinvertebrate diversity, Signal and EPT index values were mostly consistent with, or improved compared to recent surveys (and within or above their respective LTM ranges), the spring 2022 survey results returned relatively low diversity values at all sites except WGRswamp, WGRdown and WGRXdown-edge, and low EPT values at WGRup, WGRtrib1 and WGRXdown-riffle sample.

The site drainage forms are conducive to scouring of in-situ habitats and stream biota during heavy rainfall events, comprising deep and narrow, incised box-shaped channels among the upstream reference site WGRup and downstream of LDP sites in the Wollangambe River. This has been reported as a source of potential invertebrate loss for previous survey occasions, and as the weather patterns in 2022 were characterised by above average rainfall conditions with periodic intense storm activity, it is considered likely that similar phenomena have contributed to the low results at both reference sites and downstream of LDP sites in spring 2022. Additionally, algal matting (biofilms) was present on submerged habitats throughout most of the study sites in spring 2022, particularly WGRdam, which may have contributed to the limited number of specimens retained in samples.

While the autumn results recorded mountain galaxias only from the reference site(WGRref), the spring 2022 survey showed that fish passage remains viable for native fish throughout the Wollangambe River study area length.

There were no threatened or protected invertebrate or vertebrate aquatic species (as listed under the BCA, NSW *Fisheries Management Act 1994* or commonwealth *Environment Protection & Biodiversity Conservation Act 2000*) caught or observed for aquatic habitats during the 2022 Clarence Aquatic Ecology monitoring surveys. With respect to aquatic mammals there were no indications of platypus or Australian water rat usage within the study area noted for either survey in 2022.

APPENDIX A

SAMPLING DATA

AUTUMN 2022
&
SPRING 2022

Appendix Table A-1 Site Field Water Quality Readings Autumn 2022 & Spring 2022									
Site	Date	Time	Depth	Temp	Cond	DO	DO	pH	Turb
			m	°C	µS/cm	%sat	mg/L	Units	ntu
Autumn 2022									
WGRup	10/05/2022	10:26 AM	0.1	11.39	7	61.0	6.68	5.12	0.4
LDP002	10/05/2022	11:09 AM	0.2	15.48	298	60.6	6.05	7.48	1.1
WGRdam	10/05/2022	11:13 AM	0.1	15.13	273	60.3	6.07	7.29	1.5
WGRtrib1	9/05/2022	3:04 PM	0.2	9.64	12	39.6	4.51	4.74	0.1
WGRswamp	9/05/2022	1:34 PM	0.1	12.61	214	60.5	6.44	6.53	0.1
WGRdown	9/05/2022	11:02 AM	0.2	12.12	215	62.3	6.7	6.7	0.2
WGRXdown	10/05/2022	8:00 AM	0.2	12.20	213	62.5	6.71	6.69	0.3
WGRref	9/05/2022	11:17 AM	0.1	10.37	5	60.6	6.79	5.5	0.1
Spring 2022									
WGRup	5/10/2022	9:00 AM	0.1	10.14	5	82.2	9.27	5.27	0.1
LDP002	4/10/2022	3:00 PM	0.1	16.60	298	95.7	9.33	7.92	11.4
WGRdam	4/10/2022	3:15 PM	0.1	16.19	268	93.3	9.18	7.92	5.2
WGRtrib1	4/10/2022	2:30 PM	0.1	14.05	12	80.8	8.33	5.12	1.1
WGRswamp	4/10/2022	1:30 PM	0.1	15.36	249	96.1	9.62	7.19	1.2
WGRdown	4/10/2022	11:00 AM	0.1	14.18	250	98.8	10.15	7.45	3.1
WGRXdown	5/10/2022	8:00 AM	0.1	13.80	234	93	9.63	7.27	0.2
WGRref	4/10/2022	12:15 PM	0.1	9.72	3	91.7	10.44	4.99	0.1

Appendix 6: Heritage Inspection Reports

Appendix	Report Name
Appendix 6A	Aboriginal Heritage Due Diligence Assessment for the Proposed 900 Subsidence Line at Clarence (RPS, 2022a)
Appendix 6B	Phase 1 heritage monitoring of AHIMS sites 45-1-0185, 45-1-0186, 45-1-0188 (915 and 919 panels) (RPS, 2022b)
Appendix 6C	Phase 2 Heritage Monitoring AHIMS Sites 45-1-2872, 45-1-2874 and 45-1-2875 (RPS, 2022c)
Appendix 6D	Dewatering Borehole Aboriginal Heritage Due Diligence Assessment (Umwelt, 2023)

Level 13, 255 Pitt Street
Sydney NSW 2000
T +61 2 8099 3200

Our ref: PR151238-2

Date: 11 March 2022

Isobel Standfast
Environment and Community Coordinator
Centennial Coal Pty Ltd
Clarence Colliery Road,
Off Bells Line of Road,
Clarence NSW 2790

Dear Isobel,

Re: Aboriginal Heritage Due Diligence Assessment for the Proposed 900 Subsidence Line at Clarence

RPS has been engaged by Centennial Coal Company Limited (Centennial) to prepare an Aboriginal heritage due diligence assessment letter report for proposed subsidence line installation situated at the Clarence.

Desktop assessment retuned no Aboriginal sites located within the areas of proposed disturbance. However, three Aboriginal heritage sites were recorded during the visual inspection along the proposed subsidence line and registered to the AHIMS database.

Centennial is a coal mining operation which includes several holdings within the Blue Mountains area, referred to as Centennial's Western Region. Centennial is a wholly owned subsidiary of Banpu Public Company Limited. The Western Holdings are located within the Lithgow and Mid-Western Local Government Areas. The Western Region, Centennial Aboriginal Cultural Heritage Management Plan (ACHMP) provides Centennial with protocols for Aboriginal consultation, handling sensitive cultural information, detailing roles and responsibilities, document control and dispute resolution (RPS, 2021a). The ACHMP includes Clarence Colliery.

This Aboriginal heritage due diligence assessment has been undertaken in accordance with the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales (2010)*. The purpose of an Aboriginal heritage due diligence assessment is to demonstrate that reasonable and practicable measures have been taken to avoid harm to an Aboriginal object and/or place.

1.1 Project Area

Clarence Colliery has been operational since 1979 and, throughout its history, has utilised a number of mining techniques to extract coal from the Katoomba Seam. The current mining technique employs partial pillar extraction (bord and pillar) utilising continuous miners and shuttle cars. The proposed mine plan for the 900 Area includes partial extraction off an 11 heading layout and 7 heading layouts with some and mains development. Partial pillar extraction methods have been employed for over thirteen years.

Clarence Colliery is located approximately two kilometres east of the township of Clarence on the Newnes Plateau within the Lithgow Local Government Area (LGA).

1.2 Proposed Activity

The proposed activity involves minor ground surface disturbance during the installation of the subsidence line by installing vario marks into the subsoil, within the 900 Area lies in Mining Lease. This ground disturbance consists of vegetation clearing and localised ground penetration for manually installing 40 marks with 20 metre spacing.This due diligence assessment specifically relates to the installation of the subsidence line in Figure 1 and does not consider the archaeological potential outside of this area.

1.3 Information and privacy

The report was prepared by RPS Australia East Pty Ltd for Centennial Coal Company Limited.

This report has been prepared by RPS Heritage Consultant Bengi Selvi-Lamb with assistance from Kate Morris (Heritage Consultant) and reviewed by RPS Heritage Manager Susan Kennedy.

1.4 Disclaimer

This report was prepared by RPS within the terms of RPS' engagement with its client and in direct response to a scope of services. This report is supplied for the sole and specific purpose for use by RPS' client. The report does not account for any changes relating the subject matter of the report, or any legislative or regulatory changes that have occurred since the report was produced and that may affect the report. RPS does not accept any responsibility or liability for loss whatsoever to any third party caused by, related to or arising out of any use or reliance on the report.

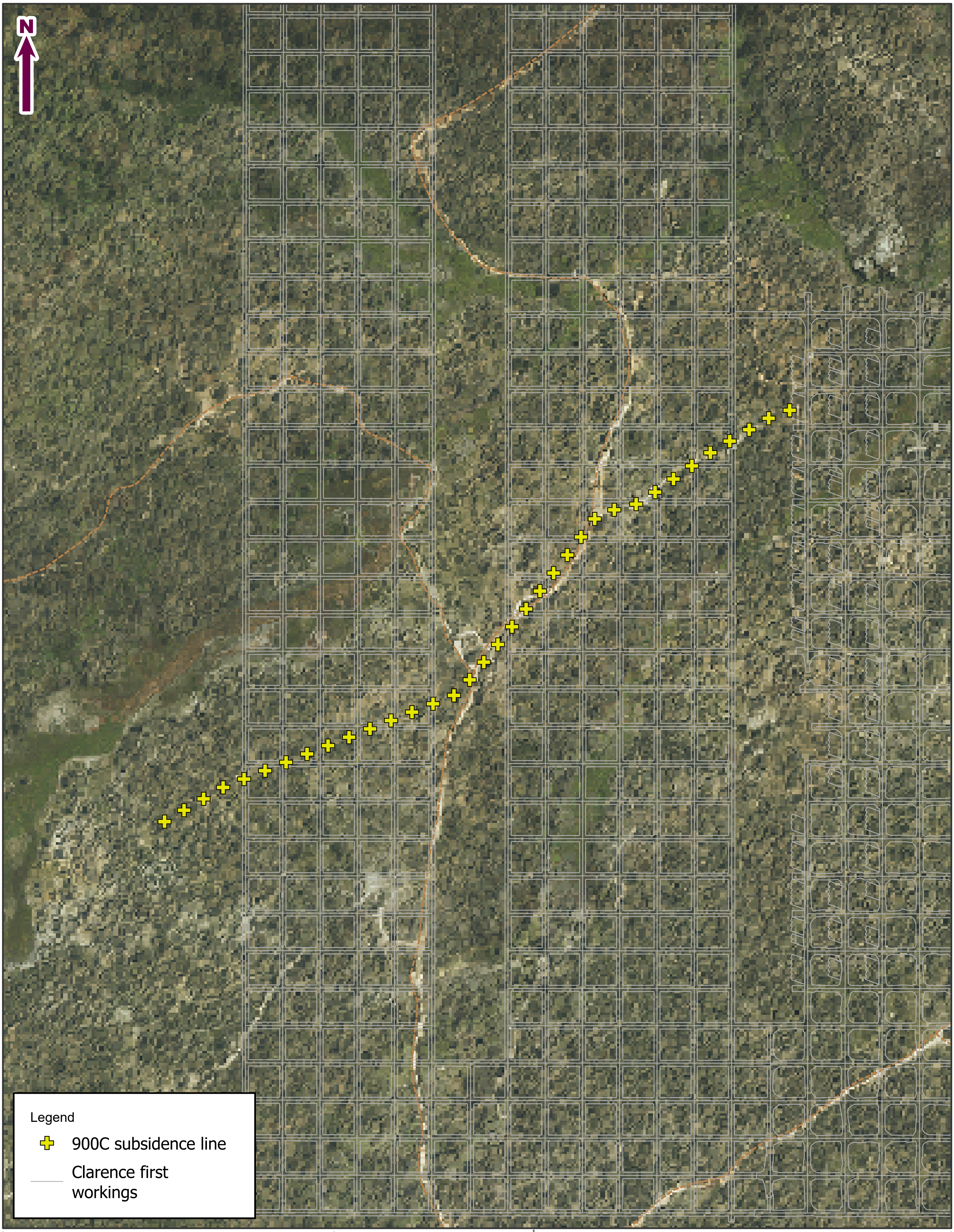

FIGURE 1
PROJECT AREA

VERSION:
A
DATE EXPORTED:
17/01/2022
TECHNICIAN:
Robert.Suansri

LOCATION:
NEWNES PLATEAU, NSW

DATA SOURCES
Centennial, RPS, Esri, HERE, Garmin, USGS, Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user

0 0.1 km

SCALE 1:5,000 AT A4 SIZE
SPATIAL REFERENCE: WGS 1984 Web Mercator Auxiliary Sphere

CLIENT: **Centennial**
PROJ: **PR151238**
PURPOSE: **Due Dilligence**

Project path: S:\Centennial\All Jobs\151238 - Centennial Clarence - Phase 2 Monitoring\10 - Drafting\Arcgis Map Documents\Arch\01_900C_DueDilligence\01_900C_DueDilligence.aprx

2 ENVIRONMENTAL CONTEXT

2.1 Geology and soils

Aboriginal people often made stone tools using siliceous, metamorphic or igneous rocks, as such, understanding the local geology can provide important information regarding resources in a project area. The nature of stone exploitation by Aboriginal people depends on the characteristics of the source, for example, whether it outcrops on the surface (a primary source), or whether it occurs as gravels (a secondary source) (Doelman et al. 2008).

The 900 Area is located in the Western Coalfield within the Sydney Basin. It lies within the Newnes State Forest on an elevated plateau (Newnes Plateau) in the upper reaches of the Bungleboori Creek. The surface of the Newnes Plateau typically comprises Triassic Narrabeen Group sandstones and claystones (King 1992). The Narrabeen Group consists of quartz, sandstone, conglomerate (Banks Wall Sandstone), red-brown claystone (Mt York Claystone), quartz sandstone, conglomerate, red-brown and grey shale (Burra-Moko Head Sandstone) and grey shale and quartz-lithic sandstone (Caley Formation) (King 1992).

The massive Narrabeen Sandstones overlie the Illawarra and Wallerawang Subgroup coal measures, which are late Permian in age (King 1992). These coal measures comprise shale, claystone, coal and minor sandstone (Farmers Creek Formation), and claystone and coal (Katoomba Seam), the overburden being characterised by massive Triassic sandstones (King 1992).

Two soil landscapes were present in the Project Area. First, Mount Sinai soil landscape consists of shallow topsoil (up to two centimetres in depth) which may occur across two horizons (A1and A2). A1 horizon consists of single grained loose pebbly quartz sand, which is of light grey to dull orange. A2 horizon consists of brownish black loamy sand (King 1992). The underlying subsoils (B horizons) may occur between 0 and 70 centimetres in depth. The subsoils consist of dull yellow orange loamy sand and of bright yellowish brown clayey sand (King 1992).

Second, Deanes Creek soils landscape is characterised by a dense vegetation which prevents erosion from occurring in the valley base, however, minor sheet erosions can occur on the swamp margins (King 1992). Soils consist of black organic rich sandy clay loam topsoil, greyish yellow brown sandy loam either as topsoil or subsoil, light grey sandy clay topsoil and bright yellowish brown coarse sand subsoil (King 1992). The swamp centres are generally water logged and organic rich loam topsoil overlying the sandy loam subsoil, which in turn overlays both the light grey sandy clay and the bright yellow brown coarse sands (King 1992). The swamp margins are either moderately well drained or waterlogged and consist of black organic rich soils which overlie the sandy loams. (King 1992).

2.2 Topography and hydrology

The topography of the Project Area is characterised by localised slopes, rock outcrop and the effects of erosion by water action and shallow soils. Plateau areas are flat topped with the side slopes ranging from gently inclined to moderately inclined. Local rock outcrop commonly occurs as small benches, cliffs and low broken scarps in the broad area. Small windblown dunes occur on parts of the Newnes Plateau (King 1992), but none are located in the immediate 900 Area. Swampy drainage depressions are common. The Paddy's Creek is the closest watercourse to the Project Area, Bungleboori Creek and its tributaries are the permanent water source in proximity.

2.3 Flora and fauna

The broad 900 Area encompasses the Sydney Montane Dry Sclerophyll Forest, which is characterised by a range of plant communities including the Blue Mountain Ash and Sydney Peppermint (Keith 2006). The ridges are dominated by Hard Leaved Scribbly Gum and Silvertop Ash and shrubs such as Wattle and herbs such as Blue Flax Lily.

Fauna species encountered within the 900 Area include macropods such as Swamp Wallaby and Red-Necked Wallaby, arboreal mammals, such as Possums and the Greater Glider (Keith 2006), and a moderate diversity of open forest birds including Grey Currawongs, Red-Browed Treecreepers, Scarlet Robins and Flame Robins.

2.4 Land use and disturbance

While the wider region is predominately State Forest and National Park, coalmining occurs in the area. The Project Area is within the mining site of Clarence Colliery and the broad area largely disturbed due to mining activities, infrastructure and tracks.

3 HERITAGE CONTEXT

The local Aboriginal heritage context provides a review of previous archaeological work conducted in the local landscape, identifies whether Aboriginal sites have been previously recorded in the Project Area and informs the predictive model of Aboriginal sites.

3.1 Aboriginal Heritage Management System (AHIMS)

An extensive search was undertaken of the AHIMS on 13 January 2022 (ID 651267) encompassing, Eastings: 240955 - 241610, Northings: 6298532– 6299043 with no buffer. This extensive search identified five (5) sites within the search parameters, including the sites were recorded during the site visit, two of which are located within the subsidence line location (Table 1) (Figure 2).

Table 1 Summary of AHIMS within the searched coordinates

Site Type	Quantity	%
Artefact Scatter	2	40%
Isolated Artefact	3	60%
TOTAL	**5**	**100%**

Three (3) AHIMS site (45-1-2872, 45-1-2874, 45-1-2875) is located along the subsidence line within the Project Area which were identified during the visual inspection. There are also two AHIMS sites in the vicinity of the Project Area. These AHIMS sites are 45-1-2873 and 45-1-0185 which are all located within 150 metres of the Project Area.

AHIMS 45-1-2875 was recoded during this due diligence site visit which contains four artefacts and will be evaluated in detail in Section 5. Additionally, AHIMS 45-1-2872 and 45-1-2874 are also recorded during the same site visit along the vehicle tracks as isolated artefacts.

Two artefact scatters and three isolated artefacts were located either within or close proximity to the Project Area. Therefore, the most common site type is almost equally isolated artefacts and artefact scatters.

It is important to note that the AHIMS register only contains information on Aboriginal sites for which site cards have been submitted, and the presence/absence of recorded Aboriginal sites on the AHIM register does not preclude other sites from being present.

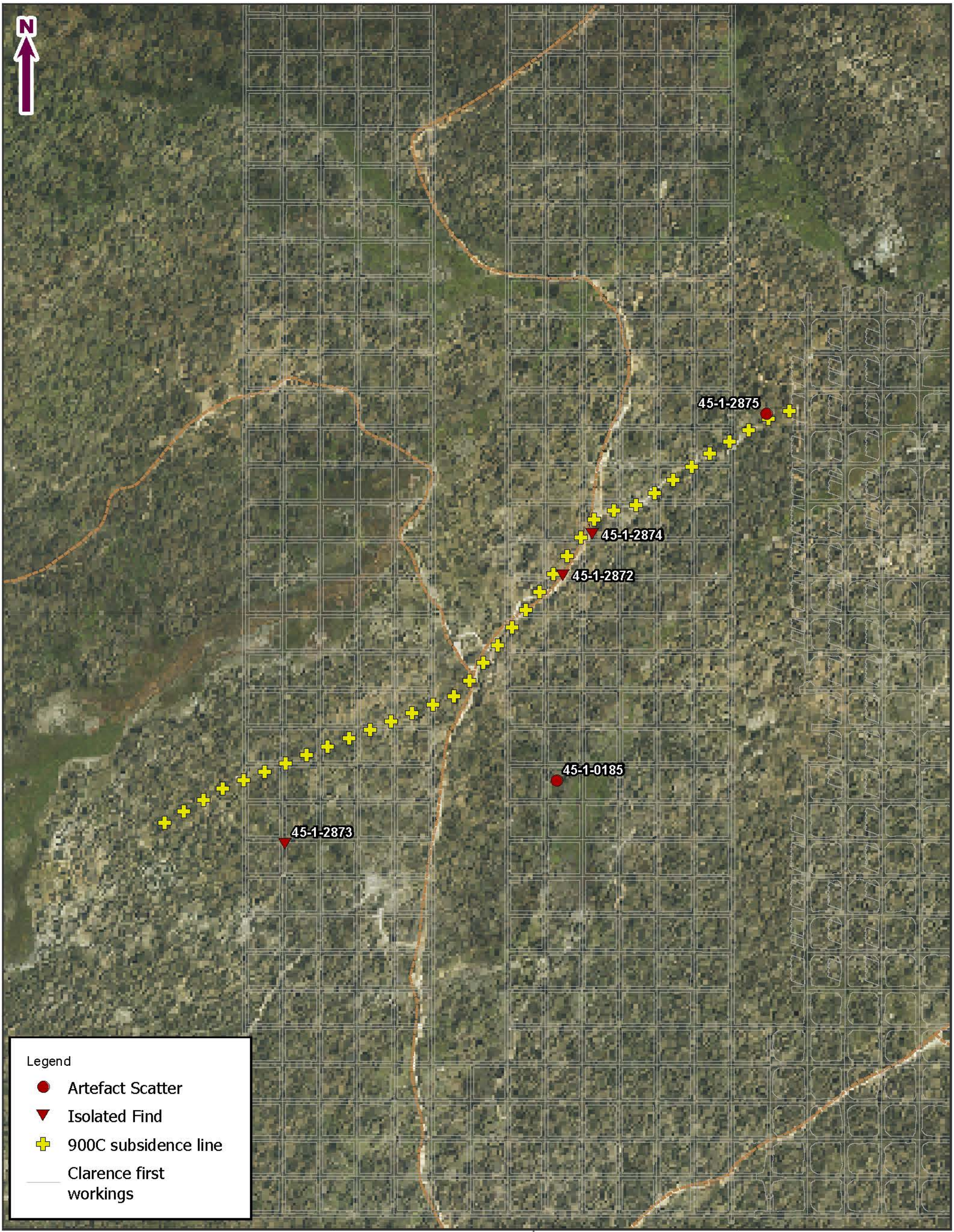

FIGURE 2
PROJECT AREA WITH AHIMS

VERSION:
A
DATE EXPORTED:
17/01/2022
TECHNICIAN:
Robert.Suansri

LOCATION:
NEWNES PLATEAU, NSW

DATA SOURCES
Centennial, RPS, Esri, HERE, Garmin, USGS, Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user

0 0.1 km

SCALE 1:5,000 AT A4 SIZE
SPATIAL REFERENCE: WGS 1984 Web Mercator Auxiliary Sphere

CLIENT: **Centennial**
PROJ: **PR151238**
PURPOSE: **Due Dilligence**

rps

Project path: S:\Centennial\All Jobs\151238 - Centennial Clarence - Phase 2 Monitoring\10 - Drafting\Arcgis Map Documents\Arch\01_900C_DueDilligence\01_900C_DueDilligence.aprx

4 ARCHAEOLOGICAL HERITAGE LITERATURE REVIEW

The majority of the archaeological surveys and excavations in the Blue Mountains region, including the Newnes Plateau, have been in conjunction with environmental assessments for the coal mines, installation of power lines, telecommunications, and state forest works. Based on the information available, a number of trends in site location and patterning are evident. The review of previous archaeological work includes relevant local research publications, as well as archaeological consultancy reports and provides a framework for assessing significance.

Mills, 2000. An Archaeological Survey for the Proposed Extensions to Clarence Colliery, Near Lithgow.

In 2000, Mills was commissioned by International Environmental Consultants Pty Ltd on behalf of Centennial Coal to conduct an archaeological survey ahead of the proposed extension of existing mining operations at Clarence Colliery. The assessment was divided into Area 1, which was approximately 3 x 7 kilometres in size and Area 2, which was approximately 2.5 x 2 kilometres in size. Area 1 comprised the western extension and was characterised by a raised plateau area, hanging swamps and creek lines, low ridge lines, gorges and exposed sandstone cliffs. Area 2, in the eastern extension, was dominated by an east-west flat ridge. This ridge separated the catchment areas of Dumbano Creek to the north and the Wollangambe River to the south.

A total of six sites were identified in Area 1. In Area 2, a complex of scarred trees, two isolated finds, two PADs, one area of potential archaeological sensitivity were identified. A protection zone was also recommended in Area 2; this protection area included exposed sandstone escarpments on the northern, eastern and southern boundaries of the lease and portions of creek lines containing sandstone outcrops. Mills predicted that the greatest threat to heritage sites in the area would be from non-mine associated activities, including unrestricted motocross and four-wheel driving.

RPS, 2012, Due Diligence Assessment for Four Boreholes for Clarence.

RPS was commissioned by Clarence Colliery to undertake a due diligence assessment for four borehole locations to the north of the Clarence Colliery Pit Top. A total of 95 previously recorded Aboriginal sites had been registered within a five kilometre radius of the Project Area, though none were located within the Project Area itself.

A visual inspection of the Project Area was undertaken in March 2012. The visual inspection confirmed that the Project Area was disturbed by previous land uses and ground surface visibility was assessed as low. No Aboriginal cultural heritage material was identified in the Project Area (RPS 2012).

RPS, 2013, Cultural Heritage Assessment for Clarence 900 SMP Area

RPS was engaged by Clarence Colliery to undertake a Cultural Heritage Assessment (CHA) as part of a Subsidence Management Plan for the Clarence 900 Area.

An archaeological field survey was conducted by RPS on February 2013 and three of the nine sites previously identified on the AHIMS database were groundtruthed. AHIMS 45-1-003 is considered to be highly significant at a local level and moderately significant on a regional level. The report concluded that design of the mine has already taken the significance of this site into account and limit subsidence at this location.

The impact assessment concluded that using the performance criteria of no more than 100 millimetres subsidence, the actual 20-70 millimetres expected is comfortably within the limits and therefore the risk of harm to archaeological sites in the 900 Area from subsidence and ground surface disturbance is considered to be negligible.

5 VISUAL INSPECTION AND FIELD RESULTS SUMMARY

A visual inspection of the Project Area was undertaken to identify whether Aboriginal objects are present on the ground surface or are likely to be present below the ground surface. The site visit was conducted in accordance with the *Due Diligence Code of Practice* (DECCW 2010).

5.1 Visual Inspection

The visual inspection of the Project Area was conducted on 7 December 2021 by RPS Heritage Consultant Bengi Selvi-Lamb, together with Centennial Environment and Community Officer, Isobel J. Standfast and Registered Aboriginal Party Sharon Brown (Gundungurra Tribal Council Aboriginal Corporation).

5.2 Field Results

The subsidence line was inspected from southwest to northeast along the Paddy's Creek stream bank. Three isolated artefacts and one Aboriginal artefact scatter were identified in the fieldwork area (Figure 2). One previously recorded AHIMS 45-1-0185 is located 150m to the Project Area. Table 2 shows the name of the sites recorded during this visual inspection with their location (Figure 3).

Table 2 The sites recorded during the visual inspection

Site Name	AHIMS Site Number	Easting	Northing
Clarence Mine AFT-900-01	45-1-2873	241126	6298587
Clarence Mine AFT-900-02	45-1-2872	241366	6298830
Clarence Mine AFT-900-03	45-1-2874	241391	6298867
Clarence Mine AFT-900-04	45-1-2875	241542	6298977

AHIMS 45-1-2873

Clarence Mine AFT-900-01 was identified during the site visit. This isolated artefact was located mid-slope to the south east of the subsidence line from the access track (Plate 1). The area is an open woodland with moderate (around 40%) ground visibility. Ground surface exposure displayed sand with sandstone, natural quartz and basalt inclusions (Plate 2**)**. Damage from the recent bush fires is visible in the area. Recorded as AHIMS 45-1-2873, consisted of one artefact, made from quartz had typical diagnostic features including platform and termination (Plate 3 and Plate 4).

A GPS point was taken from artefact's location. There were no other artefacts visible in close proximity, therefore no PAD will be present. The dimensions of the quartz flake are 6.5mm (length), 4.7mm (width) and 4mm (thickness). The flake is outside the footprint of proposed impact and has been registered on the AHIMS (45-1-2873).

Plate 1 Looking north general view of AHIMS 45-1-2873

Plate 2 Ground visibility and surface exposure at AHIMS 45-1-2873

Plate 3 Ventral surface of the flake

Plate 4 Ventral surface of the flake

AHIMS 45-1-2872

Recorded as Clarence Mine AFT-900-02 during the site visit. This isolated artefact was located on the road boundary **(**Plate 5). This artefact was found on a disturb vehicle track. The ground visibility was high (80%) exposing sand with natural small quartz pebbles.

The artefact identified as quartzite blade (Plate 6 and Plate 7), with diagnostic features such as platform and termination were removed. The dimensions of blade are 6mm (length), 2.5mm (width) and 3.2mm (thickness). The location of the artefact was recorded via handheld GPS, this site is within the footprint of proposed impact and has been registered on the AHIMS (45-1-2872).

Plate 5 Looking north, general view of AHIMS 45-1-2872

Plate 6 Dorsal view of the blade found on AHIMS 45-1-2872

Plate 7 Ventral view of the blade

AHIMS 45-1-2874

Clarence Mine AFT-900-03 was identified during the site visit, approximately 50 metres north of AHIMS 45-1-2872 on eastern side of the road boundary (Plate 8). This artefact was found on a disturb vehicle track. The ground visibility was moderate (50%) and the ground exposure revealed sand with small pebbles.

This site was located on mid-slope adjacent to the disturbed side boundary of a vehicle track. The artefact was made of IMT (Indurated Mudstone/Tuff) flake piece (Plate 9 and Plate 10), with diagnostic features such as platform and termination were removed. The dimensions of the medial flake are 6x3.1x2mm. The location of the artefact was recorded via handheld GPS. It is within the footprint of proposed impact and has been registered on the AHIMS (45-1-2874).

Plate 8 General view of AHIMS 45-1-2874

Plate 9 Dorsal surface of the medial flake

Plate 10 Ventral surface of the flake

AHIMS 45-1-2875

This artefact scatter recorded during the site visit as Clarence Mine AFT-900-04. This artefact scatter is located on the mid slope in close proximity of the north end of the subsidence line. The ground visibility was high (80%) in the site exposing sand with sandstone and natural quartz pebbles.

Four (4) quartz artefacts were identified in one metre radius. The surrounding ground surfaces were inspected for further artefacts but there were no artefacts visible, therefore, there was no evidence of PADs. Two (2) quartz multidirectional cores were exhibiting multiple flake removals and two platforms were present on each core. Additionally, two quartz flakes were found less than a metre to these cores both contained diagnostic features such as platforms and bulbs. The location of the site was recorded via handheld GPS. This artefact scatter is within the footprint of proposed impact and has been registered on the AHIMS (45-1-2874).

Plate 11Looking north general view of AHIMS 45-1-2875

Plate 12 The artefact scatter from AHIMS 45-1-2875

Plate 13The artefact scatter from the site

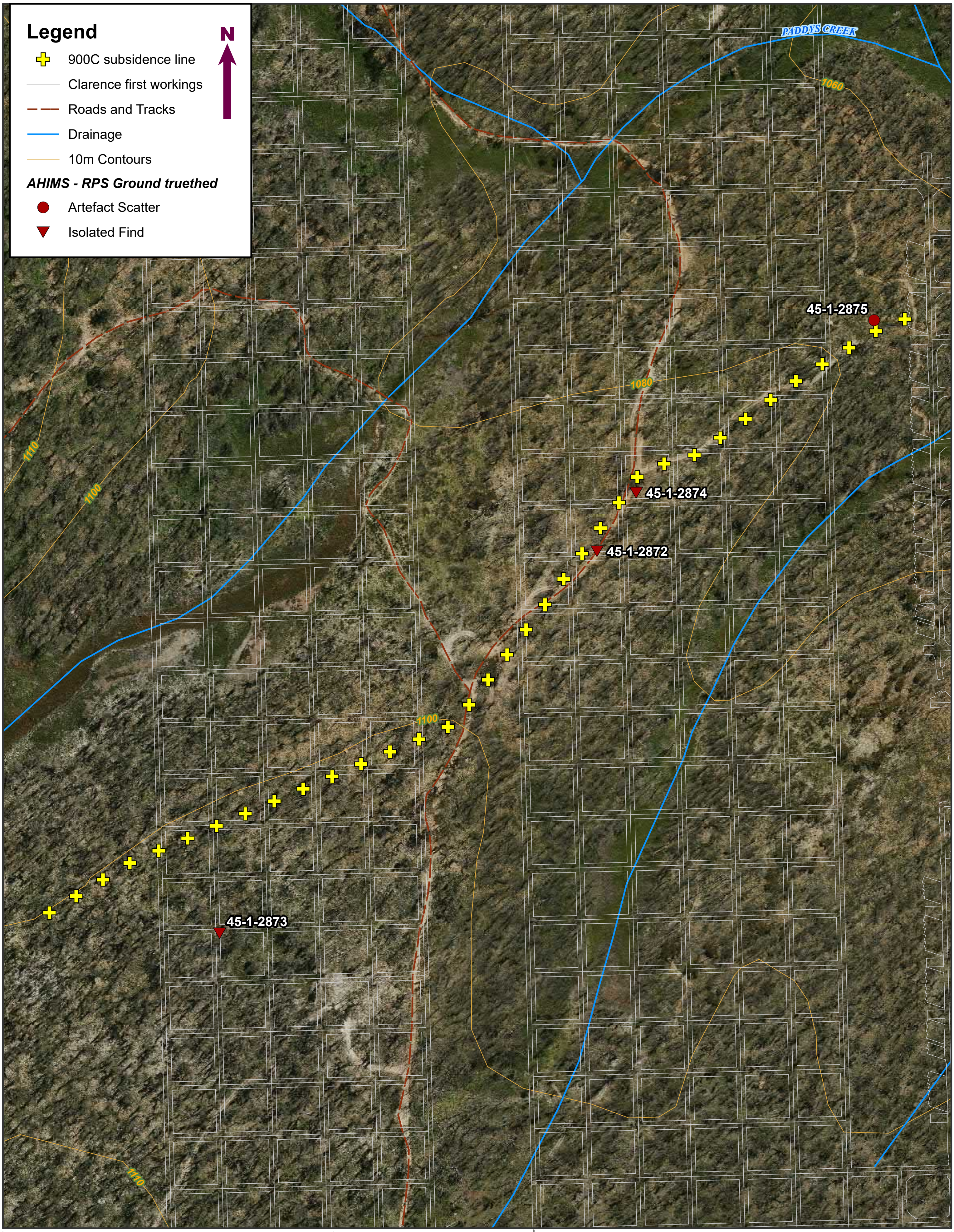

FIGURE 3:
SURVEY RESULTS

VERSION:
A
DATE EXPORTED:
18/02/2022
TECHNICIAN:
Natalie.Wood

LOCATION:
900C Subsidence Line, Clarence

DATA SOURCES
Centennial, RPS, Esri, CGIAR, Esri, HERE, Garmin, FAO, NOAA, USGS

0 20 40 60 80 100 m

SCALE 1:3,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial Coal**
PROJ: **PR151238**
PURPOSE: **Due Dilligence**

Project path: S:\Centennial\All Jobs\151238 - Centennial Clarence - Phase 2 Monitoring\10 - Drafting\Arcgis Map Documents\Arch\01_900C_DueDilligence\01_900C_DueDilligence.aprx

5.3 Visual Inspection Summary

Three isolated artefacts and one artefact scatter were identified during the visual inspection of the proposed subsidence line. The ground visibility was moderate to high with exposed surfaces and vehicle track disturbance. The ground surfaces were inspected with Registered Aboriginal Party Sharon Brown for stone artefacts. Additionally, the trees in the open woodland were inspected for modified/scar trees, however, no trees showed signs of cultural modifications.

6 IMPACT ASSESSMENT

The purpose of a due diligence assessment is to identify whether Aboriginal objects are present, or likely to be present, in the Project Area; to determine whether proposed activities are likely to harm Aboriginal objects (if present).

In response to **Section 8** of the Due Diligence Code outlines the process to guide due diligence assessments, summarised below in relation to the proposed works.

1. *Will the activity disturb the ground surface or any culturally modified trees?*

Yes. The proposed works will include ground surface and subsurface disturbance as the proposed works are the instalment of the subsidence line. The current proposed works include removal of vegetation, and manually hammering 40 pins into subsurface with 20 metre intervals. No culturally modified trees have been registered within the Project Area and none were identified as part of the visual inspection undertaken to inform this assessment.

2. *Are there any:*

   Relevant confirmed site records or other associated landscape feature information on AHIMS?

   Any other sources of information of which a person is already aware?

   Landscape features that are likely to indicate the presence of Aboriginal objects?

No sites were previously recorded within the Project Area, however, three artefact/artefact scatter sites were identified during the visual inspection. These sites have since been recorded in the AHIMS register. As such, there is a high likelihood the identified Aboriginal objects will be impacted during the proposed works.

The Due Diligence Code identifies sensitive landscapes features that indicate the likely existence of Aboriginal objects. These include landscapes features within 200 metres of waters, within 20 metres of a cave/cave mouth/rockshelter, located on a ridgeline/headland, located within 200 metres of a cliff face and located within a sand dune.

Paddy’s Creek is about 150 metres from the Project Area. The proposed subsidence line location is in proximity to a cliff face. Therefore it is determined that the proposed works will occur in proximity to a HNSW defined sensitive landscape which is supported by the survey findings.

3. *Desktop Assessment and Visual Inspection:*

Sections 4 and 5 of this report provide the details of the desktop assessment and visual inspection of the Project Area. The desktop assessment found that while there were nil previously recorded AHIMS sites within Project Area, its environment would have been conducive to potential Aboriginal occupation due to the surrounding landforms. However, visual inspection identified three Aboriginal isolated artefacts, two of which are located within the subsidence line, and one artefact scatter, also within the subsidence line.

During the visual inspection it was noted that the site was minimally disturbed due to 4WD access. The Due Diligence Code specifies:

‘Land is disturbed if it has been the subject of human activity that’s has changed the lands surface, being changes that remain clear and observable’

The results of the AHIMS search and the visual inspection indicate that there are three Aboriginal objects/AHIMS sites within the Project Area.Four (4) Aboriginal sites were identified during the visual inspection, three of which are within the Project Area.

Centennial’s Western Region ACHMP Section 4.1.1 states that:

> *Ground surface movement (including subsidence and/or upsidence) generally poses little harm to artefact scatters and isolated finds, but any form of displacement due to mining activity would still be regarded as an offence under legislation. Although artefacts may not be greatly affected if they are situated on the plane of movement, ones located above the fracture zones may fall into cracks, which ultimately damages the integrity of the site. The assessment of harm to artefact scatters and isolated finds will be assessed on a case by case scenario because the complexity and density of the site coupled with the ground surface integrity influences the potential harm posed to the site.*

On the basis of the above, it is assessed that there is a likelihood that the proposed works will result in harm to Aboriginal objects. The installation of the subsidence line may have a moderate impact on the three AHIMS sites (45-1-2827, 45-1-2874, 45-1-2875) which were recorded during the visual inspection. The location of the vario marks to be installed for subsidence line should avoid these site locations (Figure 4 and Figure 5).

FIGURE 4:
EXCLUSION ZONES FOR 45-1-2872 AND 45-1-2874

VERSION:
A
DATE EXPORTED:
18/02/2022
TECHNICIAN:
Natalie.Wood

LOCATION:
900C Subsidence Line, Clarence

DATA SOURCES
Centennial, RPS, Esri, CGIAR, Esri, HERE, Garmin, FAO, NOAA, USGS

0 10 20 30 40 m

SCALE 1:1,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial Coal**
PROJ: **PR151238**
PURPOSE: **Due Dilligence**

Project path: S:\Centennial\All Jobs\151238 - Centennial Clarence - Phase 2 Monitoring\10 - Drafting\Arcgis Map Documents\Arch\01_900C_DueDilligence\01_900C_DueDilligence.aprx

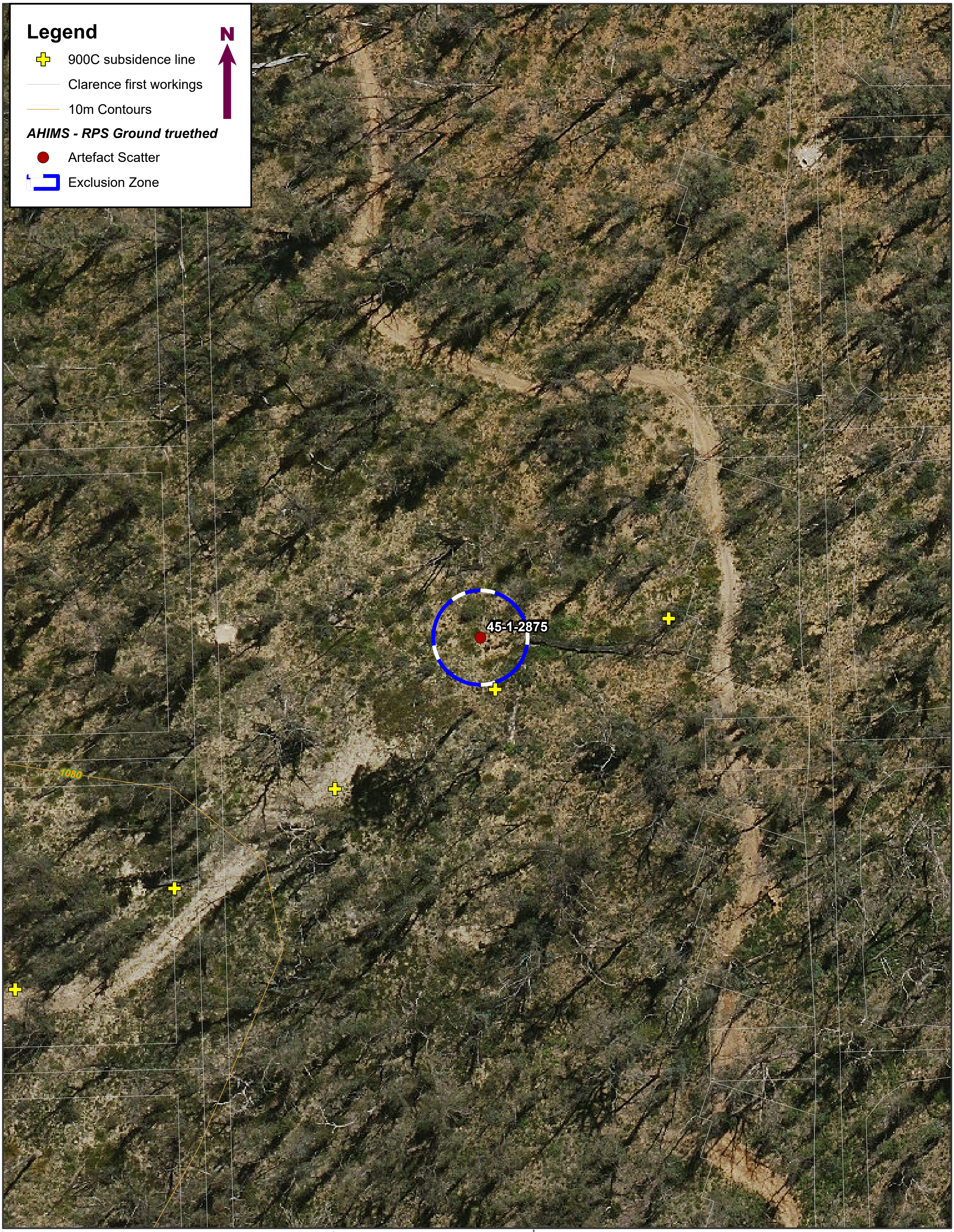

FIGURE 5:
EXCLUSION ZONES FOR 45-1-2875

VERSION:
A
DATE EXPORTED:
18/02/2022
TECHNICIAN:
Natalie.Wood

LOCATION:
900C Subsidence Line, Clarence

DATA SOURCES
Centennial, RPS, Esri, CGIAR, Esri, HERE, Garmin, FAO, NOAA, USGS

0 5 10 15 20 m

SCALE 1:500 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial Coal**
PROJ: **PR151238**
PURPOSE: **Due Dilligence**

Project path: S:\Centennial\All Jobs\151238 - Centennial Clarence - Phase 2 Monitoring\10 - Drafting\Arcgis Map Documents\Arch\01_900C_DueDilligence\01_900C_DueDilligence.aprx

7 CONCLUSION AND RECOMMENDATIONS

This report has considered the environmental and archaeological information available for the Project Area, previous disturbances and the condition of the land and the nature of the proposed activities in order to assess potential impacts to Aboriginal objects.

The search of the AHIMS database revealed no previously recorded Aboriginal site within the proposed location, except for one (1) AHIMS site in 150 m south east of the Project Area. The visual inspection on the 7 December 2021, revealed three (3) AHIMS sites within the proposed subsidence line location and one (1) in close proximity. These sites are identified as isolated artefacts and artefact scatter should not be damaged. Therefore, these sites should be marked and exclusions zones should be implemented to avoid the potential harm.

On the basis of the desktop assessment and visual inspection, it is assessed that there is a moderate likelihood that the proposed works will result in harm to Aboriginal sites and objects.

Recommendations

Recommendation 1: Avoiding and minimising harm

The subsidence line should be limited to existing footprint and registered AHIMS sites 45-1-2827, 45-1-2874, 45-1-2875 should be avoided with buffer of 5 metres.

Recommendation 2: Record keeping

This due diligence assessment must be kept by Clarence Colliery so that it can be presented, if needed, as a defence from prosecution under *Section 86(2) of the National Parks and Wildlife Act 1974.*

Recommendation 3: Unexpected finds procedure, Aboriginal object/s

If unrecorded Aboriginal object/s are identified in the Project Area during works, all works in the immediate area must case and the area cordoned off. The area is to be managed in accordance with the procedures outlined in *Centennial's Western Region ACHMP*.

Recommendation 4: Unexpected finds procedure, historic

If, during the course of development works, suspected historic cultural heritage material is uncovered, work should cease in that area immediately. Protocols under the *Historic Heritage Management Plan – Western Region* are to be followed and works recommence only when an appropriate and approved management strategy is implemented.

Yours sincerely,
for RPS Australia East Pty Ltd

Bengi Selvi-Lamb
Heritage Consultant
bengi.selvi-lamb@rpsgroup.com.au
+61 2 8099 3335

References

DECCW. (2010), "Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales," *Part 6 National Parks and Wildlife Act 1974*.

Doelman, T., et al. (2008), "Source Selectivity: An Assessment of Volcanic Glass Sources in the Southern Primorye Region, Far East Russia," *Geoarchaeology: An International Journal*, 23, 243-273.

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King, D P, 1992. Soil Landscape of the Wallerawang 1:100 000 Sheet, Department of Conservation & Land Management, Sydney.

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Unit 2A, 45 Fitzroy Street
Carrington NSW 2294
T +61 2 4940 4200

Our ref: PR151487

Date: 7 April 2022

Isobel Standfast
Environment and Community Officer
Centennial Coal Company Limited
Clarence Colliery Road, Off Bells Line of Road
Clarence NSW 2790

Dear Isobel,

Re: Phase 1 heritage monitoring of AHIMS sites 45-1-0185, 45-1-0186, 45-1-0188 (915 and 919 panels)

Introduction

RPS has been engaged by Centennial Coal Company Limited to prepare a baseline recording report of AHIMS sites 45-1-0185, 45-1-0186, and 45-1-0188 that are located over the 915 and 919 panels at Clarence Colliery (hereafter known as the 'Project Area') (Figure 1). The Clarence Colliery, the NSW western coalfield, is approximately 8.5 kilometres north-east of Lithgow and 80 kilometres west of Sydney in the Lithgow Local Government Area (LGA). The requirement for this assessment has been triggered under the Monitoring and Management of requirements of Centennial Coal Company Limited's Western Region Aboriginal Cultural Heritage Management Plan (WRACHMP) (RPS, 2021).

This Phase 1 assessment has been undertaken in accordance with procedures outlined in the WRACHMP. The purpose of the phased assessments is to record the base conditions of a site and monitor for any mining impacts immediately after and approximately 6-12 months post mining. These assessments demonstrate that reasonable and practicable measures have been taken to avoid harm to an Aboriginal object and/or place.

Background

The WRACHMP states the following:

> "In the process of undertaking mining activities there is potential for impact to Aboriginal cultural heritage sites, particularly as a result of surface works and/or subsidence. Any activity which results in the disturbance of the surface has the potential to harm Aboriginal heritage sites. Similarly, the process of underground mining can also induce changes to the ground surface and disturb Aboriginal cultural heritage sites. The level of impact to Aboriginal cultural heritage sites depends on the nature of the surface works/subsidence and the physical characteristics of the Aboriginal cultural heritage site types. (WRACHMP RPS, 2021, p. 15)

Details of specific Aboriginal cultural heritage site types located within Centennial's Western Holdings and how they may be affected by mining and mining associated activities are detailed in the ACHMP.

This report is the Phase 1 baseline recording for AHIMS 45-1-0185, 45-1-0186, and 45-1-0188 located over the 915 and 919 panels at Clarence Colliery. AHIMS 45-1-2872 and 45-1-2874 are also located over the panels, however, these were recorded by RPS within the last two months and their state as described in their site cards will be an adequate baseline assessment. AHIMS 45-1-2872 and 45-1-2874 should be incorporated into the Phase 2 inspection.

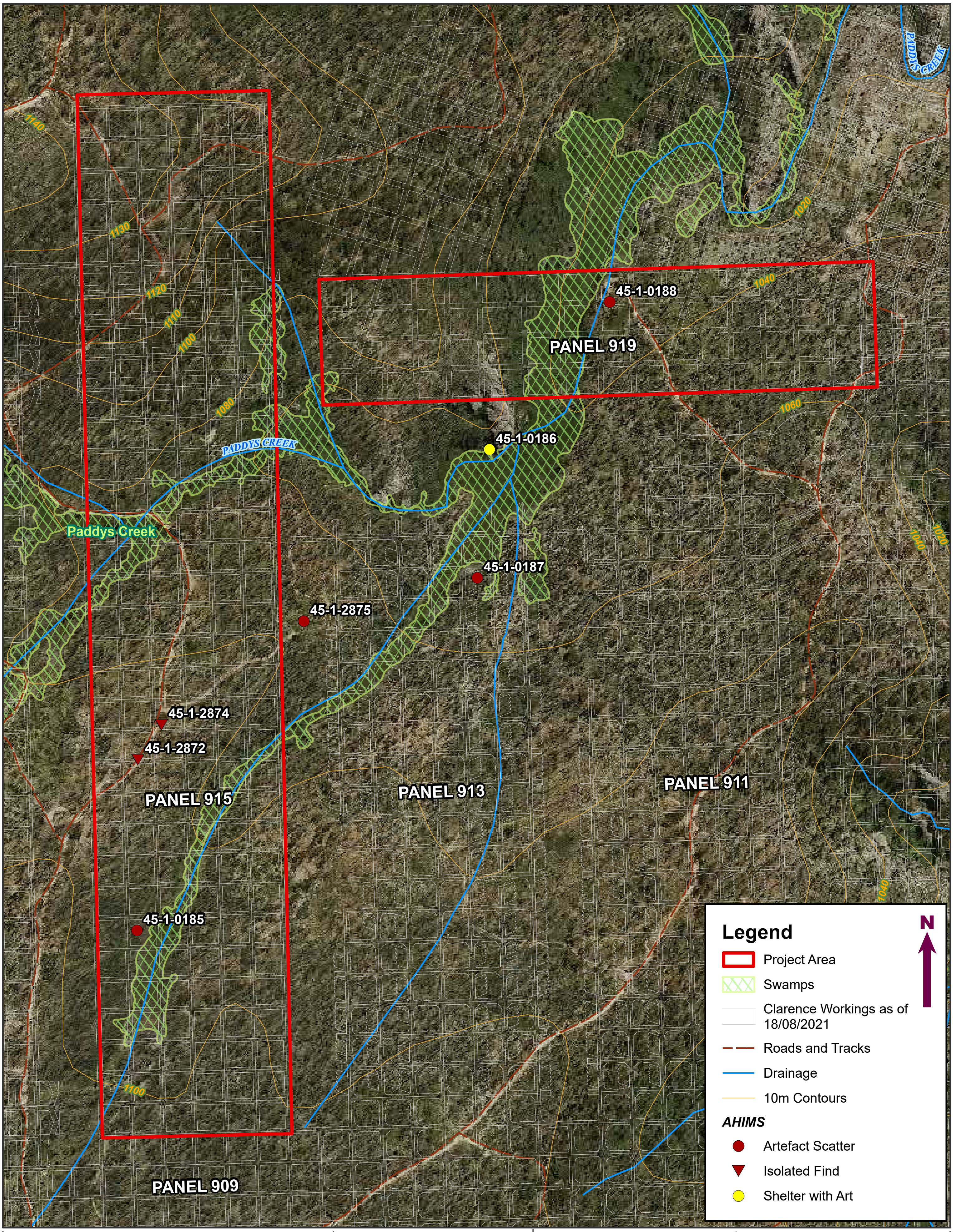


FIGURE 1:
PROJECT AREA WITH AHIMS

VERSION:

DATE EXPORTED:
31/08/2021
TECHNICIAN:
Natalie.Wood

LOCATION:
Clarence Mine

DATA SOURCES
Centennial, RPS, Flown Mar2021

CLIENT: **Centennial**
PROJ: **PR151487**
PURPOSE: **HERITAGE**

Project path: S:\Centennial\All Jobs\151487 - Clarence Colliery\10 - Drafting\Arcgis Map Documents\Arch\151487 Phase 1 Figures.aprx

Phase 1 Inspection

The Phase 1 inspection was conducted on 22 February 2022 by RPS Heritage Consultant Kate Morris, Centennial Environment and Community Officer Isobel Standfast, and Registered Aboriginal Parties (RAPs) including; Wellington Valley Wiradjuri Aboriginal Corporation Site Officer, Bradly Bliss, Warrabinga Native Title Claimants Site Officer, Tyrone Pennell, Gundungurra Tribal Council Aboriginal Corporation Site Officer, Jason Brown and North East Wiradjuri Corporation Site Officer, Coral Williams.

The Project Area comprised swamp land with active streams and dense vegetation. The Ground Surface Visibility (GSV) was generally very poor (<10%) but dependant on the associated landform. All sites surveyed within the Project Area had a minimal level of disturbance. Most sites were in good condition with one in poor/weathered condition. One additional site was identified during the inspection.

45-1-0188

This site was originally identified in 1983 and recorded as an open site comprising two (2) indurated mudstone flakes and >10 quartz flakes. It was noted that the scatter was located on an eroded area due to a swamp sump pump track. The site coordinates were located using a GPS (Plate 1). The area suffered bushfire damage during 2019/2020 with regrowth of low-lying shrubs now limiting GSV. Site descriptions and coordinates in a 2016 update to the site card by RPS match the GPS coordinates and site (discarded sump equipment present). Therefore, the registered location is likely correct.

Knee high grasses, juvenile trees, leaf litter and regrowth vegetation hindered GSV (<25%) and GSEs. Few GSEs occurred near tree bases and revealed a brown sand with charcoal and clear, white and pink quartz pebbles.

No artefacts were identified at the site location. An approximate 50 metre area was surveyed around the registered coordinates, with only one artefact identified (Plate 2, Figure 2). The artefact is a single quartz flake that was noted between the registered coordinates and the 4WD track.

Plate 1: 45-1-0188 **Plate 2: Single quartz flake identified at 45-1-0188**

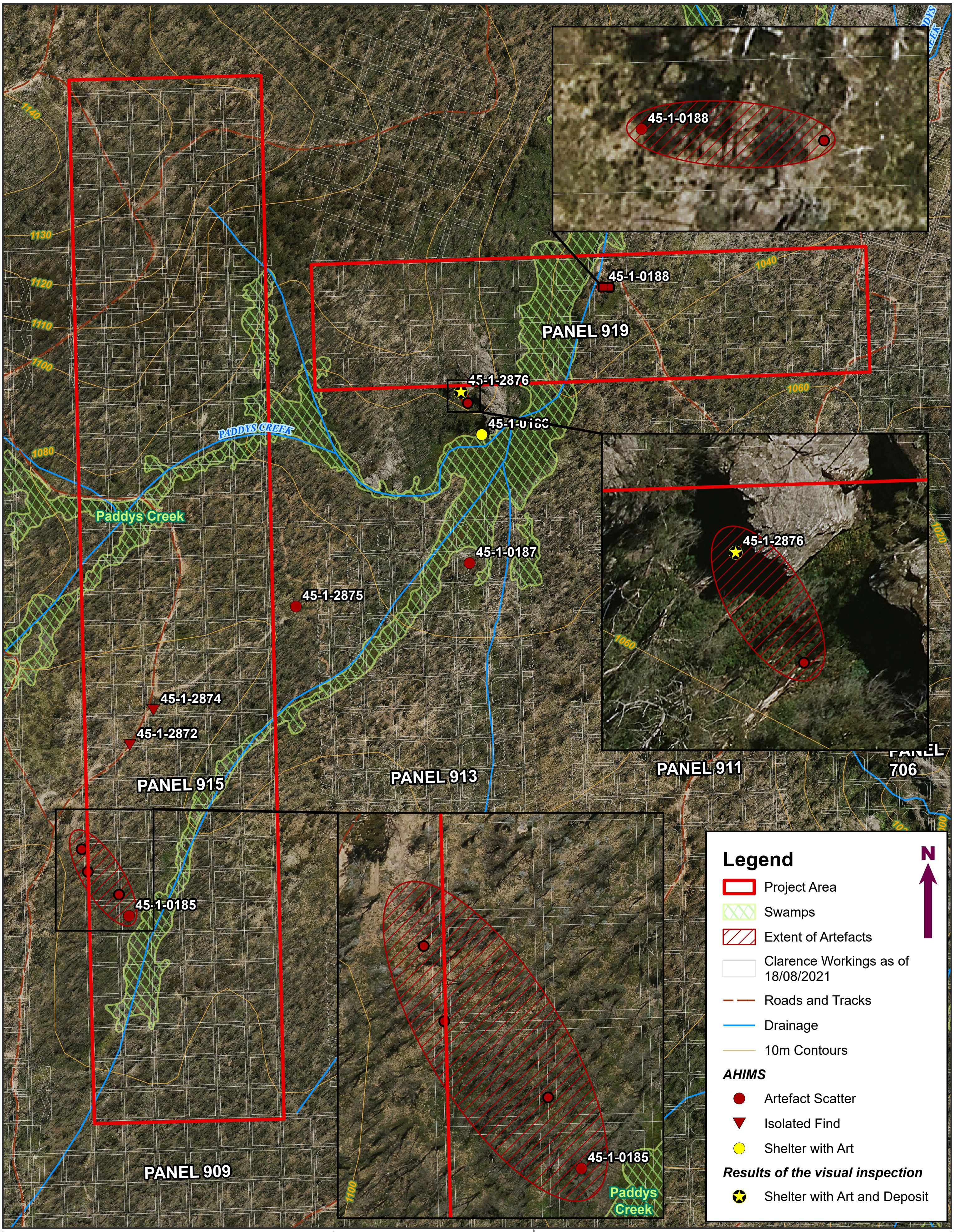


FIGURE 2: SURVEY RESULTS

VERSION:

DATE EXPORTED:
16/03/2022
TECHNICIAN:
Natalie.Wood

LOCATION:
Clarence Mine

DATA SOURCES
Centennial, RPS, Flown Mar2021

50 0 50 100 m

SCALE 1:5,000 AT A4 SIZE
SPATIAL REFERENCE: GDA 1994 MGA Zone 56

CLIENT: **Centennial**
PROJ: **PR151487**
PURPOSE: **HERITAGE**

Project path: S:\Centennial\All Jobs\151487 - Clarence Colliery\10 - Drafting\Arcgis Map Documents\Arch\151487 Phase 1 Figures.aprx

45-1-0185

This site was also originally identified in 1983 as an open site artefact scatter. The scatter comprised >10 quartz cores and flakes. Some disturbance was noted in the area related to logging activities and natural erosion.

The site coordinates were located using a GPS (Plate 3). The area had suffered significant bushfire damage during 2019/2020 with regrowth limiting the GSV (Plate 3). Ground Surface Exposures (GSE) occurred (45%) but were impacted by leaf litter, vegetation regrowth, charcoal, and burnt logs and branches. GSEs revealed a brown silty sand with quartz pebbles. Wet weather appeared to have slightly eroded the soil on the slope and increased the water level of the stream in Paddys Creek swamp.

Site descriptions match the GPS coordinates and therefore the registered location is likely correct, however, no artefacts were identified at the site location. An approximate 50 metre area was surveyed around the registered coordinates, with four artefacts identified upslope from the registered coordinates (Figure 2). The artefacts comprise one broken quartz flake (at the base of the slope, adjacent to the swamp and closest to the registered coordinates) (Plate 4), one medial grey chert flake (upslope) (Plate 5), one distal quartz flake (further upslope) (Plate 6), one quartz microlith blade (on the ridge at the top of the slope) (Plate 7). As these artefacts are in close proximity to the original site and are mostly the same raw material as originally recorded, these artefacts are considered to be part of 45-1-0185. It is likely that many of the artefacts originally recorded are currently under the water level, as the site illustration on the site card conveys the site immediately adjacent to the swamp, on the flat bottom of the slope. This site does not appear to be significantly disturbed, though it is located near an existing 4WD track and piezometers (Plate 8).

Plate 3: 45-1-0185, Paddys Creek swamp to the right

Plate 4: Broken quartz flake near 45-1-0185

Plate 5: Medial chert flake near 45-1-0185

Plate 6: Distal quartz flake near 45-1-0185

Plate 7: Quartz microlith near 45-1-0185

Plate 8: Piezometers near 45-1-0185, circled

45-1-0186

This site was also originally identified in 1983. The site was recorded as a shelter with art on a 15m high pagoda. The art comprised faint red hand stencils. Preservation was poor and the sandstone wall was damp.

The site coordinates were located using a GPS (Plate 9). The surrounding area had been damaged in the 2019/2020 bushfires and fire damage was evident on the base of the sandstone pagoda. Vegetation regrowth and the active stream directly adjacent to the site hindered GSV, however, the very base of the pagoda had good GSE despite a number of large ferns growing toward the stencils. The stencils were very faint red, significantly weathered, and fire damage was evident directly beneath them (Plate 10). The technique used to create the rock art appeared to be the method of blowing pigment over a hand placed against the rock face, creating a hand outline. Additional faint red stencils were identified to the left of the two originally recorded and are more clearly identified in colour-enhanced images (Plate 11) (courtesy Warrabinga Native Title Claimants 2022).

Apart from the fire damage and natural weathering, no other disturbances appear to have occurred near this site. It is difficult to access which should continue to protect it from any human disturbance.

Plate 9: 45-1-0186, Paddys Creek swamp to the right

Plate 10: Very faint red hand stencils

Plate 11: Colour-enhanced image of 45-1-0186, courtesy Warrabinga Native Title Claimants 2022, conveying the two hand stencils and an additional hand stencil to the left, next to the fern

Plate 12: Colour-enhanced image of 45-1-0186, courtesy Warrabinga Native Title Claimants 2022, hand stencils circled

Newly identified site

A rock shelter with art was identified upslope of 45-1-0186 during this inspection (Plate 13, Figure 2). The site comprised a sandstone overhang with a small shelter at the base. The shelter had a south facing aspect and is approximately 8m in length, 3m depth and 1.5m in height (Plate 14). The ground slopes upwards toward the sandstone with soil deposit and ochre present in the shelter. One faint red hand stencil was identified on the back wall in the west (Plate 15) and a quartz flake was identified on the slope between 45-1-0186 and this shelter (Plate 16). This site, inclusive of the flake, has been registered by RPS on 4 March 2022 as one site on the AHIMS (45-1-2876) (Appendix A).

Plate 13: Looking upslope toward the rock shelter, quartz flake in the bottom right of image

Plate 14: Shelter, view facing West

Plate 15: Very faint outline of red hand stencil

Plate 16: Quartz flake identified on the midslope

Visual Inspection Summary

The Phase 1 baseline recording for AHIMS 45-1-0185, 45-1-0186, and 45-1-0188 located over the 915 and 919 is complete. One artefact (quartz flake) was identified in proximity to 45-1-0188 though over 10 quartz artefacts were initially recorded in 1983. This is likely due to the low GSV and few GSEs. Four artefacts (3 quartz flakes, 1 chert flake) were identified in proximity to 45-1-0185 though over 10 quartz flakes and cores were initially recorded in 1983. As these artefacts are in close proximity to the original site and are mostly the same raw material as originally recorded, these artefacts are considered to be part of 45-1-0185. However, the site description places the scatter at the base of the slope. This area is now likely under water from the rising Paddys Creek swamp. AHIMS 45-1-0186 is in a state of poor preservation (as recorded in 1983) but appeared to have been affected by the 2019/2020 fires in addition to weathering.

An additional site (AHIMS 45-1-2876) was identified during this inspection upslope of AHIMS site 45-1-0186. This new site comprises a rock shelter with art and an artefact. This site has been registered on the AHIMS (45-1-2876) and must be incorporated into the WRACHMP.

Conclusions and Recommendations

The baseline inspection for AHIMS 45-1-0185, 45-1-0186, and 45-1-0188 has been completed. All AHIMS sites demonstrate evidence of the 2019/2020 bushfires. Due to the poor preservation of rock art at 45-1-0186 and the newly identified rock shelter (45-1-2876) upslope of 45-1-0186, it is recommended that a photogrammetric recording of the art works is conducted during the Phase 2 inspection. This would ensure a full record of the art would be maintained despite expected continued weathering. This new site must also be incorporated into the WRACHMP.

The Phase 2 inspection should also include AHIMS 45-1-2872 and 45-1-2874 that were recorded by RPS within the last two months. The site cards for AHIMS 45-1-2872 and 45-1-2874 are an adequate baseline assessment.

The ongoing management of these sites is to be considered in close consultation with the RAPs. The Phase 2 visual inspection will be required after undermining as per Centennial's Western Region ACHMP (2021).

Yours sincerely,
for RPS Australia East Pty Ltd

Kate Morris
Heritage Consultant
kate.morris@rpsgroup.com.au

REFERENCES

RPS. (2021). *Centennial Aboriginal Cultural Heritage Management Plan (Western Region)*.

ABBREVIATION GLOSSARY

Table 1: Abbreviation Definitions

Definitions	
Abbreviation/Term	**Meaning**
Aboriginal Object	"any deposit, object or material evidence (not being a handicraft made for sale) relating to the Aboriginal habitation of the area that comprises NSW, being habitation before or concurrent with (or both) the occupation of that area by persons of non-Aboriginal extraction, and includes Aboriginal remains" (DECCW 2010:18).
Aboriginal culturally modified tree	Defined in the NPW Act as; "a tree that, before or concurrent with (or both) the occupation of the area in which the tree is located by persons of non-Aboriginal extraction, has been scarred, carved or modified by an Aboriginal person by: (a) the deliberate removal, by traditional methods, of bark or wood from the tree, or (b) the deliberate modification, by traditional methods, of the wood of the tree.
Activity	A project, development, or work (this term is used in its ordinary meaning and is not restricted to an activity as defined by Part 5 *EP&A Act 1979*).
ACHMP	Aboriginal Cultural Heritage Management Plan
AHIMS	Aboriginal Heritage Information Management System
Archaeological investigation	The process of assessing the archaeological potential of an impact area by a qualified archaeologist.
Archaeological site	An area that contains surface or sub-surface material evidence of past human activity in which material evidence (artefacts) of past activity is preserved.
DEC	Department of Environment and Conservation (restructured to become DECC)
DECC	Department of Environment, Conservation and Climate (restructured to become DECCW)
DECCW	Department of Environment, Climate Change and Water (restructured to become the Office of Environment and Heritage – OEH)
DPIE	Department of Planning, Industry and Environment, now HNSW
Due diligence	Taking reasonable and practicable steps to determine whether a person's actions will harm an Aboriginal object and, if so, what measures can be taken to avoid that harm.
EP&A Act	*Environmental Planning and Assessment Act 1979 (NSW)*
HNSW	Heritage NSW
Isolated artefact / find	A single artefact found in an isolated context.
LALC	Local Aboriginal Land Council
LEP	Local Environment Plan
LGA	Local Government Area
NPW Act	The *National Parks and Wildlife Act 1974*
OEH	NSW Goverment Office of Environment and Heritage (restructured to become the DPIE)
PADs	Potential Archaeological Deposit
RPS	RPS Australia East Pty Ltd
Site	A place where past human activity is identifiable.
WRACHMP	Western Region Aboriginal Cultural Heritage Management Plan

Appendix A
Site Card

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

Office of Environment & Heritage — NSW Government

AHIMS site ID: 45-1-2876

Date recorded: 04-03-2022

Site Location Information

Site name: Clarence ShelterwithArtandDeposit

Easting: 241716

Northing: 6299202

Coordinates must be in GDA (MGA)

Horizontal Accuracy (m): 10

Zone: 56

Location method: Non-Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Ms.	Morris	Kate

Organisation: RPS Australia Asia Pacific

Address: Unit 2A, 45 Fitzroy Street, Carrington NSW

Phone: 0249404200

E-mail: kate.morris@rpsgroup.com.au

Site Context Information

Land Form Pattern: Mountains

Land Use: Mining

Land Form Unit: Slope

Vegetation: Open Woodland

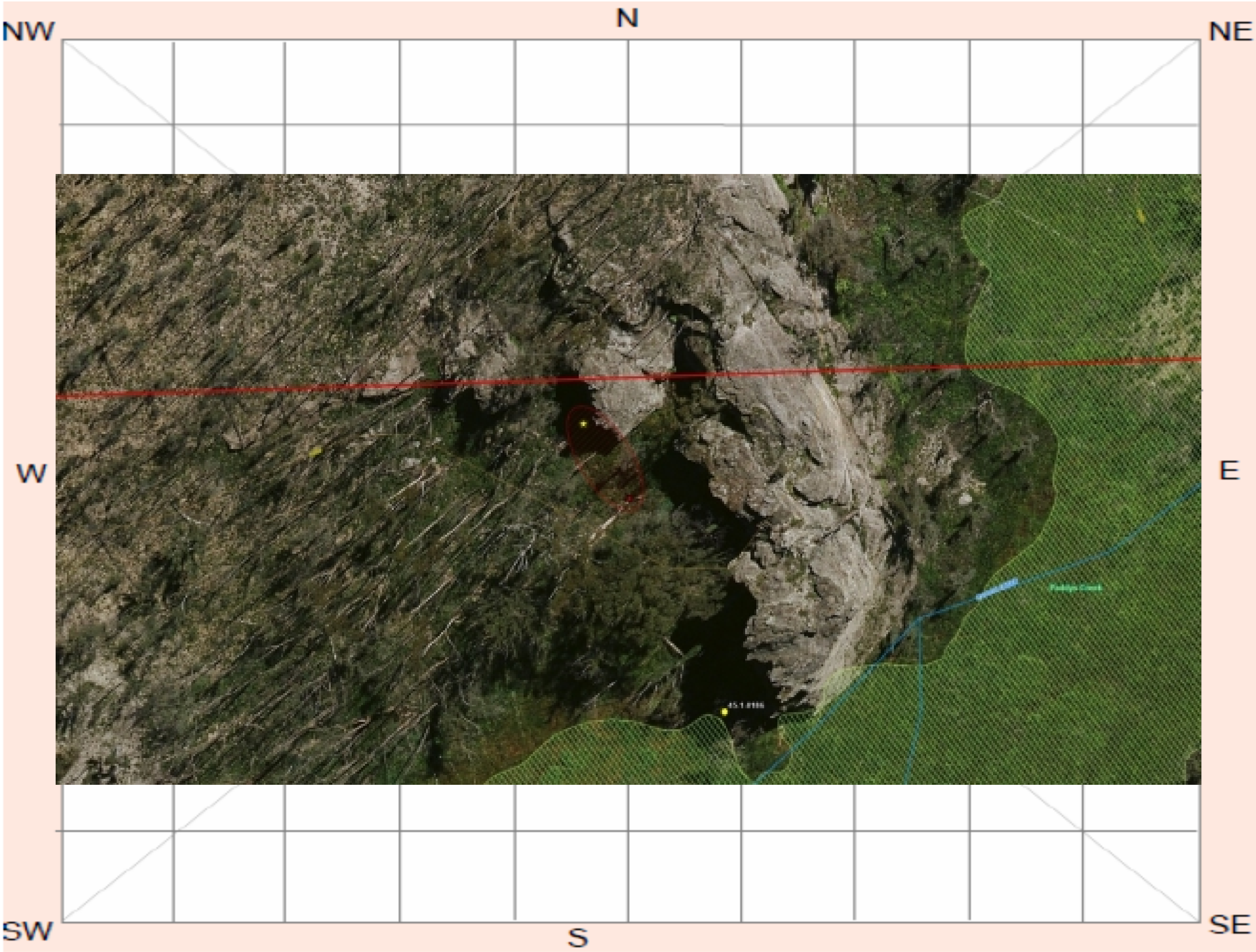
Distance to Water (m): 60

Primary Report:

How to get to the site: Follow Old Bells Line of Road. Turn R at Clarence Sands onto an unnamed track. Take the 2nd R 400m along. Take the 1st L 1.2km along. Stop at end of track. Walk SW along Paddys Ck for 200m. Head N at pagoda, 50m N-W upslope of 45-1-0186

Other site information: A sandstone overhang with a small shelter at the base (8x3x1.5m) with art was identified upslope of 45-1-0186. One faint red hand stencil was identified on the back wall in the west and a quartz flake was identified on downslope between 45-1-0186 and this shelter

Site location map



Site contents information

open/closed site: Closed

Site condition: Poor

Features:

	Feature	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1.	Art	1	1	1				

Description:

A rock shelter with art was identified upslope of 45-1-0186. One faint red hand stencil was identified on the back wall of the shelter in the west (blowing pigment over hand technique). The shelter had a south facing aspect and is approximately 8m in length, 3m depth and 1.5m in height

Features:

	Feature	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.	Artefact	1	1	1				

Description:

A white quartz flake was identified approximately 20m downslope from the shelter and may have eroded during the recent rain

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Regrowth (cm)	Scar shape	Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Regrowth (cm)	Scar shape	Tree Species
4.							

Description:

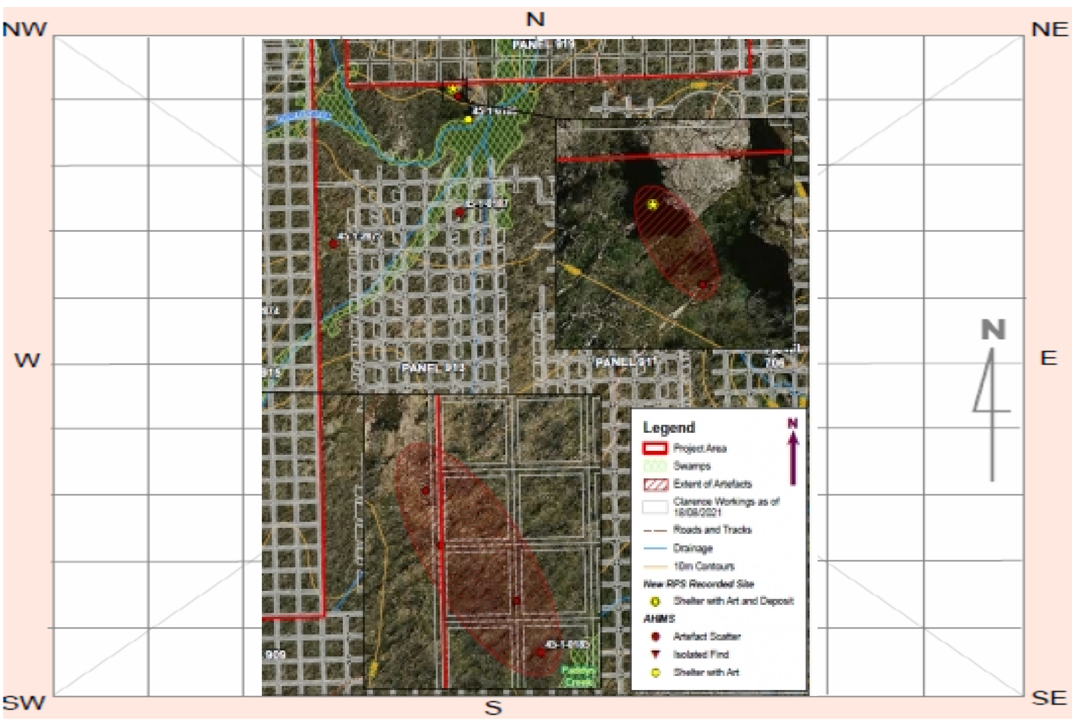
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Regrowth (cm)	Scar shape	Tree Species
5.							

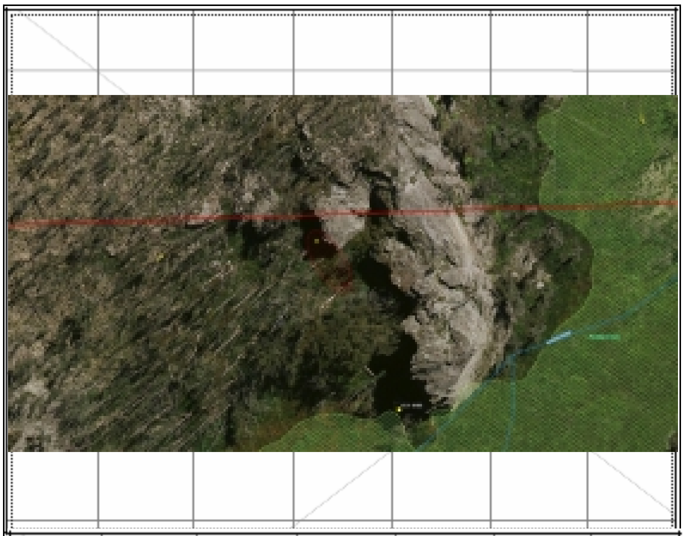
Description:

Other Site Info: A sandstone overhang with a small shelter at the base (8x3x1.5m) with art was identified upslope of 45-1-0186. One faint red hand stencil was identified on the back wall in the west and a quartz flake was identified on downslope between 45-1-0186 and this shelter

Site plan



Site photographs



Description: Location in relation to 45-1-0186

Description: Shelter, view facing West

Description: Very faint red hand stencil

Description: Looking upslope toward the rock shelter, quartz flake in the bottom right of image

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

Title	**Surname**	**First name**

Organisation:

Address:

Phone: **E-mail:**

Our ref: AU213005912

Level 13, 420 George Street
Sydney NSW 2000
T +61 2 8099 3200

Date: 15 November 2022

Matt Ribas
Environment and Community Coordinator
Centennial Coal Pty Ltd
Clarence Colliery Road,
Off Bells Line of Road,

Dear Matt,

Phase 2 Heritage Monitoring AHIMS Sites 45-1-2872, 45-1-2874 and 45-1-2875

Introduction

RPS has been engaged by Centennial Coal Company Limited (Centennial) to prepare a Phase 2 heritage monitoring letter report for AHIMS Sites 45-1-2872, 45-1-2874 and 45-1-2875 which are located over the 915 panel at Clarence Colliery (refer to Figure 1 for Project Area).

In June 2018, RPS prepared an Aboriginal Cultural Heritage Management Plan (ACHMP) for the Western Holdings to provide Centennial with protocols for Aboriginal consultation, handling sensitive cultural information, detailing roles and responsibilities, document control and dispute resolution. The ACHMP includes Clarence Colliery (RPS 2018). The ACHMP was prepared in consultation with the registered Aboriginal parties, Heritage NSW and NSW Department of Planning and Environment.

This letter report has been prepared in accordance with the ACHMP to meet the monitoring requirements for Aboriginal Heritage Information Management System (AHIMS) sites: 45-1-2872, 45-1-2874 and 45-1-2875 identified in Table 1.

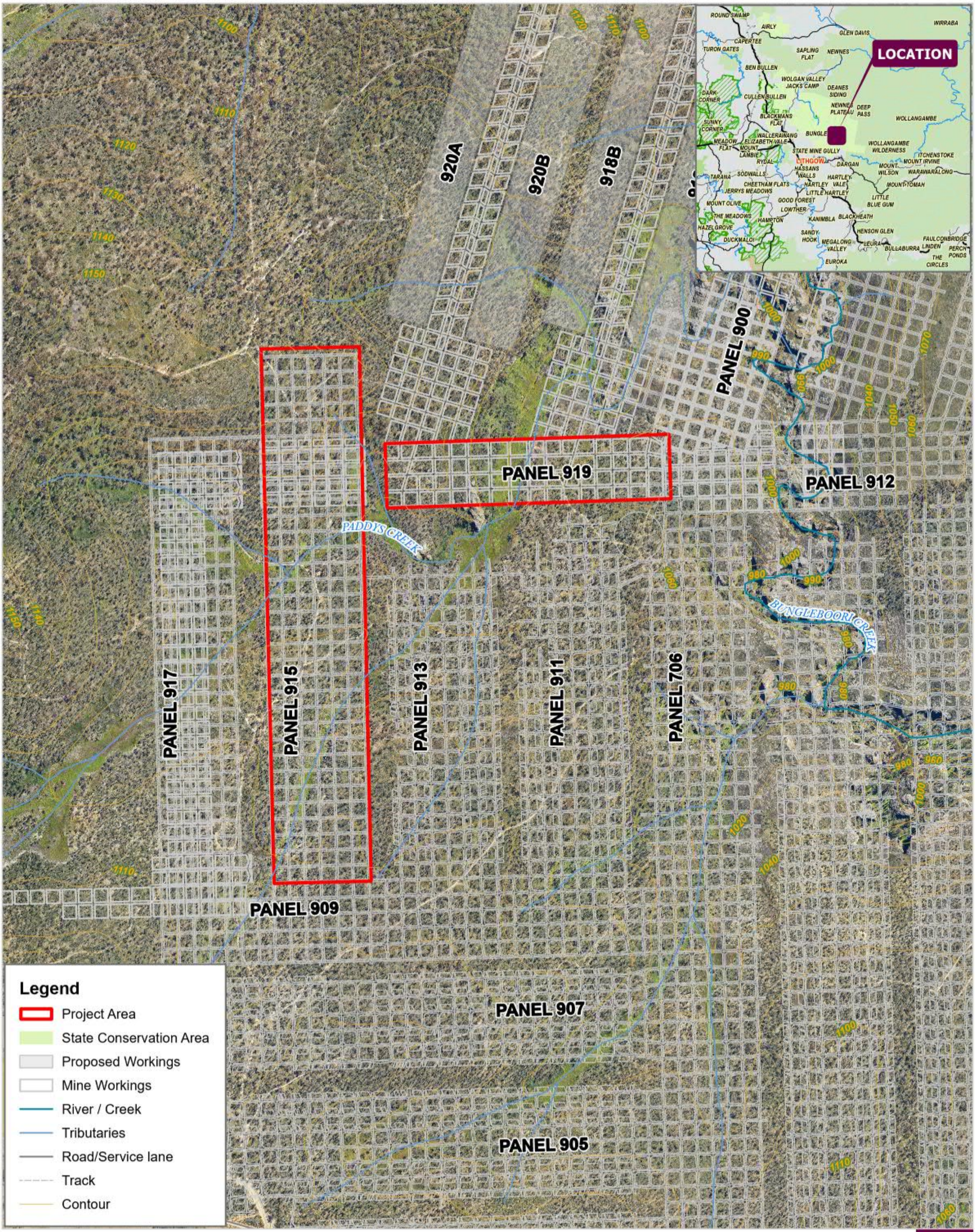
Table 1 AHIMS site coordinates (GDA94)

AHIMS Site	Site Type	Eastings	Northings
45-1-2872	Isolated Artefact	241366	6298829
45-1-2874	Isolated Artefact	241391	6298866
45-1-2875	Artefact Scatter	241542	6298976

Background

In the process of undertaking mining activities there is potential for impact to Aboriginal cultural heritage sites, any activity which results in the disturbance of the surface has the potential to harm Aboriginal heritage sites. Similarly, the process of underground mining can also induce changes to the ground surface and disturb Aboriginal cultural heritage sites. The level of impact to Aboriginal cultural heritage sites depends on the nature of the surface works/subsidence and the physical characteristics of the site type.

Details of specific Aboriginal cultural heritage site types located within Centennial's Western Holdings and how they may be affected by mining and mining associated activities are detailed in the ACHMP.



PROJECT AREA LOCATION

CLIENT: Centennial
PROJ: AU213005912
LOCATION: LW 919 and 915

DATA SOURCES
Centennial, RPS, NSWSS,

MAP: Figure 1
VERSION: A
DATE EXPORTED: 9/11/2022
TECHNICIAN: Natalie.Wood

0 50 100 150 200 250 300 350 m

SCALE 1:10,000
A4 SIZE / Projection: GDA 1994 MGA Zone 56

N

FIGURE 1

rps

PROJECT PATH: S:\Centennial\All Jobs\AU213005912 - PHASE 1 AND PHASE 2 AHIMS INSPECTIONS CLARENCE\10 - Geospatial\03_Projects\CLR_Panel_919_Figures.aprx

Monitoring Protocols for Artefact Scatters/Isolated Finds

Phase 2 monitoring for isolated artefacts and artefact scatters require re-assessment of the condition of the sites post mining (RPS 2018). The monitoring program records the condition of the site before mining (baseline survey and baseline check), and the condition of the site after mining (post mining initial condition and post mining secondary condition check) and thus has been separated into three phases (RPS 2018):

- Phase 1: Baseline recording (prior to site being undermined)
- Phase 2: Post mining initial condition (immediately after undermining)
- Phase 3: Post mining secondary condition (approximately 8 months after undermining)
- Phase 3a (longwall mining) – in instances where final subsidence is not achieved until after a number of longwall extractions have taken place, then additional inspections by a qualified cultural heritage consultant may be required to assess risks to Aboriginal cultural heritage sites.

This report is the Phase 2 recording for AHIMS sites 45-1-2875, 45-1-2874 and 45-1-2872, post mining initial condition. The purpose of Phase 2 is to document any changes after mining related activities have taken place.

Phase 2: Following the completion of undermining, the condition of the site will be reinspected, and the condition of the site compared to the last documented results. If the level of harm to the site becomes evident immediately post-mining, Centennial will endeavour to protect the site from further harm for example, by using non-invasive barrier fencing to prevent erosion. The Centennial Environmental Team will notify and inform OEH (now Heritage NSW) (Enviroline: 131 555) if that there is a potential for harm to the site and follow the advice given by Heritage NSW.

Phase 1 site inspection: AHIMS sites 45-1-2872, 45-1-2874 and 45-1-2875

The visual inspection of the Project Area was conducted on 7 December 2021 by RPS Heritage Consultant Bengi Selvi-Lamb, together with Centennial Environment and Community Officer, Isobel J. Standfast and Registered Aboriginal Party Sharon Brown (Gundungurra Tribal Council Aboriginal Corporation). Three isolated artefacts and one artefact scatter were identified during the visual inspection of the proposed subsidence line which included recording of the baseline conditions of these three AHIMS sites (45-1-2872, 45-1-2874 and 45-1-2875). The ground visibility was moderate to high with exposed surfaces and vehicle track disturbance.

Phase 2 site inspection AHIMS sites 45-1-2872, 45-1-2874 and 45-1-2875

The Phase 2 inspection was conducted on 10 October 2022 and carried out by RPS Heritage Consultant Bengi Selvi-Lamb and Centennial Environment and Community Officer Robert Setter. The registered Aboriginal parties (RAPs) were invited to attend the site inspection and one RAP group registered interest, however, could not attend due to unforeseen circumstances. The report will be made available to the registered parties for review and comment.

AHIMS site 45-1-2872

Recorded as Clarence Mine AFT-900-02 during the baseline inspection. The artefact was relocated during this inspection which was 7 metres north east of the original GPS coordinates (Figure 2).

This isolated artefact was located under the vegetation adjacent to the road boundary (Plate 1 and Plate 2). This artefact was found on a disturb vehicle track. The ground visibility was high (80%) exposing sand with natural small quartz pebbles. It was identified as quartzite blade with diagnostic features such as platform and termination were removed. The GPS coordinates of 45-1-2872 will be updated on AHIMS.

Plate 1 AHIMS 45-1-2872

Plate 2 AHIMS 45-1-2872

AHIMS site 45-1-2874

This site was recorded as Clarence Mine AFT-900-03 (Plate 3)during the baseline inspection and approximately 50 metres north of AHIMS 45-1- 2872 on eastern side of the road boundary (Figure 2). This artefact was found on a disturb vehicle track and was made of IMT (Indurated Mudstone/Tuff) flake piece.

AHIMS 45-1-2874 could not be relocated during the Phase 2 inspection (Plate 4 and Plate 5). The area was inspected around 10 metre radius of the AHIMS coordinates. However, due to leaf litter and grass coverage no artefacts were identified.

Plate 3 Location of AHIMS 45-1-2874 (RPS, 2022)

Plate 4 AHIMS 45-1-2874 site area during site inspection, aspect south west

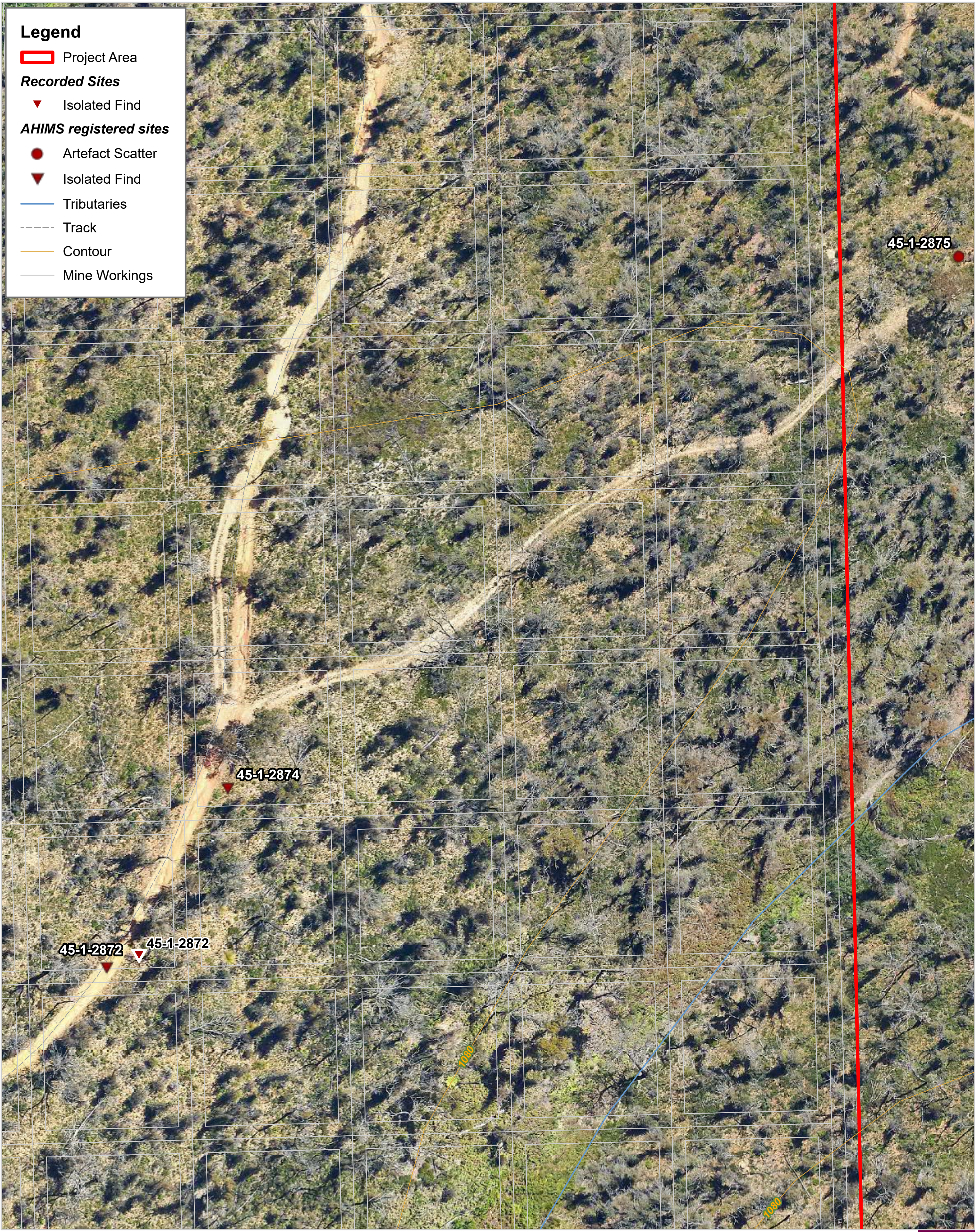
Plate 5 AHIMS 45-1-2874 site area during site inspection, aspect north east

AHIMS site 45-1-2875

This artefact scatter was recorded in 2021 on the mid slope in close proximity of the north end of the subsidence line (Figure 2). AHIMS 45-1-2875 was relocated under a young gumtree (Plate 6), during the Phase 2 investigations based on the GPS coordinates. This site consists of Two (2) quartz multidirectional cores and two quartz flakes (Plate 7).

Plate 6 Location of the AHIMS 45-1-2875

Plate 7 Detail view of artefacts



INSPECTION RESULTS

CLIENT: Centennial
PROJ: AU213005912
LOCATION: LW 919 and 915

DATA SOURCES
Centennial, RPS, NSWSS,

MAP: Figure 2 915
VERSION: A
DATE EXPORTED: 11/11/2022
TECHNICIAN: Natalie.Wood

0 10 20 30 m

SCALE 1:1,000
A4 SIZE / Projection: GDA 1994 MGA Zone 56

N

FIGURE 2

IMPORTANT NOTE
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4. The aerial photography used in this plan has not been rectified. This image has been overlaid as a best fit on the boundaries shown and position is approximate only.

PROJECT PATH: S:\Centennial\All Jobs\AU213005912 - PHASE 1 AND PHASE 2 AHIMS INSPECTIONS CLARENCE\10 - Geospatial\03_Projects\CLR_Panel_919_Figures.aprx

Visual inspection summary

The Phase 2 of AHIMS sites 45-1-2872, 45-1-2874 and 45-1-2875 post mining initial condition is complete.

AHIMS 45-1-2874 has not been located at the registered coordinates due to low visibility. No artefacts were identified at this site.

AHIMS 45-1-2872 was identified at different coordinates and updated on AHIMS.

Conclusions and recommendations

Phase 1 and Phase 2 visual inspection have now been completed. No mining related impacts have been observed, however 2019 bushfires have impacted the region.

Another attempt to ground truth the location of AHIMS 45-1-2874 is recommended during the Phase 3 inspection.

The ongoing management of these sites is to be considered in close consultation with the registered Aboriginal parties. Therefore, this report should be sent to RAPs for review and comment.

The Phase 3 visual inspection will be required in approximately 8 months as required in Centennial's Western Region ACHMP.

This report has been prepared by RPS Heritage Consultant Bengi Selvi-Lamb.

Yours sincerely,
for RPS AAP Consulting Pty Ltd

Bengi Selvi-Lamb
Heritage Consultant
bengi.selvi-lamb@rpsgroup.com.au
+61 2 8099 3335

References

RPS. (2018). Centennial Aboriginal Cultural Heritage Management Plan (Western Region).

RPS (2022) Due Diligence Assessment for the Proposed 900 Subsidence Line Clarence

Inspired People.
Dedicated Team.
Quality Outcomes.

Our Ref: 23109_R01_ Dewatering_Borehole_
Aboriginal_Heritage_
Due_Diligence_Assessment

27 April 2023

Matt Ribas
Environment & Community
Coordinator
Centennial Coal Clarence

E|Matt.ribas@centennialcoal.com.au

1.0 Introduction

Umwelt (Australia) Pty Ltd (Umwelt) was engaged by **Centennial Coal Company Pty Limited (Centennial)** to undertake an Aboriginal Heritage Due Diligence Assessment to assess the potential impacts associated with proposed construction of a new dewatering bore and ancillary infrastructure at the Clarence Colliery (Clarence) located off Bells Line of Road in Clarence, New South Wales (hereafter 'the Project').

This Aboriginal Heritage Due Diligence Assessment report documents the results of Umwelt's assessment and has been compiled with reference to the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in NSW* 2010 (Department of Environment, Climate Change and Water NSW [former], 2010). This code was developed to assist proponents in exercising due diligence when carrying out activities that may result in harm to Aboriginal objects.

1.1 The Project

Umwelt understands Centennial plan to construct a new dewatering bore and associated ancillary pumping and pipeline infrastructure within the Clarence Colliery located off Bells Line of Road in Clarence, New South Wales. The proposed new borehole will be advanced by a truck mounted drill rig to create a 355 mm diameter borehole. All associated cuttings and drilling fluid will be retained and contained by a portable sump or contained underground. Associated pumping infrastructure will be located underground and a new 300 - 350 mm diameter, polyethylene pipeline will be laid on the surface on plinths similar to existing pipelines in the area. It is understood that that the borehole compound will require approximately 203 m^2 of vegetation clearance to accommodate the drill rig and associated infrastructure and support vehicle/s.

This Aboriginal Heritage Due Diligence Assessment investigates risk to Aboriginal cultural heritage associated with the construction of the bore, installation of ancillary infrastructure and vegetation clearance activities.

Umwelt (Australia)
Pty Limited

ABN 18 059 519 041

T| 1300 793 267
E| info@umwelt.com.au

www.umwelt.com.au

1.2 The Project Area

The Project area for this assessment, shown on **Figure 1.1** comprises an approximate 203 m^2 footprint located within the Clarence Colliery Consolidated Coal Lease 705 (CCL705) area.

FIGURE 1.1

Project Area

1.3 The Proponent

The proponent for this assessment is **Centennial Coal Company Pty Limited (Centennial)** (ABN: 30 003 714 538), an Australian mining company supplying coal to both domestic and export markets.

1.4 Authorship

Luke Wolfe (Umwelt, Principal Archaeologist) managed all aspects of the project and was the primary author of this report.

1.5 Disclaimer

This document has been prepared for the sole use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that for which it was supplied by Umwelt (Australia) Pty Ltd (Umwelt). No other party should rely on this document without the prior written consent of Umwelt.

Umwelt undertakes no duty, nor accepts any responsibility, to any third party who may rely upon or use this document. Umwelt assumes no liability to a third party for any inaccuracies in or omissions to that information. Where this document indicates that information has been provided by third parties, Umwelt has made no independent verification of this information except as expressly stated.

No consultation with Aboriginal groups and/or individuals was undertaken for the current assessment.

This report does not address risks to historic heritage, which is managed under standalone legislation.

2.0 Statutory Context

2.1 Commonwealth

2.1.1 Environmental Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The (*Environment Protection and Biodiversity Conservation Act 1999*, n.d.) (EPBC Act) provides for the statutory protection of all items of National environmental significance, and includes protection to heritage items of Commonwealth, National and World significance. The EPBC Act and its regulations also set out the processes for undertaking works within (or in the vicinity of) World, National or Commonwealth heritage items, including where approvals under the EPBC Act are required.

The full extent of requirements for environmental approvals are set out in Subdivision A and AA or Part 4 of the Act. The key trigger for requiring approval is whether works – referred to as an 'action' in the Act, will have a significant impact on the item of National environmental significance. If the proposed action is assessed as having, or likely to have, a significant impact, the matter must be referred to the Minister for Environment for approval.

2.1.2 Native Title Act 1993

The *Native Title Act 1993* (NT Act) recognises that Aboriginal people have rights and interests to land and waters which derive from their traditional laws and customs. Native title may be recognised in places where Indigenous people continue to follow their traditional laws and customs and have maintained a link with their traditional country. It can be negotiated through a Native Title Claim, Indigenous Land Use Agreement (ILUA) or future Act agreements.

The Project area is subject to a registered Native Title Claim NC2018/002 (Warrabinga-Wiradjuri) but not currently subject to any ILUAs.

2.2 State

2.3 Environmental Planning and Assessment Act 1979

The *Environmental Planning and Assessment Act 1979* (EP&A Act) enables responsibility for heritage (both Aboriginal and Non-Aboriginal) to be shared by state and local government agencies. The Act provides local government with the power to protect items and places of heritage significance in the local area through local environmental plans (LEPs) and development control plans.

The EP&A Act requires consideration be given to environmental impact – including heritage – as part of the land use planning process, and the provisions of the EP&A Act allow for the implementation of LEPs which provide the statutory framework for heritage conservation within a particular local government area (LGA).

Clarence operates under Development Consents DA504-00 and DA174-93 which were granted in 2005 and 1993 respectively by the planning minister and Lithgow Council respectively under the *EP&A Act*. Both consents were issued with reference to the Environmental Impact Statement (EIS) which included Heritage Impact Assessments. The management of Aboriginal cultural heritage at Clarence is undertaken in accordance with the *Centennial Coal Western Region Aboriginal Cultural Heritage Management Plan* (ACHMP 2017). The ACHMP was developed in accordance with Aboriginal cultural heritage consultation requirements and has an established Aboriginal Heritage Committee with regular twice-yearly meetings and consultation with registered Aboriginal parties.

2.3.1 National Parks and Wildlife Act 1974

The *National Parks and Wildlife Act 1974* (NPW Act), administered by the Department of Planning and Environment, is the primary legislation for the protection of Aboriginal cultural heritage in NSW. The NPW Act is accompanied by the *National Parks and Wildlife Regulation 2019* (the Regulation). The NPW Act gives the Heritage NSW the responsibility for the proper care, preservation and protection of 'Aboriginal objects' and 'Aboriginal places', defined under the Act as:

- An ***Aboriginal object*** is any deposit, object or material evidence (that is not a handicraft made for sale) relating to the Aboriginal habitation of NSW, before or during the occupation of that area by persons of non-Aboriginal extraction (and includes Aboriginal remains)
- An ***Aboriginal place*** is a place declared so by the Minister administering the NPW Act because the place is or was of special significance to Aboriginal culture. It may or may not contain Aboriginal objects.

Part 6 of the NPW Act provides specific protection for Aboriginal objects and places by making it an offence to harm them and includes a 'strict liability offence' for such harm. A 'strict liability offence' does not require someone to know that it is an Aboriginal object or place they are causing harm to in order to be prosecuted. Defences against the 'strict liability offence' in the NPW Act include the carrying out of certain 'Low Impact Activities', prescribed in Clause 80B of the National Parks and Wildlife Amendment Regulation 2010 (NPW Regulation), and the demonstration of due diligence.

In general, an Aboriginal Heritage Impact Permit (AHIP) issued under Section 90 of the NPW Act is required if impacts to Aboriginal objects and/or places cannot be avoided. An AHIP is a defence to a prosecution for harming Aboriginal objects and places if the harm was authorised by the AHIP and the conditions of that AHIP were not contravened.

2.4 Local

The Project area falls within the Lithgow City Local Government Area (LGA) of which the relevant Environmental Planning Instrument (EPI) is the Lithgow Local Environmental Plan (LEP) 2014.

Part 5.10 of the LEP provide specific provisions for the protection of heritage items and relics within the Lithgow City LGA, in order to:

a. to conserve the environmental heritage,
b. to conserve the heritage significance of heritage items and heritage conservation areas, including associated fabric, settings and views,
c. to conserve archaeological sites,
d. to conserve Aboriginal objects and Aboriginal places of heritage significance.

Under the LEP, development consent is required for any of the following:

a. demolishing or moving any of the following or altering the exterior of any of the following (including, in the case of a building, making changes to its detail, fabric, finish or appearance):
    i. a heritage item,
    ii. an Aboriginal object,
    iii. a building, work, relic or tree within a heritage conservation area,

b. altering a heritage item that is a building by making structural changes to its interior or by making changes to anything inside the item that is specified in *Schedule 5* in relation to the item,

c. disturbing or excavating an archaeological site while knowing, or having reasonable cause to suspect, that the disturbance or excavation will or is likely to result in a relic being discovered, exposed, moved, damaged or destroyed,

d. disturbing or excavating an Aboriginal place of heritage significance,

e. erecting a building on land:

    i. on which a heritage item is located or that is within a heritage conservation area, or

    ii. on which an Aboriginal object is located or that is within an Aboriginal place of heritage significance,

f. subdividing land:

    i. on which a heritage item is located or that is within a heritage conservation area, or

    ii. on which an Aboriginal object is located or that is within an Aboriginal place of heritage significance.

Schedule 5 of the LEP provides a list of heritage items within the Lithgow City LGA. There a no items of Aboriginal cultural heritage significance currently listed on the LEP within the current Project area.

2.5 Management Plans

2.5.1 Western Region Aboriginal Cultural Heritage Management Plan

The Western Region Aboriginal Cultural Heritage Management Plan (ACHMP; Umwelt (Australia) Pty Ltd, 2022a) was prepared to provide Centennial with a consistent approach to Centennial's consultation with the local Aboriginal communities regarding Aboriginal cultural heritage matters as well as identifying consistent minimum standards and processes for Aboriginal cultural heritage identification, monitoring and management across Centennial's western operations which includes Clarence Colliery.

Key elements to the Western Region ACHMP include minimum requirements for Aboriginal consultation and minimum standards for Aboriginal heritage identification, assessment, monitoring and management. The Western Region ACHMP identifies the roles and responsibilities of Centennial staff, Aboriginal parties and the heritage consultant as well as protocols for dealing with disputes and document control. The protocols detailed in the Western Region ACHMP are informed by the legislative requirements and understanding of previous archaeological investigations undertaken in the area.

Centennial's operations operate under an Environmental Management Strategy (EMS). The Environmental Management Strategy identifies Environmental Management Plans (EMPs) required including:

- Operational Environmental Management Plans;
- Regional Environmental Management Plans; and
- Operational Extraction Plan and Sub-Plans.

The Regional Environmental Management Plan, using a regional framework for consistency, identifies baseline monitoring, compliance monitoring, adaptive management, reporting and review processes to be adopted across the operations.

Extraction Plans and Sub-Plans required under the *Mining Act 1992* are constrained to a mining area and specific to requirements outlined in the Extraction Plan Guidelines (NSW Department of Planning & Environment, 2015).

3.0 Aboriginal Heritage

3.1.1 Data Sources

Information regarding the known and potential Aboriginal heritage resource of the Project area was obtained from:

- A review of the landscape context of the Project area and surrounds.
- A review of existing Aboriginal Heritage Information Management System (AHIMS) data for land within and surrounding the Project area, obtained from Heritage NSW on 9 December 2022 (AHIMS search #739643).
- A search of the National Native Title Register (NNTR) and Register of Native Title Claims (RNTC) administered by the National Native Title Tribunal (NNTT) for land within and surrounding the Project area (9 December 2022).
- A review of the findings of past Aboriginal archaeological investigations within the Project area and surrounds.
- A visual inspection of the Project area by Umwelt Principal Archaeologist Luke Wolfe on 6 December 2022

3.1.2 Landscape Context

Consideration of the landscape context of the Project area is based on the concept that the nature and distribution of Aboriginal sites are connected to the environments in which they occur. Environmental variables such as topography, geology, hydrology and local vegetation and faunal communities are a key consideration to determining how Aboriginal peoples lived and utilised their Country prior to, and around the time of colonisation. In practical terms, these variables would have influenced the suitability of campsites, travelling routes, drinking water, plant and animal resources, and raw materials for the manufacture of stone and organic implements. Finally, a review of historical and contemporary land use activities contributes to a critical understanding of how these processes have potentially impacted the integrity of archaeological deposits.

Key observations from a review of the landscape context of the Project area is presented in **Table 3.1**.

Table 3.1 Review of landscape context of the Project area

Environmental Variable	Key Observations
Topography	The Project area lies within the Newnes Plateau, an elevated, gently undulating geographic region which rises to 1,180 m at Birds Rock and is the most northerly extension of the Blue Mountains Range. Elevations within the Plateau range from approximately 1,000 to 1,180 m, with topography characterised by rounded crests and moderately to steeply inclined sideslopes. Crests are generally narrow (<50 m) and convex. Localised rock outcrops form as pagodas (refer below), cliffs and low broken scarps which descend into drainage lines and hanging swamps. The localised topography of land within the local environs surrounding the Project area relative to its suitability for Aboriginal occupation, suggests that landscape elements within it would have been favourable to occupation, though these are generally absent from the immediacy of the Project area (including freshwater sources and sandstone overhangs suitable for periodic occupation and tool manufacture).
Hydrology	The primary watercourse within the vicinity of the Project area environs is the Wollangambe River, the upper reaches of which pass the Project area approximately 100 m to the north and west. The Wollangambe River headwaters lie approximately 1 kilometre southeast of Happy Valley Springs and flows approximately north to east, where it discharges to the Colo River approximately 35 km north-east of the Project area. In addition to ephemeral and minor perennial watercourses throughout the dissected sandstone valleys of the Newnes Plateau, there are many swamp-filled valleys known the 'Newnes Plateau Shrub Swamps' present across the region and are recognised as ecologically and culturally significant landscape elements. They occur as narrow, elongated swamps formed in low-slope headwaters in predominantly sandstone catchments of Triassic Narrabeen Group geology. The swamps continue to provide an important habitat for both flora and fauna and were focal points for Aboriginal occupation and resource use on the Newnes Plateau.
Geology and Soils	The Project area is located within the Western Coalfield in the Sydney Basin, with surface geology dominated by the Banks Wall Sandstone and Mount York Claystone Members of the Grose Sandstone members of the Narrabeen Sandstone group. The lithology of the parent material is predominately quartz-lithic sandstone interbedded with thin red, grey and green claystone, shale and occasional conglomerate and ironstone lenses. A characteristic feature of the region is the formation of 'pagoda'-like structures, comprising both 'platy pagodas' (generally stepped-cone shapes with semi-regular ironstone bands); and 'smooth pagodas' (comprising less ironstone bands) (Haydn Washington and Wray, 2011). Typically, areas dominated by sandstone geology are often characterised by steep escarpments and deeply dissected terrain, the former generating overhangs suitable for occupation and surfaces for grinding tools (i.e., grinding grooves) and engraved art. Raw materials suitable for flaked artefact manufacture are generally absent from the Project area and environs, though opportunistic alluvial sources (e.g., gravel deposits in creeks, conglomerates etc). Tertiary alluvial units known to contain raw materials (i.e., the St Marys formation) are mapped approximately 50 km east of the Project area near Maroota. These geological formations/phenomena are of demonstrated Aboriginal archaeological significance. The St Marys formation consists of alluvial channel remnants incised into Triassic Wianamatta Group shales, and contains abundant quantities of silcrete, as well as silicified wood, quartzite and quartz (Corkhill, 1999):56). Recorded deposits, which occur on ridge flanks and crests across the northern

Environmental Variable	Key Observations
	Cumberland Plain, vary in thickness from approximately 1 to 10 m. Silcrete from the St Marys formation is typically light red or yellowish brown in colour, with a bleached weathering rind, and occurs in the form of complete and fragmentary pebbles, cobbles and boulders (Corkill 1999). King (1994:97) maps soils within the Project area as belonging to the Wollangambe soil (*wo*) soil landscape. Soils of the Wollangambe soil (wo) landscape are described as forming on sandstone bedrock and on crests, will generally comprise discontinuous leaf litter and coarse, loose quartz-rich sands abruptly overlying <30cm of single-grained loamy sand. Existing archaeological, environmental and historical reference materials for the Project area and environs suggest that a range of geomorphic processes are likely to have affected the Aboriginal archaeological record. Potentially significant phenomena include bushfire and erosion. Possible effects of these processes include: • Reduced archaeological site visibility in areas of sediment deposition. • Stratigraphic mixing and translocation of cultural deposits. • Truncation of archaeological deposits.
Flora and Fauna	Vegetation communities within the Project area environs generally comprise uncleared open-woodland with the broader local environs including low open-forests located within the more sheltered valleys (King 1994:111). Woody vegetation species in the general environs include black ash (*Eucalyptus sieberi),* narrow-leaved stringybark (*Eucalyptus oblonga*), red bloodwood (*Eucalyptus gummifera*), and brittle gum (*Eucalyptus mannifera*) in more exposed areas, with blue mountains ash (*Eucalyptus oreades*), broad-leaved peppermint (*Eucalyptus dives*), grey gum (*Eucalyptus punctata*), sydney peppermint (*Eucalyptus piperita*), and narrow-leaved peppermint (*Eucalyptus radiata*) in sheltered areas. Understorey species are dominated by broad-leaved hakea (*Hakea dactyloides*), hill banksia (*Banksia spinulosa*), waratah (*Telopea speciosissima*), small-leaved boronia (Boronia microphylla), laurel geebung (*Persoonia laurina*), broad-leaf geebung (*Persoonia levis*), and various acacia species. Consideration of pre-European vegetation regimes suggests that a range of terrestrial faunal resources would have been present in the area. Locally occurring resources from valley floor and freshwater environs, for example, are likely to have consisted of localised of fish and other freshwater mammals from the Wollangambe River, its associated tributaries and hanging swamp environs. A diverse array of terrestrial mammals (e.g., echidna, possums and macropods), as well as birds, reptiles and amphibians, would have also been available in open woodland areas.

3.2 Aboriginal Archaeological Context

3.2.1 Aboriginal Heritage Information System (AHIMS)

The Aboriginal Heritage Information System (AHIMS) database, administered by Heritage NSW, contains records of all Aboriginal objects reported to Heritage NSW in accordance with Section 89A of the *NPW Act*. It also contains information about Aboriginal places, which have been declared to have Aboriginal cultural significance. Recorded Aboriginal objects and declared Aboriginal places are defined under the NPW Act as 'Aboriginal sites'.

A search of the AHIMS register undertaken on the 9 December 2022 for an approximate 5 km buffer centred on the Project area (i.e., the 'AHIMS search area'; AHIMS search # 739643) identified 41 Aboriginal sites (**Table 3.2; Figure 3.1**). Of those, a single site (1) was identified as 'not a site', resulting in forty (40) valid Aboriginal sites reported in the AHIMS search area. As is typical for South-eastern Australia, open artefact sites (comprising one or more stone artefacts) were the most common site type represented within the AHIMS search area, accounting for 80% (n = 32) of known sites. Art sites, associated with the prevalence of overhangs and sandstone bedrock exposure, were relatively less common, accounting for 12.5% (n=5) of the total search results. The remaining site types included a single culturally modified tree (i.e., scarred tree), a single stone arrangement and a single grinding groove.

Of those Aboriginal sites reported in the AHIMS search results, none fall within the Project area. The nearest Aboriginal site, 'Wollangambie [sp] Creek 1;Newnes Junction 1' (AHIMS ID #45-1-0055) is located approximately 950 m north-east of the Project area. Reference to the listing indicates the site comprises a rockshelter site, with artefact(s), potential archaeological deposit and art indicated on the listing.

Table 3.2 AHIMS Search Results

Aboriginal Site Type	Frequency (n)	Percentage
Grinding Groove	1	2.5%
Stone Arrangement	1	2.5%
Culturally Modified Tree	1	2.5%
Art Site	5	12.5%
Open Artefact Site	32	80.0%
Total	40	100.0%

Source: Department of Planning and Environment, 9/12/2022, AHIMS Search ID #739643).

FIGURE 3.1

Aboriginal Sites

3.3 Native Title

A search of the National Native Title Register (NNTR) and Register of Native Title Claims (RNTC) administered by the National Native Title Tribunal was undertaken for the City of Lithgow LGA, inclusive of land within and surrounding the Project area. The Project area is currently subject to a registered Native Title Claim NC2018/002 (Warrabinga-Wiradjuri) but not currently subject to any ILUAs.

3.4 Previous Aboriginal Archaeological Assessments

The City of Lithgow LGA, Newnes Plateau and environs have been subject to a limited series of Aboriginal cultural heritage and archaeological investigations, with those primarily associated with urban development and infrastructure upgrades. For contextual purposes, the results of a selection of these investigations, including those undertaken within and/or near the current Project area, are summarised in **Table 3.3.**

Table 3.3 Previous Aboriginal Heritage Assessments

Assessment	Description	Location
Gollan (1987) *Archaeological investigations on Newnes Plateau, a report to the National Parks and Wildlife Service*	Gollan's investigations on behalf of NPWS formed part of the Newnes Plateau Research Project. The investigations were undertaken in response to the pressures that were faced at that time around 'opening up' the plateau to uses other than forestry, and the perceived need for NPWS to identify the potential cultural heritage significance of the Newnes Plateau. Gollan's investigation remains the most comprehensive archaeological study of the plateau undertaken to date. Comparative site type and distribution data was collected by surveying 13 sample areas across three (3) land systems, including swamp environments, local peaks and their associated high-level ridges, and talus slopes on the plateau escarpment. These investigations led Gollan to the following conclusions: • Open camp sites were located on the surfaces of sandy fan deposits around swamp margins. • An observable association existed between open artefact sites and extant stands of useable plants (including spiny-headed mat-rush or basket grass and saw-edge or sword grass) located on swamp margins. • The presence of visible sites was strongly determined by the surface characteristics and aspect of the site location. • Artefact sites contained both utilised and unutilised flakes manufactured from a range of locally and regionally available lithic materials. Sites were found to either predominately contain quartz, or to contain a range of stone materials.	<1 km

Assessment	Description	Location
McIntyre (1990) *Archaeological survey of the proposed Kariwara Longwall coal mine, report to the Electricity Commission of NSW*	McIntyre undertook a survey for the Kariwara Project Area on behalf of the Electricity Commission of NSW. The project involved the extensive survey of cliff lines, and test excavation of several rockshelter sites. The resulting investigations recorded 41 rock shelter sites and a single (1) culturally scarred tree. Major site complexes were recorded at Mt Horne, the upper reaches of the Wolgan River and Blackfellow's Hands. From data collected, McIntyre drew the following conclusions: • Major site complexes were located at the head of open gullies where there was relatively easy access from ridge tops to the resources provided by major creeks and rivers. • Such complexes were also located on the plateau at locations where vantage points were combined with localised resources. • Large sites were located along the western flank of the plateau where streams entered the Cox's River Valley. • Smaller sites, representing intermittent visits, were found at the end of long ridges.	7 km north-west
Kohen (1992) *An archaeological survey of four areas adjacent to the Clarence Colliery Pit Top*	Kohen undertook two archaeological surveys within the Clarence Colliery holdings in 1992. No Aboriginal archaeological sites were identified as a result of either survey. Kohen concluded that the absence of sites in the survey areas was due to the absence of 'favoured' landforms including exposed sandstone, cliff lines, hanging swamps and creek lines.	<1 km
Archaeological and Heritage Services (AHS) (2000) *An archaeological survey for the proposed extensions to Clarence Colliery, Near Lithgow, prepared for Centennial Coal*	An archaeological survey of a proposed extension to Clarence Colliery was undertaken in 2000. This survey included the proposed mine expansion area, encompassing an area of 2.5 x 2 km to the east and 3 x 7 km to the west. AHS's predictive model determined that open camp sites would be the most likely site type in the area, likely associated with talus slopes, spring fed creek lines and hanging swamps. Additionally, sites were predicted to be found in association with sandstone landform areas (i.e., rockshelters, art sites, grinding grooves, etc.). As such, rockshelters were anticipated to be present at the base of sandstone outcrops or within eroded sandstone outliers below cliff lines in locations with access to swamps and creek lines. Grinding grooves were anticipated in association with watercourses, with scarred trees potentially occurring in remnant old growth forest. The survey recorded six (6) 'open camp sites' (four of which were identified to have PAD), a single PAD site, two (2) isolated artefacts, a scarred tree complex and two (2) rockshelters with artefacts.	<1 km

Assessment	Description	Location
RPS (2014) *Cultural Heritage Impact Assessment - Springvale Mine Extension Project, prepared for Springvale Coal Pty Ltd*	RPS assessed an area of the Newnes Plateau to the west of the current Project area from Sawyers Swamp in the northwest to the intersection of Glowworm Tunnel Road and Old Bells Line of Road in the southeast. RPS predicted that the most common types of sites would be rock shelters (with art, deposit or artefacts) and open artefact scatters/isolated finds. It was predicted further that the archaeological contents of such artefact sites would comprise flaked stone artefact, with anticipated raw materials including quartz, quartzite, chert, mudstone and some silcrete. RPS concluded that any Aboriginal sites would likely be located within 100 m of watercourses. As a result of the survey, four (4) new Aboriginal sites were identified, comprising two (2) culturally scarred trees, a single (1) isolated artefact and a rockshelter complex containing art and a grinding groove.	<1 km
Umwelt (Australia) Pty Ltd (2022) *900F Subsidence Line and 918/920 Panels GNSS stations Installation – Aboriginal Due Diligence Assessment*	Umwelt undertook a due diligence assessment fort the proposed installation of a 900F subsidence monitoring line and associated 918 and 920 Panels GNSS Stations within the Clarence Colliery. No Aboriginal objects or archaeological potential was observed during the visual inspection, nor did the desktop assessment identify any existing Aboriginal sites.	5km north-west

3.5 Key Observations

Key observations to be drawn from a review of both the environmental and Aboriginal archaeological context of the Project area and environs are as follows:

- A review of the topography and geology of the Project area suggests that localised landscape elements within the general environs would have been favourable to occupation, through largely restricted to opportunistic sandstone overhangs, which are not located within the immediacy of the Project area. Instances of sandstone bedrock exposure may also have retained evidence of engraved and/or pecked art and grinding grooves, as indicated by sub-regional Aboriginal site modelling.

- Soil materials of the Project area may have limited potential to retain archaeological evidence within biomantle strata (i.e., topsoil). However, such soils are susceptible to erosion and impacts from bushfire, which may have translocated archaeological evidence, if present.

- Culturally scarred trees may be present within the Project area, only if mature vegetation remains. Rockshelters, with or without other forms of evidence, may be present in the general environs. Open artefact sites (comprising one or more artefacts) and grinding grooves may be present within the Project area.

4.0 Visual Inspection

A visual inspection of the Project area was undertaken by Umwelt Principal Archaeologist Luke Wolfe on 6 December 2022. The primary aim of the inspection was to record the existing conditions of the Project area, with particular emphasis on areas of proposed construction activities. The visual inspection also aimed to identify any existing surface evidence of past-Aboriginal occupation and activity within the Project area and immediate environs. The inspection path was tracked in real-time using a handheld GPS unit, with associated transect data (e.g., Ground Surface Visibility (GSV) and Ground Integrity (GI) ratings) and photographs recorded. The following key observations were made during the visual inspection:

- The Project area itself is characterised by an approximately north-east to south-west trending sandstone ridgeline that drops off steeply to both the east and west. No overhangs were present within the immediate Project area. A vehicle access track was located to the immediate east of the Project area, with additional dewatering bores and associated infrastructure and pipeline/s.

- Ground surface visibility in the inspected areas of the Project area was generally good, though limited by leaf litter and vegetation. Sandstone bedrock was observed at the surface in areas not obscured by vegetation.

- Native vegetation within the Project area appeared to be generally intact but limited to scrub and juvenile trees.

- No Aboriginal sites were observed during the visual inspection.

5.0 Summary of Key Findings

The key findings of this assessment are as follows:

- No existing, registered Aboriginal sites are present within the Project area.
- Areas of sandstone bedrock exposure were present, suggesting limited potential to retain grindings grooves and/or engraved/pecked rock art.

6.0 Impact Assessment

The previous sections have presented a review of the environmental and archaeological context of the Project area and environs to develop a framework for identifying risks to Aboriginal heritage resource of the Project area. The following provides a summary of the key questions asked as part of the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wale*s (DECCW, 2010:10). Should the answer to Question 4 be 'yes', further investigation and impact assessment would be required.

1.Will the activity disturb the ground surface or any culturally modified trees?

Yes, the proposed works will impact the ground surface. The Project will require approximately 203 m^2 of vegetation clearance to accommodate a drill rig and associated infrastructure. A single borehole will be advanced by a truck-mounted drill rig to create a 355 mm diameter borehole. All associated cuttings and drilling fluid will be retained and contained by a portable sump or contained underground. Associated pumping infrastructure will be located underground and a new 300 - 350 mm diameter, polyethylene pipeline will be laid on the surface on plinths similar to existing pipelines in the area. No culturally modified trees are present within the Project area. ***Proceed to Question 2***

2a. Are there any relevant confirmed site records or other associated landscape feature information on AHIMS?

The AHIMS database holds records of known Aboriginal sites located within the vicinity the Project area. Searches of the AHIMS database and reference to the relevant site card recordings confirmed that the nearest site is located approximately 950 m north-east of the current Project area. ***Proceed to Question 2b***

2b. Are there any other sources of information of which a person is already aware?

Umwelt has reviewed all available literature and pertinent sources of information pertaining to the known Aboriginal resource of the Project area and surrounds. All relevant information is presented in Section 3.0 of this report. ***Proceed to Question 2c***

2c. Are there any landscape features that are likely to indicate presence of Aboriginal objects?

Available environmental evidence and site observations suggests that there is low potential for extant Aboriginal sites to be present in subsurface contexts within the Project area. Regional Aboriginal site modelling suggests that site types that may be present within presently obscured (by vegetation and/or leaf litter) portions of the Project area and would be limited to grinding grooves and/or engraved art within extant sandstone bedrock. ***Proceed to Question 3***

3. Can harm to Aboriginal objects listed on AHIMS or identified by other sources of information and/or can the carrying out of the activity at the relevant landscape features be avoided?

This assessment has identified that there are no known sites within the Project area and previously unidentified extant Aboriginal archaeological evidence is unlikely to be present. The visual assessment component of the current assessment did not identify any extant Aboriginal evidence. ***Proceed to Question 4***

4. Does a desktop assessment and visual inspection confirm that there are Aboriginal objects or that they are likely?

Umwelt has undertaken a review of both environmental and archaeological context of the Project area and local environs, as well as visually inspecting the immediate Project area. In general, the archaeological potential of the immediate Project area was assessed as low. Reference to sub-regional archaeological modelling suggests that Aboriginal sites associated with bedrock environs are likely to be limited to grinding grooves and/or engraved art, with rockshelter sites present in escarpment areas outside the current Project area. While unlikely, presently obscured areas of bedrock may have the potential to retain grinding grooves and/or engraved art. Recommendations for the management of unexpected Aboriginal cultural heritage that may be encountered during the Project are presented in **Section 8.0** of this report.

7.0 Conclusions

Through a review of environmental and archaeological context for the Project area and environs and identified that there are no Aboriginal sites are located within the footprint of the proposed works, and the Project area itself generally retains low archaeological potential. Under Section 2.13 of the *State Environmental Planning Policy (Resources and Energy) 2021,* Section 4 (c), the construction, maintenance and use of any minor drill hole or minor shaft within the mine, being a drill hole or shaft used for emergency or safety purposes or that has a diameter of no more than 500 millimetres is classified as exempt development, conditional to the works being of minimal environmental impact. This report has concluded that the Project will have negligible impact to known and/or potential Aboriginal sites and as such, works may proceed without any further archaeological assessment, approvals or associated constraint.

8.0 Management Recommendations

On the basis of the above findings, the Project may proceed subject to the following recommendations:

Recommendation 1. All relevant contractors and personnel should be made aware of the nature and location of previously recorded Aboriginal sites that lie within and near the Project area. All relevant contractors and personnel should also be made aware of their legal responsibilities under the *NP&W Act 1974* and the need to avoid impacts to Aboriginal sites.

Recommendation 2. If, in the unlikely event that Aboriginal objects/sites are identified during the Project, all works in the area must cease immediately and the ***Unexpected Heritage Finds Procedure*** presented in **Appendix B** must be implemented.

Recommendation 3. In the event that the proposed design and/or location of the proposed works is altered for any reason, or impact to areas to land that has not been assessed in this report, further Aboriginal heritage assessment may be required. Any proposed alteration must be evaluated by a qualified heritage consultant to determine if the location represents a risk to Aboriginal cultural heritage.

9.0 References

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Umwelt (Australia) Pty Ltd, 2022a. Clarence 918 and 920 Panels Heritage Management Plan.

Umwelt (Australia) Pty Ltd, 2022b. 900F Subsidence Line and 918/920 Panels GNSS stations Installation – Aboriginal Due Diligence Assessment.

Appendix A AHIMS Search Results

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : 23109 Clarence

Client Service ID : 739643

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
45-1-0201	BHT 2;NEWNES SF;	AGD	56	243100	6295850	Closed site	Valid	Artefact : -	Shelter with Deposit	
	Contact	Recorders	Klim Gollan					Permits		
45-1-2693	RPS CL IF1	GDA	56	240335	6294685	Open site	Valid	Artefact : -		
	Contact	Recorders	Ms.Gillian Goode,RPS Australia East Pty Ltd - Blacktown					Permits		
45-1-2700	C-OS-5 and PAD	AGD	56	242390	6293416	Open site	Valid	Artefact : 3, Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd					Permits		
45-1-2817	Waterworks Hand Stencils	GDA	56	239931	6295893	Closed site	Valid	Art (Pigment or Engraved) : -		
	Contact	Recorders	Mr.Mark Roebuck					Permits		
45-1-2704	C-IF-2 (Lithgow)	AGD	56	247640	6295020	Open site	Valid	Artefact : 1		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd					Permits		
45-1-2697	C-OS-1	GDA	56	242214	6296753	Open site	Valid	Artefact : 2		
	Contact	Recorders	Ms.Gillian Goode,RPS Australia East Pty Ltd - Hamilton					Permits		
45-1-0085	Old Bells Line of Road 2	AGD	56	241600	6294500	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Eugene Stockton					Permits		
45-1-0103	Newnes Junction (Lithgow)	AGD	56	243120	6294940	Open site	Valid	Artefact : -	Open Camp Site	993
	Contact	Recorders	Laura-Jane Smith,Miss.Lisa Smith,Grant Aitken					Permits		
45-1-0064	Newnes Junction (Bald Trig)	AGD	56	243180	6295750	Closed site	Valid	Artefact : -	Shelter with Deposit	130
	Contact	Recorders	Helen Brayshaw					Permits		
45-1-2801	Mt Clarence Twin Caves	GDA	56	240516	6290702	Closed site	Valid	Art (Pigment or Engraved) : -		
	Contact	Recorders	Mr.Mark Roebuck					Permits	4770	
45-1-0194	FC 3;NEWNES SF;	AGD	56	241150	6295800	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Klim Gollan					Permits		
45-1-0053	Wollangambie River 3;Newnes Junction 3;	AGD	56	245710	6294800	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	
	Contact	Recorders	ASRSYS					Permits		
45-1-0054	Wollangambie River 2;Newnes Junction 2;	AGD	56	245940	6294700	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	
	Contact	Recorders	ASRSYS					Permits		
45-1-2699	C-OS-4	GDA	56	248600	6295250	Open site	Valid	Artefact : 2		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd,RPS Australia E					Permits		
45-1-0202	BHT 1;NEWNES SF;	AGD	56	243250	6295800	Closed site	Valid	Artefact : -	Shelter with Deposit	

Report generated by AHIMS Web Service on 09/12/2022 for Luke Wolfe for the following area at Lat, Long From : -33.4983, 150.1758 - Lat, Long To : -33.4267, 150.2994. Number of Aboriginal sites and Aboriginal objects found is 41

NSW GOVERNMENT

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : 23109 Clarence

Client Service ID : 739643

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
	Contact	Recorders	Klim Gollan					Permits		
45-1-0166	Bell Creek;	AGD	56	248200	6290600	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Wieslaw Lichacz					Permits		
45-1-0059	Brown's Gap;Clarence Trig;Blackman's Creek 1;	AGD	56	240400	6290560	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	1333
	Contact	Recorders	L Bostock					Permits		
45-1-0055	Wollangambie Creek 1;Newnes Junction 1;	AGD	56	244870	6294550	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	
	Contact	Recorders	ASRSYS					Permits		
45-1-0056	Bald Hill / Bald Trig	AGD	56	243250	6295720	Open site	Not a Site	Art (Pigment or Engraved) : -	Not an Aboriginal Site	
	Contact	Recorders	Wieslaw Lichacz					Permits		
45-1-2698	C-OS-3 and PAD2	GDA	56	247151	6296298	Open site	Valid	Artefact : 11		
	Contact	Recorders	Ms.Lisa Campbell,RPS Australia East Pty Ltd - Hamilton					Permits		
45-2-0047	Bell Creek;	AGD	56	248200	6290600	Closed site	Valid	Artefact : -	Shelter with Deposit	
	Contact	Recorders	Wieslaw Lichacz					Permits		
45-1-0246	Blackmans Ck;	AGD	56	240350	6290450	Closed site	Valid	Artefact : -	Shelter with Deposit	1333
	Contact	Recorders	Warren Bluff					Permits		
45-1-2779	CLARENCE ISOLATED FIND 1	GDA	56	240741	6294391	Open site	Valid	Artefact : 1		102712
	Contact	Recorders	Ms.Emily Mccuistion					Permits		
45-1-2703	C-IF-1 (Lithgow)	GDA	56	248500	6295190	Open site	Valid	Artefact : 1		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd,RPS Australia E					Permits		
45-1-0063	Newnes Junction Bald Trig	AGD	56	243380	6295800	Open site	Valid	Grinding Groove : -	Axe Grinding Groove	130
	Contact	Recorders	Helen Brayshaw					Permits		
45-1-2810	Lithgow Waterworks Gallery	GDA	56	240730	6295633	Closed site	Valid	Art (Pigment or Engraved) : -		
	Contact	Recorders	Mr.Mark Roebuck					Permits		
45-1-0195	FC 2;NEWNES SF;	AGD	56	241200	6296500	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Klim Gollan					Permits		
45-1-2696	C-OS-2 and PAD	AGD	56	241875	6294849	Open site	Valid	Artefact : -, Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd					Permits		
45-1-0196	FC 1;NEWNES SF;	AGD	56	241100	6296600	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Klim Gollan					Permits		

Report generated by AHIMS Web Service on 09/12/2022 for Luke Wolfe for the following area at Lat, Long From : -33.4983, 150.1758 - Lat, Long To : -33.4267, 150.2994. Number of Aboriginal sites and Aboriginal objects found is 41

NSW GOVERNMENT

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : 23109 Clarence

Client Service ID : 739643

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status **	SiteFeatures	SiteTypes	Reports
45-1-0077	Bell;Blue Mountains;	AGD	56	246500	6290200	Open site	Valid	Stone Arrangement : -, Artefact : -	Open Camp Site,Stone Arrangement	
	Contact	Recorders	Wieslaw Lichacz					Permits		
45-1-0061	Brown's Gap;Clarence Trig;Blackman's Creek 3;	AGD	56	240390	6290540	Closed site	Valid	Art (Pigment or Engraved) : -, Artefact : -	Shelter with Art,Shelter with Deposit	1333
	Contact	Recorders	L Bostock					Permits		
45-1-2690	RPS CL AS1	GDA	56	241876	6294849	Open site	Valid	Artefact : 1		
	Contact	Recorders	Ms.Gillian Goode,RPS Australia East Pty Ltd - Hamilton					Permits		
45-1-0193	FC 4;NEWNES SF;	AGD	56	241450	6296000	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Klim Gollan					Permits		
45-1-0192	HVS 1;NEWNES SF;	AGD	56	241550	6296900	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	Recorders	Klim Gollan					Permits		
45-1-2702	C-S-1 and PAD5	AGD	56	241029	6296473	Open site	Valid	Artefact : -, Potential Archaeological Deposit (PAD) : -		
	Contact	Recorders	Ms.Gillian Goode,RPS Australia East Pty Ltd - Hamilton					Permits		
45-1-0057	Newnes Junction;Bald Hill;Bald Trig;	AGD	56	243220	6295730	Closed site	Valid	Artefact : -, Art (Pigment or Engraved) : -	Shelter with Art,Shelter with Deposit	
	Contact	Recorders	Wieslaw Lichacz					Permits		
45-1-2819	Hatters Cave	GDA	56	245776	6290297	Closed site	Valid	Art (Pigment or Engraved) : 2		104212
	Contact	Recorders	Phil Purcell					Permits	4770	
45-1-2705	C-ST-1 New	GDA	56	248276	6295349	Open site	Valid	Modified Tree (Carved or Scarred) : -, Artefact : 1		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd,RPS Australia E					Permits		
45-1-0060	Brown's Gap;Clarence Trig;Blackman's Creek 2;	AGD	56	240420	6290550	Closed site	Valid	Art (Pigment or Engraved) : -, Artefact : -	Shelter with Art,Shelter with Deposit	1333
	Contact	Recorders	L Bostock					Permits		
45-1-2701	C-OS-6	AGD	56	242131	6293411	Open site	Valid	Artefact : 3		
	Contact	Recorders	Mrs.Robynne Mills,Mills Archaeological & Heritage Services Pty Ltd					Permits		
45-1-0058	Bungleboori;	AGD	56	244800	6297650	Closed site	Valid	Art (Pigment or Engraved) : -, Artefact : -	Shelter with Art,Shelter with Deposit	
	Contact	Recorders	L Bostock					Permits		

Report generated by AHIMS Web Service on 09/12/2022 for Luke Wolfe for the following area at Lat, Long From : -33.4983, 150.1758 - Lat, Long To : -33.4267, 150.2994. Number of Aboriginal sites and Aboriginal objects found is 41

Appendix B Management of Unexpected Finds and Potential Human Remains

Procedure on the Discovery of Aboriginal Sites/Objects

Should a suspected Aboriginal site be identified at any point throughout the life of the Project, the following standard procedure should be adopted:

1. All works must cease immediately in the area to prevent any further impacts to the site;
2. Engage a suitably qualified heritage consultant to determine the nature, extent and significance of the find and provide appropriate management advice. Management action(s) will vary according to the type of evidence identified, its significance (both scientific and cultural) and the nature of potential impacts; and
3. Prepare and submit an AHIMS site card for the site.

Management of Skeletal Remains

This section outlines the procedure that should be followed in the case that potential human remains are discovered during the life of the Project. The procedure takes into account the following documents:

- Manual for the Identification of Aboriginal Remains (NSW Department of Environment & Conservation, 2006)
- Skeletal Remains - Guidelines for the management of human skeletal remains under the Heritage Act 1977 (NSW Heritage Office, 2008); and
- The Aboriginal Cultural Heritage Standards and Guidelines Kit (NSW National Parks and Wildlife Service, 1997).

In the event that potential human skeletal remains are identified at any point during the life of the drilling program, the following standard procedure should be followed.

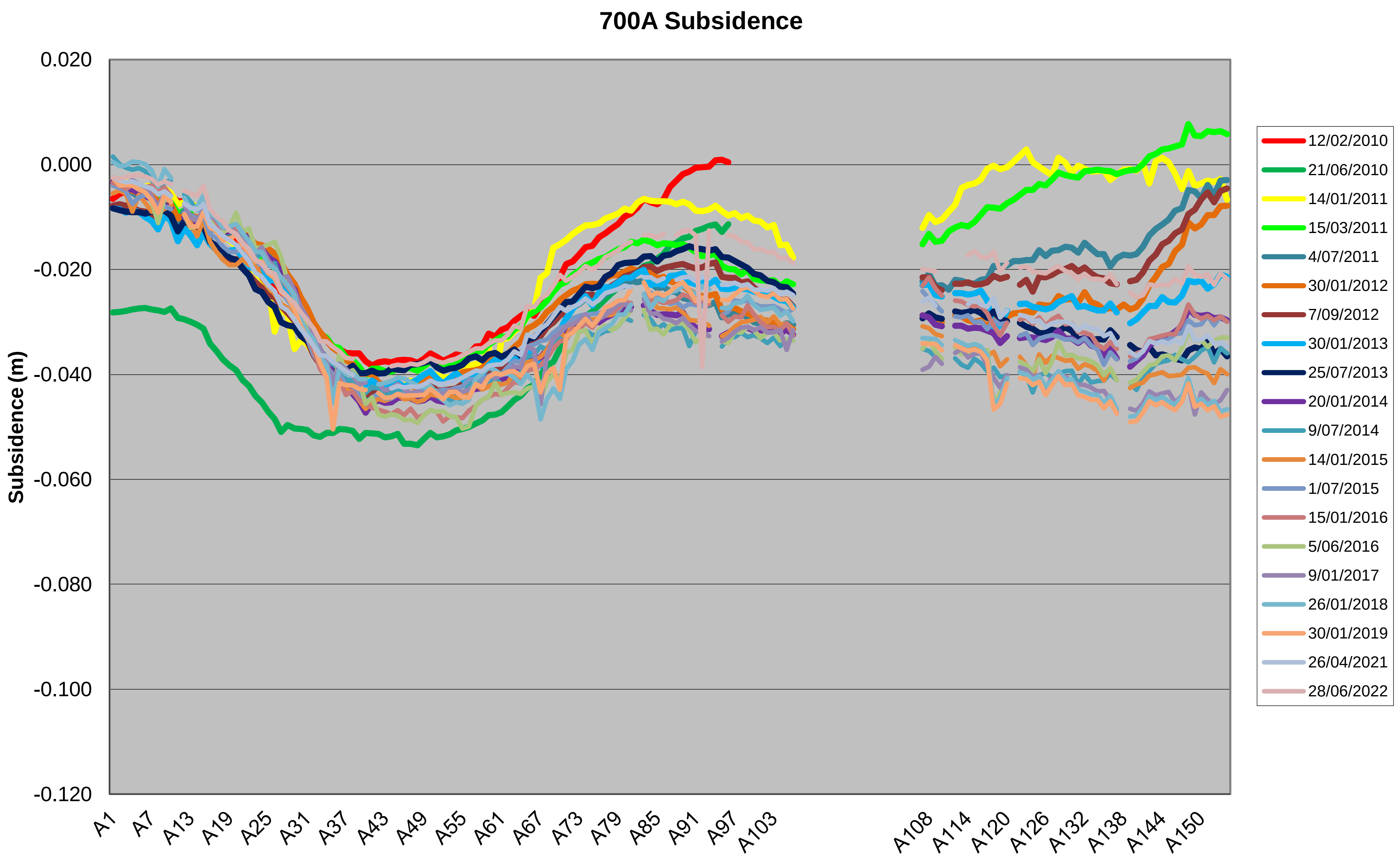
4. All work in the vicinity of the remains should cease immediately;
5. The location should be cordoned off and the NSW Police notified.
6. If the Police suspect the remains are Aboriginal, they will contact Heritage NSW and arrange for a forensic anthropologist or archaeological expert to examine the site.

Subsequent management actions will be dependent on the findings of the inspection undertaken under Point 3.

- If the remains are identified as modern and human, the area will become a crime scene under the jurisdiction of the NSW Police;
- If the remains are identified as pre-contact or historic Aboriginal, Heritage NSW and any Aboriginal stakeholders (including Metropolitan Local Aboriginal Land Council) are to be formally notified in writing. Where impacts to exposed Aboriginal skeletal remains cannot be avoided an appropriate management mitigation strategy will be developed in consultation with Heritage NSW and Aboriginal stakeholders;

- If the remains are identified as historic non-Aboriginal, the site is to be secured and the Heritage NSW contacted; and
- If the remains are identified as non-human, work can recommence immediately.

Appendix 7: Subsidence Monitoring Results



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-0.060
-0.080
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-0.120
A1
A7
A13
A19
A25
A31
A37
A43
A49
A55
A61
A67
A73
A79
A85
A91
A97
A103
A108
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A144
A150
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21/06/2010
14/01/2011
15/03/2011
4/07/2011
30/01/2012
7/09/2012
30/01/2013
25/07/2013
20/01/2014
9/07/2014
14/01/2015
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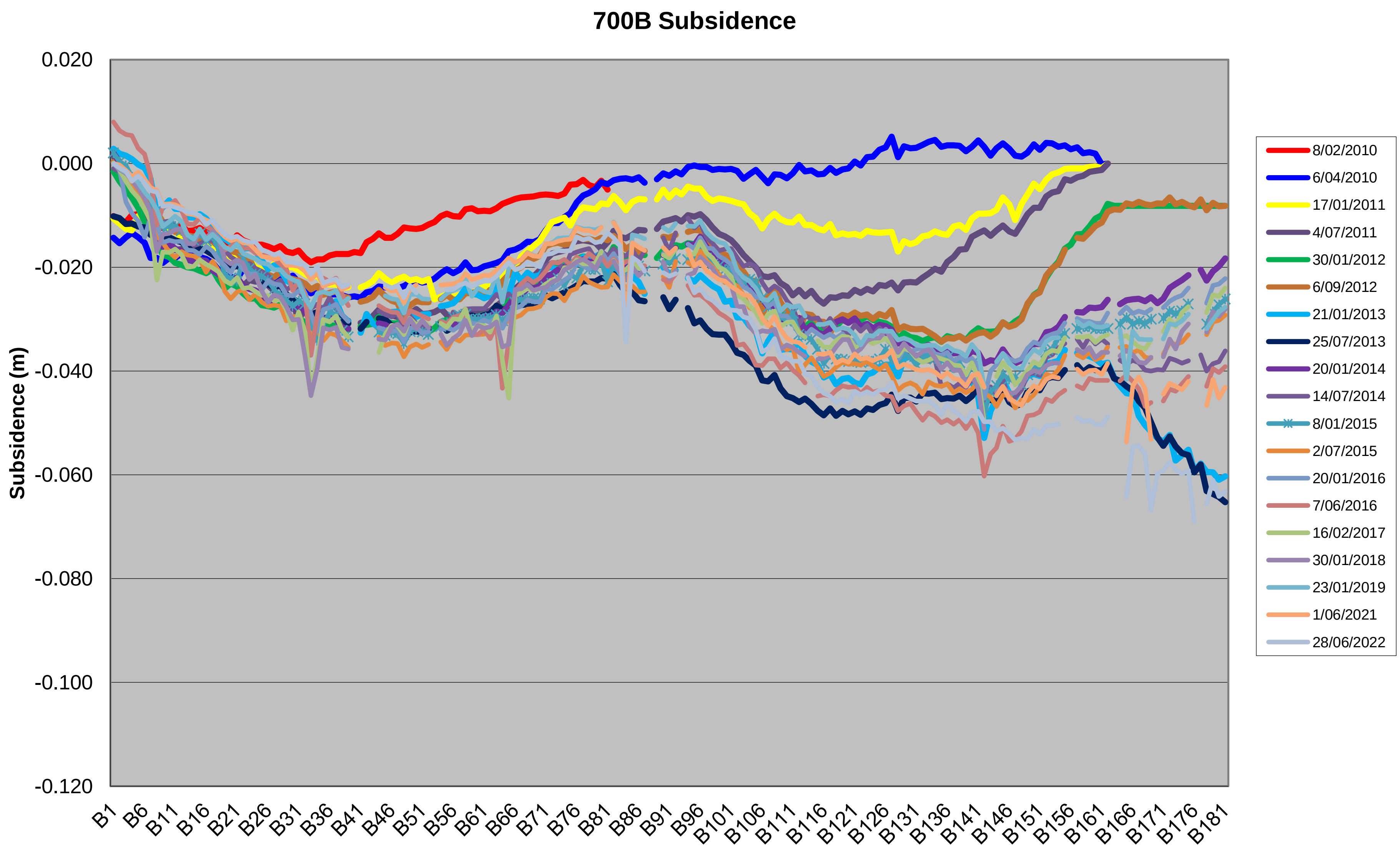
26/04/2021
28/06/2022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-0.100
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B1
B6
B11
B16
B21
B26
B31
B36
B41
B46
B51
B56
B61
B66
B71
B76
B81
B86
B91
B96
B101
B106
B111
B116
B121
B126
B131
B136
B141
B146
B151
B156
B161
B166
B171
B176
B181
8/02/2010
6/04/2010
17/01/2011
4/07/2011
30/01/2012
6/09/2012
21/01/2013
25/07/2013
20/01/2014
14/07/2014
8/01/2015
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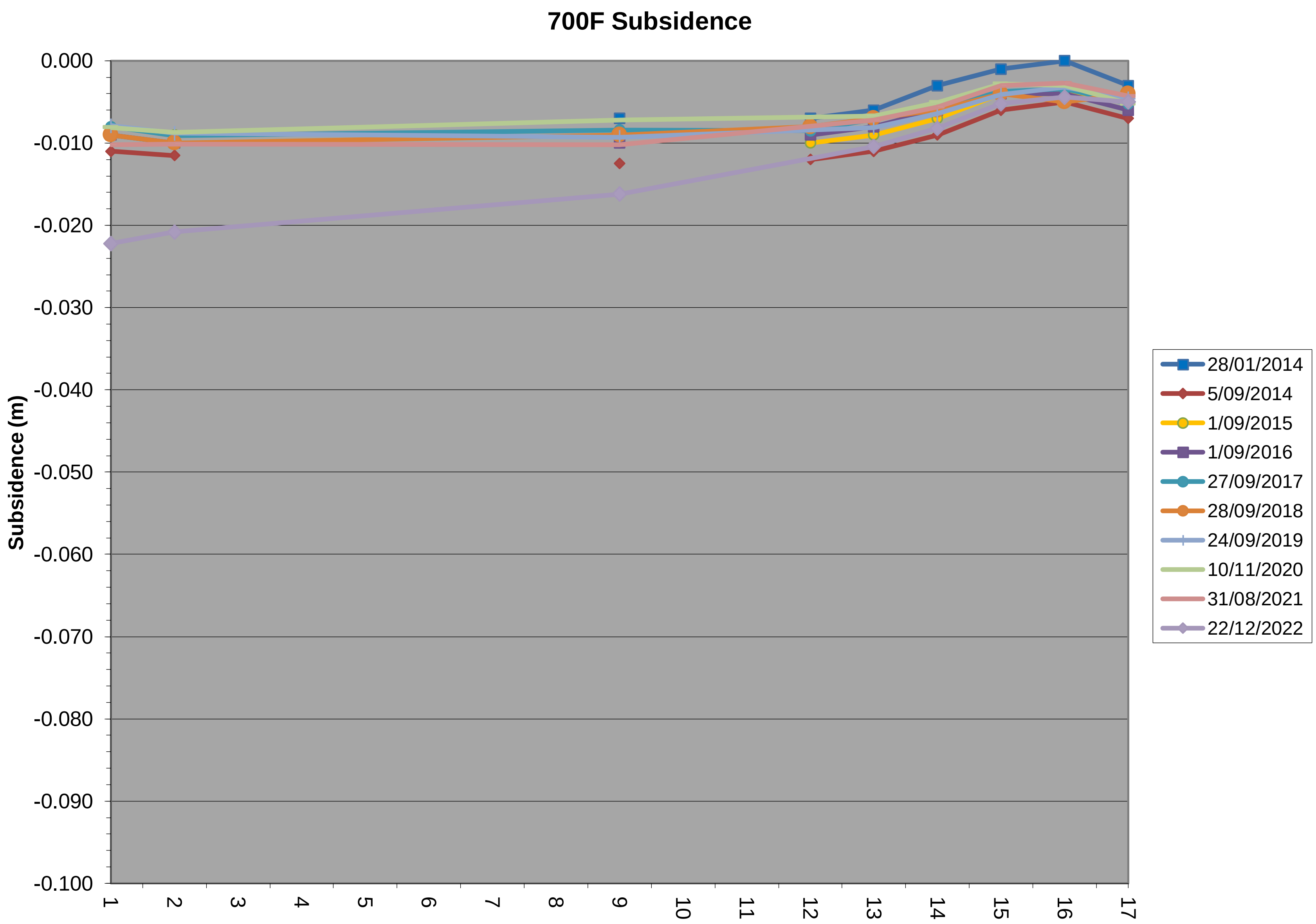
1/06/2021
28/06/2022



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-0.060
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-0.080
-0.090
-0.100
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
28/01/2014
5/09/2014
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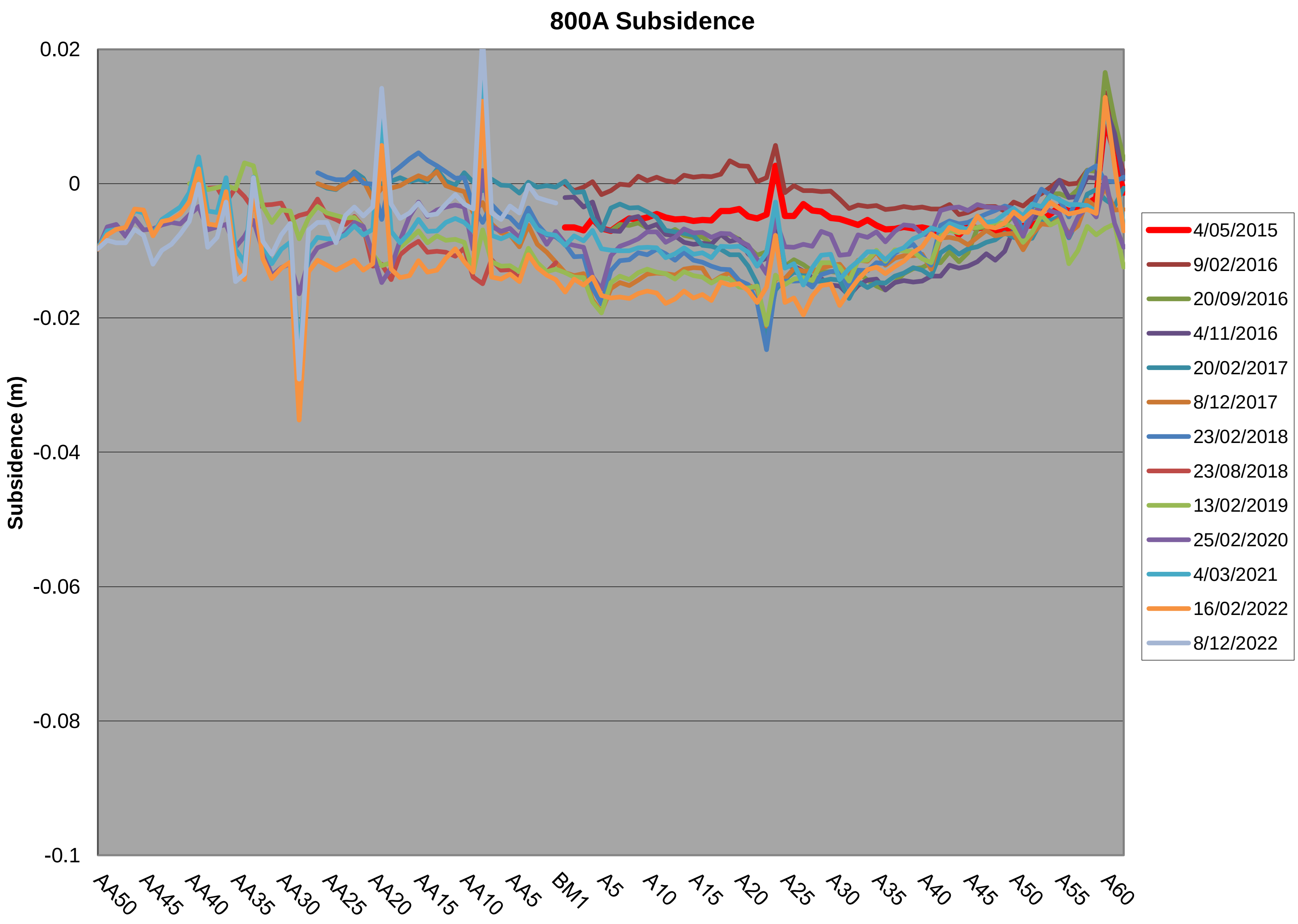
31/08/2021
22/12/2022



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-0.1
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AA45
AA40
AA35
AA30
AA25
AA20
AA15
AA10
AA5
BM1
A5
A10
A15
A20
A25
A30
A35
A40
A45
A50
A55
A60
4/05/2015
9/02/2016
20/09/2016
4/11/2016
20/02/2017
8/12/2017
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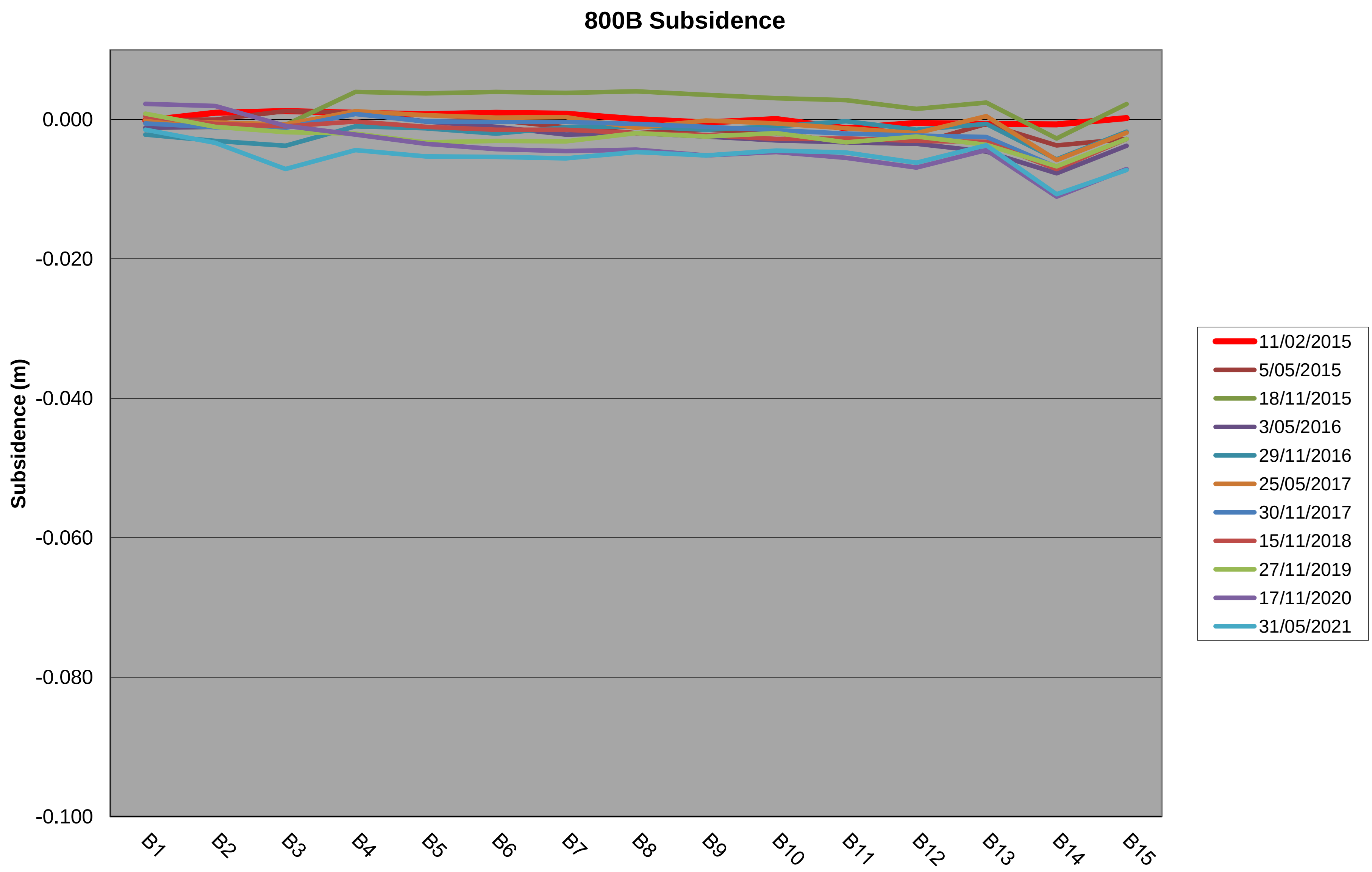
23/08/2018
13/02/2019
25/02/2020
4/03/2021
16/02/2022
8/12/2022



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Subsidence (m)
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-0.040
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-0.080
-0.100
B1
B2
B3
B4
B5
B6
B7
B8
B9
B10
B11
B12
B13
B14
B15
11/02/2015
5/05/2015
18/11/2015
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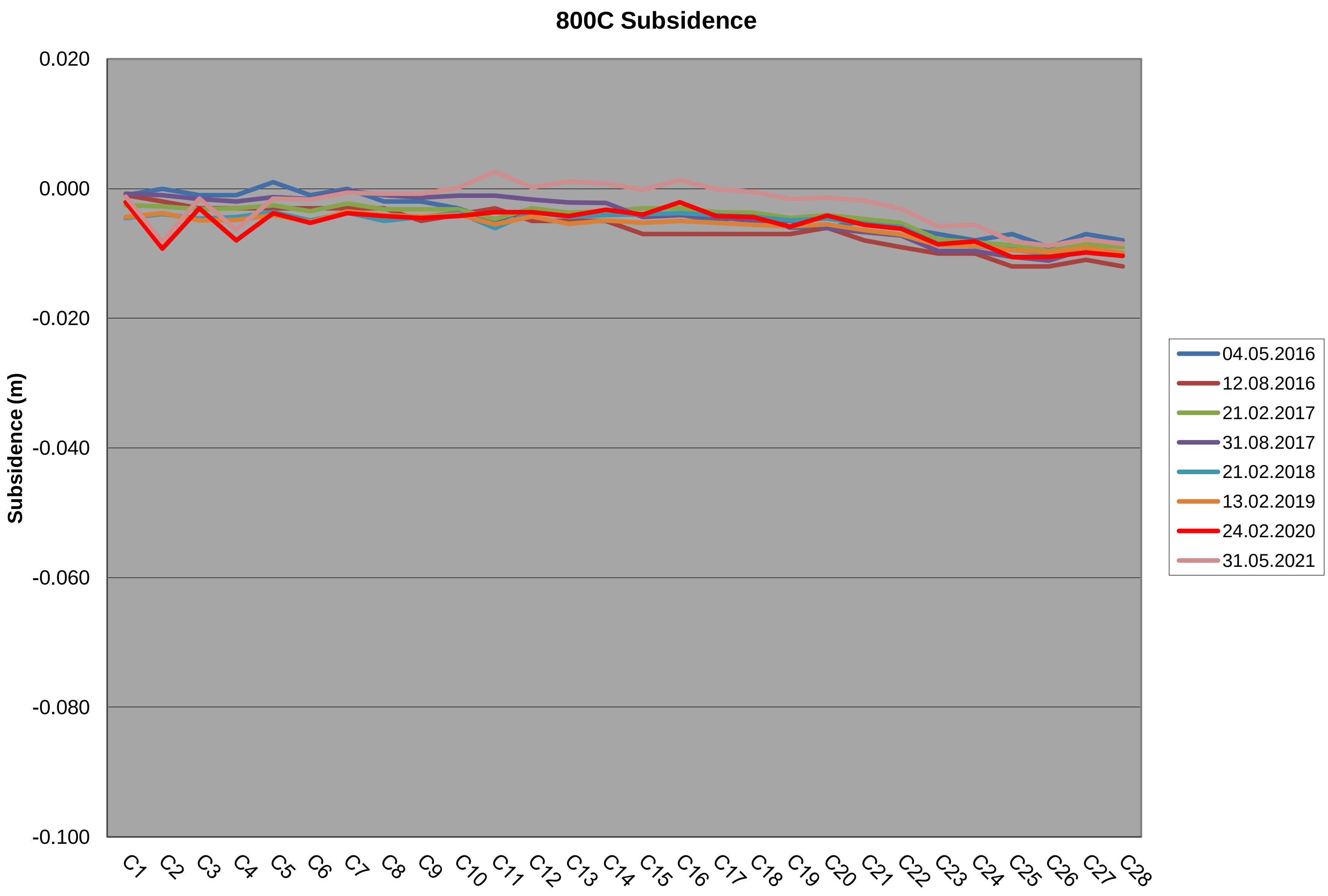
27/11/2019
17/11/2020
31/05/2021



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-0.100
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21.02.2017
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13.02.2019
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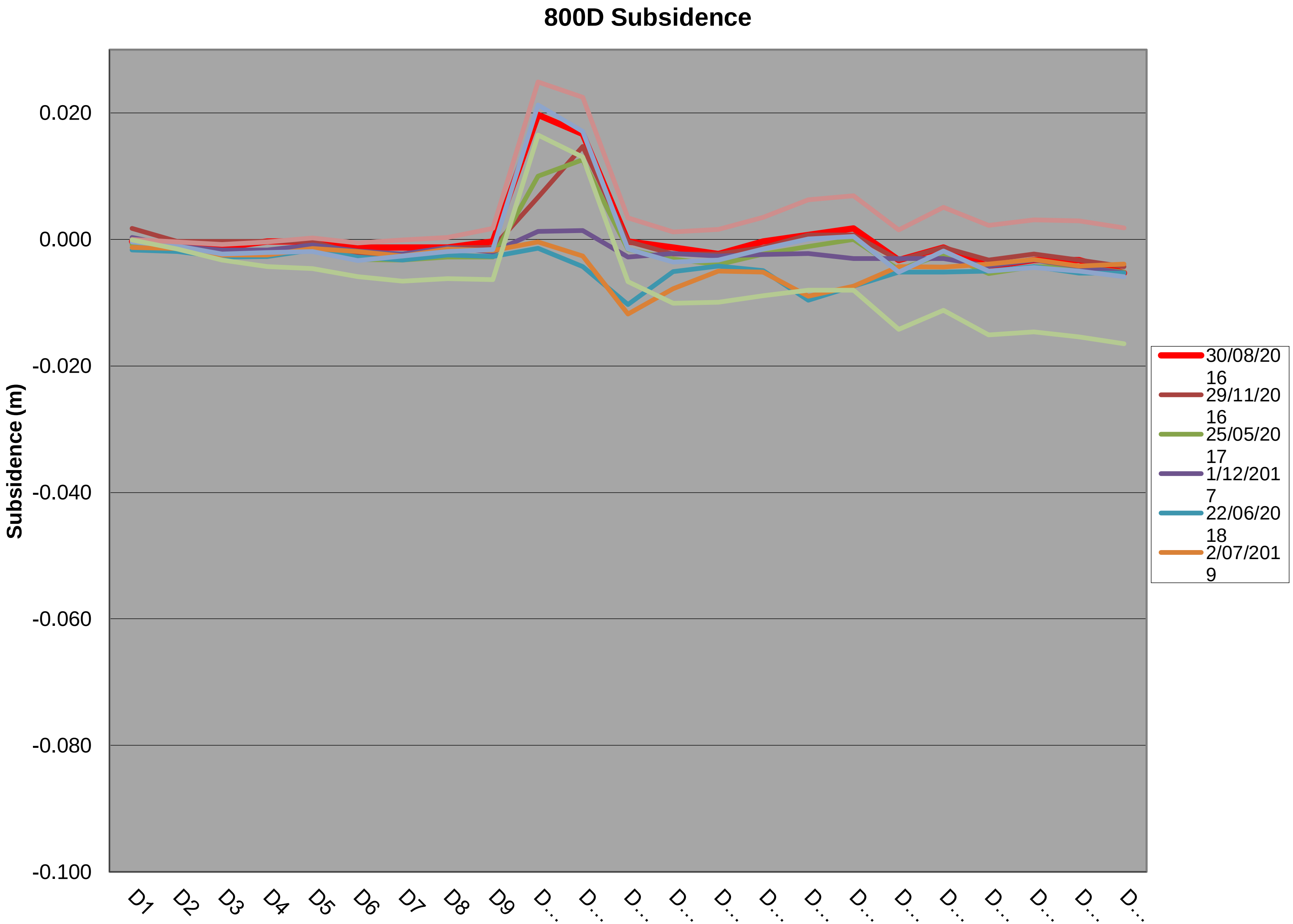

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-0.040
-0.060
-0.080
-0.100
D1
D2
D3
D4
D5
D6
D7
D8
D9
D…
30/08/2016
29/11/2016
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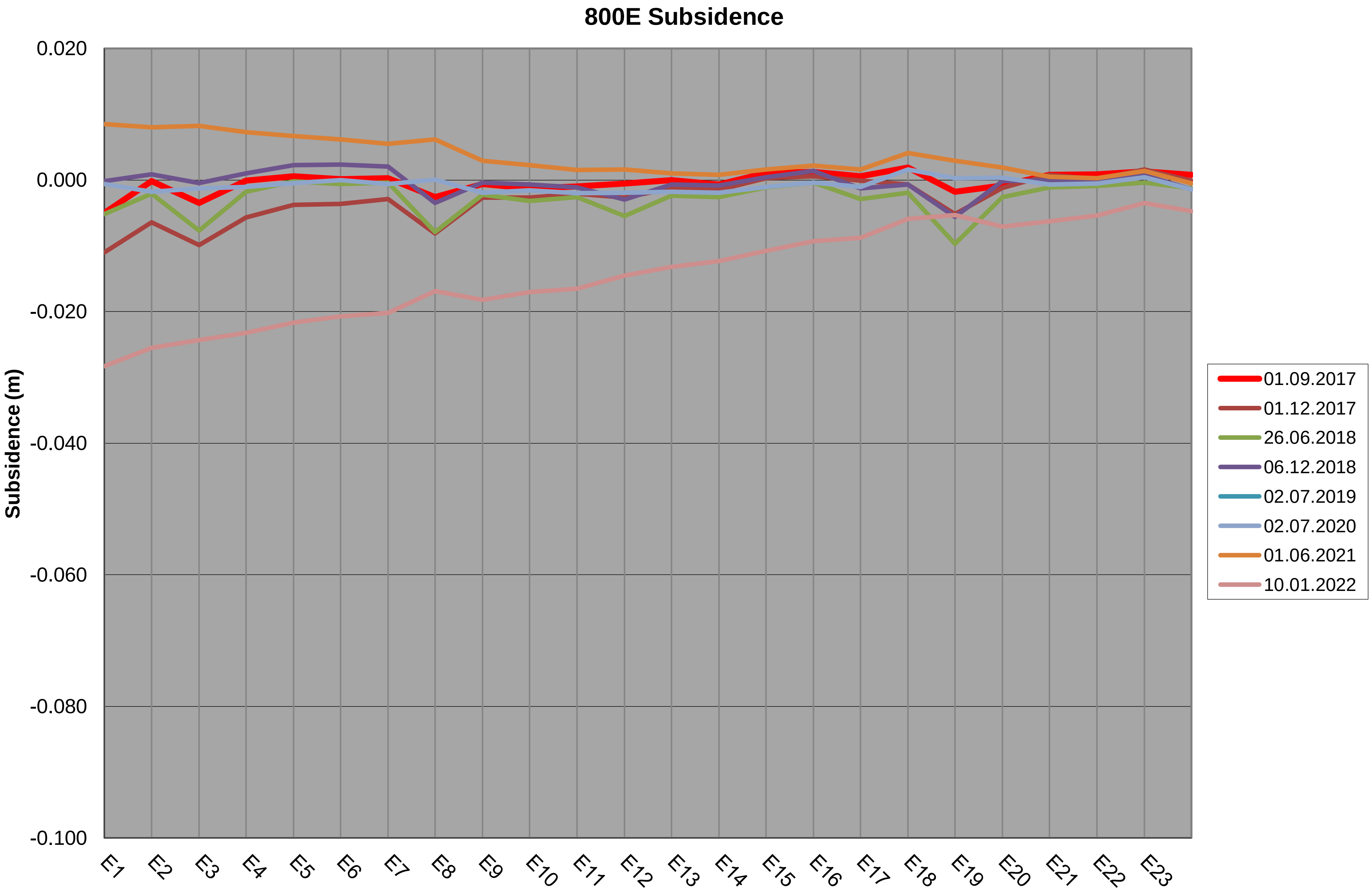
22/06/2018
2/07/2019



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Subsidence (m)
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-0.060
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-0.100
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E17
E18
E19
E20
E21
E22
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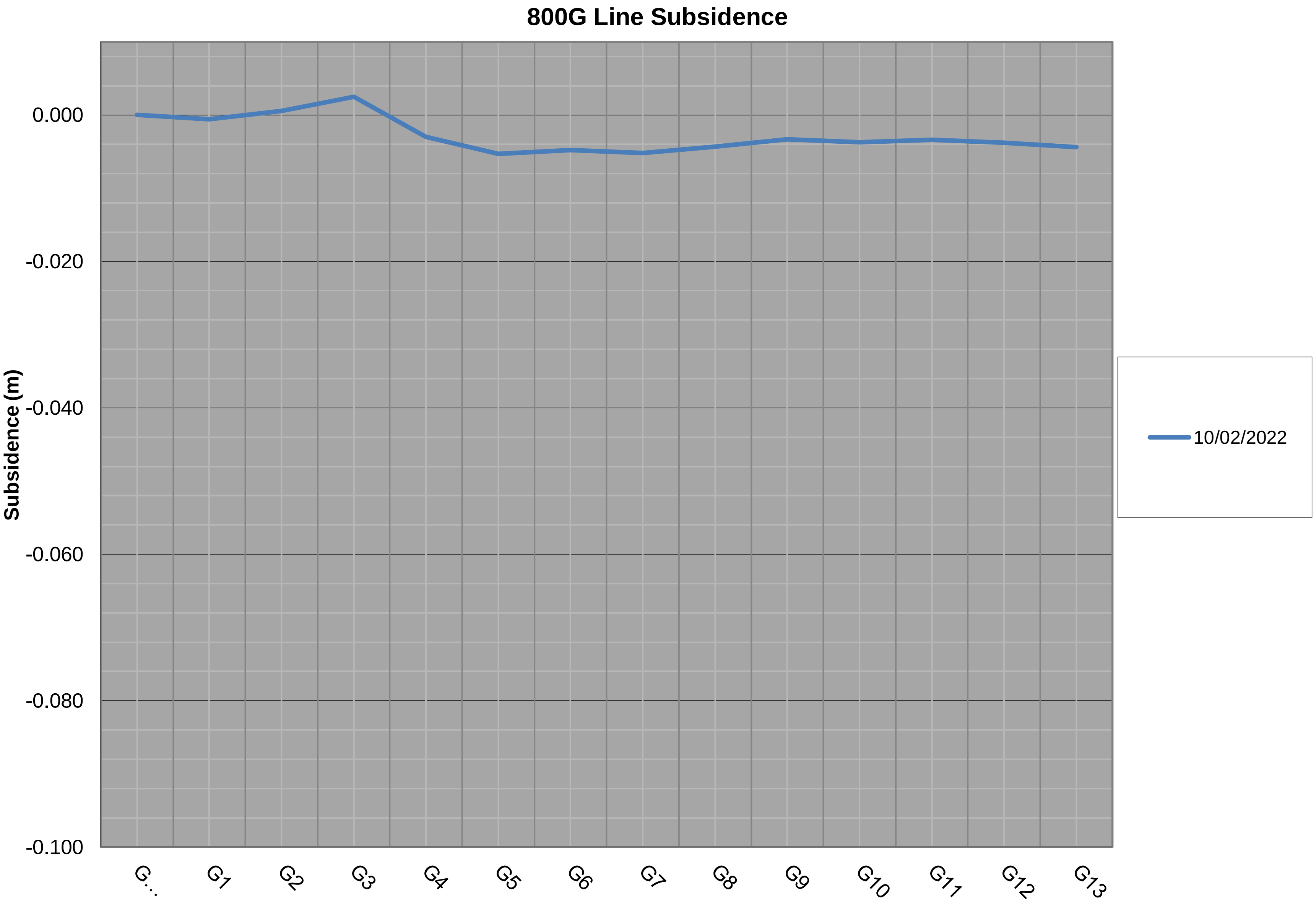

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Subsidence (m)
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-0.060
-0.080
-0.100
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G5
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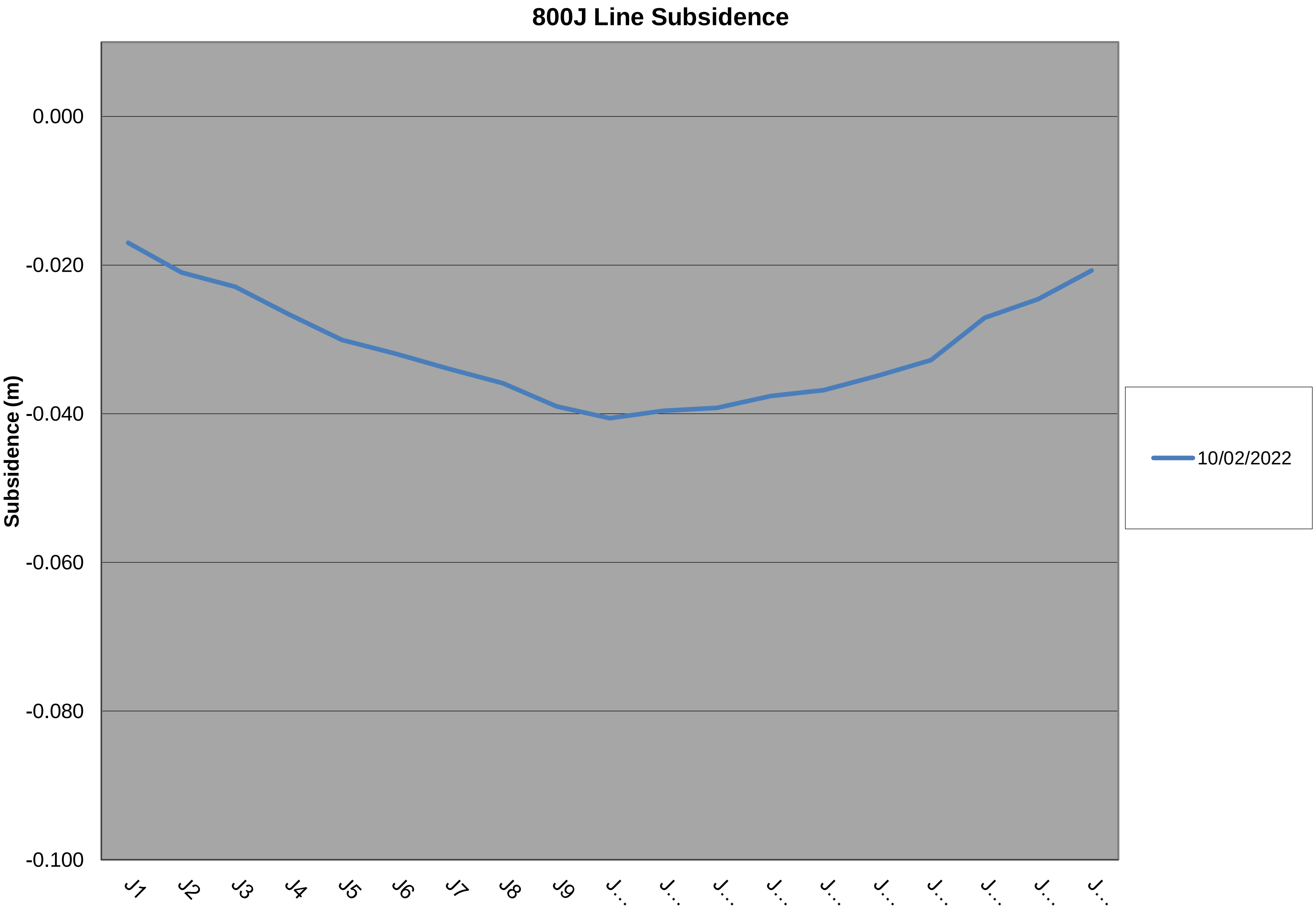
G13
10/02/2022



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Subsidence (m)
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-0.100
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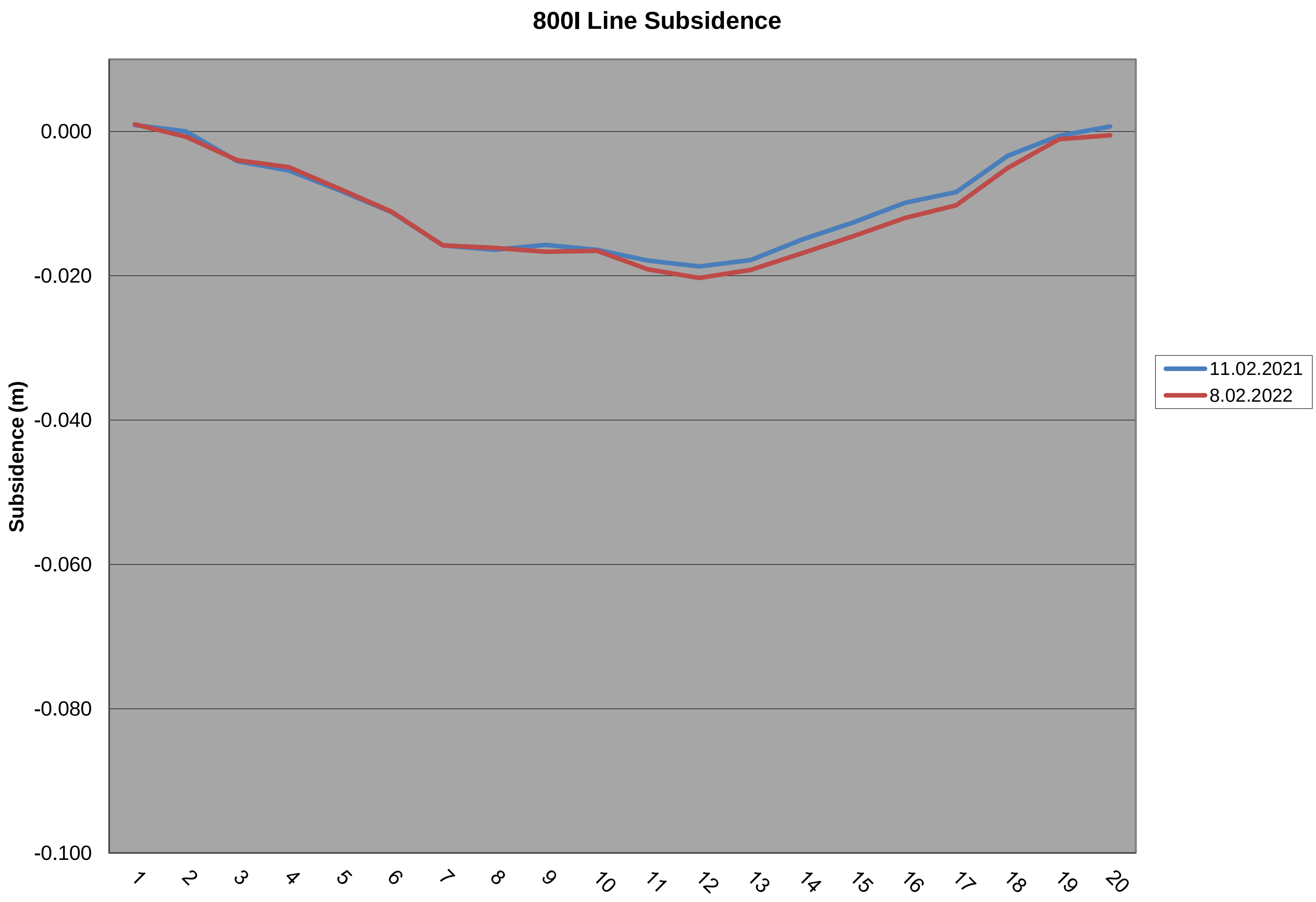
J3
J4
J5
J6
J7
J8
J9
J...
J...
J...
J...
J...
J...
J...
J...
J...
J...
10/02/2022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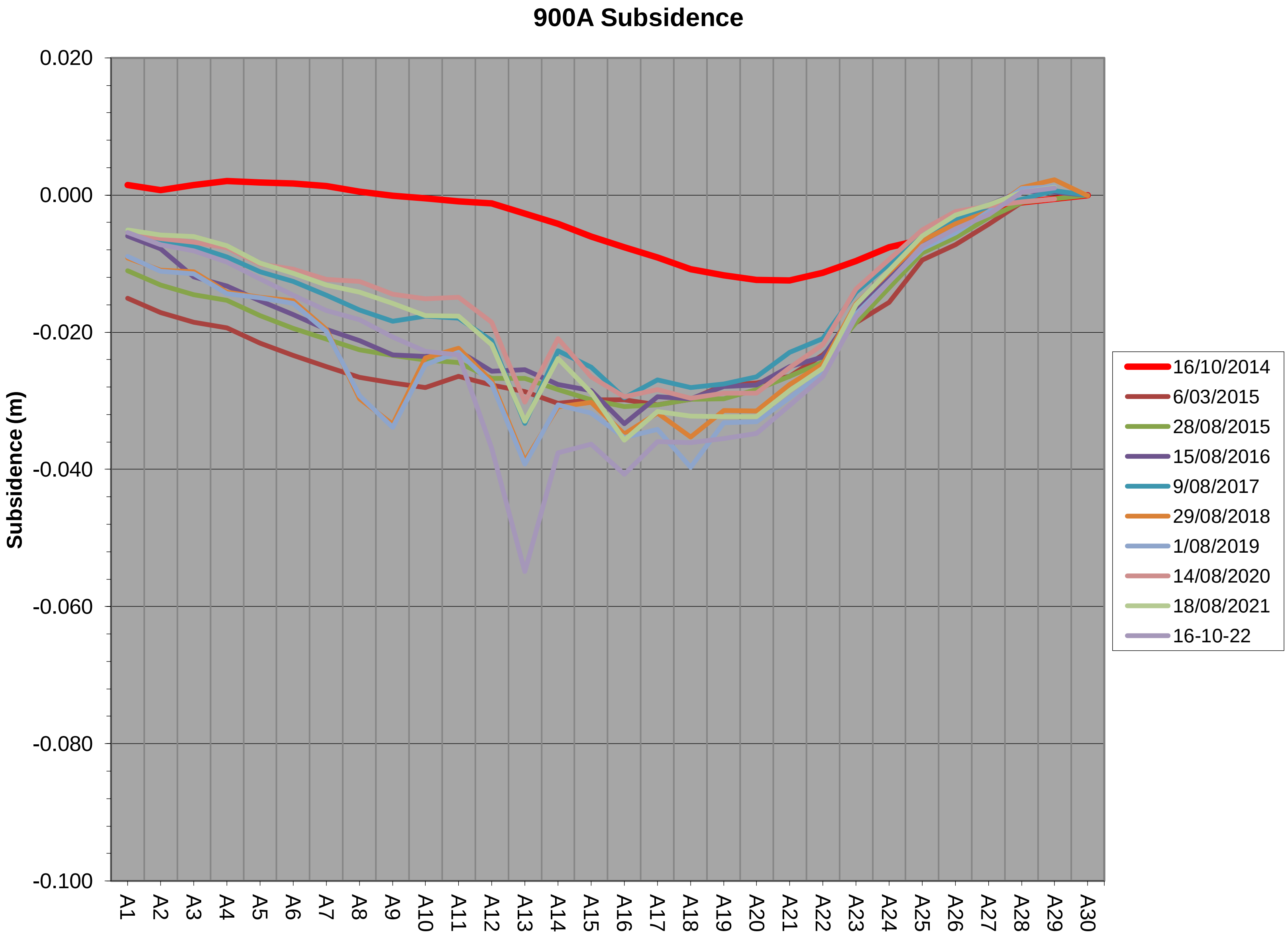
8.02.2022



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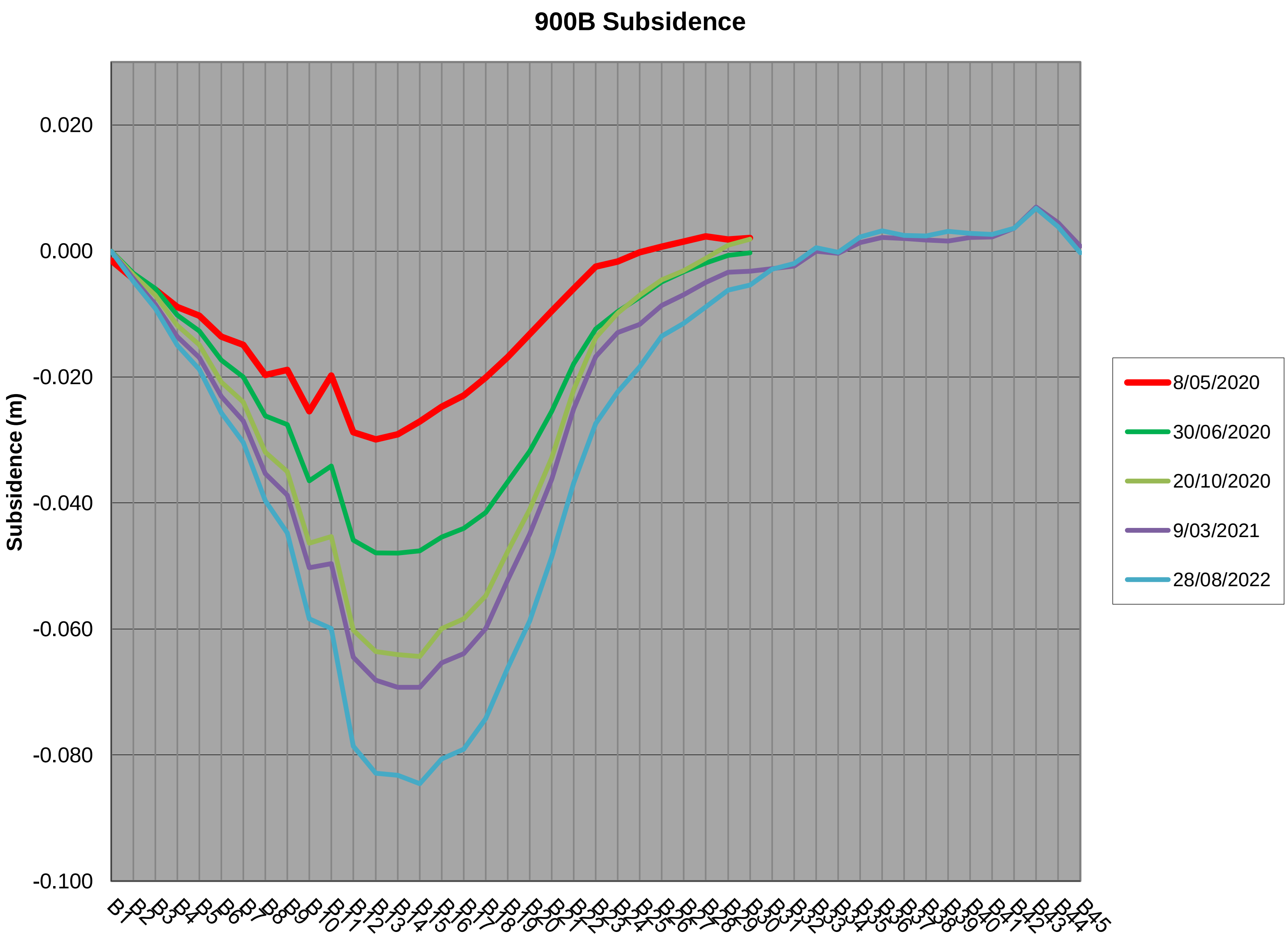
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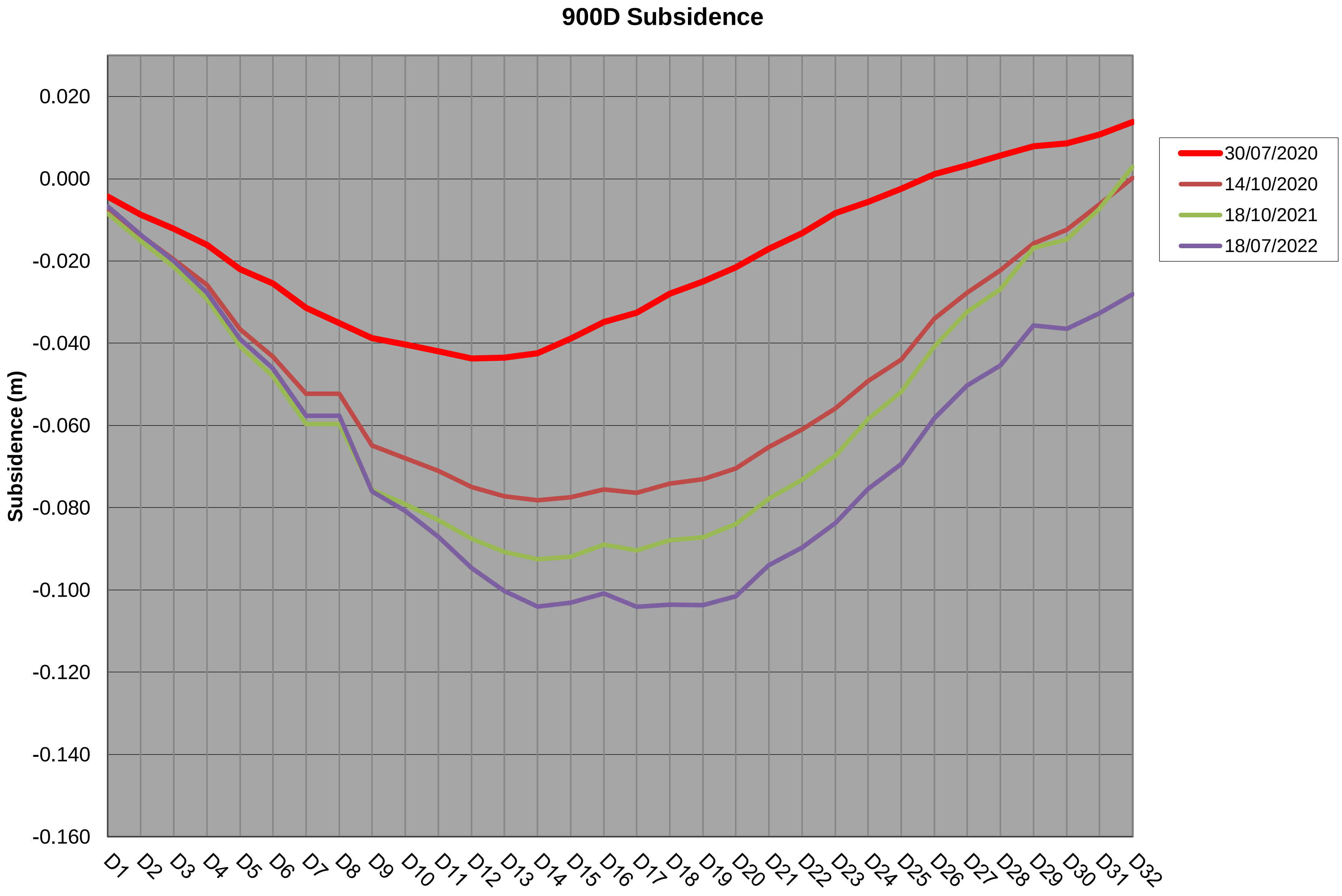
8/05/2020
30/06/2020
20/10/2020
9/03/2021
28/08/2022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-0.160
D1 D2 D3 D4 D5 D6 D7 D8 D9 D10 D11 D12 D13 D14 D15 D16 D17 D18 D19 D20 D21 D22 D23 D24 D25 D26 D27 D28 D29 D30 D31 D32
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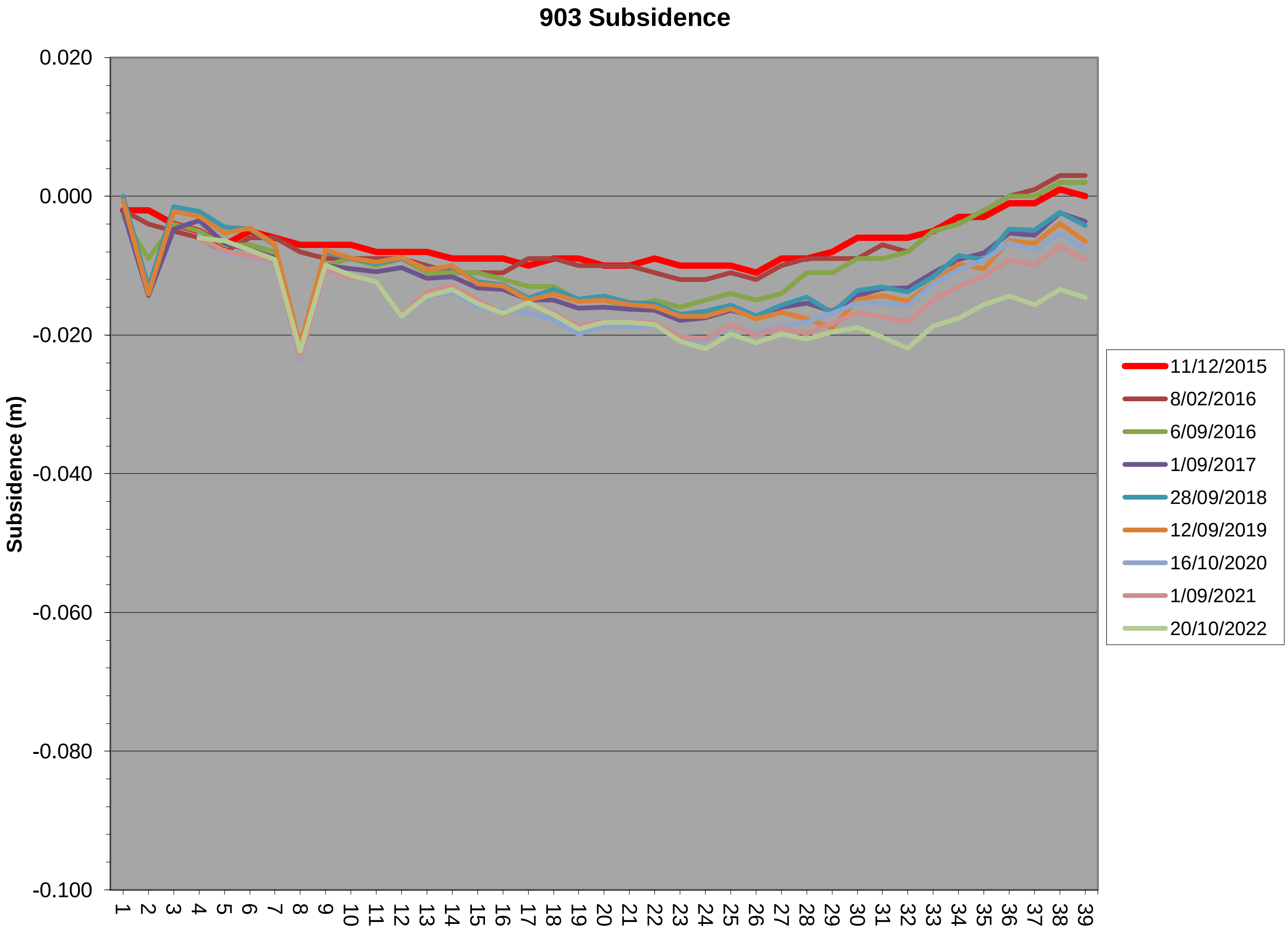
18/07/2022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-0.100
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11/12/2015
8/02/2016
6/09/2016
1/09/2017
28/09/2018
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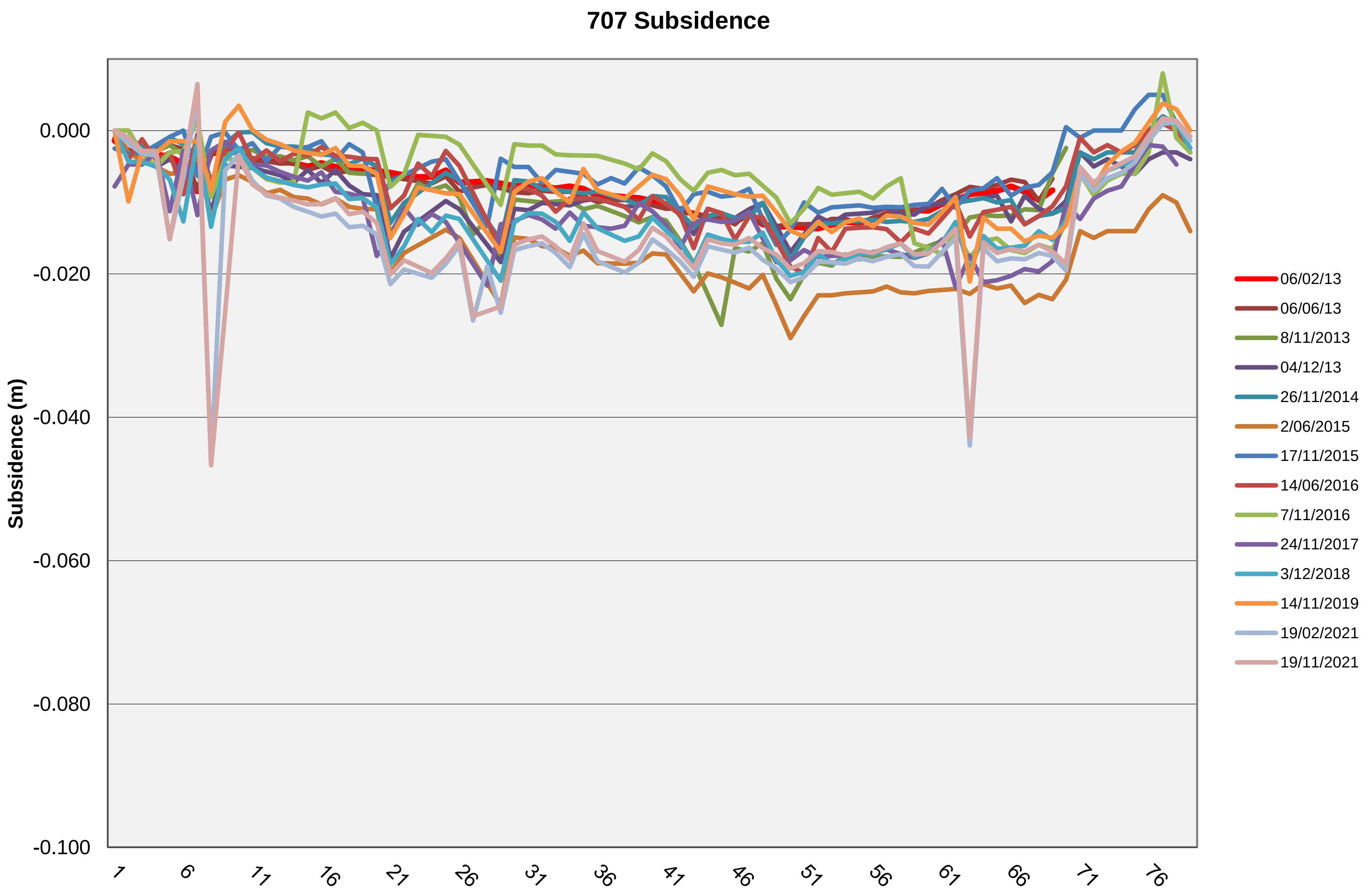
16/10/2020
1/09/2021
20/10/2022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-0.080
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21
26
31
36
41
46
51
56
61
66
71
76
06/02/13
06/06/13
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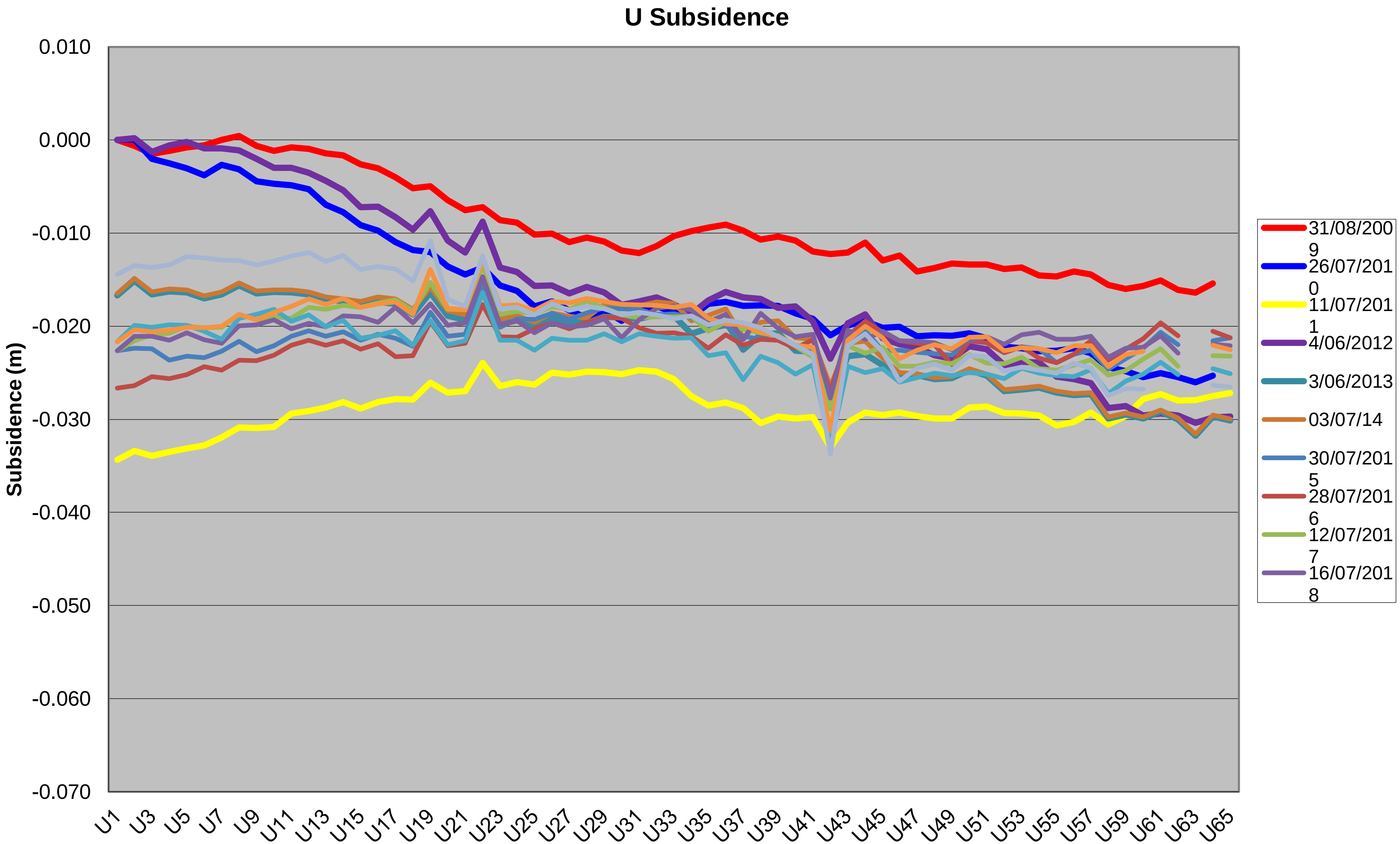
19/02/2021
19/11/2021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-0.030
-0.040
-0.050
-0.060
-0.070
U1
U3
U5
U7
U9
U11
U13
U15
U17
U19
U21
U23
U25
U27
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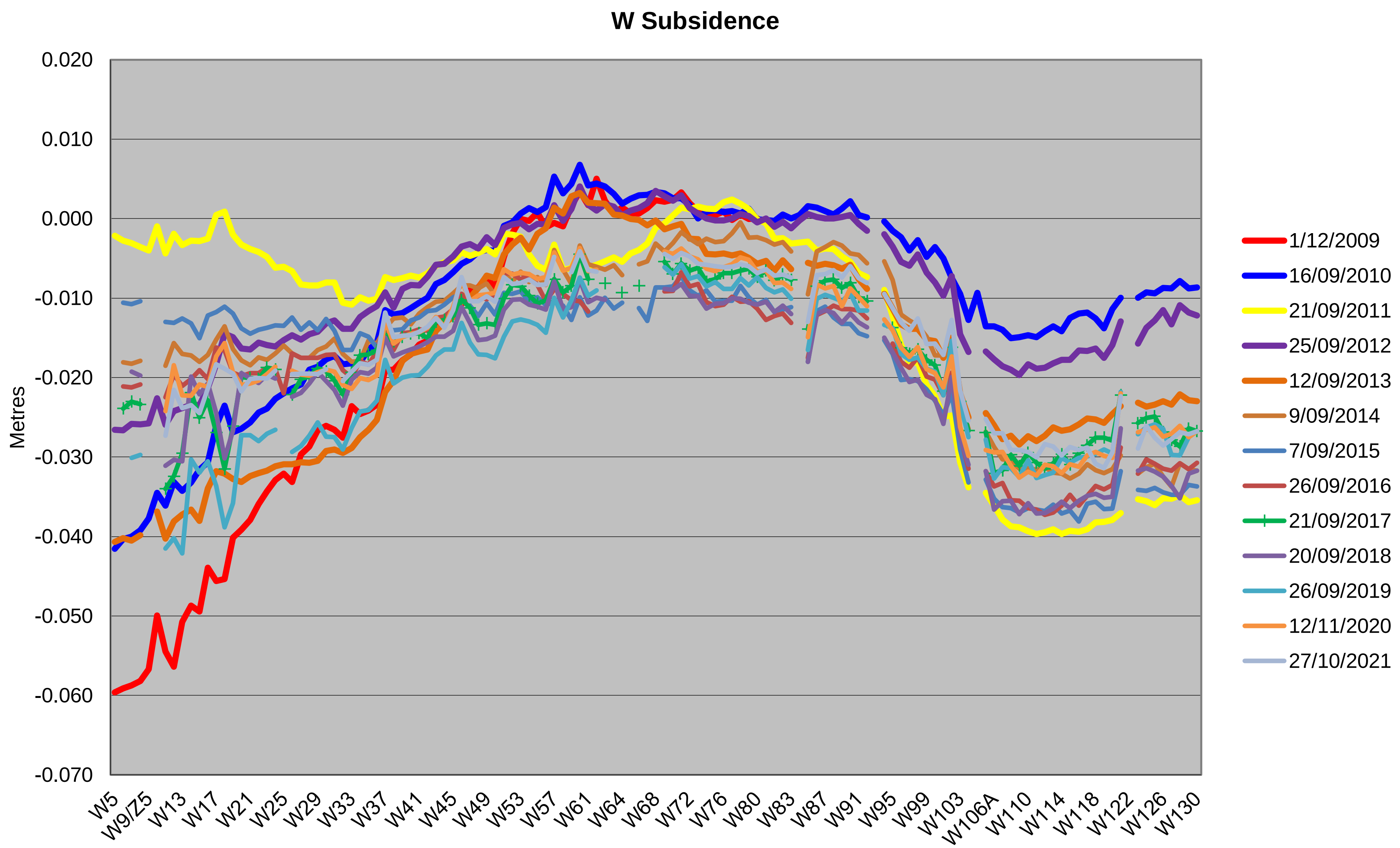

W Subsidence
Metres
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0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
W5
W9/Z5
W13
W17
W21
W25
W29
W33
W37
W41
W45
W49
W53
W57
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W103
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W118
W122
W126
W130
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16/09/2010
21/09/2011
25/09/2012
12/09/2013
9/09/2014
7/09/2015
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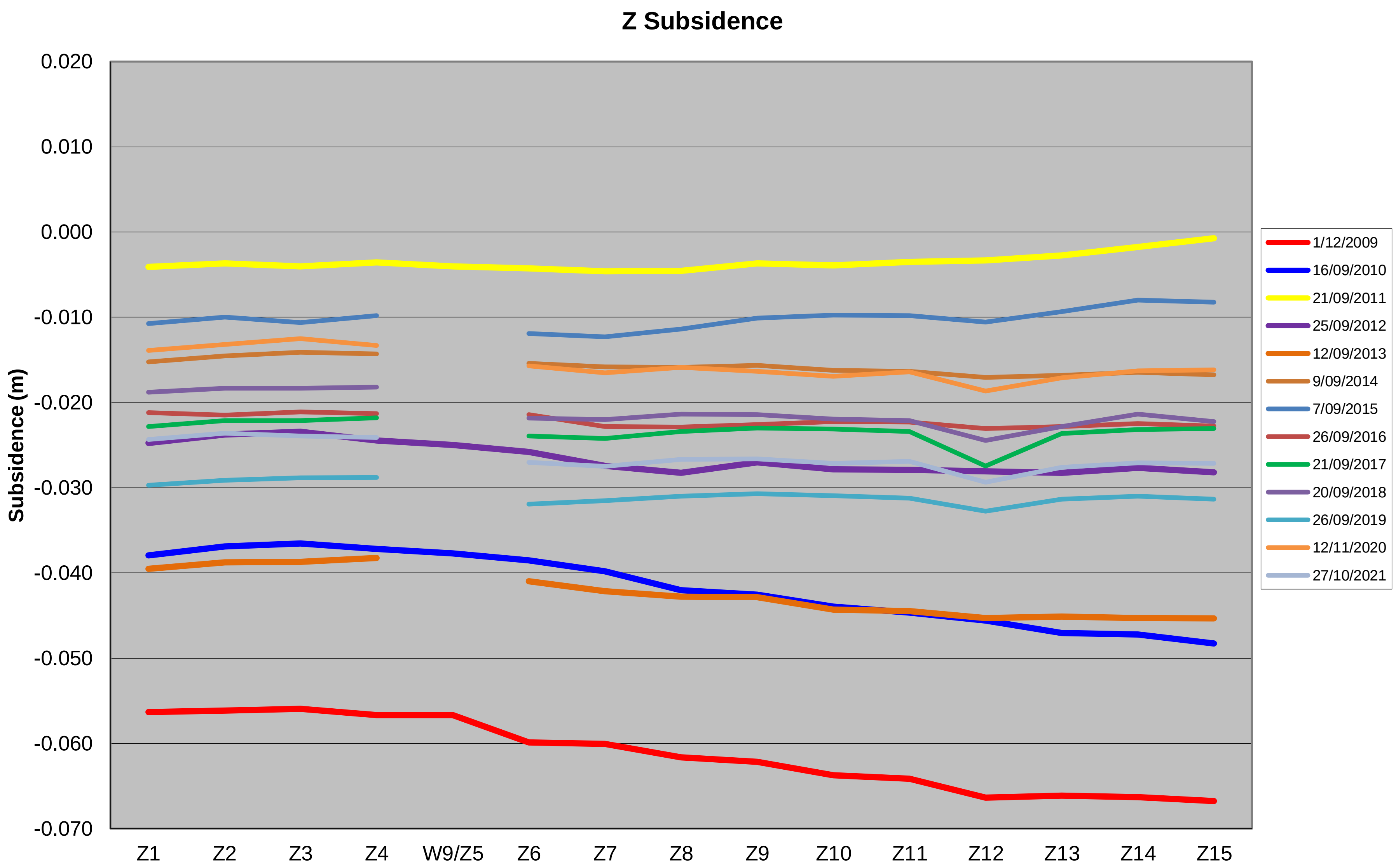
20/09/2018
26/09/2019
12/11/2020
27/10/2021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Subsidence (m)
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0.000
-0.010
-0.020
-0.030
-0.040
-0.050
-0.060
-0.070
Z1
Z2
Z3
Z4
W9/Z5
Z6
Z7
Z8
Z9
Z10
Z11
Z12
Z13
Z14
Z15
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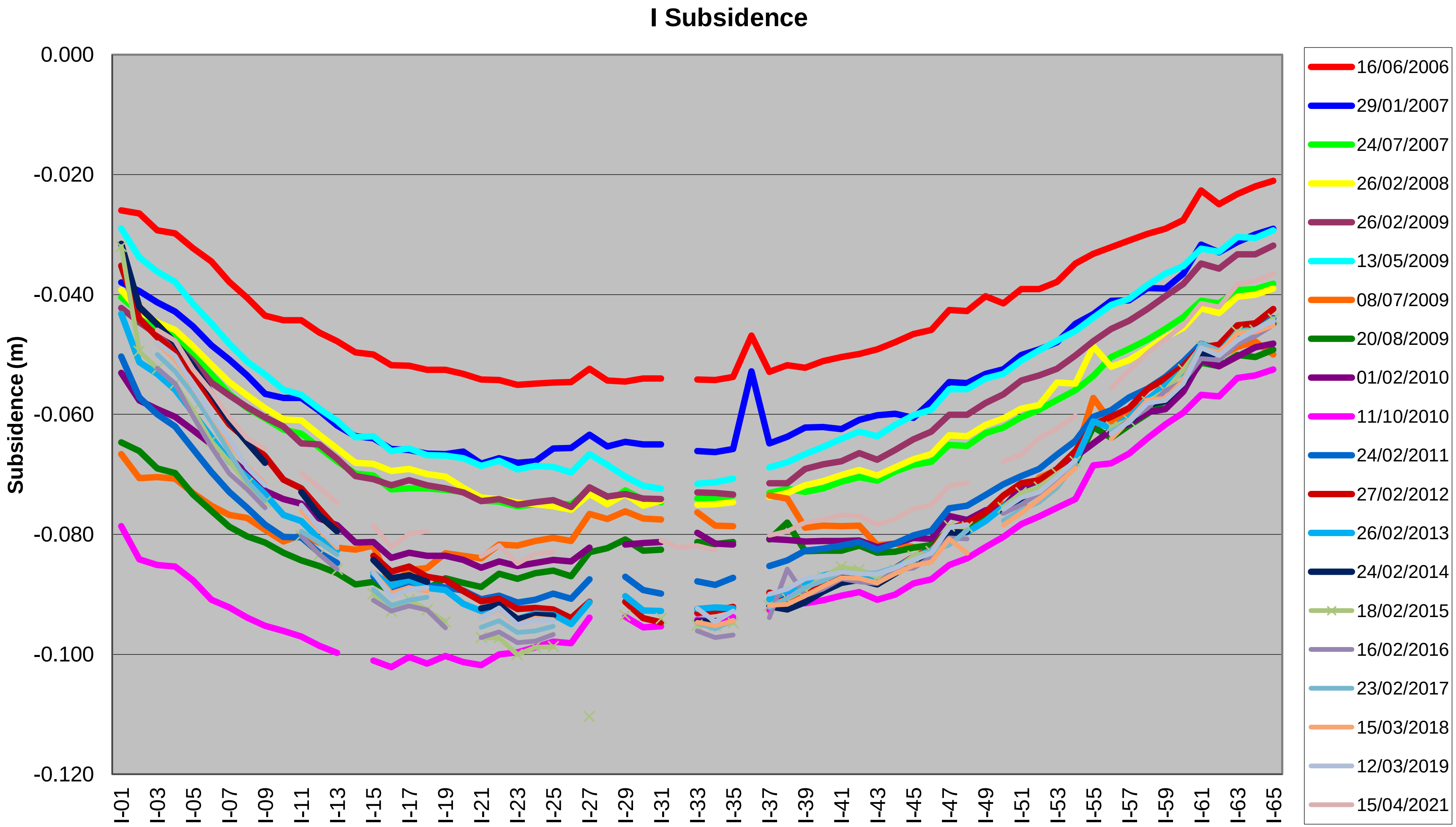
27/10/2021



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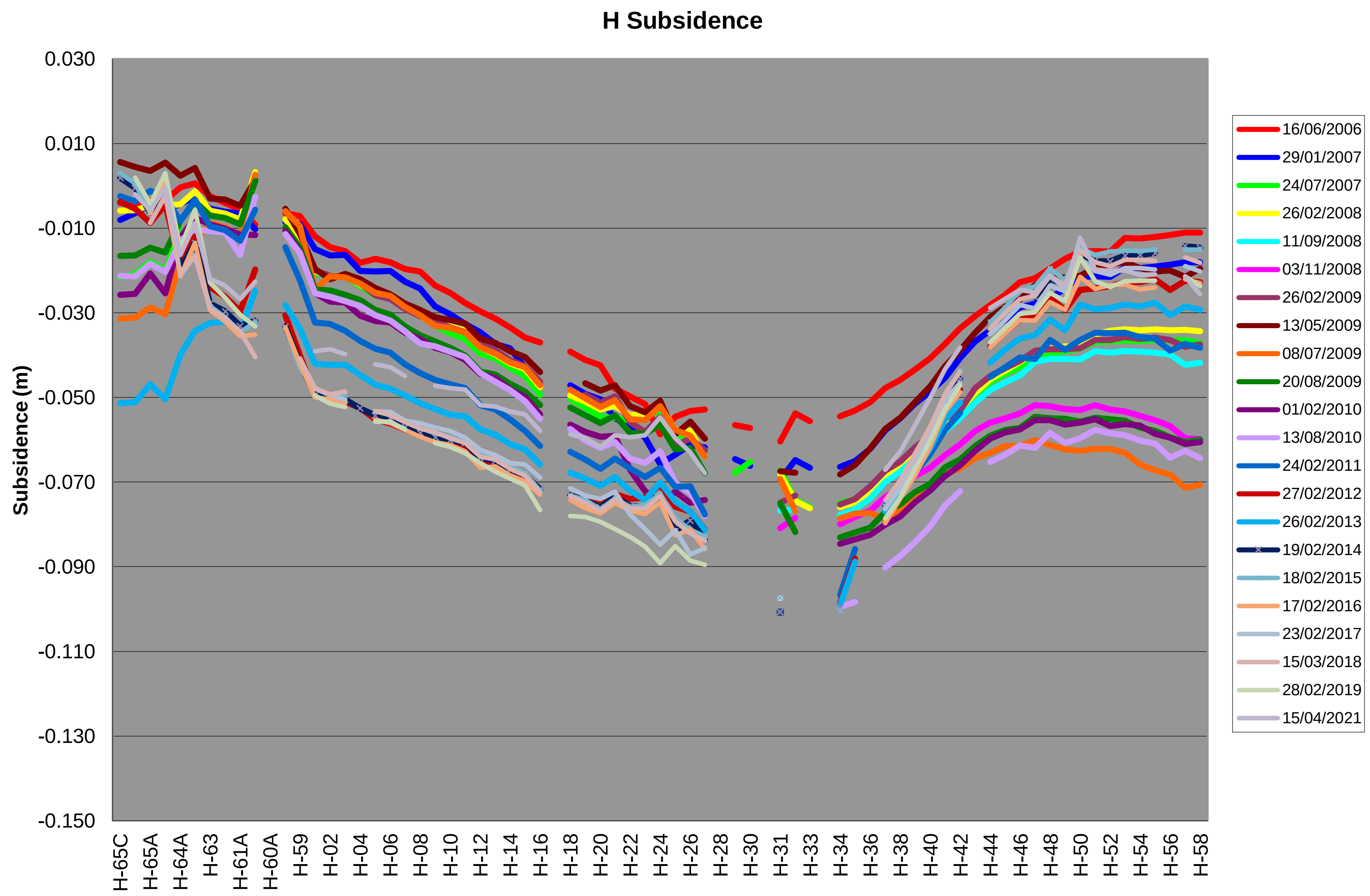
Subsidence (m)
0.000
-0.020
-0.040
-0.060
-0.080
-0.100
-0.120
I-01
I-03
I-05
I-07
I-09
I-11
I-13
I-15
I-17
I-19
I-21
I-23
I-25
I-27
I-29
I-31
I-33
I-35
I-37
I-39
I-41
I-43
I-45
I-47
I-49
I-51
I-53
I-55
I-57
I-59
I-61
I-63
I-65
16/06/2006
29/01/2007
24/07/2007
26/02/2008
26/02/2009
13/05/2009
08/07/2009
20/08/2009
01/02/2010
11/10/2010
24/02/2011
27/02/2012
26/02/2013
24/02/2014
18/02/2015
16/02/2016
23/02/2017
15/03/2018
12/03/2019
15/04/2021



H Subsidence
Subsidence (m)
0.030
0.010
-0.010
-0.030
-0.050
-0.070
-0.090
-0.110
-0.130
-0.150
H-65C
H-65A
H-64A
H-63
H-61A
H-60A
H-59
H-02
H-04
H-06
H-08
H-10
H-12
H-14
H-16
H-18
H-20
H-22
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H-31
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H-34
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H-38
H-40
H-42
H-44
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H-54
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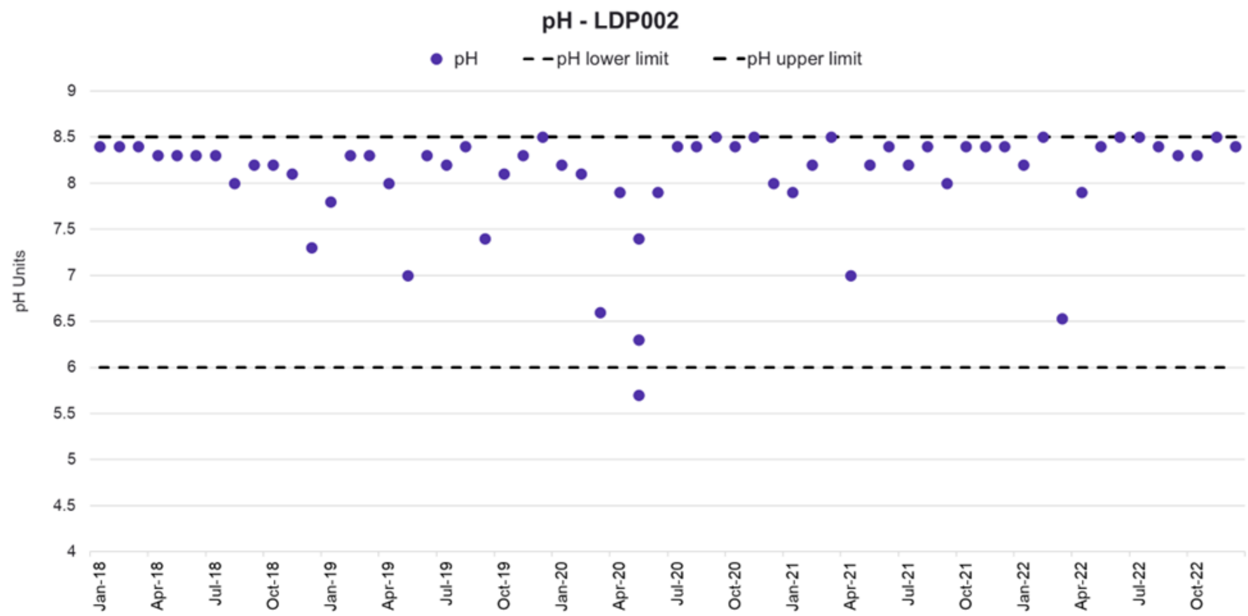
H-58
16/06/2006
29/01/2007
24/07/2007
26/02/2008
11/09/2008
03/11/2008
26/02/2009
13/05/2009
08/07/2009
20/08/2009
01/02/2010
13/08/2010
24/02/2011
27/02/2012
26/02/2013
19/02/2014
18/02/2015
17/02/2016
23/02/2017
15/03/2018
28/02/2019
15/04/2021

Appendix 8: Surface Water Monitoring Results

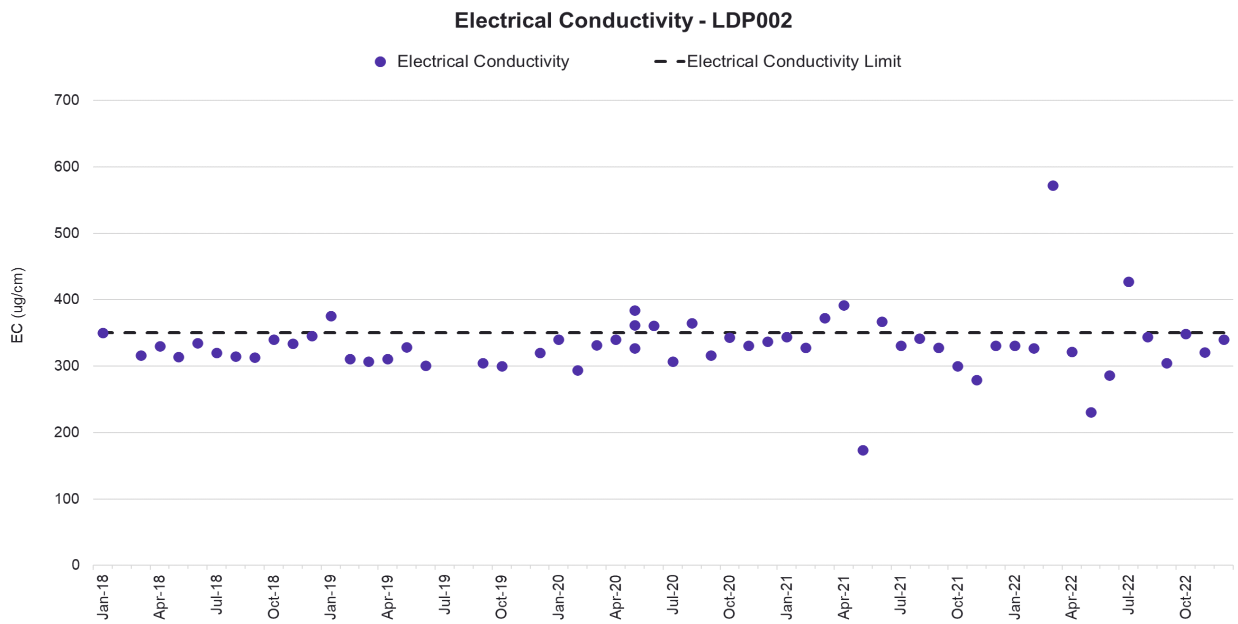
Appendix	Report Name
Appendix 8.1	LDP002 water quality results against limits (2018-2022)
Appendix 8.2	Wollangambe River Downstream Water Quality Results against Limits (2018-2022)

A8.1 LDP002 Water Quality Results against Limits

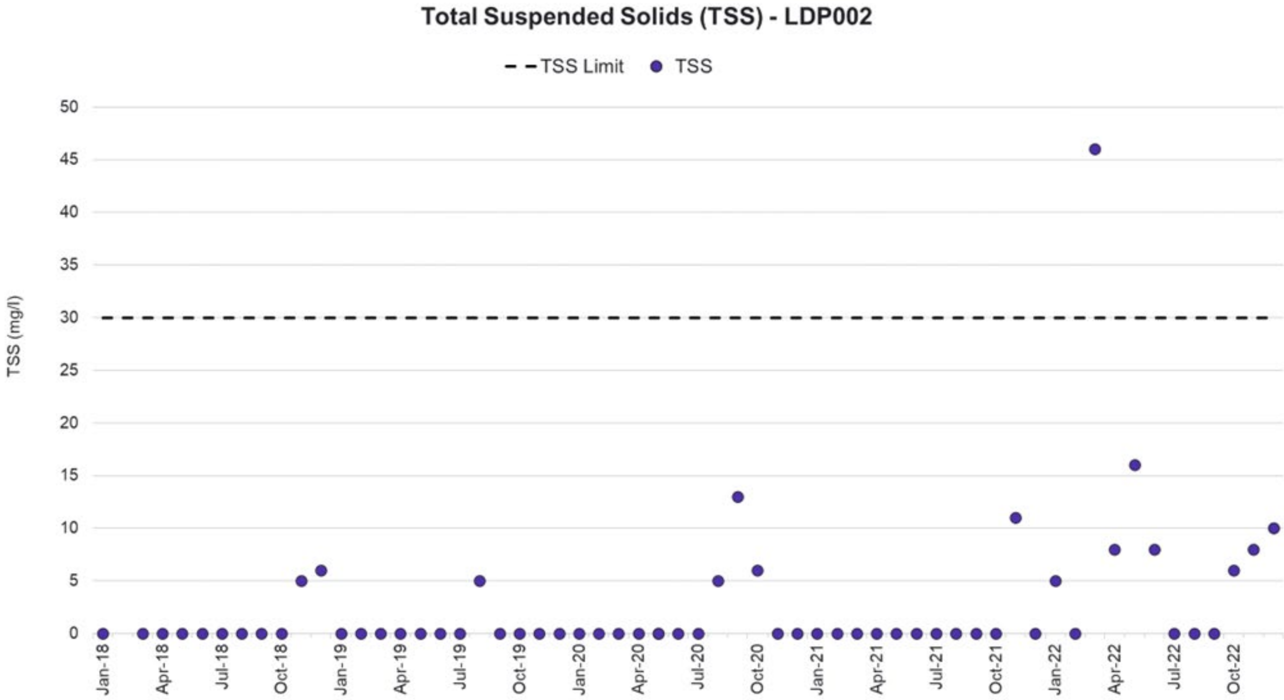
A8.1.1 pH – (2018 – 2022)



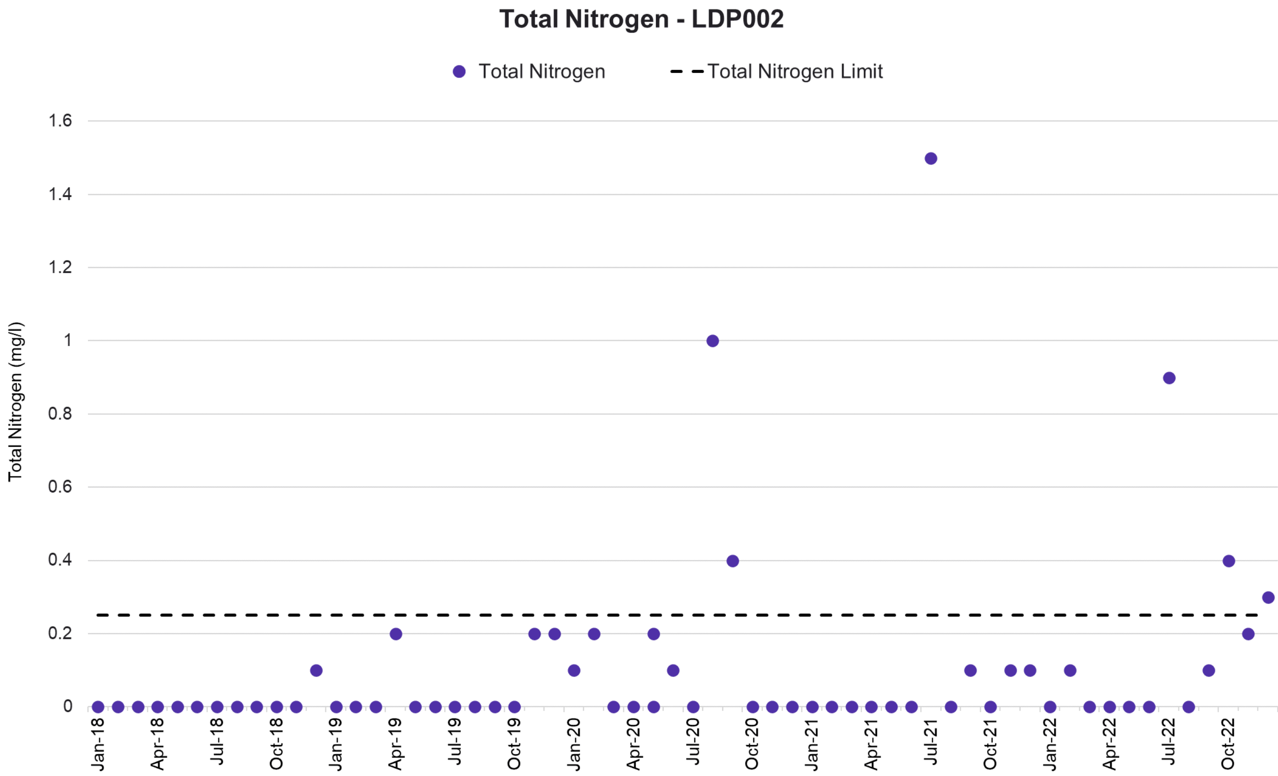
A8.2.2 Electrical Conductivity – (2018 – 2022)



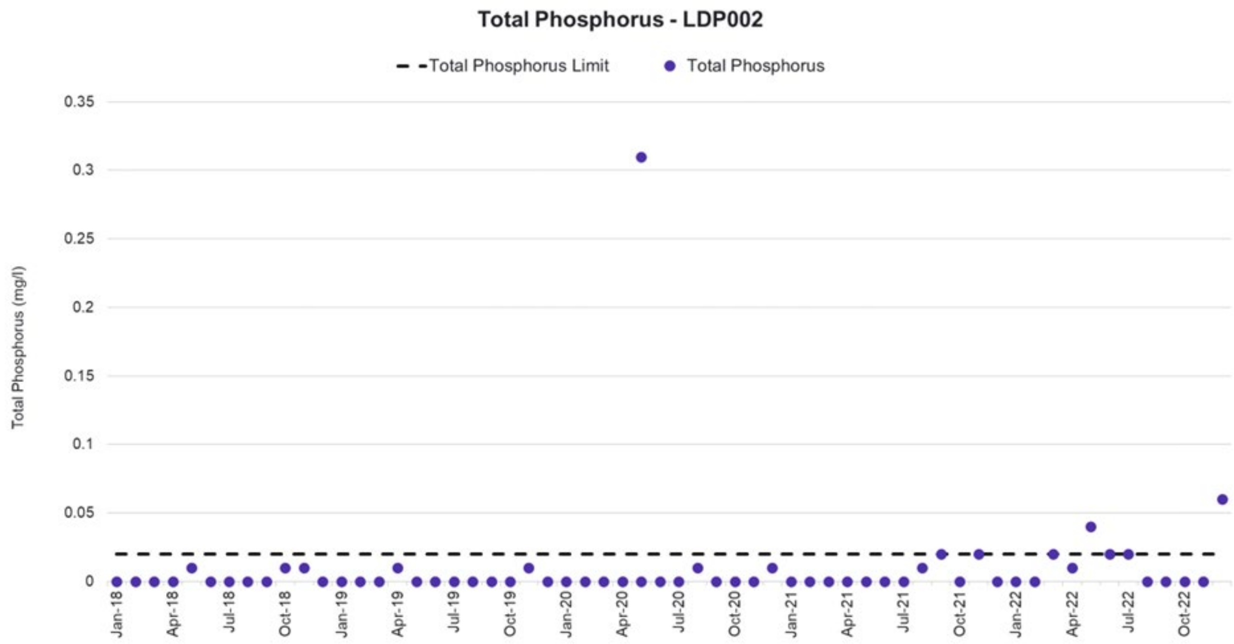
A8.1.3. Total Suspended Solids (2018 – 2022)



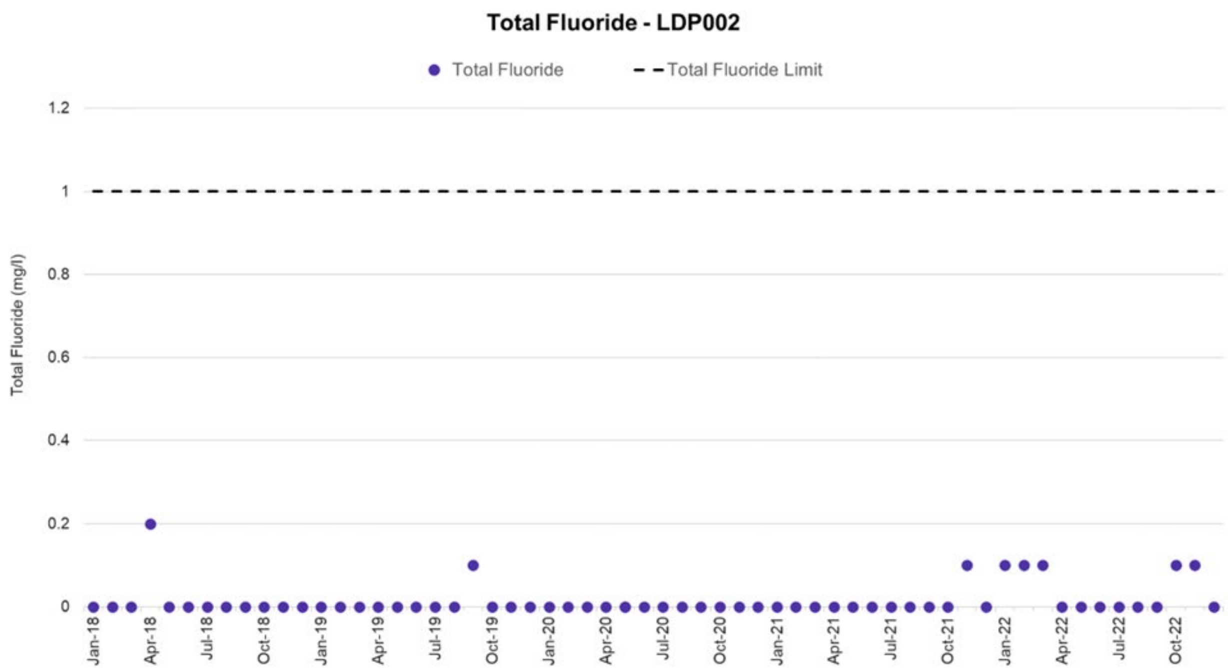
A8.1.4. Total Nitrogen (2018 – 2022)



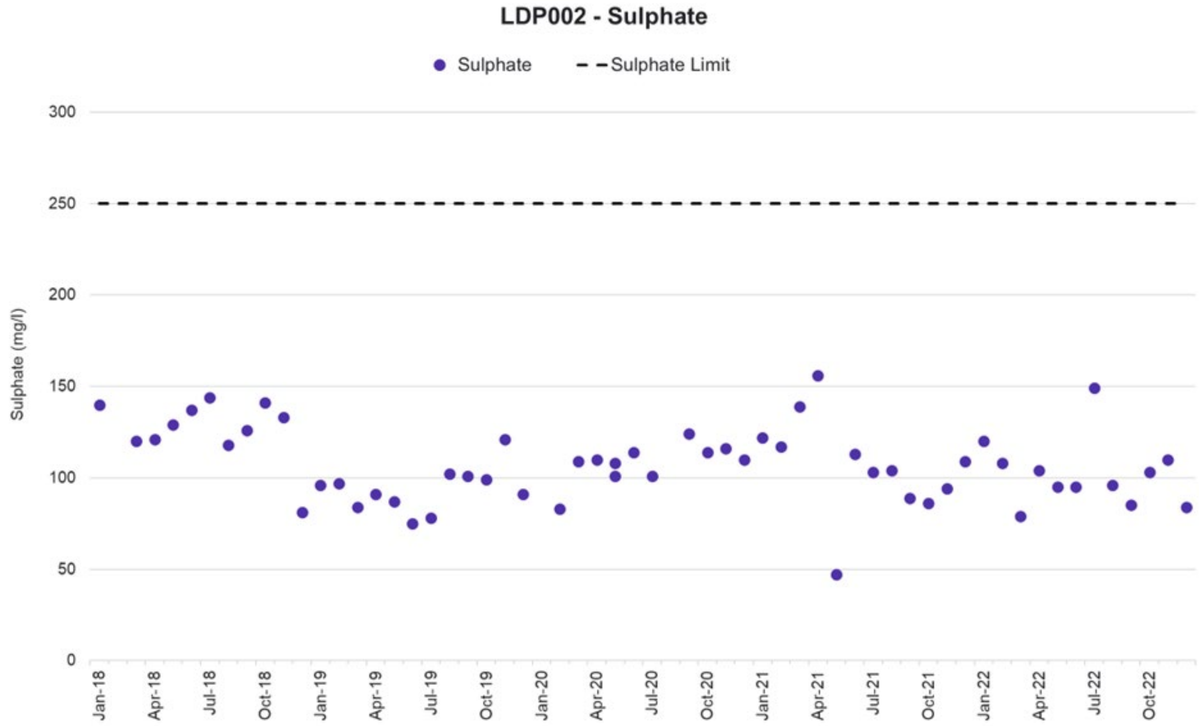
A8.1.5. Total Phosphorus (2018 – 2022)



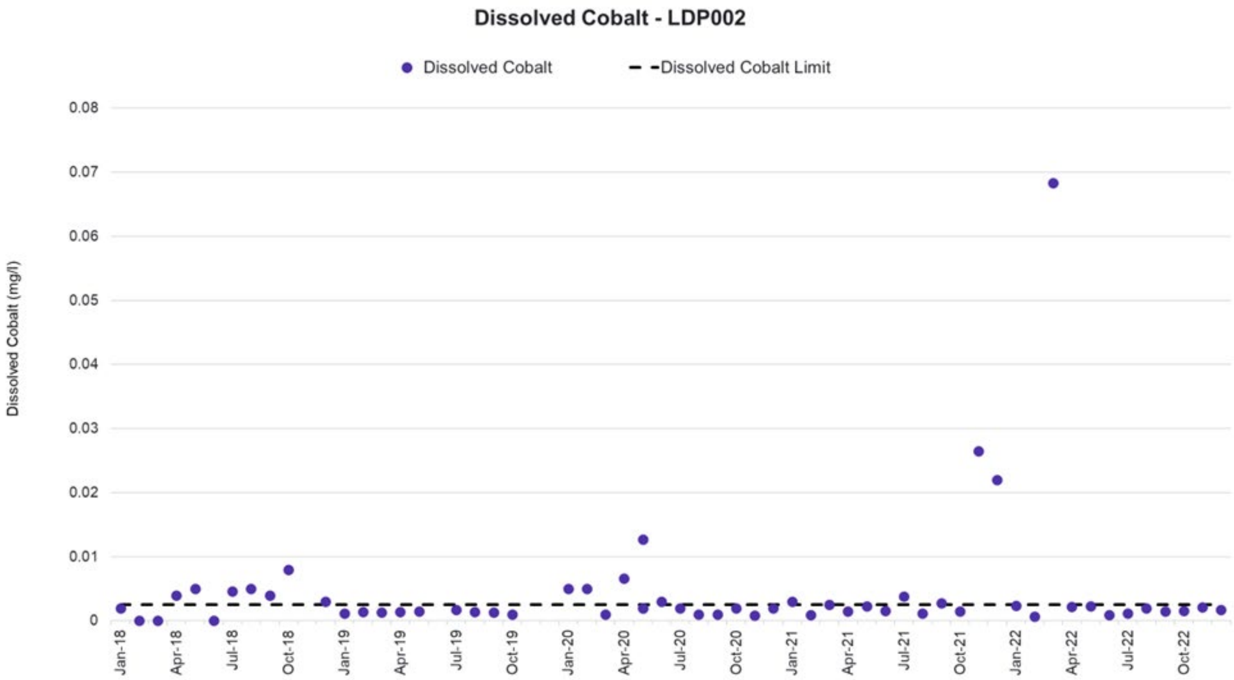
A8.1.6. Total Fluoride



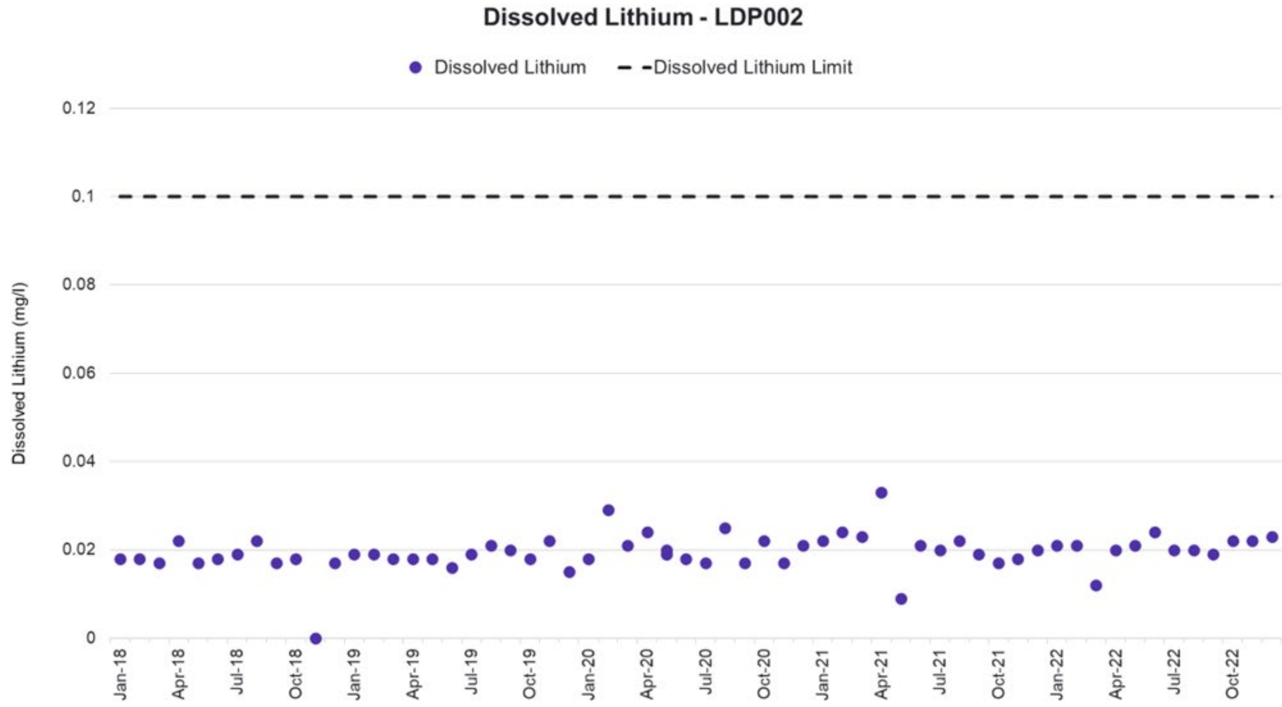
A8.1.7. Sulphate (2018 – 2022)



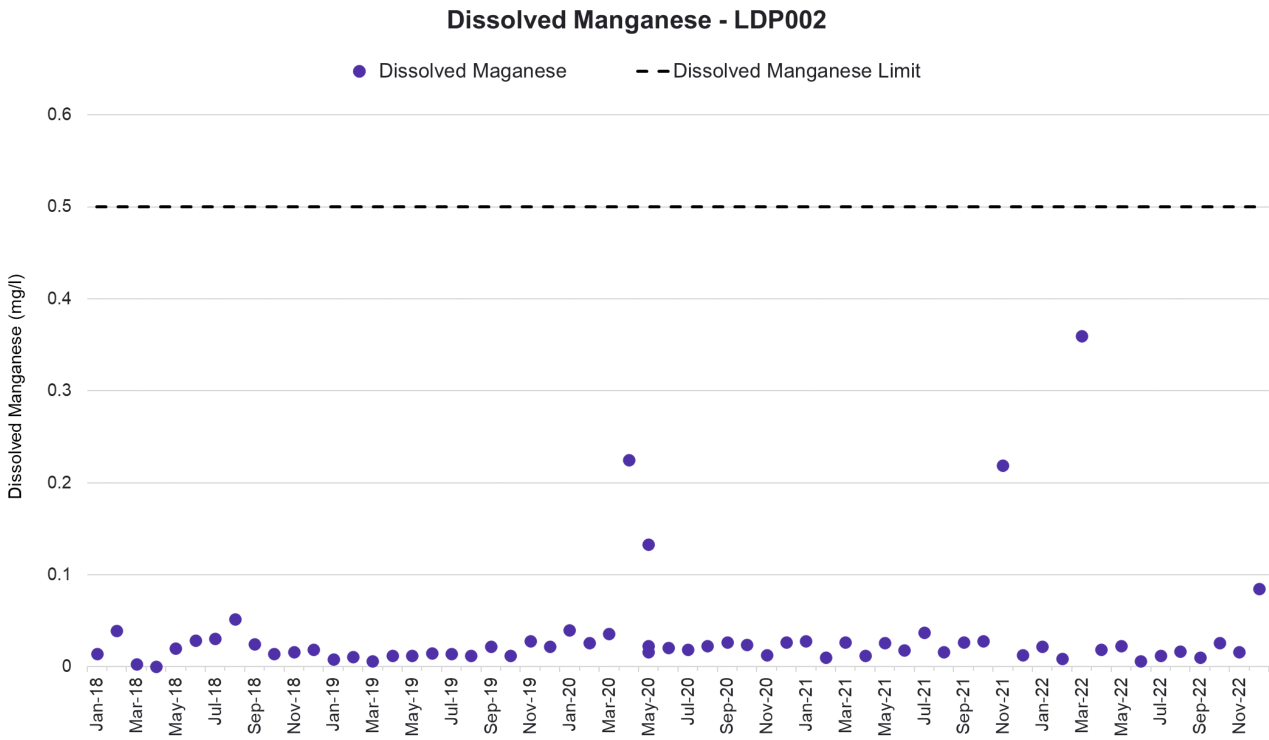
A8.1.8. Dissolved Cobalt (2018 – 2022)



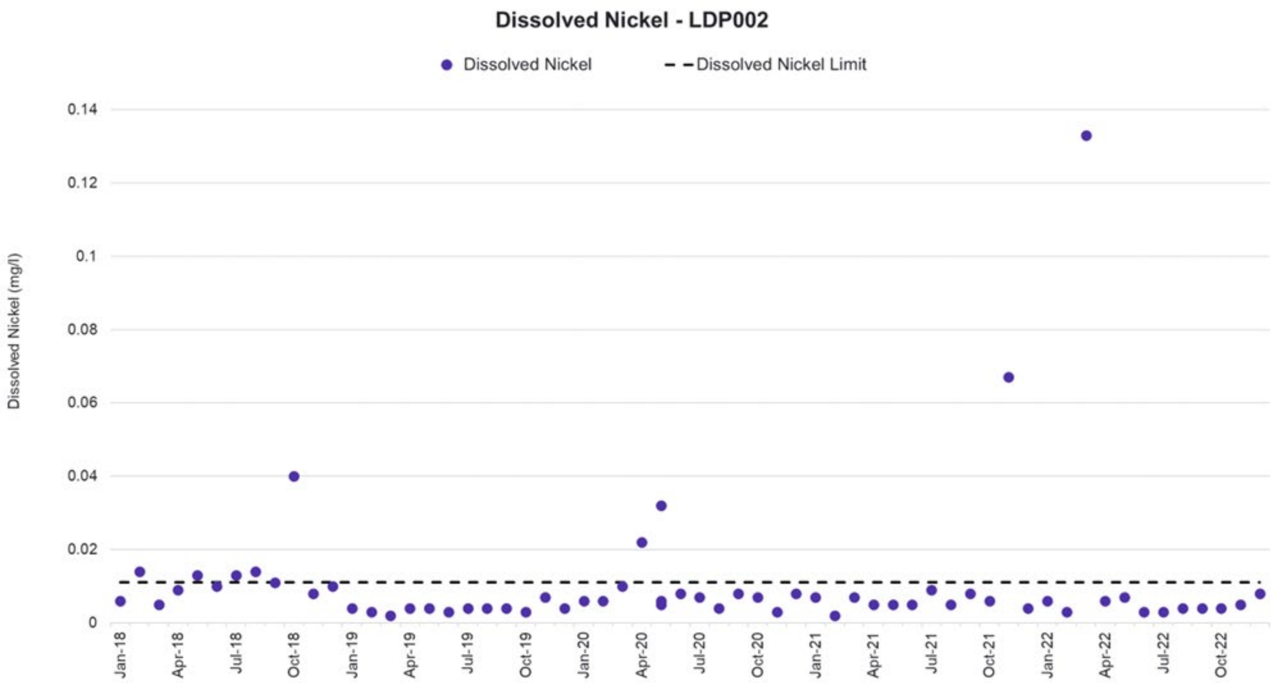
A8.1.9. Dissolved Lithium (2018 – 2022)



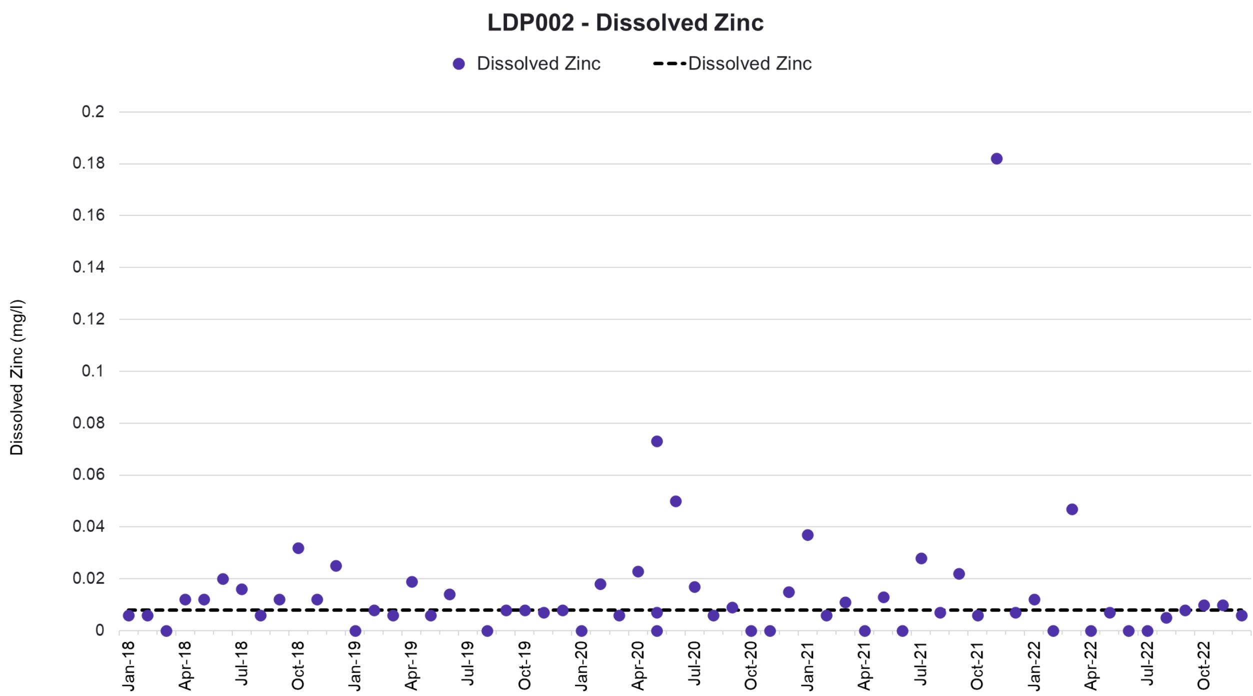
A8.1.10. Dissolved Manganese (2018 – 2022)



A8.1.11. Dissolved Nickel (2018 – 2022)

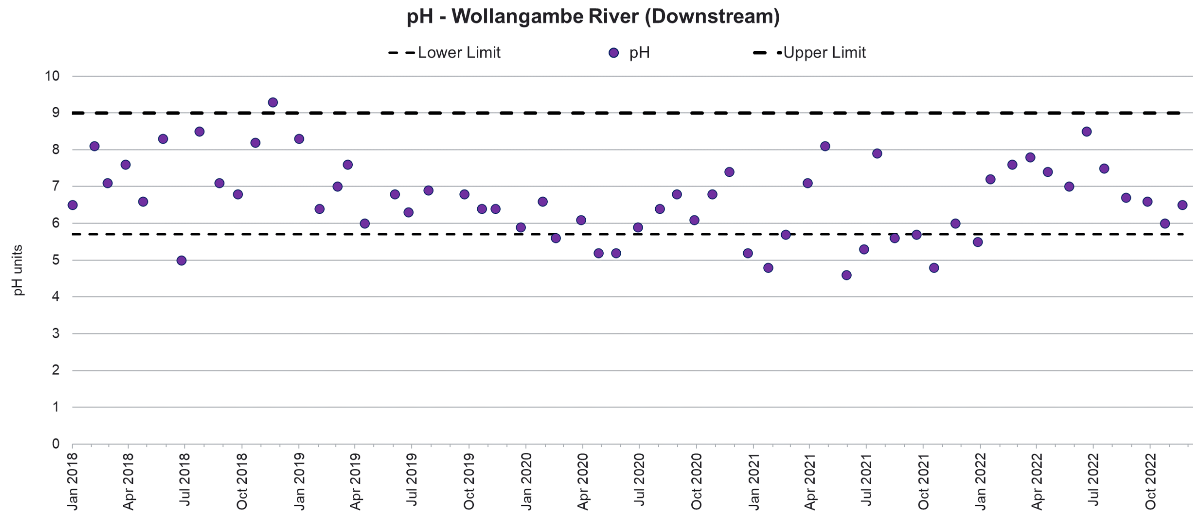


A8.1.12. Dissolved Zinc (2018 – 2022)

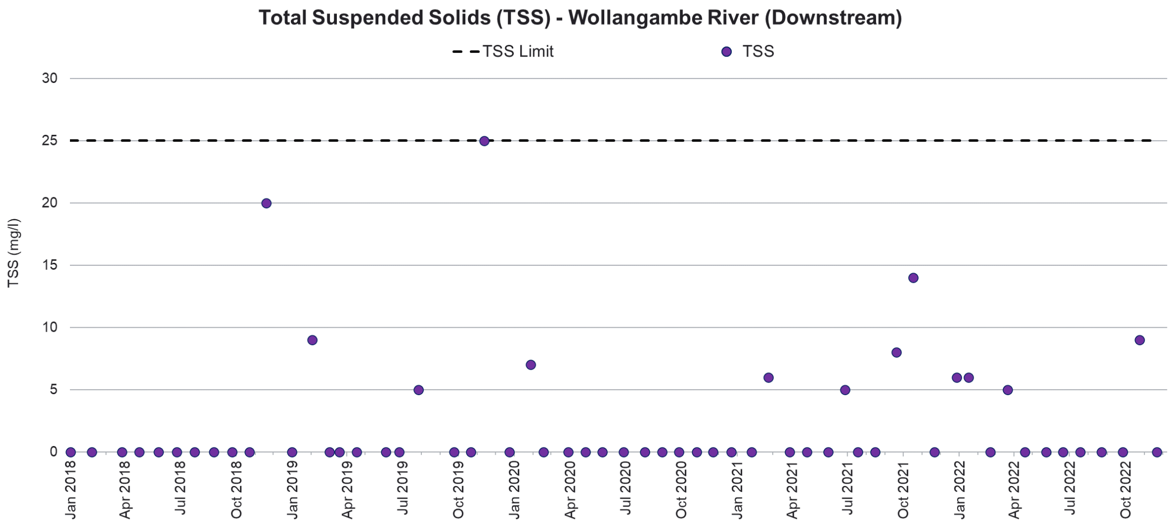


A8.2 Wollangambe River Downstream Water Quality Results against Limits

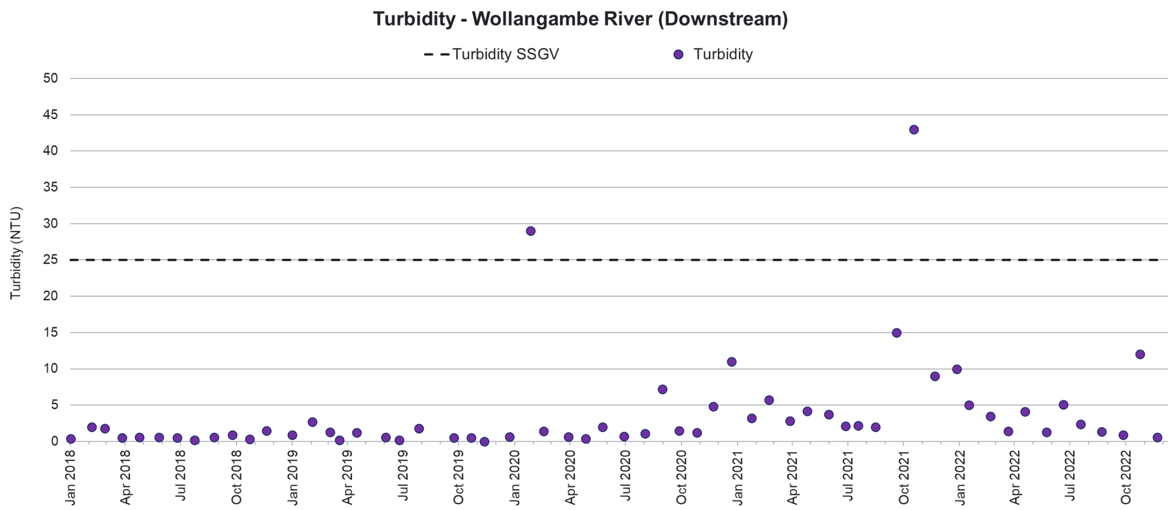
A8.2.1. pH (2018 – 2022)



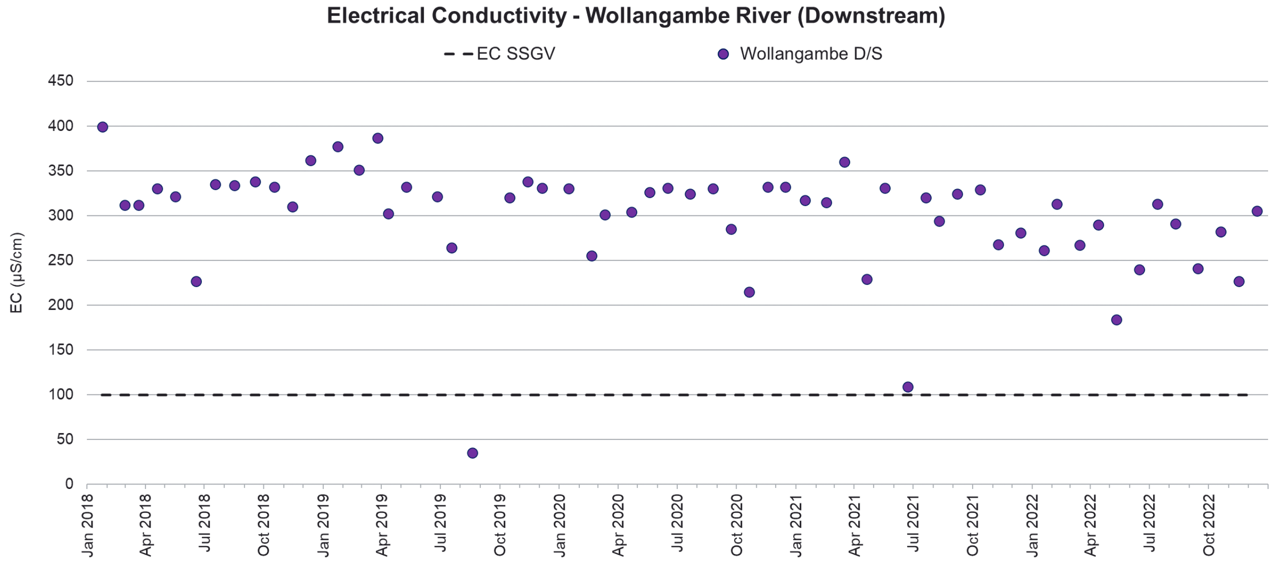
A8.2.2. Total Suspended Solids (2018 – 2022)



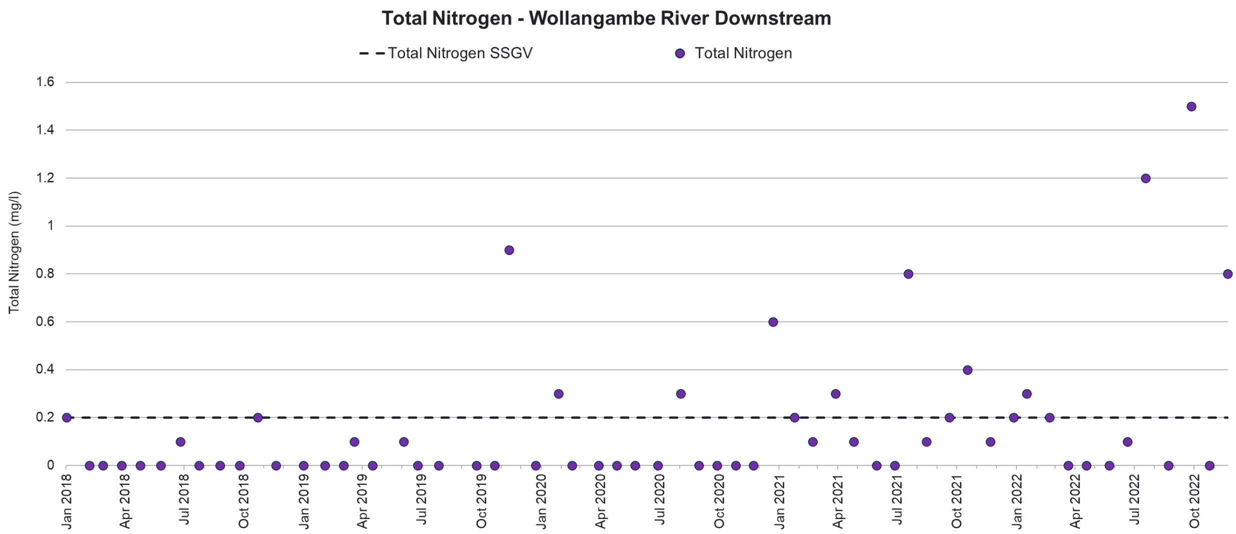
A8.2.3. Turbidity (2018 – 2022)



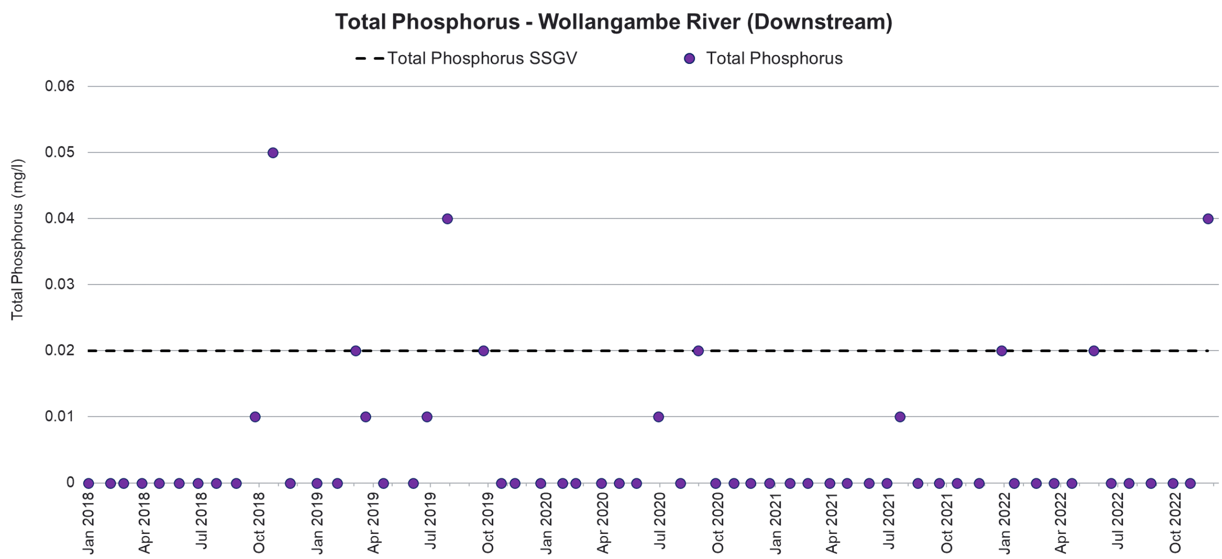
A8.2.4. Electrical Conductivity (2018 – 2022)



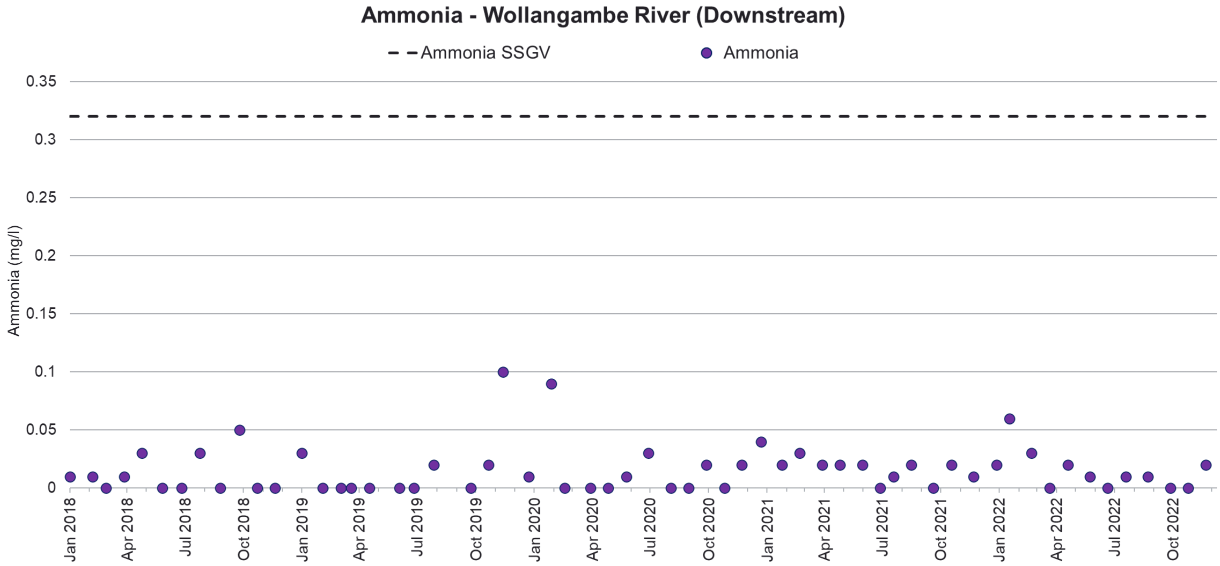
A8.2.5. Total Nitrogen (2018 – 2022)



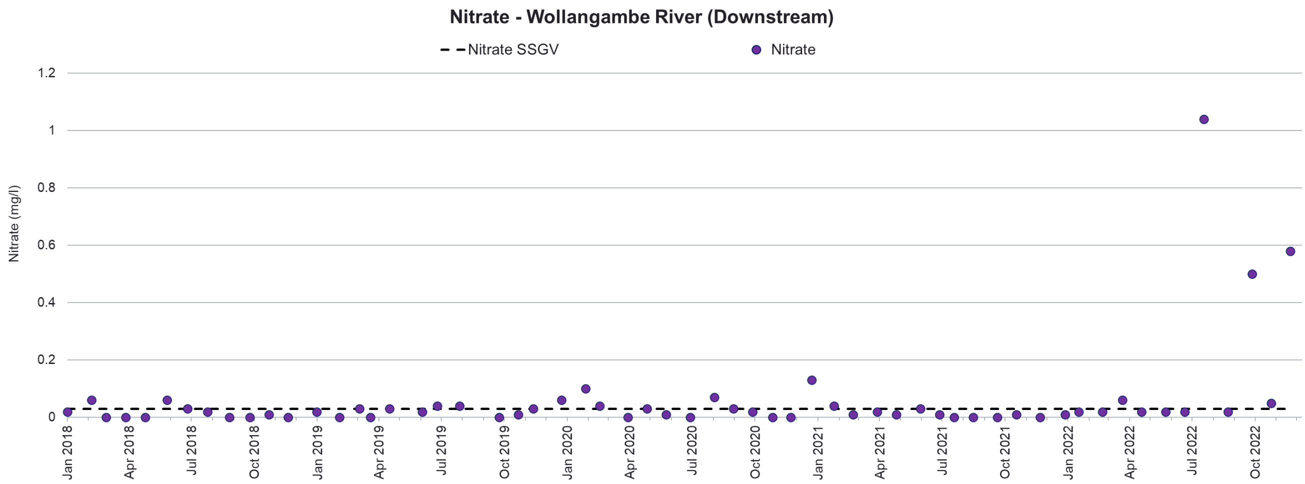
A8.2.6. Total Phosphorus (2018 – 2022)



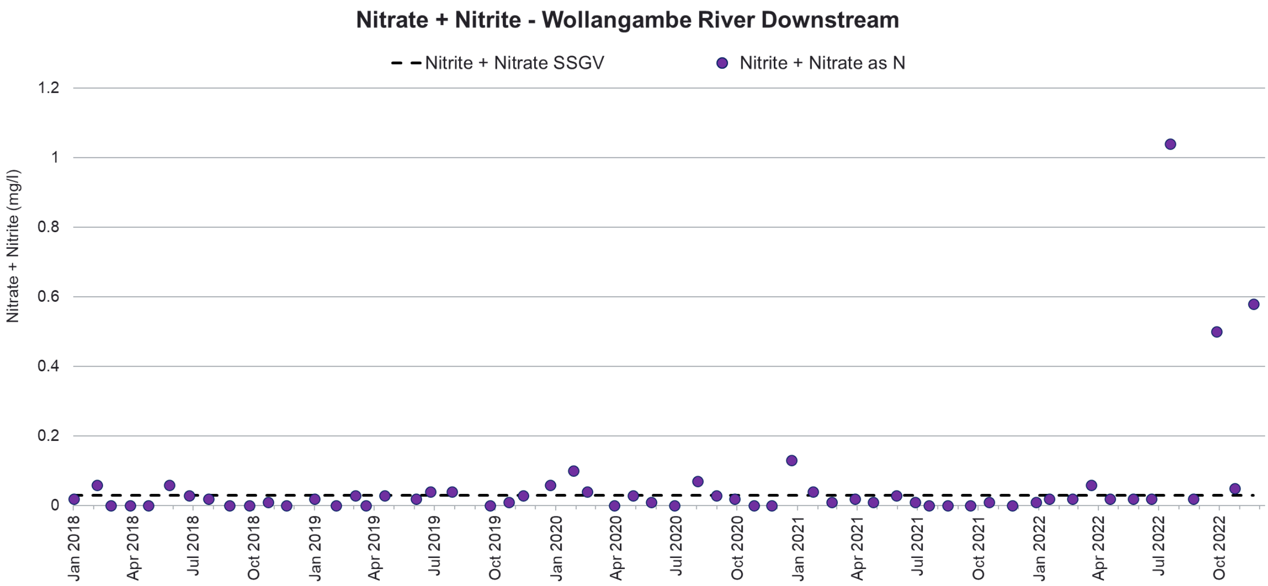
A8.2.7. Ammonia (2018 – 2022)



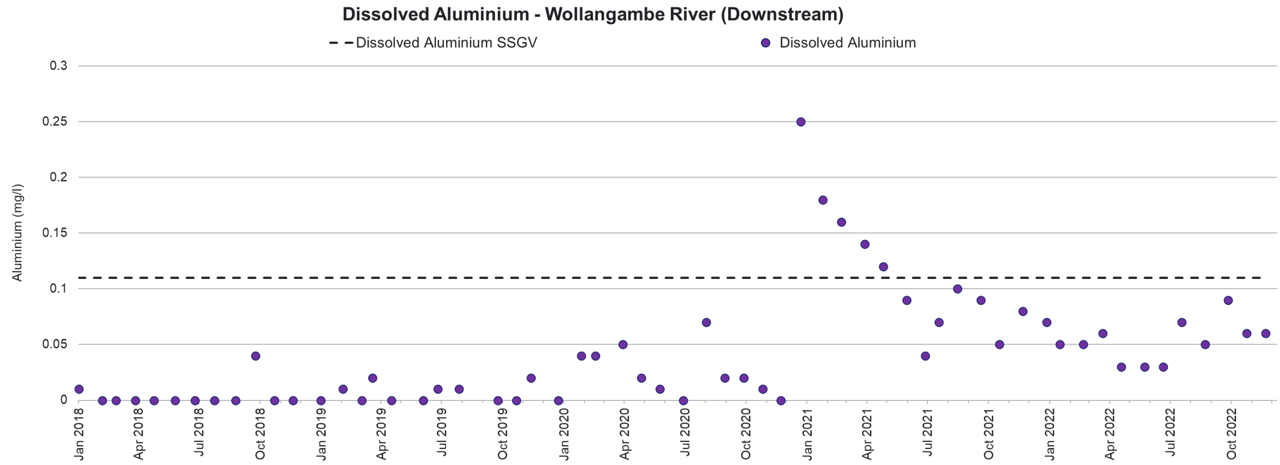
A8.2.8. Nitrate (2018 – 2022)



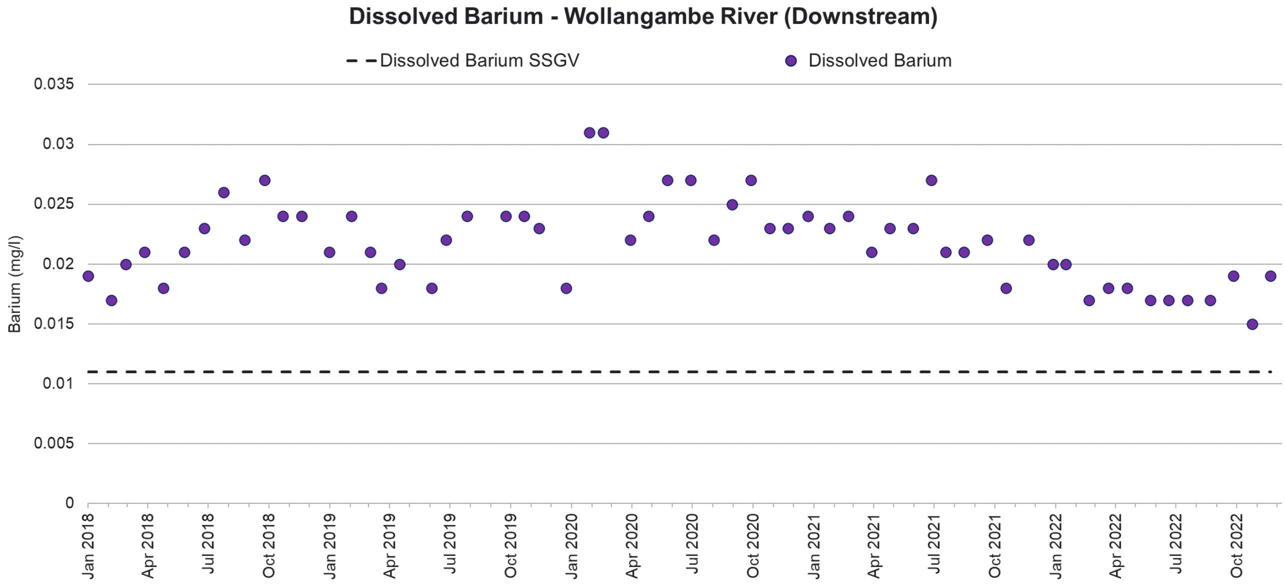
A8.2.9. Nitrate + Nitrite (2018 – 2022)



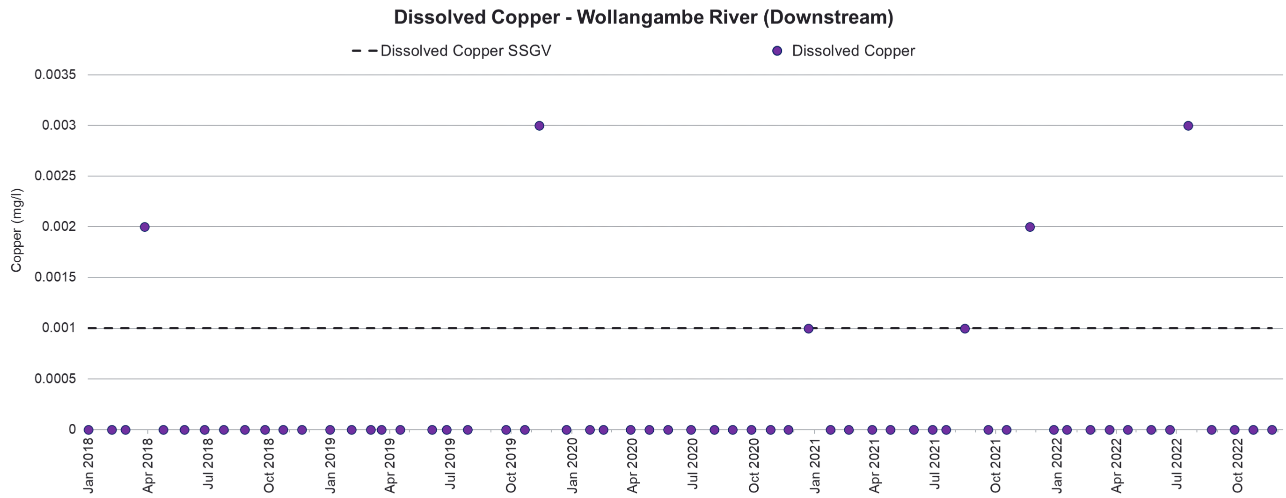
A8.2.10. Dissolved Aluminium (2018 – 2022)



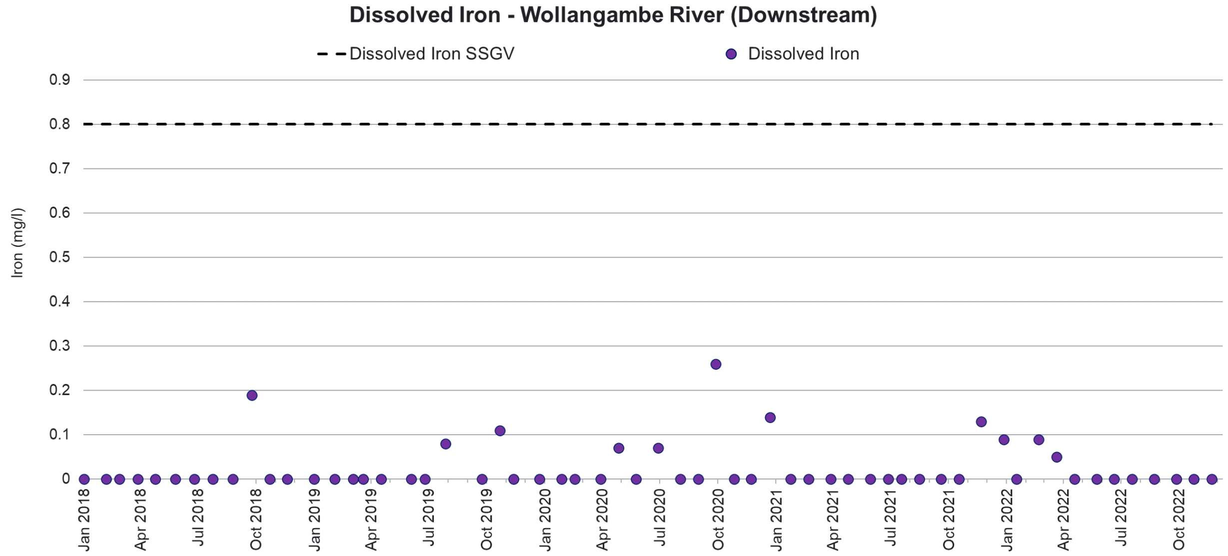
A8.2.11. Dissolved Barium (2018 – 2022)



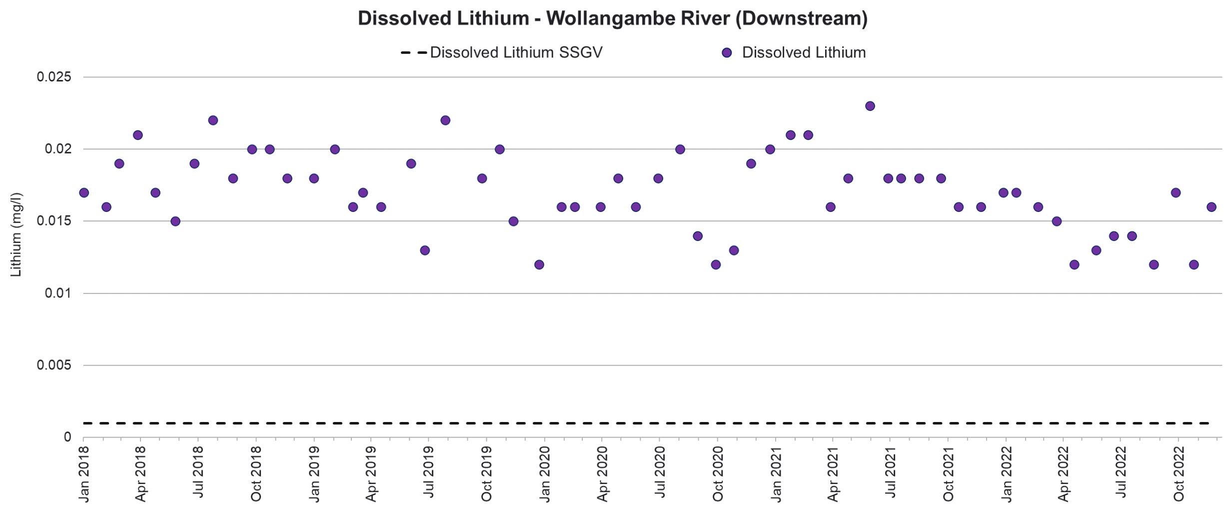
A8.2.12. Dissolved Copper (2018 – 2022)



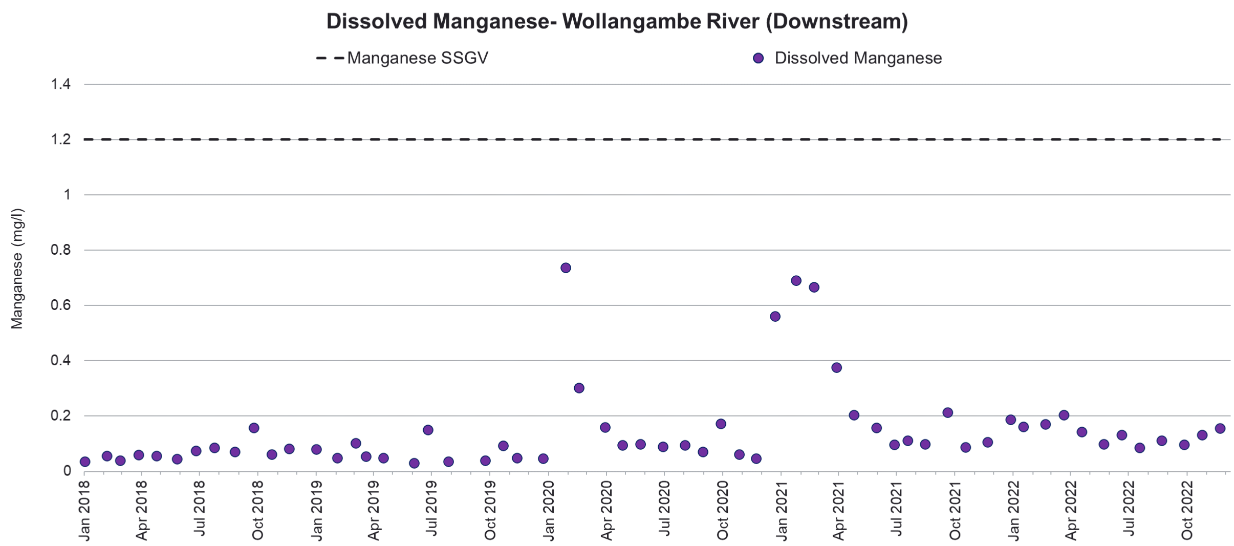
A8.2.13. Dissolved Iron (2018 – 2022)



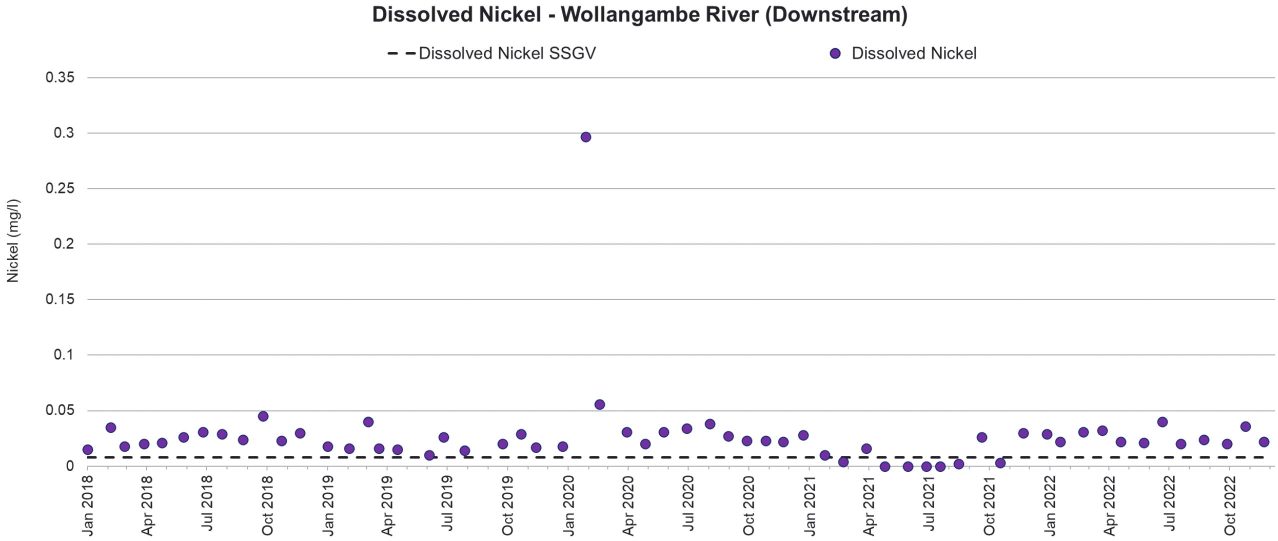
A8.2.14. Dissolved Lithium (2018 – 2022)



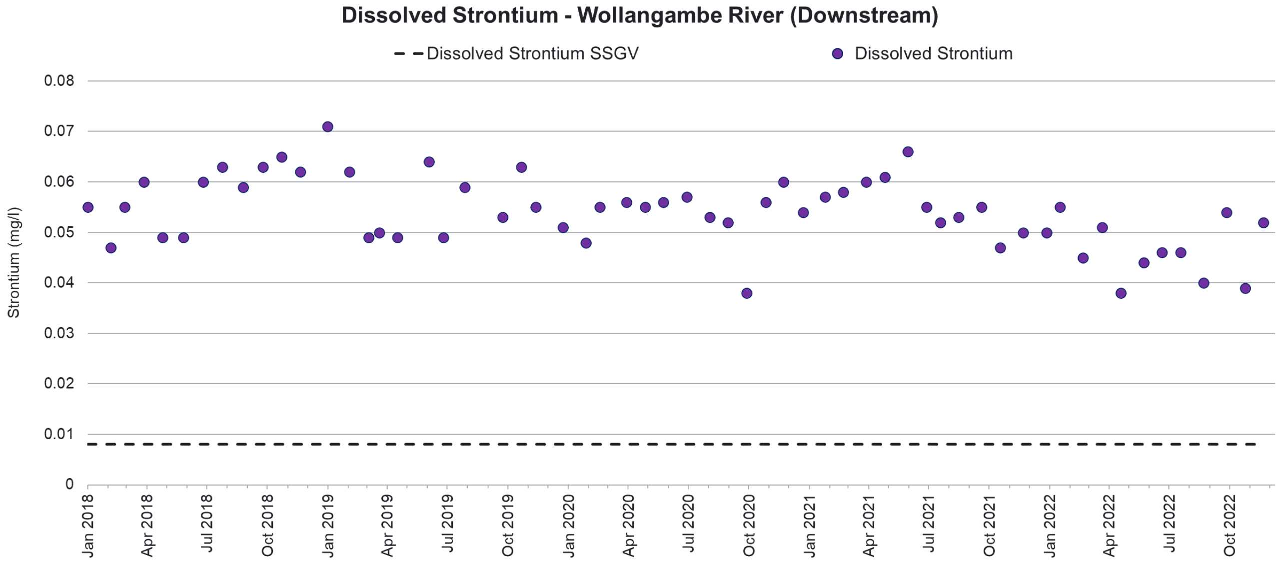
A8.2.15.Dissolved Manganese (2018 – 2022)



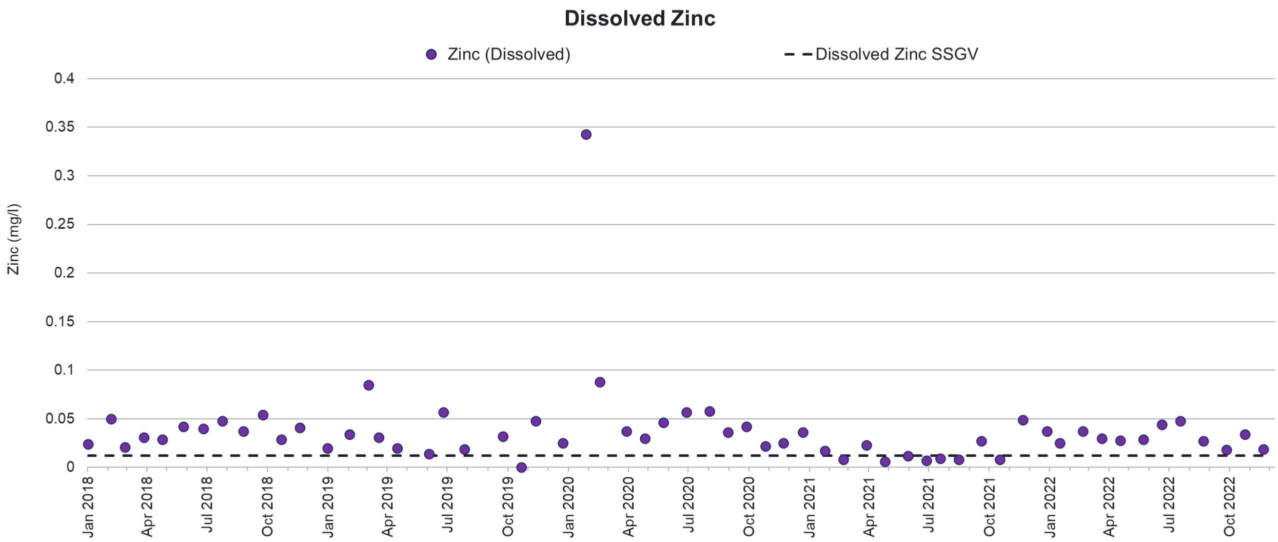
A8.2.16. Dissolved Nickel (2018 – 2022)



A8.2.17. Dissolved Strontium (2018 – 2022)



A8.2.18. Dissolved Zinc (2018 – 2022)



Clarence Colliery

Annual Environmental Monitoring Report (AEMR)
1 January 2022 to 31 December 2022

Prepared for Centennial Coal

March 2023

Clarence Colliery

Annual Environmental Monitoring Report (AEMR)
1 January 2022 to 31 December 2022

Centennial Coal

E211207CL RP#5

March 2023

Version	Date	Prepared by	Approved by	Comments
V1	6 March 2023	Jordan de Boer	Jonathon Tait	Draft
V2	16 March 2023	Jordan de Boer	Jonathon Tait	Final

Approved by

Jonathon Tait
16 March 2023

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Figures

1 Introduction

Clarence Colliery (Clarence) is an underground coal mine located in the Western Coalfields of NSW, approximately 15 kilometres (km) east of Lithgow. Clarence is operated by Centennial Coal Company Limited (Centennial) in a joint venture with SK Energy Australia Pty Ltd.

Clarence currently operates under the Consolidated Development Consent DA 504-00 (the development consent) which was granted on 19 December 2005. This DA allows Clarence to extract up to 3 million tonnes per annum of run of mine coal with the mining leases ML 1583, ML 1353, ML 1354 and Consolidated Coal Lease CCL705.

Clarence initially operated as a bord and pillar mine before switching to a long wall mining technique in 1993. Centennial purchased the mine in 1998 and reintroduced partial extraction and bord and pillar mining within the Katoomba Seam.

As part of the development consent, Clarence was required to establish several environmental monitoring programs. These programs include the Clarence Water Management Plan (WMP) (Centennial, 2021) and the Clarence 800 Area Subsidence Management Plan (SMP) (Centennial, 2017). The WMP and SMP monitoring programmes have been implemented to monitor potential impacts from underground mining on the groundwater regime. The plans focus on potential mining impacts on the Newnes Plateau Shrub Swamps (NPSS) and Newnes Plateau Hanging Swamps (NPHS) which are Endangered Ecological Community (EEC) under the **Environmental Protection and Biodiversity Conservation (EPBC) Act 1999.**

As per Schedule 5(5) of the development consent, the following report presents a review of observed anomalies and possible mining-induced groundwater related impacts during the reporting period (1 January 2022 to 31 December 2022). Any observed impacts that exceed trigger levels set out in the WMP and SMP are also identified so that appropriate management or engineering solutions may be implemented.

2 Existing environment

2.1 Rainfall Data

Daily rainfall is measured at the Newnes Plateau Prison Farm rain gauge, Clarence Colliery weather station (CLAWS001), and at the Bureau of Meteorology (BOM) rain gauge at Lidsdale (station number 063132). Rainfall data is summarised in Table 2.1. Comparative analysis of the three weather stations has been presented due to the disparate weather patterns occurring across the region, influenced by topography.

The observed rainfall at the Newnes Plateau Prison Farm was greater than the long-term average rainfall across all months during the reporting period, except February, June, November and December. The annual rainfall observed at the Newnes Plateau Prison Farm was approximately 500 mm greater than the long-term annual average. Observed rainfall at Lidsdale was greater than the long-term average rainfall in all months, except for June and December. The annual observed rainfall at Lidsdale was approximately 350 mm greater than the long-term annual average.

The cumulative rainfall deviation (CRD), from daily mean rainfall for the Newnes Plateau is shown in Figure 2.1. The CRD trend shows below average rainfall between February 2019 and February 2020, followed by neutral rainfall conditions between February 2020 to August 2021. Above average rainfall conditions have been observed from August 2021.

Table 2.1 January to December 2022 rainfall summary

Month (2022)	Newnes Prison Farm observed rainfall (mm)	Clarence Colliery observed rainfall (mm)	Lidsdale observed rainfall (mm)	Newnes Prison Farm average rainfall[1] (mm)	Clarence Colliery average rainfall[2] (mm)	Lidsdale average rainfall[3] (mm)
January	195.0	181.6	156.4	93.9	98.5	86.2
February	123.2	112.6	87.8	124.0	102.0	77.2
March	279.2	316.0	175.4	119.0	149.0	70.5
April	95.6	105.4	60.4	55.7	56.9	42.8
May	86.4	97.6	68.0	41.2	38.3	47.9
June	17.8	13.4	22.6	73.2	60.9	49.2
July	180.2	249.6	139.8	59.2	65.3	51.5
August	74.8	65.4	86.6	55.9	58.0	63.8
September	135.8	115.2	124.8	59.4	60.5	54.0
October	175.4	152.4	131.2	81.0	68.1	67.9
November	65.6	89.0	126.6	97.9	83.2	74.3
December	25.6	65.6	26.8	84.2	92.6	72.7
Annual	**1,455.0**	**1,564.0**	**1,206.4**	**950.0**	**986.0**	**766.6**

1. Average rainfall from 20 August 1998 to 31 December 2022
2. Average rainfall from 1 August 1959 to 31 December 2022
3. Average rainfall data from 6 February 2012 to 31 December 2022

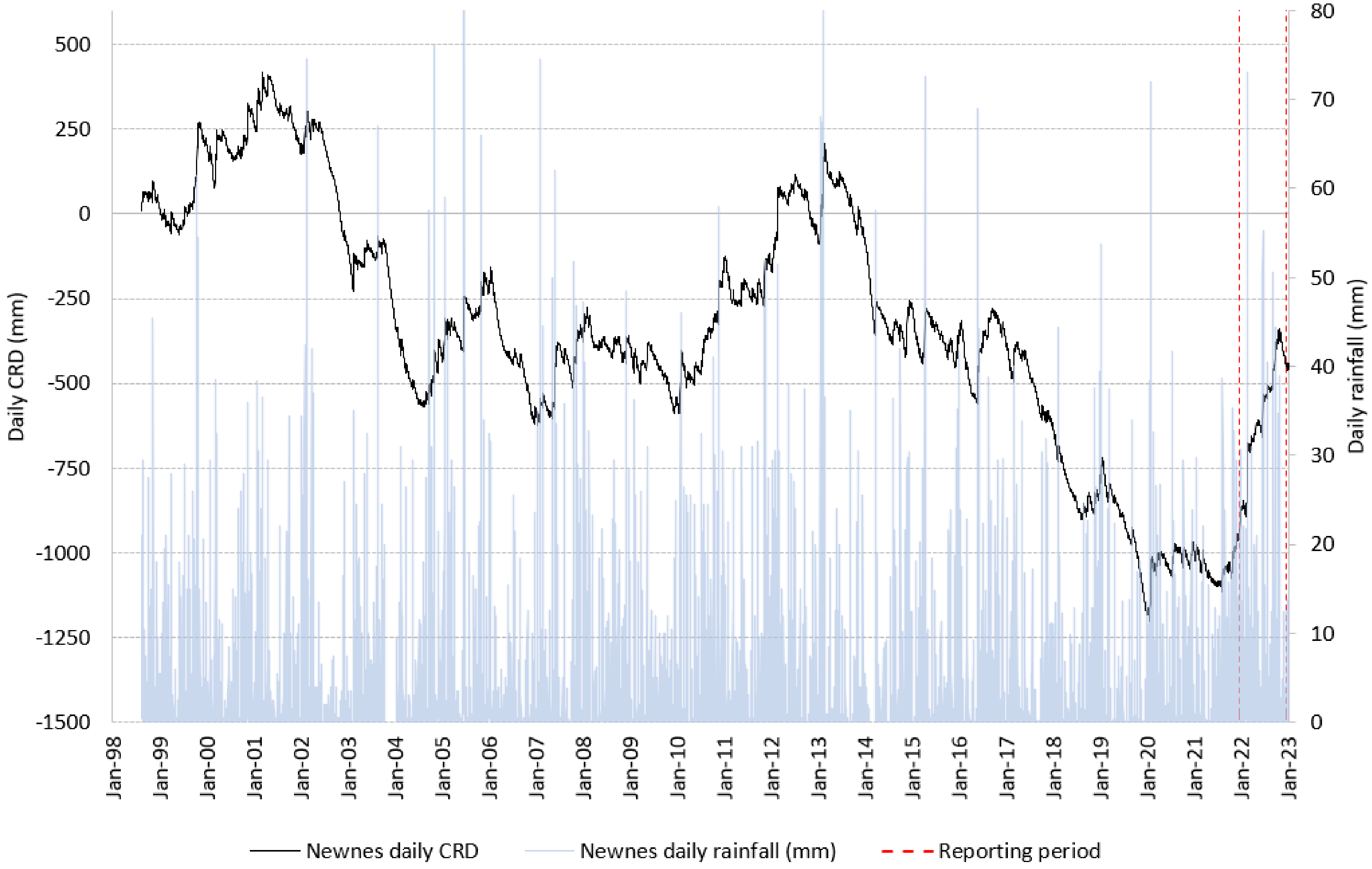


Figure 2.1 Newnes Plateau Prison Farm Daily CRD – 1998 to 31 December 2022

2.2 Hydrogeology

The hydrogeology complexities of the Clarence local area have been well researched over time. The groundwater systems interacting with the Clarence Mine have been conceptualised (McHugh, The geology of the shrub swamps within Angus place, Springvale and the Springvale Mine extension project areas, 2014) and for simplicity, are divided into three distinct groundwater systems:

- Perched groundwater system, predominantly sandstone aquifers between several claystone aquitard units.
- Shallow groundwater system, predominantly regional sandstone aquifers, ranging from unconfined to semi-confined.
- Deep groundwater system, which are confined in the project area and includes the Lithgow Coal Seam.

2.3 Perched groundwater system

The perched groundwater system is hosted within the Burralow Formation of the Triassic Narrabeen Group and is up to 110 metres (m) in thickness. The perched aquifer comprises multiple discontinuous perched localised flow bands and is recharged by excess rainfall.

The presence of seven distinct fine-grained claystone and siltstone units (YS1 to YS6, including YS5a) act as aquitards, or semi permeable layers. These claystone and siltstone units impede rainfall percolation to the shallow groundwater system associated with the underlying Banks Wall Sandstone. The NPSS and NPHS coincide with the lithographic and topographic occurrence of aquitards in the Burralow Formation (McHugh, The geology of the shrub swamps within Angus place, Springvale and the Springvale Mine extension project areas, 2018).

2.4 Shallow groundwater system – Banks Wall Sandstone

The shallow groundwater system is a regional system in the Banks Wall Sandstone (Narrabeen Group) and up to 100 m in thickness. Locally, this groundwater system is known as the Clarence Aquifer.

The shallow groundwater system is recharged by rainfall, overlying watercourses where it outcrops in incised gullies, and vertical leakage from the perched groundwater system. Regional recharge potentially occurs in areas of outcrop and sub-crop to the west and southwest of the study area (Jacobs 2019).

Local discharge is inferred to occur in incised gullies that intercept the water table with some swamps coinciding with this occurrence (McHugh 2014). Regional discharge is inferred to occur to the north-east, where the unit outcrops in the scarp of the plateau.

Groundwater flow is mainly controlled by interconnective fracturing, bedding planes and structural features such as lineaments and faults, with some contribution from pore porosity (Jacobs 2019). The low permeability of the rock matrix means that the fracture system is the primary control of groundwater flow. The direction of groundwater flow is toward the north-east, which is consistent with the dip of the strata.

At the base of the shallow groundwater system is the Mount York Claystone (MYC). This unit comprises a sequence of shale and claystones that form an aquitard which limits connectivity between the shallow and deep groundwater systems.

2.5 Deep groundwater system

The deep groundwater system, associated with the Burra-moko Head Sandstone, Caley Formation and Illawarra Coal Measures is up to 200 m in thickness and is located below the MYC.

Groundwater flow occurs primarily via interconnective fracturing, bedding planes, cleated coal seams and structural features such as lineaments and faults. The fracture system is the primary control of groundwater flow because the rock matrix has low permeability.

Groundwater flow direction in the deep groundwater system is towards the north-east, which is consistent with the dip of the strata. Regional recharge occurs in areas of outcrop and sub-crop, to the west and south-west of the study area, from rainfall, overlying watercourses, dams and leakage from the shallow groundwater system. Groundwater discharge is inferred to occur to the north-east where the units outcrop in the scarp of the plateau.

2.6 Drainage and catchments

Clarence is within the Hawkesbury-Nepean catchment and covers three adjacent catchments for the Wollangambe River, Wolgan River and upper Coxs River. Both the Wollangambe River and Wolgan River have their headwaters on the Newnes Plateau and join the Colo River to the east of the site, which contributes to the Hawkesbury River and Broken Bay. The Coxs River rises within the Ben Bullen State Forest to the north of Clarence and flows in a south-east direction to Lake Burragorang, which is impounded by Warragamba Dam (Centennial, 2021).

Drainages off the plateau are often deeply incised in their lower reaches, incorporating numerous cliff lines and pagodas bordering the valley flanks. In the upper catchment areas, drainage lines are typically poorly defined to non-existent with overland sheet flow being the typical mode of discharge during rainfall events (Jacobs, 2019)

2.7 Surface water and groundwater interaction

The dominant surface water and groundwater interactions on the Newnes Plateau involve recharge to shallow groundwater and groundwater discharge to surface water (Jacobs, 2019).

Surface water leakage to shallow groundwater occurs from overlying watercourses. Groundwater discharge to surface water occurs as seepages and drips from exposed faces of cliff lines or exposed bedrock in drainage lines, and as seepage from sub-cropping bedrock to regolith or residual soil profiles on valley flanks and valley floors (Jacobs, 2019). Where sufficient seepage occurs, the seepages may support the development of NPHS or NPSS.

Groundwater seepage may contribute to stream baseflow either directly as discharge to drainage lines in the valley floor, or indirectly as a contribution to catchment subsurface flow (Jacobs, 2019).

2.8 Mining progress

The following areas of Clarence were mined during the reporting period (1 January 2022 to 31 December 2022):

- 900 area – Panel 919, 906 and 915.
- 801 area – Panel 822 and 804.

Appendix A shows the progression of mining at Clarence during 2022.

3 Monitoring program

3.1 Groundwater Monitoring Network

The Clarence groundwater monitoring network is established to detect potential impacts to groundwater systems due to mining and subsidence. The network consists of the following:

- Swamp piezometers: are installed in eleven swamps above mining operations to detect potential mining-related impacts on the swamp groundwater regimes. Groundwater data loggers record groundwater levels on a daily basis.

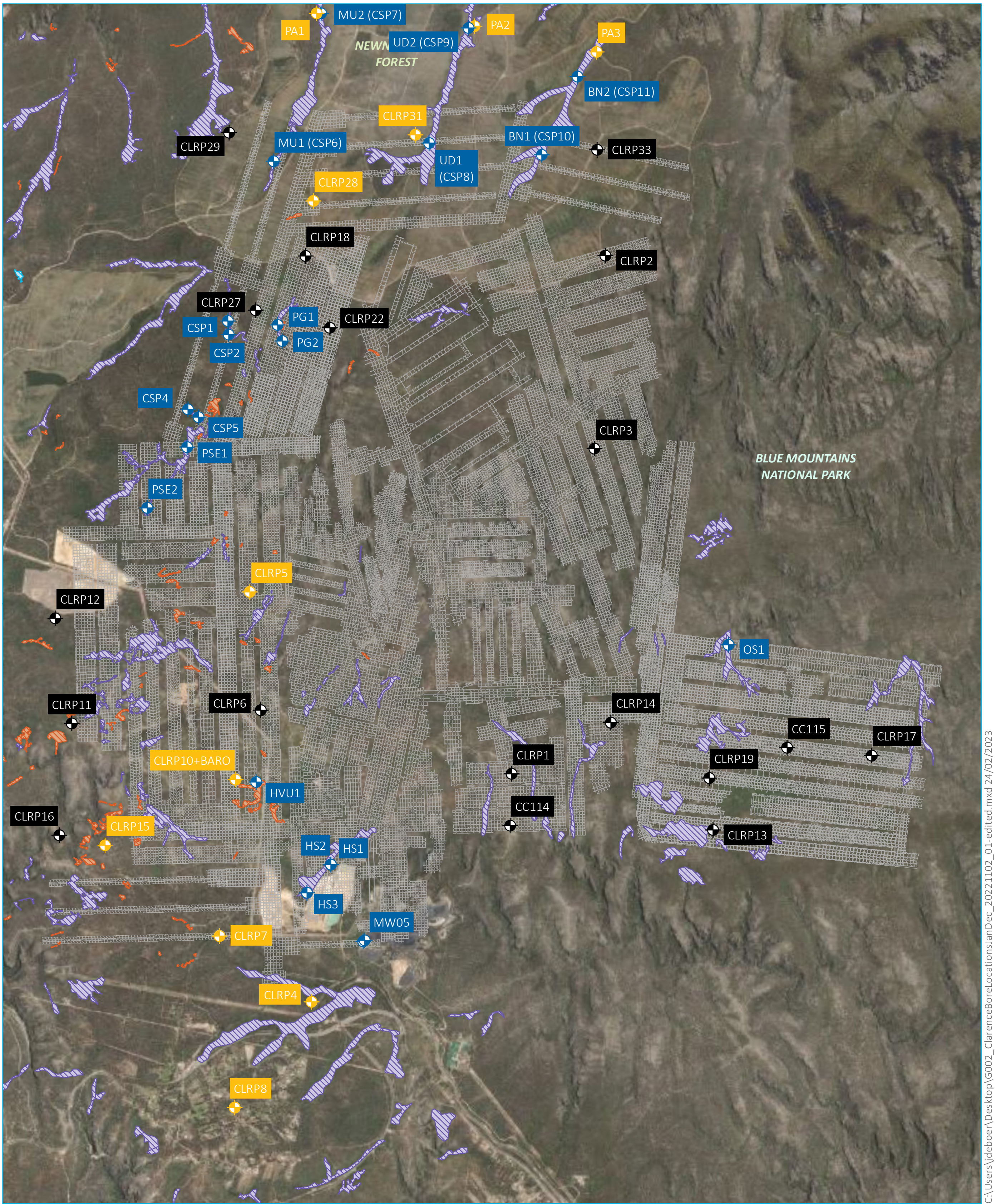
- Open borehole standpipe piezometers (standpipe piezometers): are installed within the perched and shallow groundwater systems to detect potential mining-related impacts on the Clarence Aquifer (Shallow groundwater system). Groundwater data loggers record groundwater levels on a daily basis.

- Vibrating wire piezometers (VWP): a network of VWPs measure pore pressure in multiple hydrogeological horizons above the Katoomba Seam to detect mining-related impacts within the shallow and deep groundwater systems. Additionally, VWPs are used to detect any mining induced hydraulic connectivity between the shallow and deep groundwater systems. Data is recorded by data loggers on a daily basis.

The groundwater monitoring network is shown in Figure 3.1. Further detail regarding the groundwater monitoring network is provided in Appendix B.

3.2 Performance criteria

Groundwater levels for swamp piezometers, open borehole standpipe piezometers and VWPs have been compared to trigger levels detailed in Table 6.2 of the WMP. Tables detailing the results of the trigger level review and trends over the reporting period are provided in Section 4.1, Section 4.2 and Section 4.3.



Source: EMM (2021); DFSI (2017); DPE (2015); GA (2011); ASGC (2006)

KEY

Underground workings

Monitoring bore

Standpipe

Swamp

VWP

Temperate Highland Peat Swamps on Sandstone

Hanging swamp

Shrub swamp

Snow swamp

INSET KEY

Major road

NPWS reserve

State forest

January to December 2022
Groundwater Annual Review

Centennial Coal – Clarence Colliery
Clarence groundwater AEMR
Figure 3.1

EMM
creating opportunities

4 Groundwater level monitoring

The Newnes Plateau was impacted by bushfires in October 2013 (The State Mine bushfire) and late 2019 (Gospers Mountain bushfire). These bushfires damaged some swamp piezometers and VWPs which were repaired, replaced or decommissioned. Data gaps exist where monitoring sites were affected by bushfires.

Ten swamp piezometers and three shallow piezometers (targeting the Burralow Formation and Banks Wall Sandstone) were installed during 2022. These piezometers were installed to collect baseline monitoring data for proposed mining developments. Data loggers were installed in the three shallow piezometers (PA1, PA2 and PA3) in mid-December 2022. Therefore, limited data is available and trends at PA1, PA2 and PA3 have not been discussed in this report.

Hydrographs for monitoring sites have been compared to daily CRD (mm) to distinguish between meteorological trends and potential mining impacts. The dashed red vertical lines indicate the reporting period (1 January 2022 to 31 December 2022).

4.1 Swamp piezometers

Swamp piezometer groundwater levels have been reviewed against their respective trigger values in the WMP (Centennial, 2021). Where triggers have occurred, the groundwater level response has been assessed against the Trigger Action Response Plan (TARP) (see Appendix C) to determine if a mining impact has occurred and if further investigation is required.

Comments on general groundwater level trends and trigger status during the reporting period are detailed in Table 4.1. A general overview of historical observations, mining history and hydrographs for swamp piezometers is shown in Section 4.1.1 to Section 4.1.12

Table 4.1 Swamp piezometer trigger status

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CS1	Swamp sediments	Decommissioned – piezometer damaged by bushfire.
MW05	Swamp sediments	No trigger – increasing trend.
HVU1	Swamp sediments	No trigger level defined in the WMP – stable trend.
HS1	Swamp sediments	No trigger – fluctuating with rainfall.
HS2	Swamp sediments	No trigger – fluctuating with rainfall.
HS3	Swamp sediments	No trigger – fluctuating with rainfall.
PSE1	Swamp sediments	No trigger – exceeds trigger level however, there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are highly variable, trending with the CRD and peaking with rainfall.
PSE2	Swamp sediments	No trigger – exceeds trigger level however, there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are highly variable, trending with the CRD and peaking with rainfall.
OS1	Swamp sediments	No trigger – slight increasing trend.
PG1	Swamp sediments	No trigger – stable trend.
PG2	Swamp sediments	No trigger – exceeds trigger level however there has been no significant fall in groundwater level and no indication of mining related impacts. Groundwater levels are stable, peaking with rainfall.

Table 4.1 Swamp piezometer trigger status

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CSP1 (BSE1)	Swamp sediments	No trigger level defined – stable trend, still settling due to recent instalment.
CSP2 (BSE2)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
CSP4 (PHS1)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
CSP5 (PHS2)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
MU1 (CSP6)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
MU2 (CSP7)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
UD1 (CSP8)	Swamp sediments	No trigger level defined in the WMP – slight decreasing trend.
UD2 (CSP9)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
BN1 (CSP10)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.
BN2 (CSP11)	Swamp sediments	No trigger level defined in the WMP – stable trend, still settling due to recent instalment.

4.1.1 Clarence Swamp

The hydrograph for Clarence Swamp is presented in Figure 4.1. Previously, there were three additional piezometers within the swamp: CS1, CS2 and CS3. CS1 was destroyed by bushfires and CS2 and CS3 were decommissioned for the construction of REA 6. Clarence Swamp is currently being monitored by MW05 only.

There was no mining within proximity to MW05 during the reporting period. Extraction of panel 822 remained approximately 3.5km northeast of MW05.

Groundwater levels at MW05 have shown an increasing trend since February 2020 and relative stabilisation from March 2021 to October 2021. From October 2021, and throughout 2022, an increasing trend was observed due to rainfall.

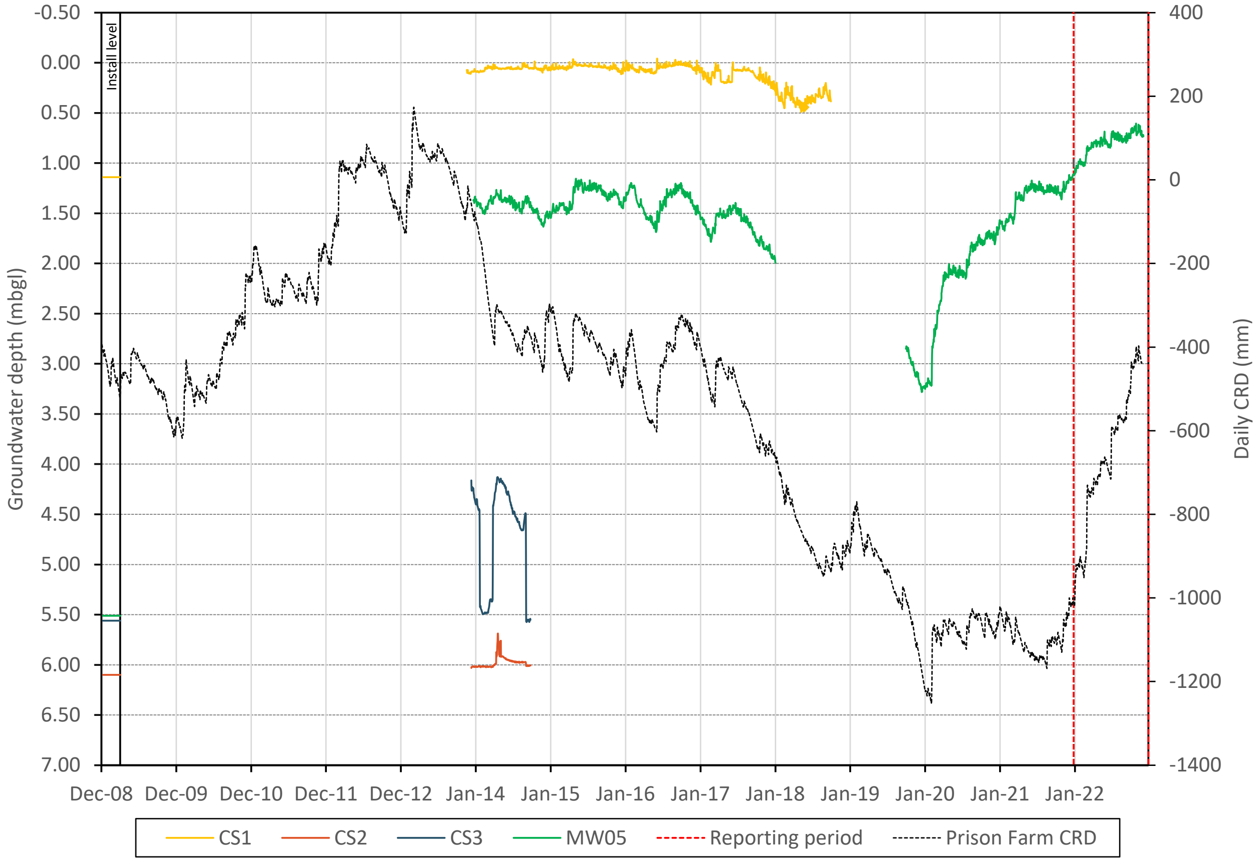


Figure 4.1 Clarence Swamp hydrograph

4.1.2 Hanson Swamp

The hydrograph for Hanson Swamp is presented in Figure 4.2. Hanson Swamp is part of the monitoring program for a proposed reject emplacement area utilising the adjacent Hanson Quarry sand pit voids. The swamp is currently monitored at three locations, HS1, HS2 and HS3. Hanson Swamp has been undermined by Panel 205 South with no apparent mining impacts. There was no mining within proximity to the Hanson Swamp piezometers during the reporting period.

Historically, HS3 has been intermittently dry, only responding to extended periods of above average rainfall. The upper reaches of the swamp are relatively free draining, where the topography has a distinct gradient and vegetation cover is sparse. Groundwater levels at HS3 were observed to be increasing due to above average rainfall extending throughout the reporting period.

Further downstream at HS1 and HS2, the swamp transitions into a permanently waterlogged swamp where the groundwater baseflow contribution from the Burralow Formation outcrops. This transition is accompanied by changes in the vegetation and the surface water in the swamp.

During the reporting period, groundwater levels at both HS1 and HS2 were observed to be increasing, due to above average rainfall extending throughout the reporting period.

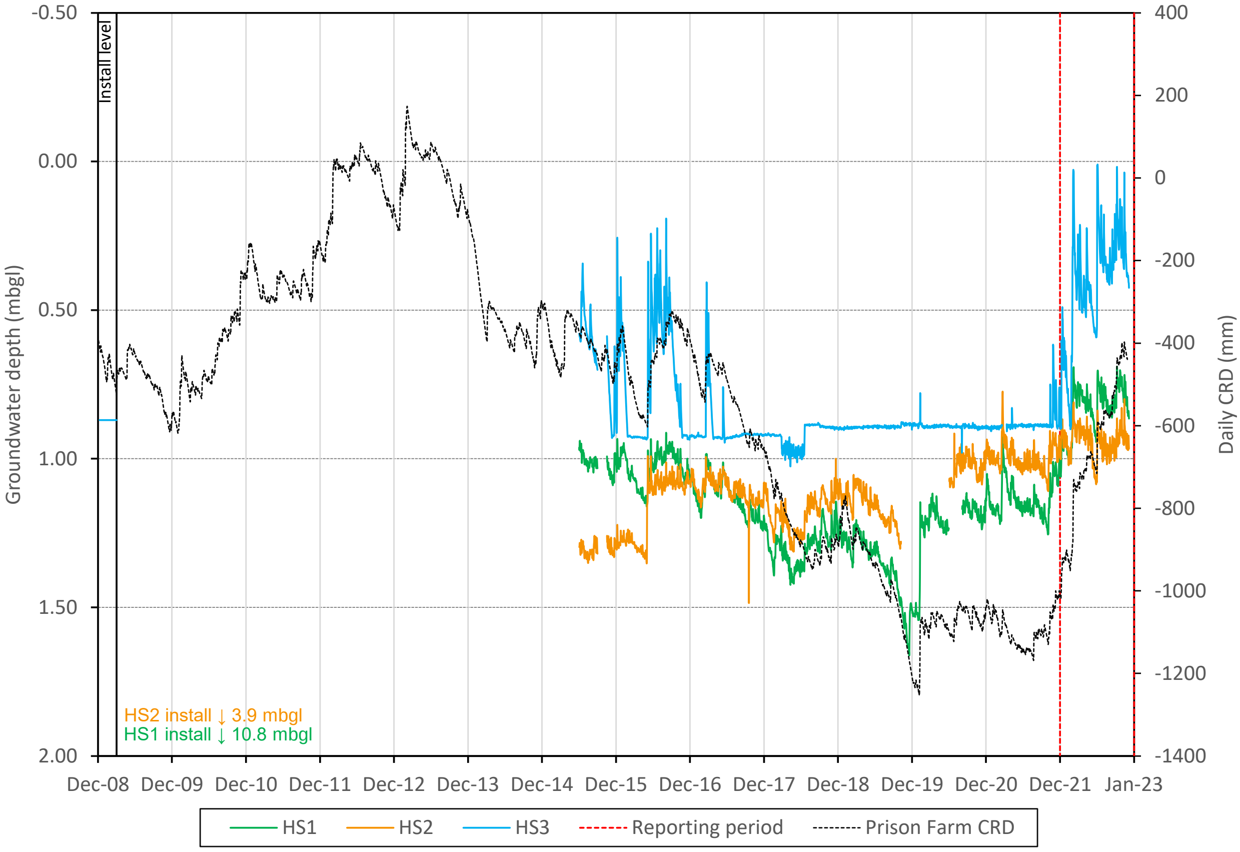


Figure 4.2 Hanson Swamp hydrograph

4.1.3 Happy Valley Swamp

The hydrograph for Happy Valley Swamp is presented in Figure 4.3. Happy Valley Swamp was previously monitored by piezometers HV1 and HV2 until they were destroyed by bushfire in 2013 and have not been replaced.

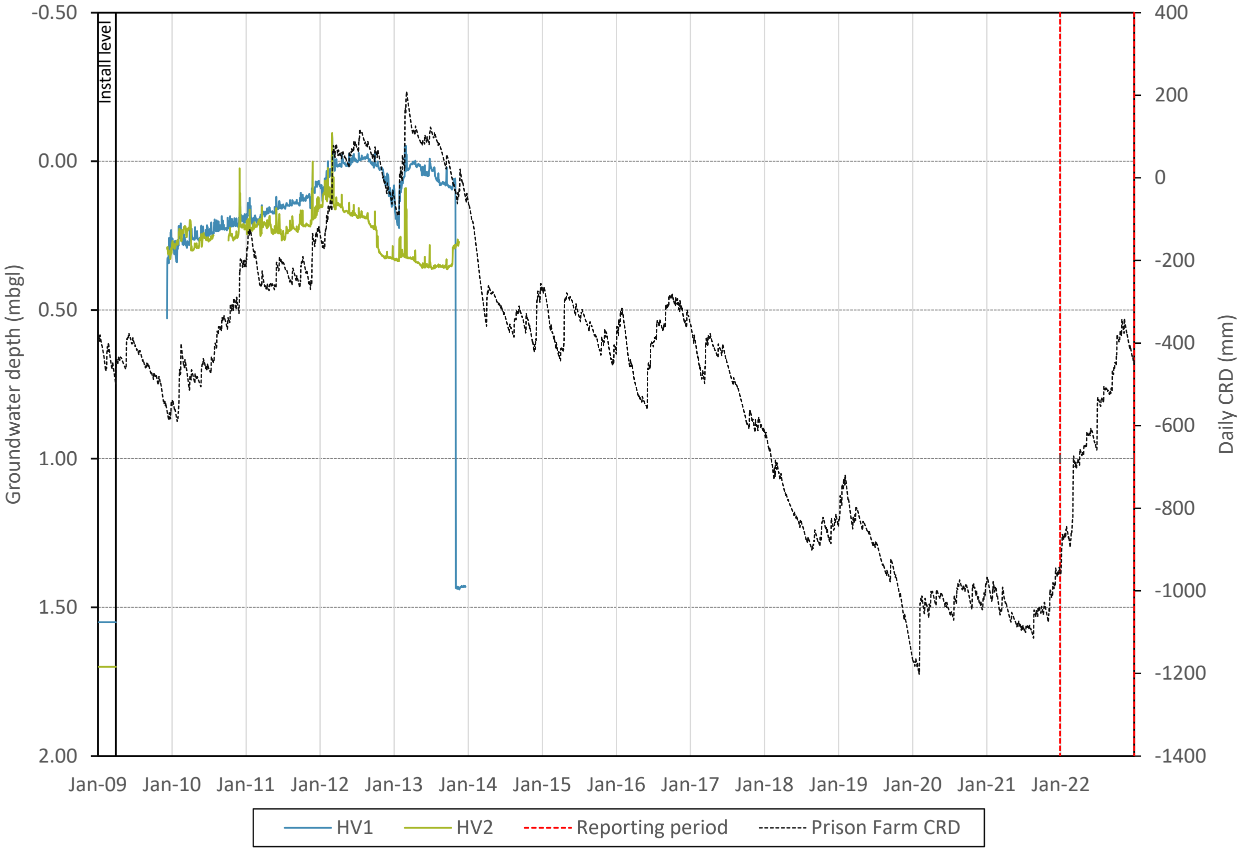


Figure 4.3 Happy Valley Swamp hydrograph

4.1.4 Happy Valley Upper Swamp

The hydrograph for Happy Valley Upper Swamp is shown in Figure 4.4. The Happy Valley upper swamp overlies Panel 704 and was undermined between 2010 and 2013. No mining impacts were observed.

HVU2 was destroyed by bushfire in 2013 and has not been replaced. HVU1 was also damaged but is still operational.

There was no mining within proximity to the Happy Valley Upper Swamp piezometers during the reporting period. HVU1 shows stable groundwater levels and a slight increasing trend consistent with rainfall.

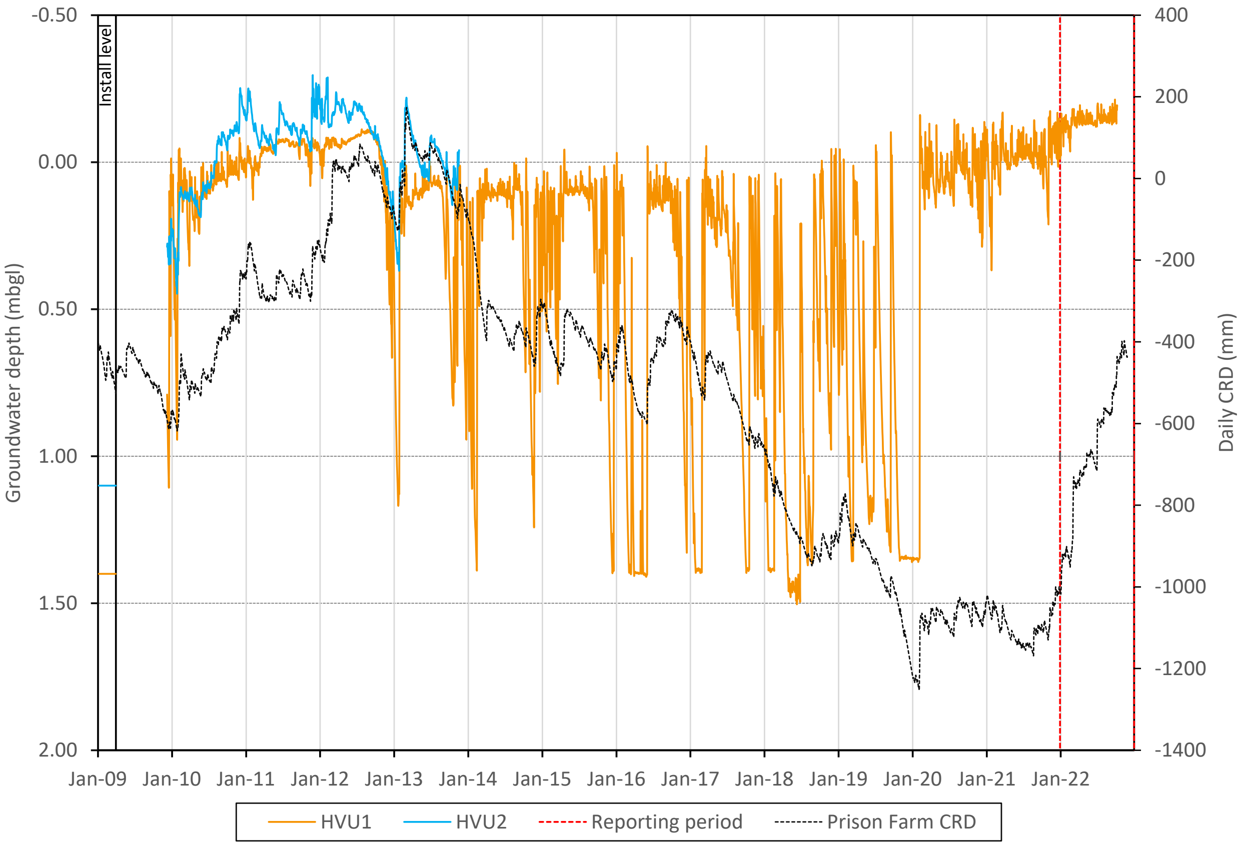


Figure 4.4 Happy Valley Upper Swamp hydrograph

4.1.5 Paddys Swamp East

The hydrograph for Paddys Swamp East is presented in Figure 4.5. Swamp piezometers in Paddys Swamp East (PSE1 and PSE2) overlie Panel 909 (PSE1) and Panel 915 (PSE2).

During the reporting period from August 2022, active mining occurred at Panel 909, approximately 200m to the east of PSE1. Groundwater levels were relatively consistent from early January until late November 2022. From late November groundwater levels showed a decreasing trend consistent with a declining CRD and historical observations. Active mining of Panel 915 occurred directly below PSE2 in August 2022. No mining impacts were observed and groundwater levels continue to trend with the CRD and rainfall.

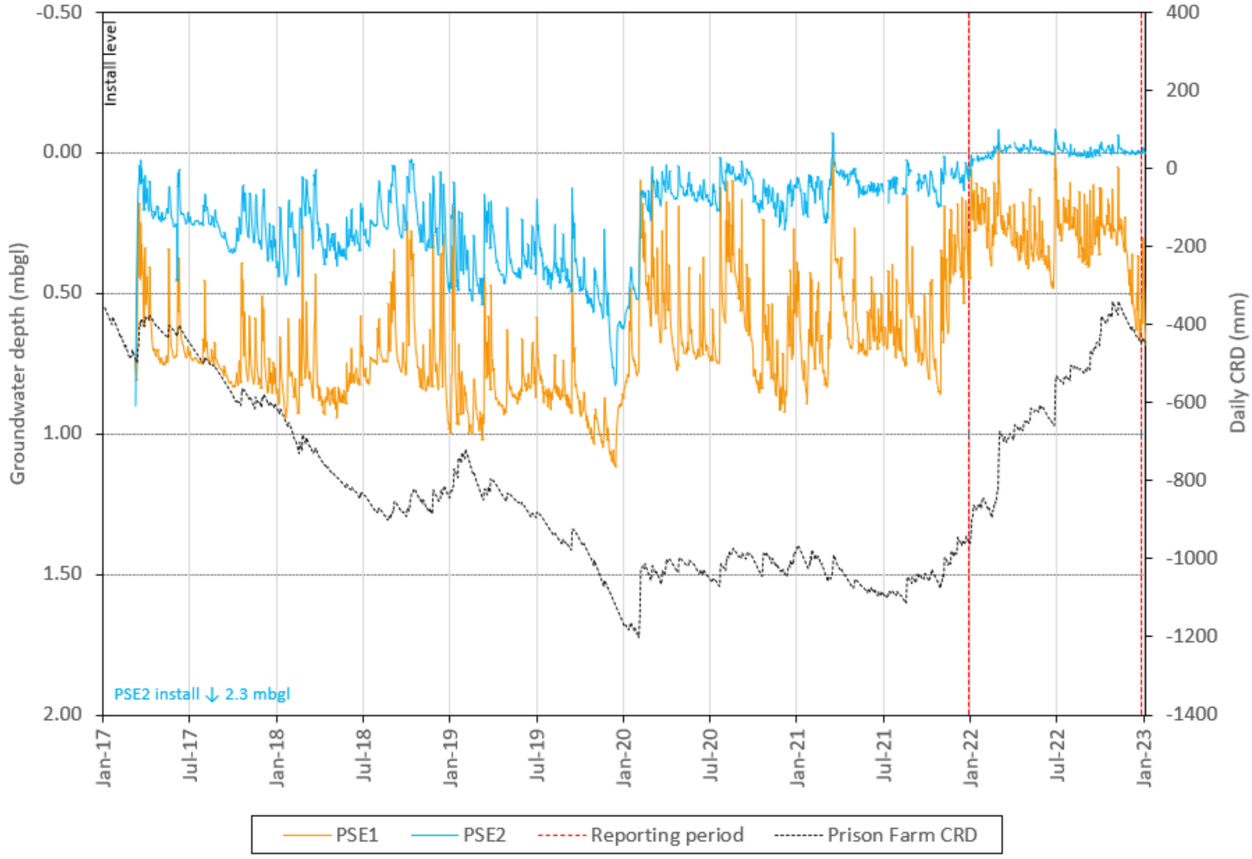


Figure 4.5 Paddys Swamp East hydrograph

4.1.6 Pagoda Swamp

The hydrograph for Pagoda Swamp is presented in Figure 4.6. The two swamp piezometers (PG1 and PG2) overlie Panel 906 which was actively mined from August 2022 in a south-west direction, coming in close proximity to PG1 in December 2022.

In 2019 and 2020, the development and partial extraction at Panel 908 and 910 occurred immediately east of Pagoda Swamp. No mining impacts were observed. During the reporting period, PG1 and PG2 continued to show stable trends and no mining impacts were observed.

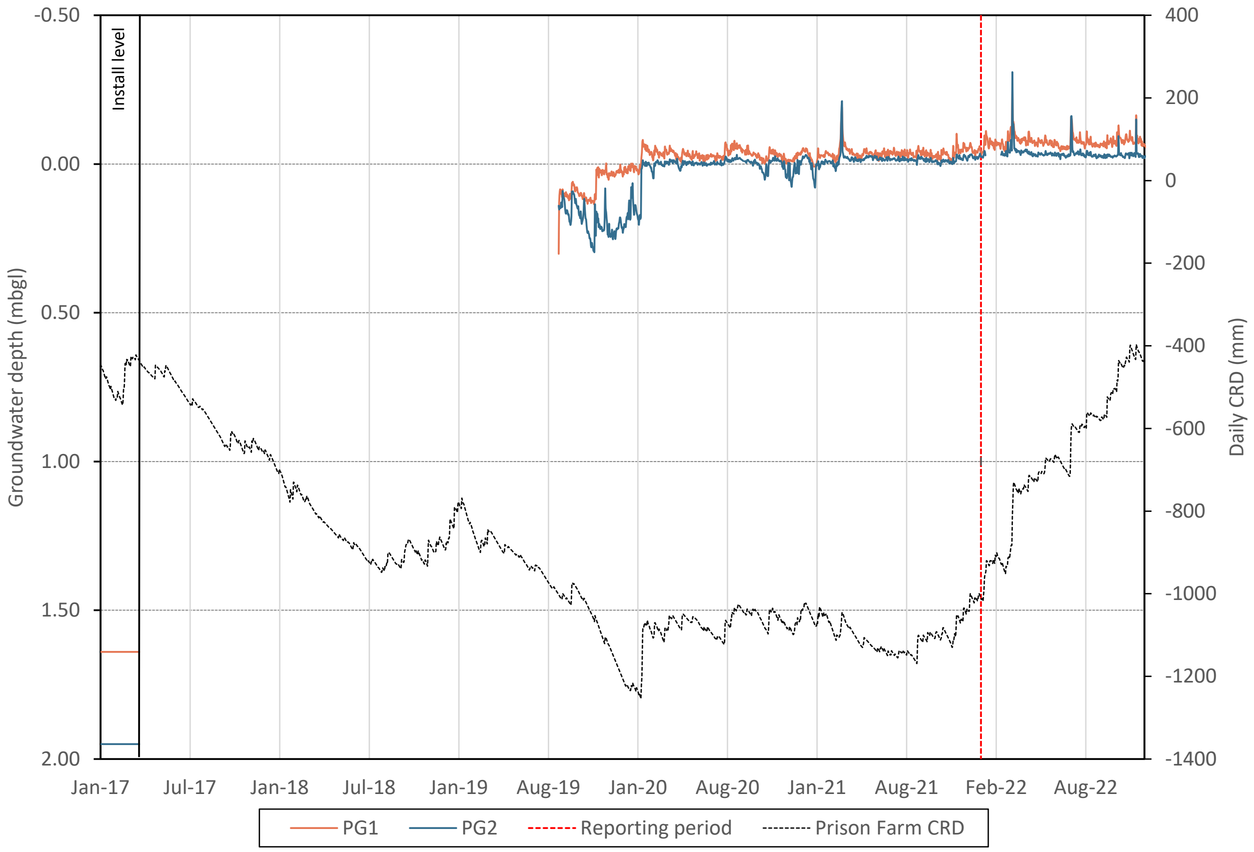


Figure 4.6 Pagoda Swamp Hydrograph

4.1.7 Oleria Swamp

The hydrograph for Oleria Swamp is presented in Figure 4.7. Oleria Swamp (OS1) overlies panel 804. In 2019 extraction in panel 806 occurred approximately 500 m from OS1 and no mining impacts were observed.

During the reporting period, Oleria Swamp was undermined by panel 804 from July 2022. The mine development continued in an easterly direction away from OS1. Overall, no mining impacts have been observed and groundwater levels have shown an increasing trend due to above average rainfall.

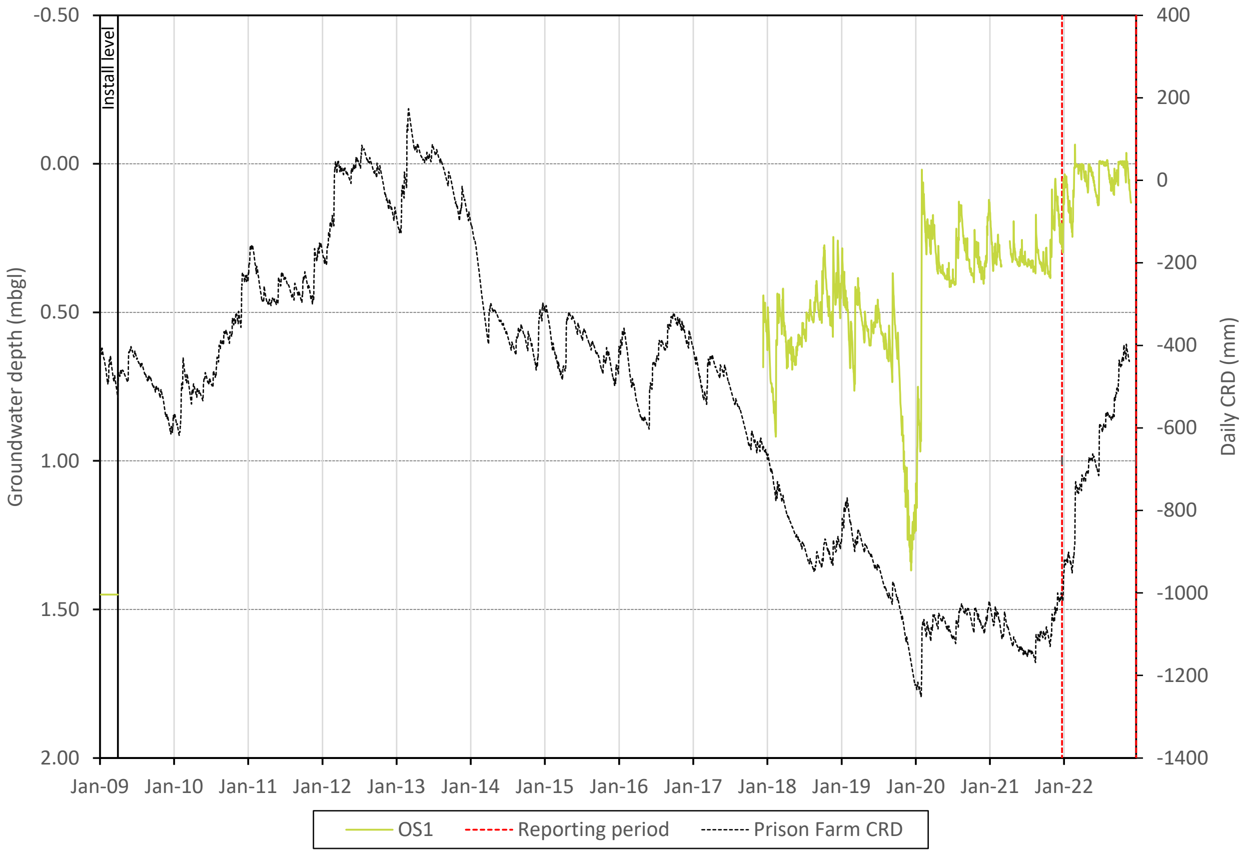


Figure 4.7 Oleria Swamp hydrographs

4.1.8 Upper Dingo Swamp

The hydrograph for Upper Dingo Swamp is presented in Figure 4.8. The two swamp piezometers (UD1 and UD2) were installed to collect baseline data for the proposed northern mining area.

Data loggers have been recording groundwater levels since late September 2022 and have shown a stable trend until mid-November. From mid-November a declining trend was observed corresponding with the CRD.

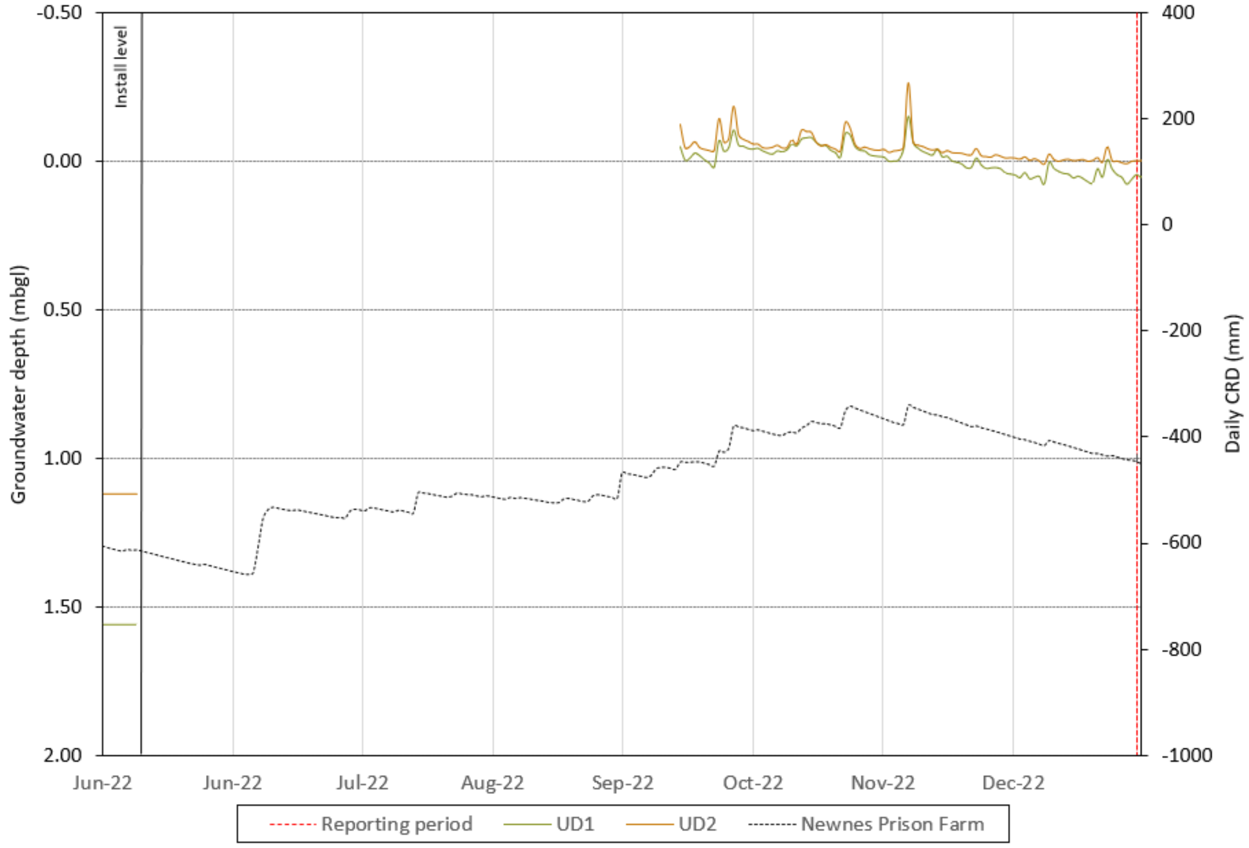


Figure 4.8 Upper Dingo Swamp Hydrograph

4.1.9 Bungleboori North Swamp

The hydrograph for Bungleboori North Swamp is presented in Figure 4.9. The two swamp piezometers (BN1 and BN2) were installed to collect baseline monitoring data for the proposed northern mining area.

Data loggers have been recording groundwater levels since mid-November 2022 and have shown a declining trend corresponding with the CRD.

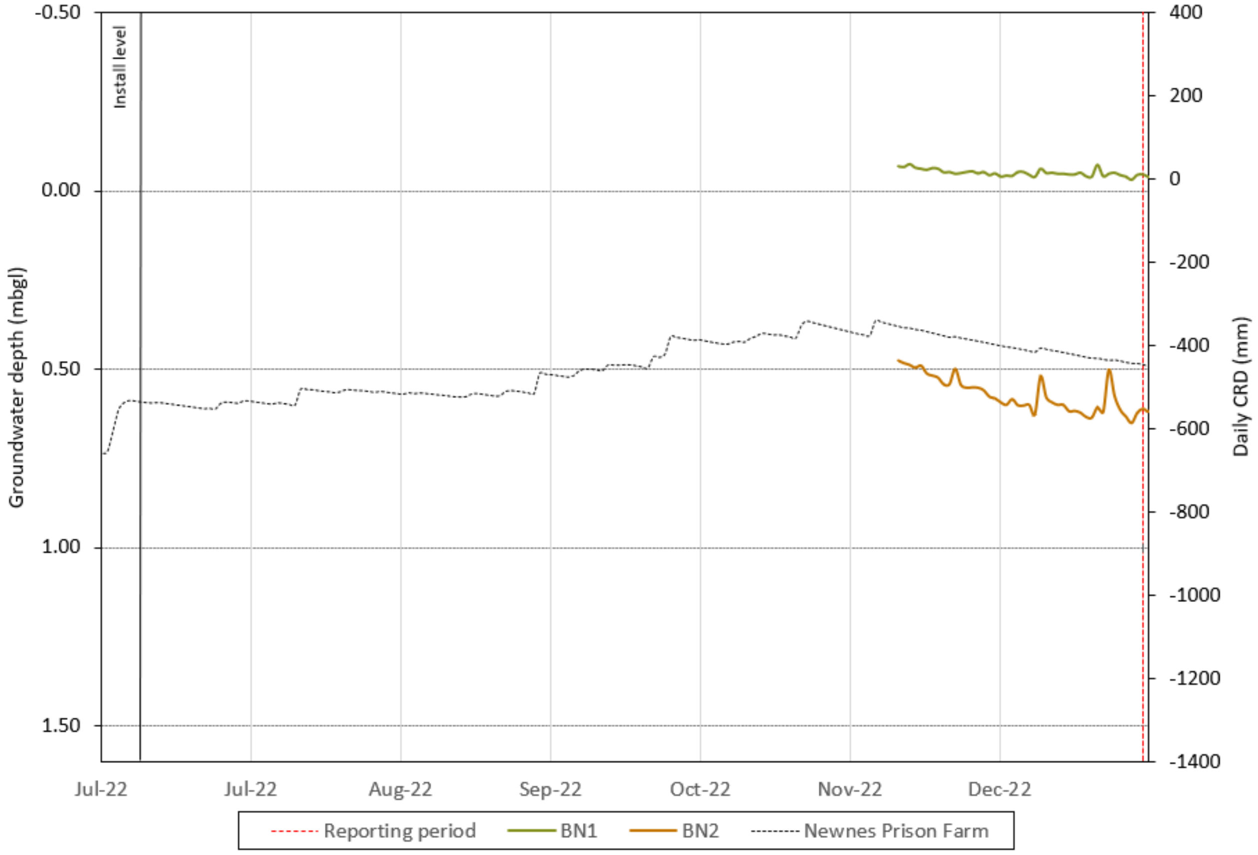


Figure 4.9 Bungleboori North Swamp Hydrograph

4.1.10 Bungleboori Southeast Swamp

The hydrograph for Bungleboori Southeast Swamp is presented in Figure 4.10. The two swamp piezometers (BSE1 and BSE2) were installed to collect baseline monitoring data for the proposed 918 and 920 panels.

Data loggers have been recording groundwater levels since early August 2022 and have shown a stable trend.

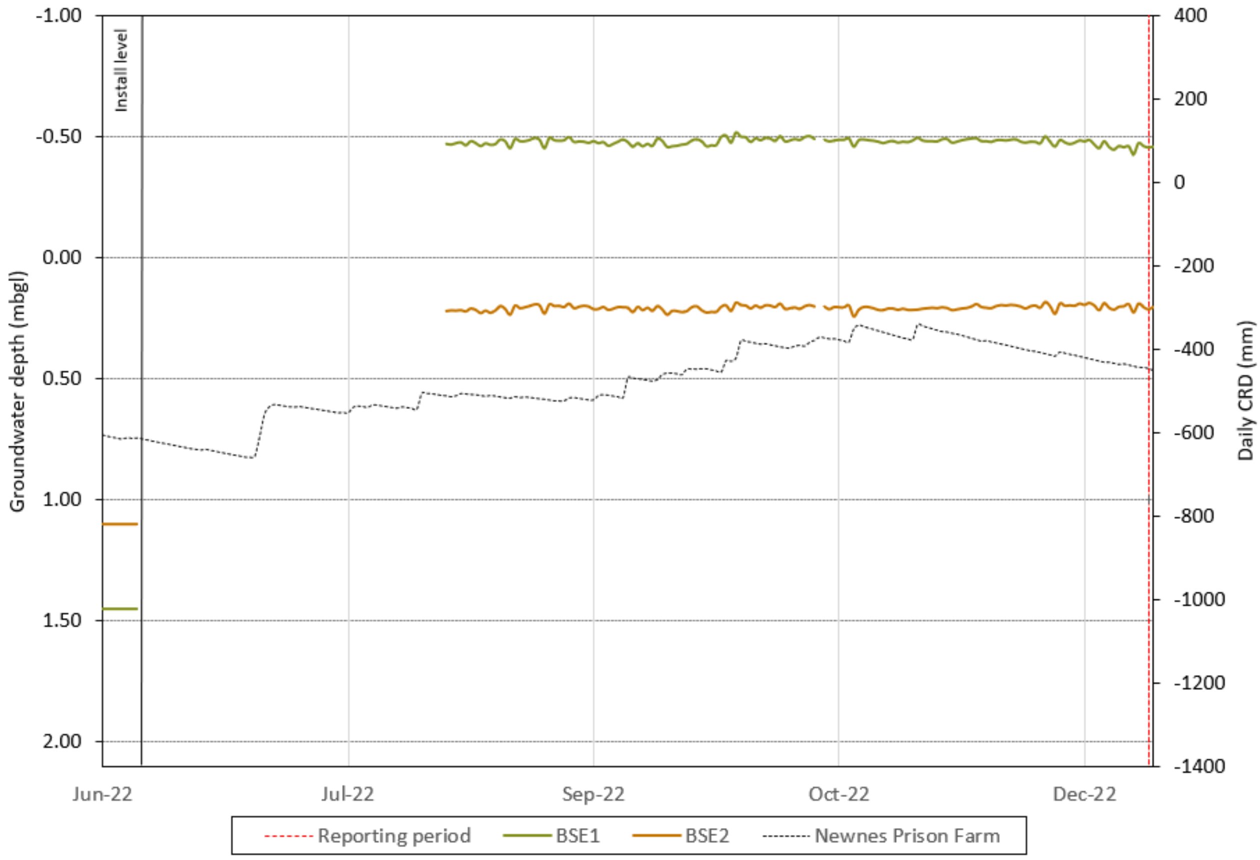


Figure 4.10 Bungleboori Southeast Swamp Hydrograph

4.1.11 Murrays Swamp

The hydrograph for Murrays Swamp is presented in Figure 4.11. The two swamp piezometers (MU1 and MU2) were installed to collect baseline data for the northern mining area.

Data loggers have been recording groundwater levels since mid-August 2022. MU2 showed stable groundwater levels while a gradual increase at MU1 was observed from early November.

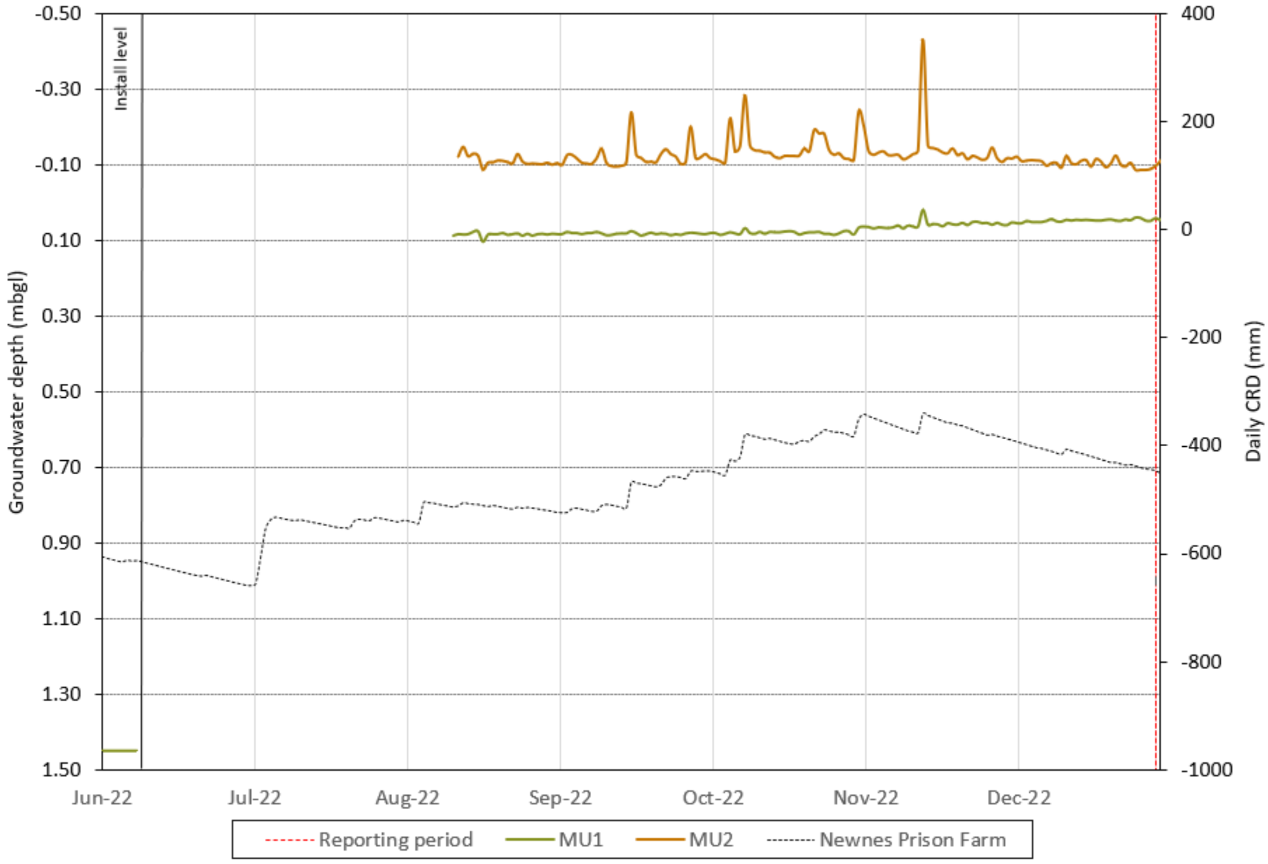


Figure 4.11 Murrays Swamp Hydrograph

4.1.12 Paddys Hanging Swamp

The hydrograph for Paddys Hanging Swamp is presented in Figure 4.12. The two hanging swamp piezometers were installed to collect baseline monitoring data for the proposed 918 and 920 panels. From August 2022 active mining occurred in Panel 909 approximately 300 m south of PHS1.

Data loggers have been recording groundwater levels since early August 2022 and have shown a relatively stable trend until early November. From early November 2022 a declining groundwater trend was observed, corresponding with the CRD.

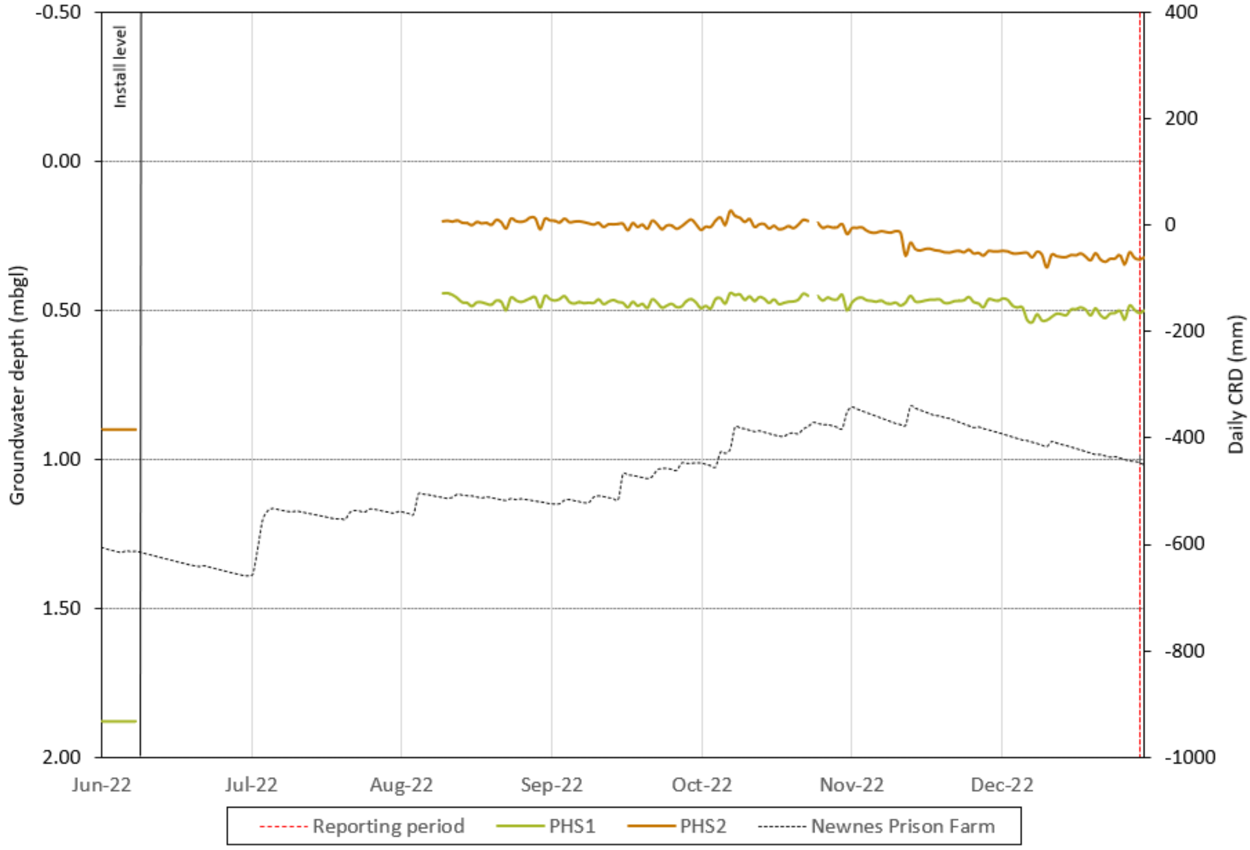


Figure 4.12 Pine Hanging Swamp Hydrograph

4.2 Shallow groundwater system

Standpipe piezometer groundwater levels have been reviewed against their respective trigger values in the WMP. Where triggers have occurred, the groundwater level response has been assessed against the TARP to determine if a mining impact has occurred and if further investigation is required.

General comments on historical observations and mining history for open borehole standpipe piezometers is provided in Section 4.2.1 to Section 4.2.9. The hydrograph for standpipe piezometers is shown on Figure 4.13. Comments on groundwater level trends and standpipe piezometer trigger status during the reporting period are detailed in Table 4.2.

Table 4.2 Open borehole standpipe piezometer trigger status

Bore ID	Target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP4	Banks Wall Sandstone	No trigger – increasing trend.
CLRP5	Banks Wall Sandstone	No trigger – increasing trend.
CLRP7	Banks Wall Sandstone	No trigger – increasing trend.
CLRP8	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CLRP10	Banks Wall Sandstone	Below the trigger value from early August 2019 until late April 2022. Increasing trend throughout the reporting period, corresponding to the CRD.
CLRP15	Burra-Moko head Formation/Caley Formation	No trigger – groundwater levels show an increasing trend.
CLRP28	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CLRP31	Banks Wall Sandstone	No trigger level defined in the WMP – increasing trend.
CC113	Banks Wall Sandstone	No trigger level defined in the WMP – decommissioned.

4.2.1 CLRP4

CLRP4 overlies an unmined area adjacent to Browns Swamp. The groundwater level at CLRP4 is closer to the surface compared to the other open boreholes at Clarence and displays a groundwater level response that is influenced by short term trends in rainfall. The logger was replaced in August 2019 after being removed or misplaced in December 2018.

There was no active mining near CLRP4 during the reporting period and groundwater levels remained relatively stable.

4.2.2 CLRP5

CLRP5 was undermined by Panel 902 in December 2013 and January 2014. Pillar extraction occurred in 2015, but no extraction occurred directly beneath CLRP5. During the reporting period, there was no active mining within 1 km of CLRP5.

Historically, there have been no mining impacts and groundwater levels have trended with the CRD. However, from late-2019 to September 2020, there was an abnormal groundwater level decline that was not consistent with other open borehole standpipe piezometers. Given the timing of the decline coincides with the rainfall deficit prior to February 2020, the decline was likely climatically controlled.

During the reporting period groundwater levels displayed an increasing trend, consistent with the CRD.

4.2.3 CLRP7

CLRP7 overlies an unmined area south of the 700 Area. Groundwater levels at CLRP7 indicate a subdued and delayed response to the CRD. The stepped declines (late 2013–early 2019) are attributed to drawdown from groundwater sampling events.

No active mining took place near CLRP7 during the reporting period and groundwater levels showed an increasing trend, consistent with the CRD.

4.2.4 CLRP8

CLRP8 is located within an unmined area around Clarence village. Groundwater level trends reflect a subdued response to the CRD and declines are attributed to abstraction for domestic use.

No active mining took place near CLRP8 during the reporting period and groundwater levels showed an increasing trend, consistent with the CRD.

4.2.5 CLRP10

CLRP10 was directly undermined by Panel 706 in September 2011. In April 2011, pillar extraction occurred in Panel 708, approximately 250 m west of CLRP10. Panel 704, approximately 150 m east of CLRP10, was developed in April 2009, with partial pillar extraction in March 2010. In January and February 2014, pillar extraction occurred in Panel 700, approximately 700–900 m west-south-west of CLRP10. During this period, no mining impacts were observed.

There was no active mining within the vicinity of CLRP10 during the reporting period. Groundwater levels increased due to above average rainfall.

4.2.6 CLRP15

CLRP15 overlies an unmined area west of the 700 Area and is adjacent to the CLRP15 VWP. Historical data is limited, with data being removed from mid-June 2014 to August 2019, due to incorrect piezometric pressure readings (i.e. logger hanging depth).

There was no active mining near CLRP15 during the reporting period. From August 2019, a slight increasing trend in groundwater levels is observed which continued during the reporting period.

4.2.7 CLRP28

CLRP28 overlies an undeveloped mining lease owned by Clarence which is located north of the 900 area. Since CLRP28's installation in May 2020, the groundwater level has shown a steady increasing trend consistent with an increasing CRD.

4.2.8 CLRP31

CLRP31 overlies an undeveloped mining lease owned by Clarence which is located north of the 900 area. Since CLRP31's installation in May 2020, the groundwater level has shown a gradual increasing trend consistent with the CRD and rainfall.

During the reporting period, from early January 2022 to mid-April 2022, an increase in groundwater level was observed due to heavy rainfall in March. Thereafter, the trend gradually increased up to late November where groundwater levels began to recede due to a reduction in rainfall. A data gap is present from late September to late November because the logger was stuck in the piezometer until freed in late November.

4.2.9 CC113

CC113 was decommissioned in 2014. Historically, groundwater levels reflected a subdued and delayed response to the CRD.

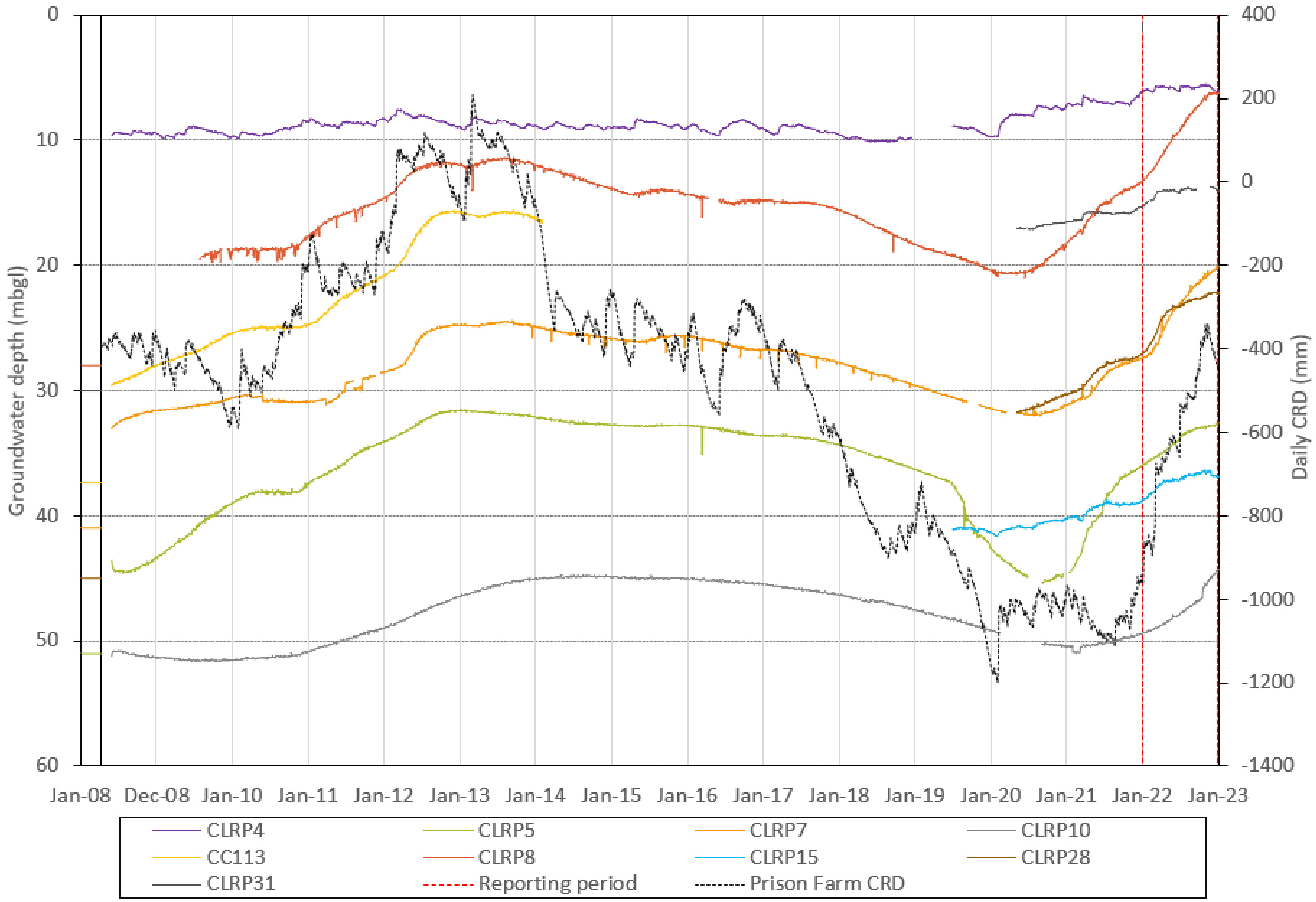


Figure 4.13 Open borehole standpipe piezometer hydrograph

4.3 Vibrating Wire Piezometers

VWP piezometric pressures have been reviewed against their respective trigger values in the WMP. Where triggers have been realised, the piezometric response has been assessed against the TARP to determine if a mining impact has occurred and if further investigation is required.

General comments on historical observations, mining history and hydrographs for VWP's are provided in Section 4.3.1 to Section 4.3.19. Each VWP contains several piezometers (piezos) which target certain formations and depths. This along with comments on piezometric pressure trends and trigger status are detailed in Table 4.3.

Table 4.3 Vibrating wire piezometer trigger status

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP1	#1 Katoomba Seam (175 m bgl)	No trigger – stable trend.
	#2 Burra-Moko head Formation/Caley Formation (150 m bgl)	No trigger – slight increasing trend, likely due to above average rainfall.
	#3 Banks Wall Sandstone (100 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
	#4 Banks Wall Sandstone (60 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
CLRP2	#1 Katoomba Seam (276 m bgl)	Communication was lost with this piezo in August 2007 due to mining.
	#2 Banks Wall Sandstone (190 m bgl)	Exceeded trigger level from 1/11/14 to 10/03/2022. Increasing trend during the reporting period likely due to above average rainfall.
	#3 Banks Wall Sandstone (130 m bgl)	Exceeded trigger level from 30/12/17 to 18/01/2022. Increasing trend during the reporting period likely due to above average rainfall.
	#4 Banks Wall Sandstone (70 m bgl)	No trigger – increasing trend, likely due to above average rainfall.
CLRP3	#1 Burra-Moko head Formation/Caley Formation (198 m bgl)	No trigger – stable trend.
	#2 Banks Wall Sandstone (138 m bgl)	No trigger – stable trend.
	#3 Banks Wall Sandstone (85 m bgl)	No trigger – stable trend.
CLRP6	#1 Burra-Moko head Formation/Caley Formation (160 m bgl)	Communication with this piezo was lost in October 2011.
	#2 Banks Wall Sandstone (100 m bgl)	Limited data due to logger issues, not enough data available to determine trends.
	#3 Banks Wall Sandstone (60 m bgl)	Limited data due to logger issues, not enough data available to determine trends.
CLRP11	#1 Burra-Moko head Formation/Caley Formation (165 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#2 Burra-Moko head Formation/Caley Formation (134.5 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#3 Banks Wall Sandstone (74.5 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.
	#4 Banks Wall Sandstone (61 m bgl)	Limited data due to logger issues, not enough data available to determine trends. The logger was replaced in February 2023.

Table 4.3 Vibrating wire piezometer trigger status

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP12	#1 Burra-Moko head Formation/Caley Formation (230 m bgl)	Access restrictions due to nearby sand quarry – decommissioned.
	#2 Burra-Moko head Formation/Caley Formation (180 m bgl)	
	#3 Banks Wall Sandstone (120 m bgl)	
	#4 Banks Wall Sandstone (100 m bgl)	
CLRP13	#1 Burra-Moko head Formation/Caley Formation (240 m bgl)	No trigger levels defined in the WMP. Depressurisation in early May, likely due to the mining of panel 822 40m south of CLRP13. Stable after depressurisation.
	#2 Burra-Moko head Formation/Caley Formation (210 m bgl)	No trigger levels defined in the WMP. Pressure increase in early May and stabilisation from late May, trending towards pressure before the increase in early May. Likely due to the mining of panel 822 40m south of CLRP13.
	#3 Banks Wall Sandstone (140 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#4 Banks Wall Sandstone (110 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#5 Banks Wall Sandstone (80 m bgl)	No trigger levels defined in the WMP. Increasing trend.
CLRP14	#1 Burra-Moko Head Formation (220 m bgl)	No trigger – Slight increasing trend, likely due to above average rainfall.
	#2 Burra-Moko Head Formation (185 m bgl)	No trigger – Stable trend.
	#3 Banks Wall Sandstone (130 m bgl)	Communication was lost with this piezo in December 2018.
	#4 Banks Wall Sandstone (100 m bgl)	Communication was lost with this piezo in April 2019.
CLRP15	#1 Burra-Moko Head Formation (160 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Burra-Moko Head Formation (130 m bgl)	No trigger levels defined in the WMP. Increasing trend.
	#3 Banks Wall Sandstone (90 m bgl)	No trigger levels defined in the WMP. Sharp increase in early July likely due to rainfall, slow decline thereafter.
	#4 Banks Wall Sandstone (60 m bgl)	No trigger levels defined in the WMP. Malfunctioned in 2019.
CLRP16	#1 Burra-Moko Head Formation (115 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Burra-Moko Head Formation (70 m bgl)	No trigger – Stable trend.
CLRP17	#1 Burra-Moko Head Formation (200 m bgl)	Communication was lost with this piezo in October 2015.
	#2 Burra-Moko Head Formation (170 m bgl)	No trigger – slight depressurisation response in August 2021 from mining Panel 818A. Gradual increase during the reporting period.
	#3 Banks Wall Sandstone (70 m bgl)	No trigger – gradual increase during the reporting period.

Table 4.3 Vibrating wire piezometer trigger status

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
CLRP18	#1 Burra-Moko Head Formation/Caley Formation (230 m bgl)	Exceeded trigger value from 2/08/17 to 10/04/22. Increasing trend, likely due to above average rainfall.
	#2 Banks Wall Sandstone (75 m bgl)	Communication was lost with this piezo in February 2021.
CLRP19	#1 Burra-Moko Head Formation (170 m bgl)	Exceeded trigger value from 1/1/21 continuing throughout the reporting period. Depressurisation response in August 2021 due to mining Panel 818A. Continued declining trend during the reporting period.
	#2 Burra-Moko Head Formation (120 m bgl)	No trigger – Stable trend.
	#3 Banks Wall Sandstone (90 m bgl)	No trigger – Gradual increase during the reporting period.
CLRP22	#1 Burra-Moko Head Formation (220 m bgl)	Communication was lost with this piezo in November 2020 due to subsidence.
	#2 Banks Wall Sandstone (90 m bgl)	Exceeded trigger value from 1/1/19 to 29/09/22. Gradual increase during the reporting period.
CLRP27	#1 Katoomba Seam (275 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#2 Caley Formation (220 m bgl)	No trigger levels defined in the WMP. Inconsistent data, possibly unsaturated.
	#3 Caley Formation (190 m bgl)	No trigger levels defined in the WMP. Fluctuating, decreasing trend.
	#4 Banks Wall Sandstone (130 m bgl)	No trigger levels defined in the WMP. Fluctuating, no trend apparent.
	#5 Banks Wall Sandstone (90 m bgl)	No trigger levels defined in the WMP. Communication was lost with this piezo in August 2021 due to a malfunction.
CLRP29	#1 Katoomba Seam (260 m bgl)	No trigger levels defined in the WMP. Increasing trend, possibly due to above average rainfall.
	#2 Katoomba Seam (248 m bgl)	No trigger levels defined in the WMP. Increasing trend, possibly due to above average rainfall.
	#3 Caley Formation (189 m bgl)	No trigger levels defined in the WMP. Increasing trend, due to above average rainfall.
	#4 Banks Wall Sandstone (70 m bgl)	No trigger levels defined in the WMP. Increasing trend, due to above average rainfall.
CLRP33	#1 Katoomba Seam (287 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#2 Caley Formation (276 m bgl)	No trigger levels defined in the WMP. Slight increasing trend.
	#3 Burra-Moko Head Formation (236 m bgl)	No trigger levels defined in the WMP. Stable trend.
	#4 Banks Wall Sandstone (67 m bgl)	No trigger levels defined in the WMP. Stable trend.
CC114	#1 Burra-Moko Head Formation (165 m bgl)	No trigger – stable trend.
	#2 Burra-Moko Head Formation (135 m bgl)	No trigger – stable trend.
	#3 Banks Wall Sandstone (75 m bgl)	No trigger – increasing trend.

Table 4.3 Vibrating wire piezometer trigger status

VWP ID	Piezo number & target formation	Trigger status and trend during the reporting period (1 January 2022 – 31 December 2022)
	#4 Banks Wall Sandstone (45 m bgl)	No trigger – slight increasing trend.
CC115	#1 Burra-Moko Head Formation (270 m bgl)	No trigger – depressurisation response in August 2021 due to mining of panel 818A. Increasing trend plateauing towards the end of the reporting period.
	#2 Burra-Moko Head Formation (200 m bgl)	No trigger – depressurisation response in August 2021 due to mining Panel 818A.Increasing trend following depressurisation.
	#3 Banks Wall Sandstone (170 m bgl)	No trigger – depressurisation response in August 2021 due to mining Panel 818A. Stable during the reporting period.
	#4 Banks Wall Sandstone (120 m bgl)	No trigger – increasing trend.

Notes: 1. mAHD – metres Australian Height Datum; 2. mbgl – metres below ground level.

4.3.1 CLRP1

The hydrograph for CLRP1 is presented in Figure 4.14. CLRP1 is located in an unmined area just south of Panel 330. Historically, there has been no significant changes in the piezometric pressure at CLRP1. Data gaps exist due to logger issues.

During the reporting period, there was no active mining within 1km of CLRP1. Piezos #1 and #2 (below the MYC) are stable with piezo #2 showing a slight increasing trend. Piezos #3 and #4 (above the MYC) show an increasing trend consistent with the CRD. No mining impacts are apparent.

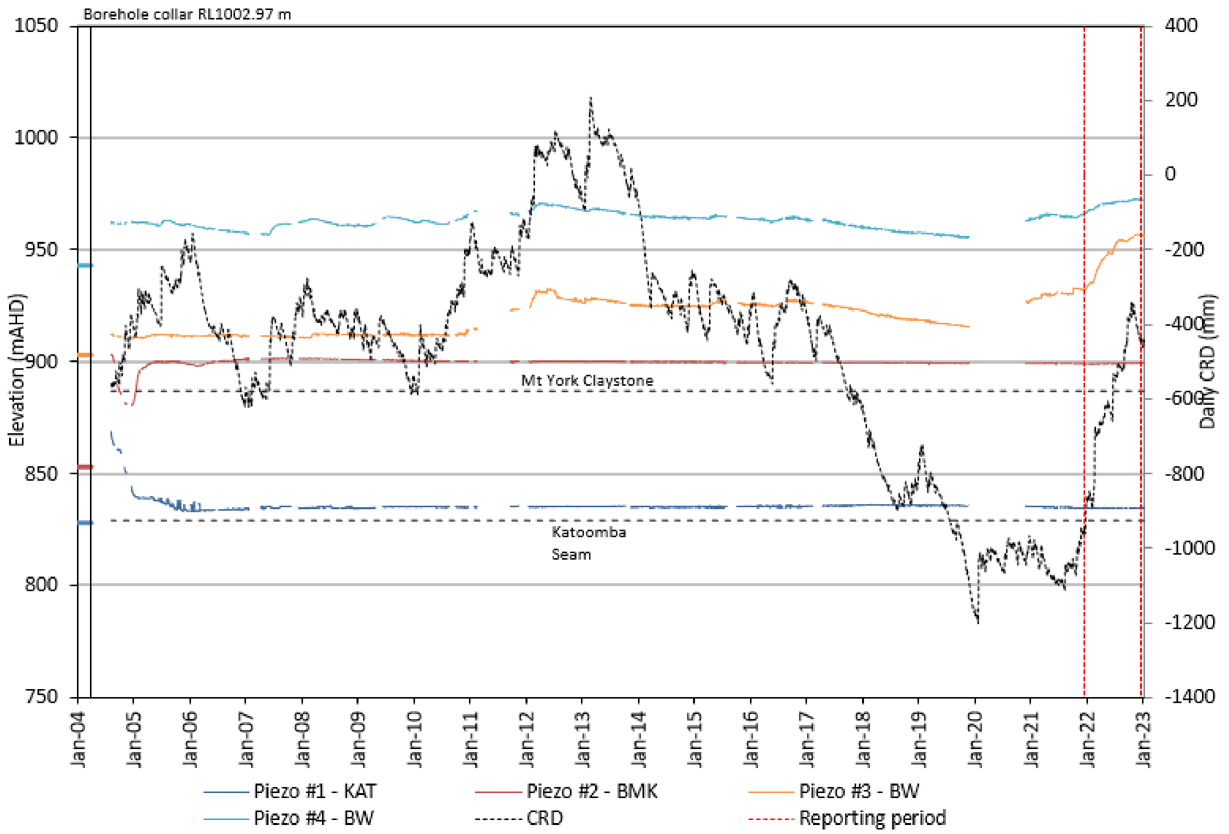


Figure 4.14 CLRP1 VWP hydrograph

4.3.2 CLRP2

The hydrograph for CLRP2 is presented in Figure 4.15. CLRP2 overlies Panel 611E which was mined in August 2007. Communication with Piezo #1 was lost following undermining. Piezos above the MYC continue to provide reliable data.

During the reporting period, no active mining occurred within the vicinity of CLRP2. Piezos #2, #3 and #4 were stable and showed a slight increase in piezometric pressure during the reporting period. Data gaps are due to intermittent logger issues. No mining impacts are apparent.

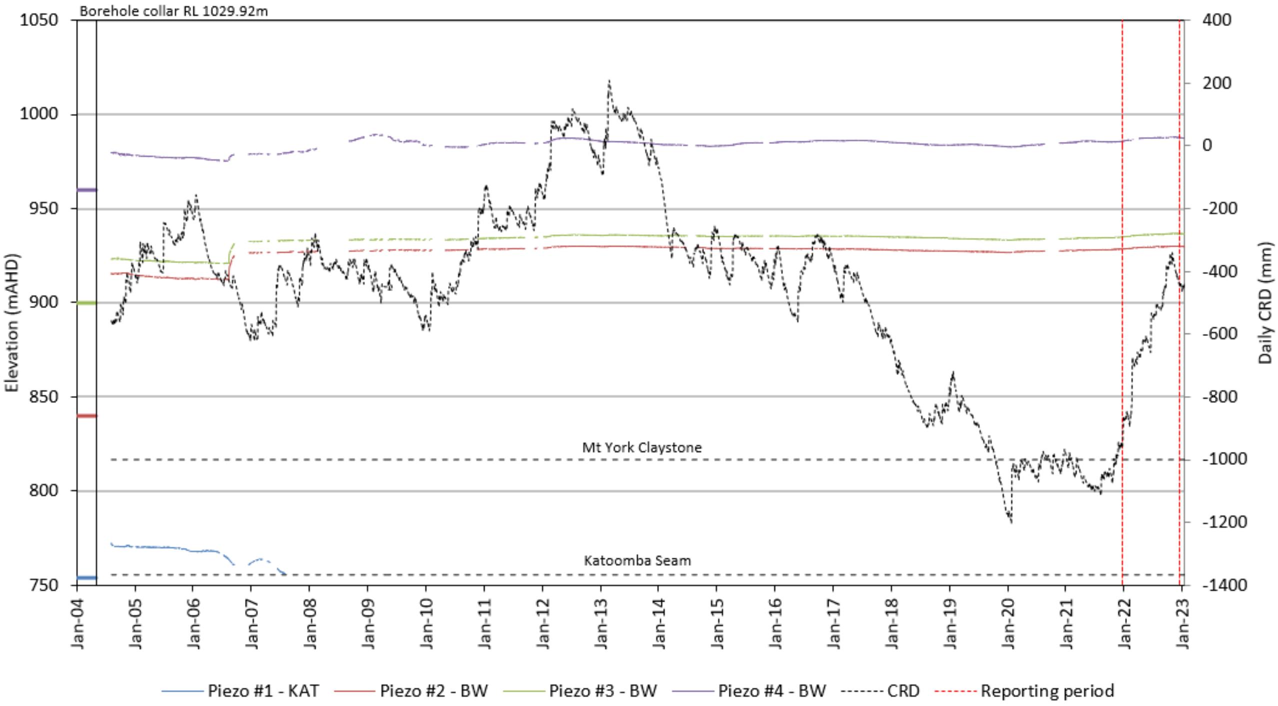


Figure 4.15 CLRP2 VWP hydrograph

4.3.3 CLRP3

The hydrograph for CLRP3 is presented in Figure 4.16. CLRP3 overlies Panel 612 and was undermined shortly after installation in 2006.

During the reporting period, there was no active mining within 1km of CLRP3. Piezos #2 and #3 displayed a continuation of stable trends. Piezo #1 in the Burra-Moko head formation was unstable at the beginning of January however stabilised with minor fluctuations. No impacts from mining were apparent.

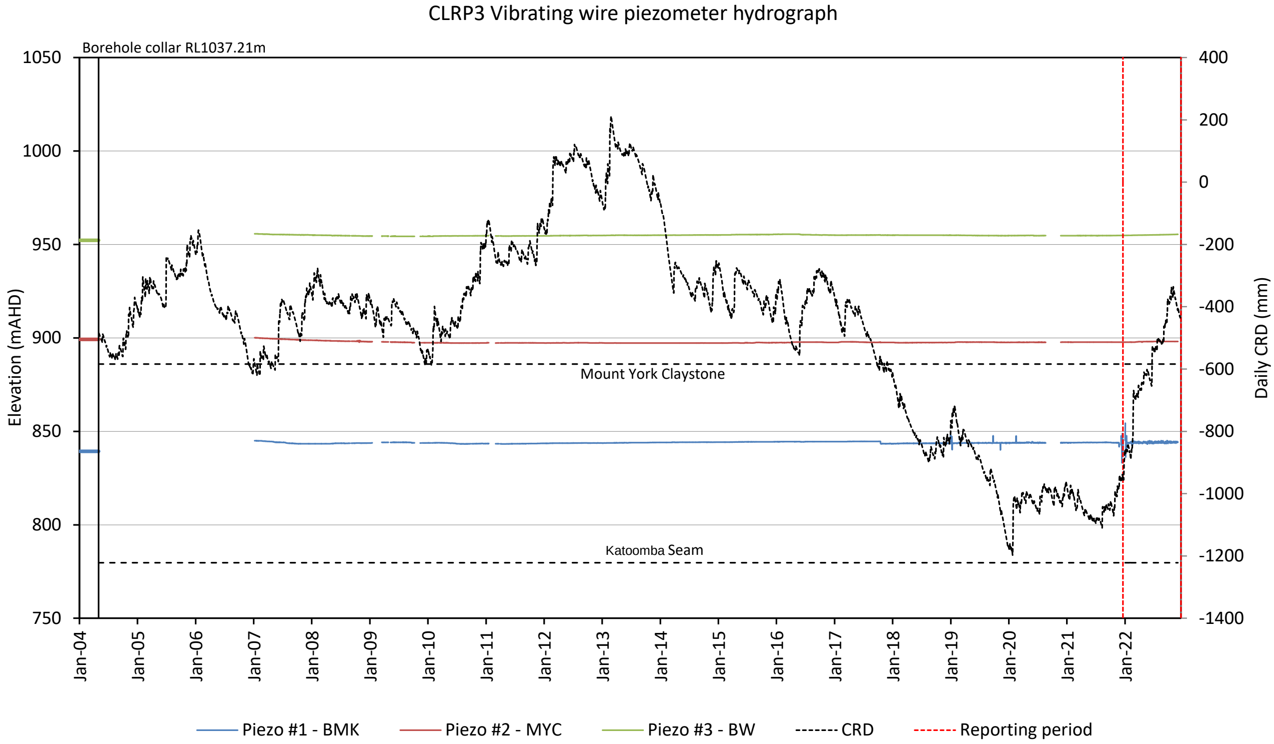


Figure 4.16 CLRP3 VWP hydrograph

4.3.4 CLRP6

The hydrograph for CLRP6 is presented in Figure 4.17. CLRP6 overlies Panel 702 and was undermined in September 2009. Further extraction near to CLRP6 occurred at Panel 704 in December 2009. Historically, the dataset has been affected by logger issues and only spot readings have been collected from late 2014.

The deepest Piezo #1 (160 m) was damaged by subsidence and failed in late-October 2010. Remaining Piezos are functional but logger issues after 2014 prevented the observation of reliable data. A new data logger was installed in mid-October 2021, but logger issues remain, and limited data was available throughout 2022. Piezo #1 remains unsaturated since being undermined.

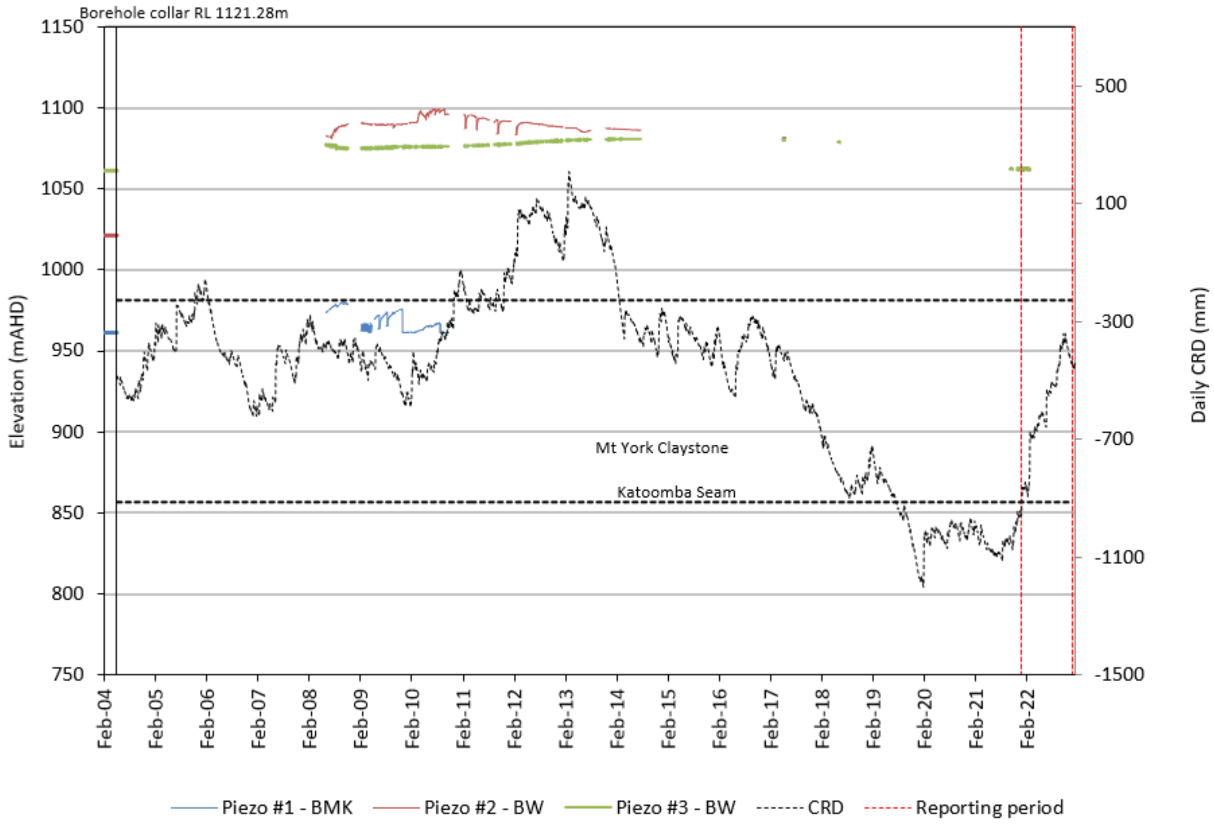


Figure 4.17 CLRP6 VWP hydrograph

4.3.5 CLRP11

The hydrograph for CLRP11 is presented in Figure 4.18. CLRP11 is located 700 m west of Panel 903, outside of planned mining development. Data gaps exist due to intermittent logger issues.

During the reporting period, no mining was within the vicinity of CLRP11. A new logger was installed in October 2021. A drop in piezometric pressure was observed following the installation of the new logger, likely due to the change in logger system. Intermittent logger issues occurred during the reporting period and limited data was obtained. This logger has since been replaced in February of 2023.

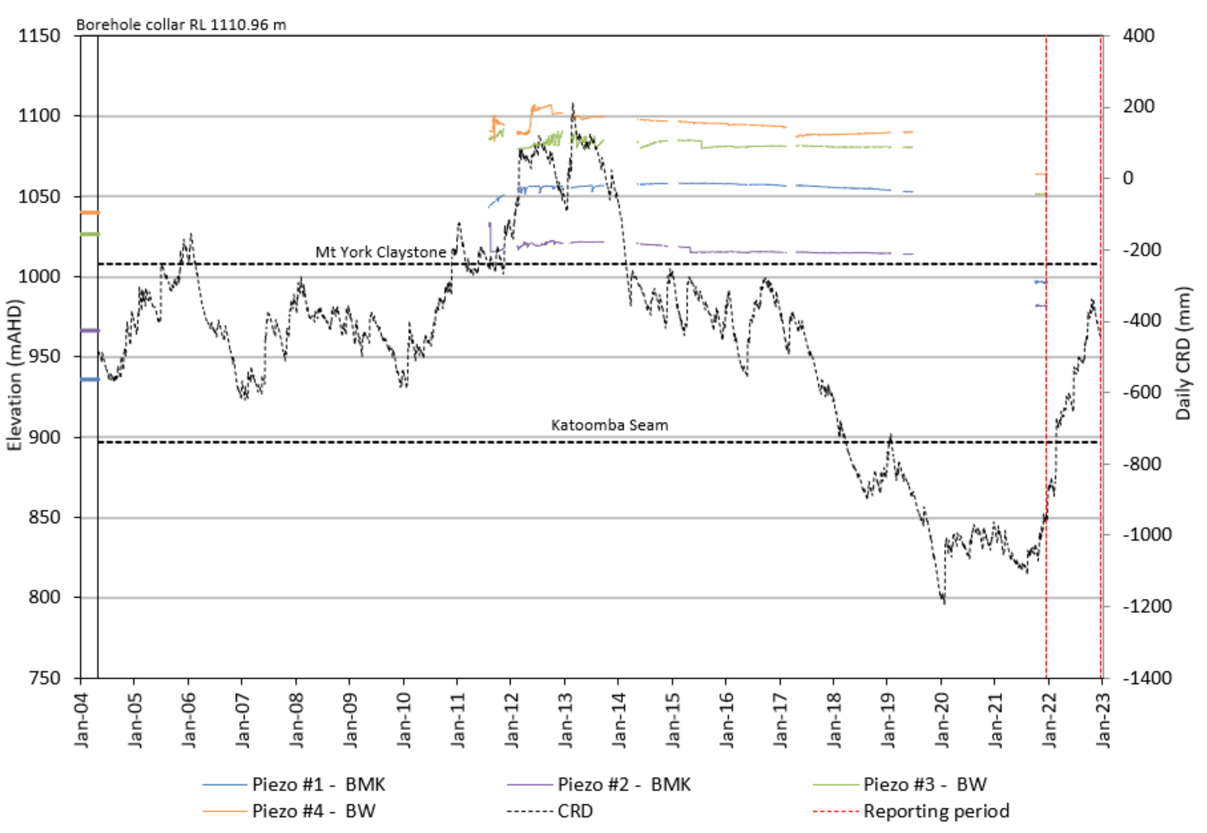


Figure 4.18 CLRP11 VWP hydrograph

4.3.6 CLRP12

The hydrograph for CLRP12 is presented in Figure 4.19. CLRP12 is located approximately 600 m west of Panel 716, outside of planned mining development.

Historically first workings and pillar extraction occurred in Panel 716 approximately 700 m to the east of CLRP12. This occurred during July and August of 2013 and no mining impacts were observed. Piezo #3 appears to have malfunctioned shortly after installation. A small depressurisation response is also observed in late 2019 due to mining.

During the reporting period, there was no active mining within 1 km of CLRP12. No data has been collected since early 2020 due to access restrictions from the nearby sand quarry.

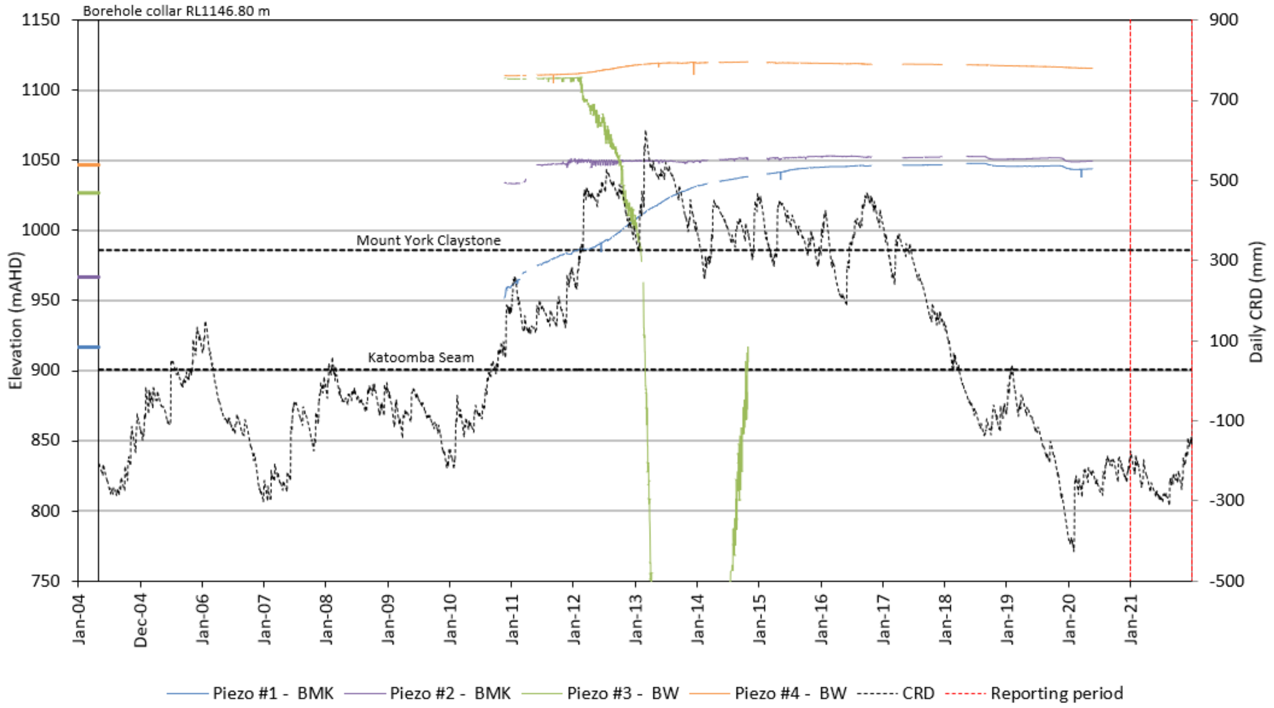


Figure 4.19 CLRP12 VWP hydrograph

4.3.7 CLRP13

The hydrograph for CLRP13 is presented in Figure 4.20. CLRP13 overlies Panel 820 which was developed in 2018. There are large data gaps from October 2018 to July 2021 due to logger issues, however all piezos are operational.

In May 2022 active mining of panel 822 was approximately 40 m south of CLRP13. Piezo #1 showed a minor depressurisation in early May 2022. Piezo 2 had a change in pressure at a similar time to piezo 1 however, continued a steady trend. Piezometric pressure in piezo #4 has remained steady. Piezos #3 and #5 increased from January and become steady from May onwards. Following depressurisation, piezometric pressures appear to have stabilised from May. CLRP13 will be closely monitored for further depressurisation above the MYC.

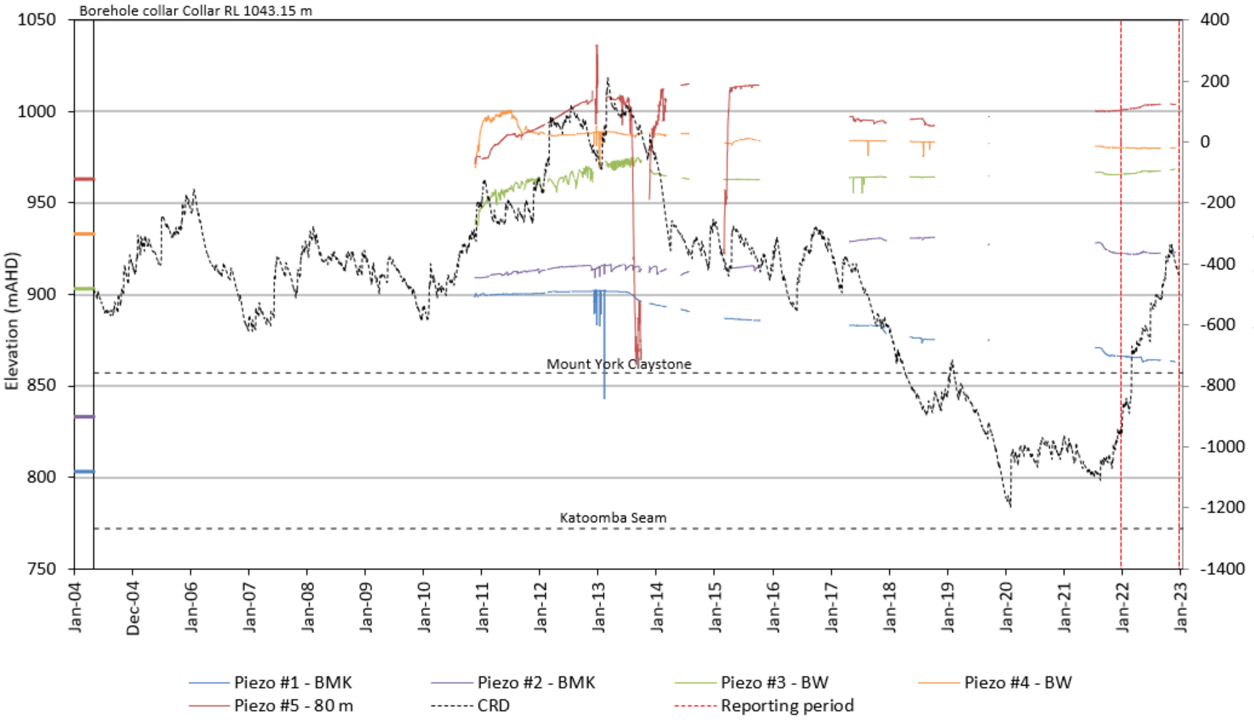


Figure 4.20 CLRP13 VWP hydrograph

4.3.8 CLRP14

The hydrograph for CLRP14 is presented in Figure 4.21. CLRP14 overlies Panel 801 which was developed in 2013 and extracted in 2014. Slight depressurisation responses were observed at Piezos #1 and #2 following extraction. No response was observed above the MYC.

A decline in piezometric pressure was observed from the start of November 2020 around the same time pillar extraction occurred, approximately 500 m from Panel 809. Piezos #1 and #2 malfunctioned in 2019 and is unrelated to mining.

During the reporting period no active mining was withing 1 km of CLRP14 and the remaining Piezos (#1 and #2) show a slight increasing trend and a stable trend respectively.

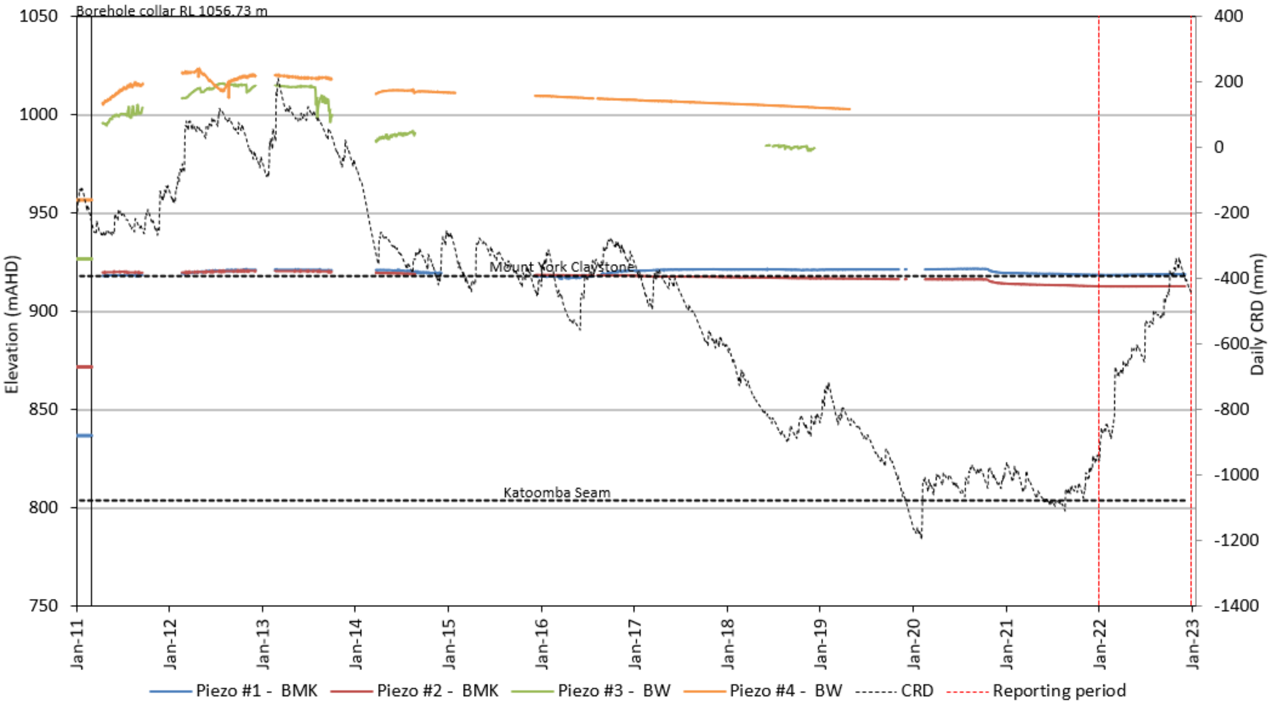


Figure 4.21 CLRP14 VWP hydrograph

4.3.9 CLRP15

The hydrograph for CLRP15 is presented in Figure 4.22. CLRP15 overlies an unmined area approximately 250 m west of Panel 707, and adjacent to the Lithgow Water Supply dam. There are large data gaps from September 2019 to October 2021 due to logger issues but all Piezos are operational. A new logger was installed in October 2021.

Mining was completed at Panel 707 in August 2012. Pillar extraction occurred in Panel 716 in September 2013 and came within 750 m of CLRP15. No mining impacts were observed.

During the reporting period, no active mining was within 1 km of CLRP15. A new logger was installed in late October 2021. Piezos #2 and #3 show an increasing trend whilst Piezo #1 remained steady. Piezo #3 had a stepped increase in early July and appeared to have a slight decline in pressure thereafter. The standpipe piezometer (CLRP15) adjacent to the CLRP15 VWP shows no mining impact during the reporting period.

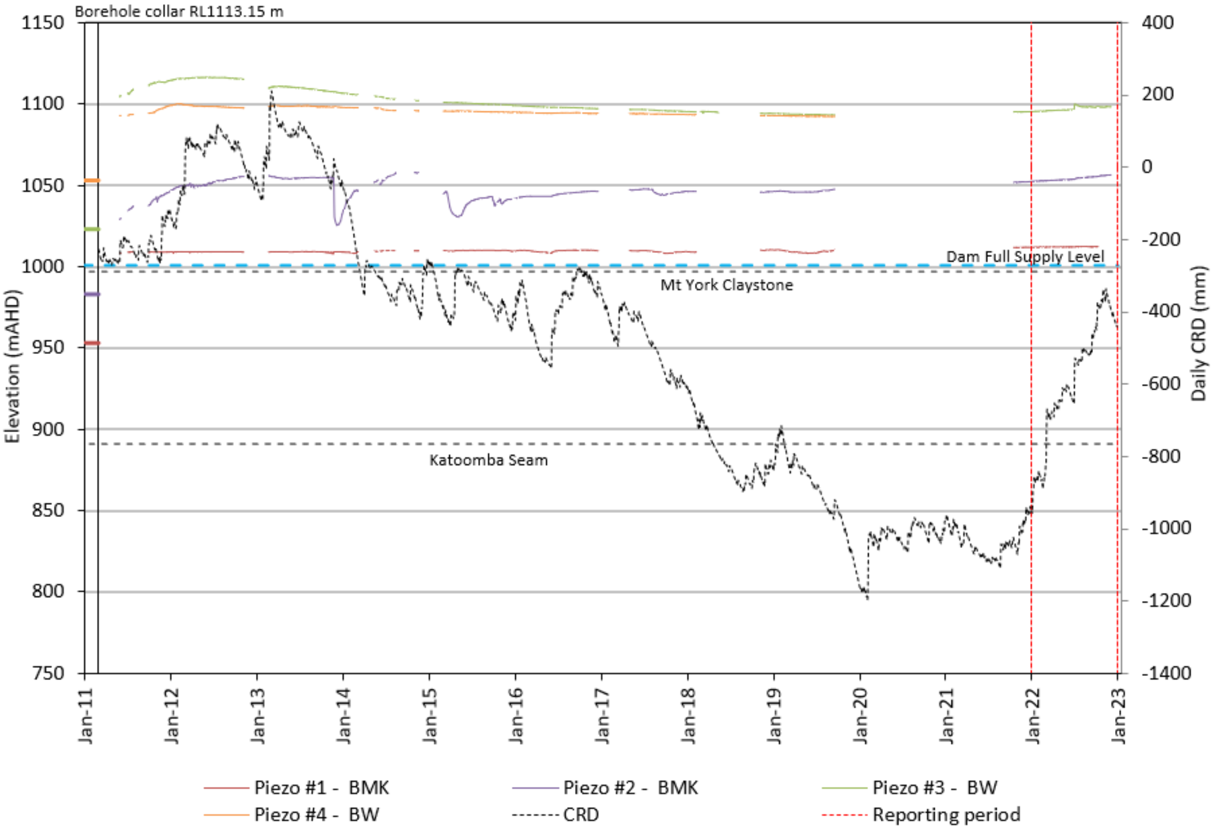


Figure 4.22 CLRP15 VWP hydrograph

4.3.10 CLRP16

The hydrograph for CLRP16 is presented in Figure 4.23. CLRP16 lies above an unmined area adjacent to the Lithgow Water Supply dam. There are large data gaps from October 2019 to October 2021 due to logger issues. A new logger was installed in late October 2021.

During the reporting period, no active mining of was within 1 km of CLRP16. Since the installation of the new logger, Piezos #1 and #2 have continued similar trends as seen prior to October 2019.

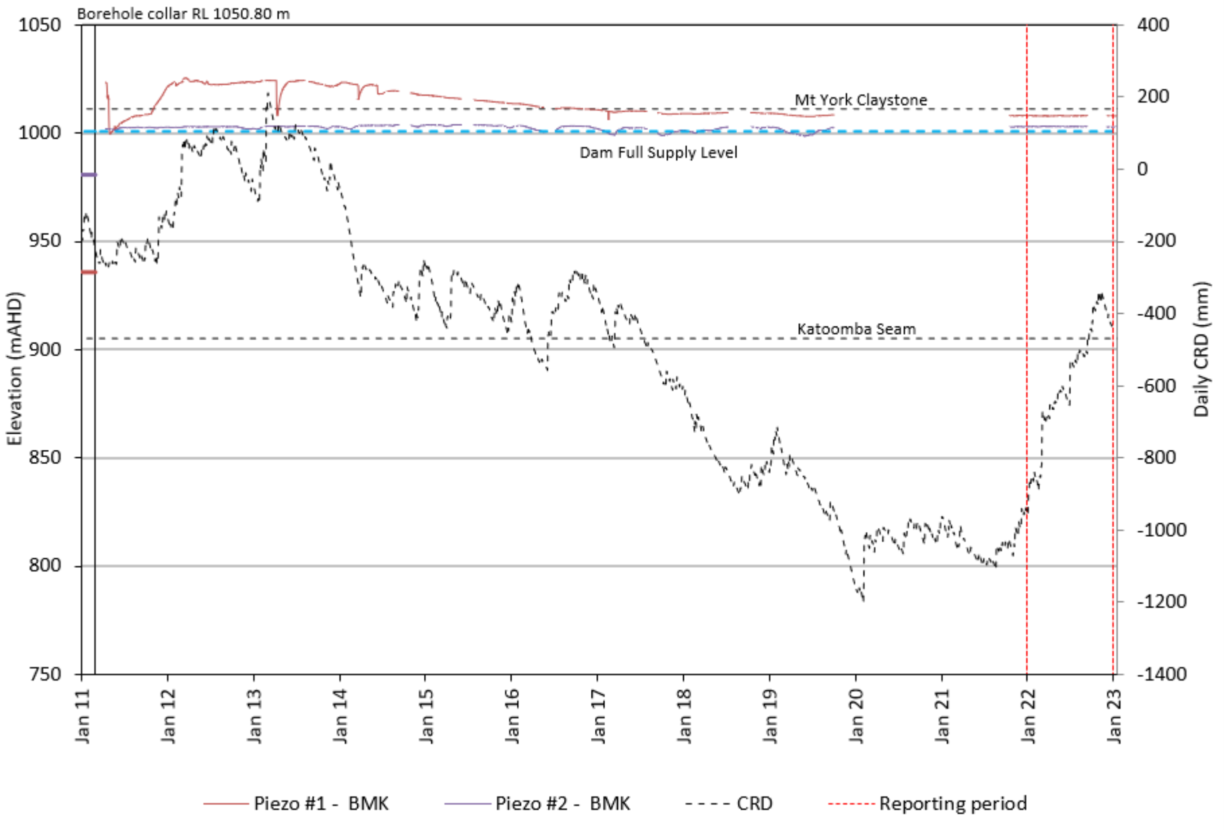


Figure 4.23 CLRP16 VWP hydrograph

4.3.11 CLRP17

The hydrograph for CLRP17 is presented in Figure 4.24. CLRP17 was undermined by Panel 816 in September 2017 and no impacts above the MYC were observed.

In May 2022 active mining occurred approximately 900 m south of CLRP17 in panel 822, no mining impacts were observed. Piezo #2 and #3 (above the MYC) showed an increasing in trend, corresponding with the CRD.

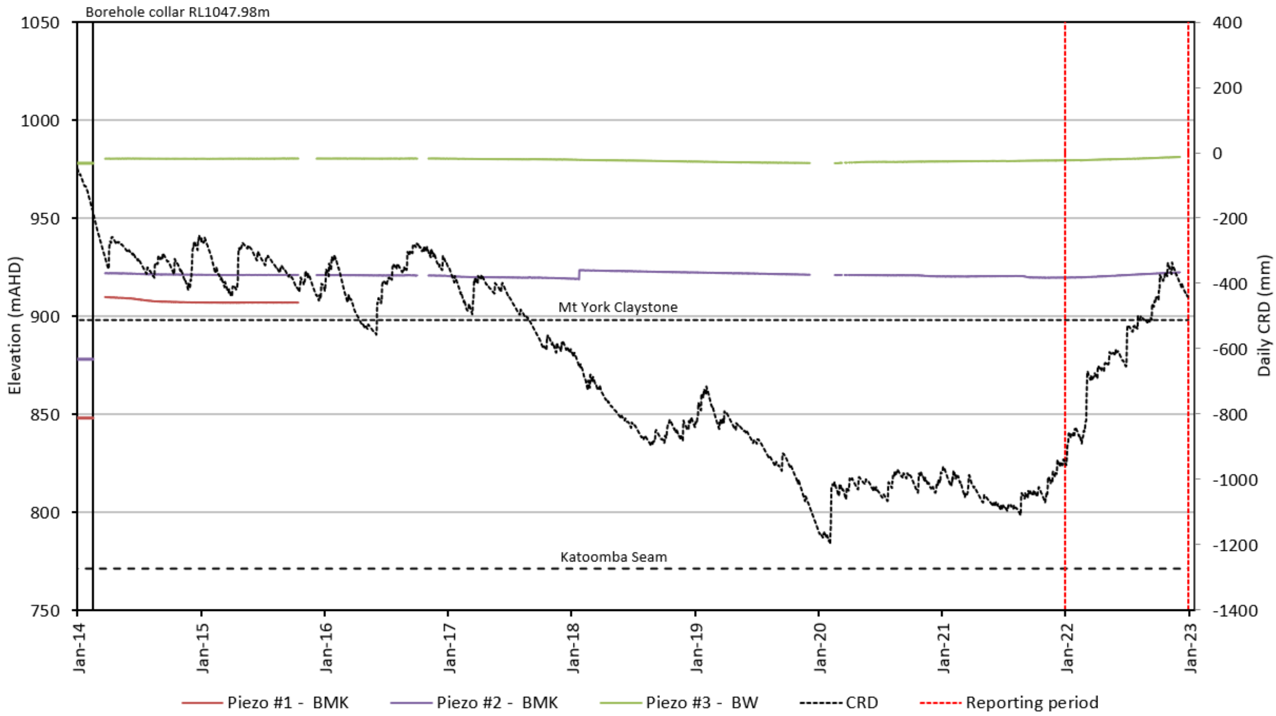


Figure 4.24 CLRP17 VWP hydrograph

4.3.12 CLRP18

The hydrograph for CLRP18 is presented in Figure 4.25. CLRP18 overlies Panel 906. Mining has occurred adjacent to CLRP18 during 2020 in Panels 908 and 910. Panel 908 was approximately 300 m from CLRP18 at its closest point.

In May 2020, extraction at Panel 908 passed through a fault zone/structured roof zone, which is connected to CLRP18. Around this time, Piezo #2 (75 m) recorded a slight decline in piezometric pressure. Piezo #2 appears to have malfunctioned in late February 2021 and is no longer recording data.

During the reporting period, the piezometric pressure in Piezo #1 (230 m) has increased possibly due to above average rainfall.

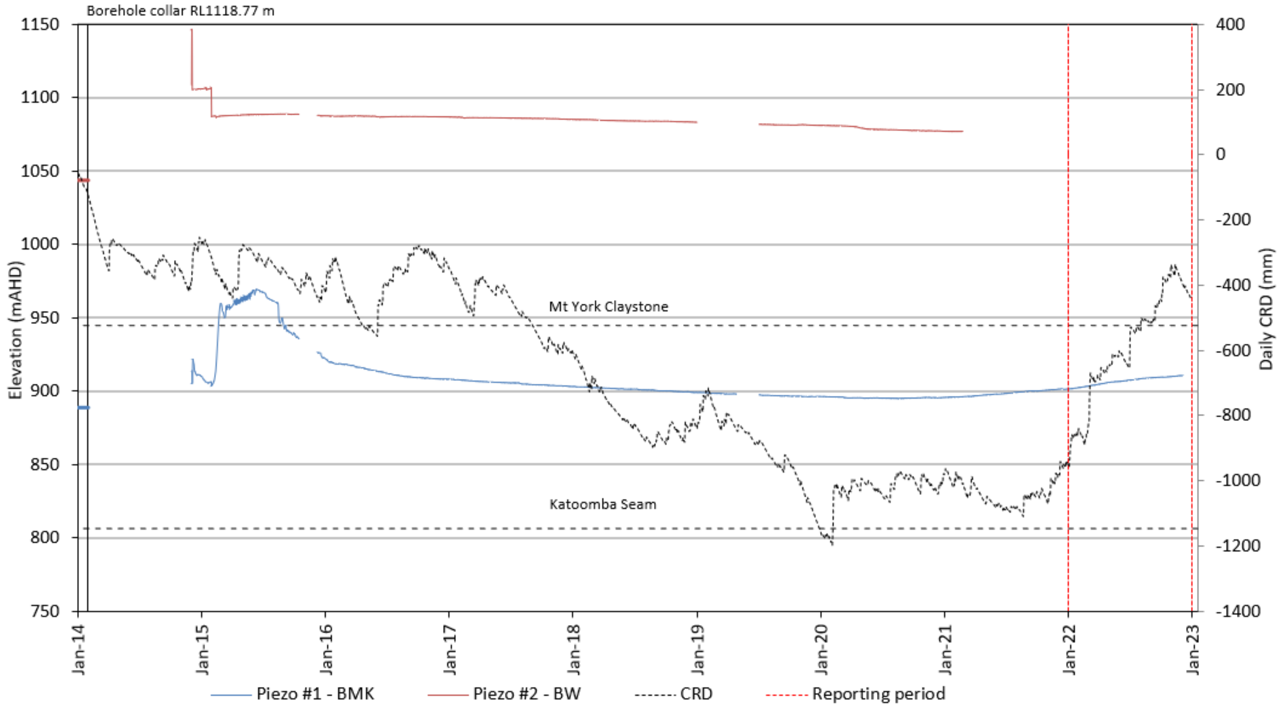


Figure 4.25 CLRP18 VWP hydrograph

4.3.13 CLRP19

The hydrograph for CLRP19 is presented in Figure 4.26. CLRP19 has been undermined by Panel 812 in March 2016 and no mining impacts were observed. Piezo #1 showed a depressurisation response in late August 2021 due to the mining of panel 818A. The change in piezometric pressure at Piezo #1 at the time was approximately 4 m. No impacts were observed above the MYC.

In February 2022 mining of Panel 822 was approximately 600 m south of CLRP19. Piezo #1 continued a declining trend following depressurisation in August 2021. Piezo #2 has displayed a continued stable trend and piezo #3 has displayed an increasing trend corresponding to the CRD.

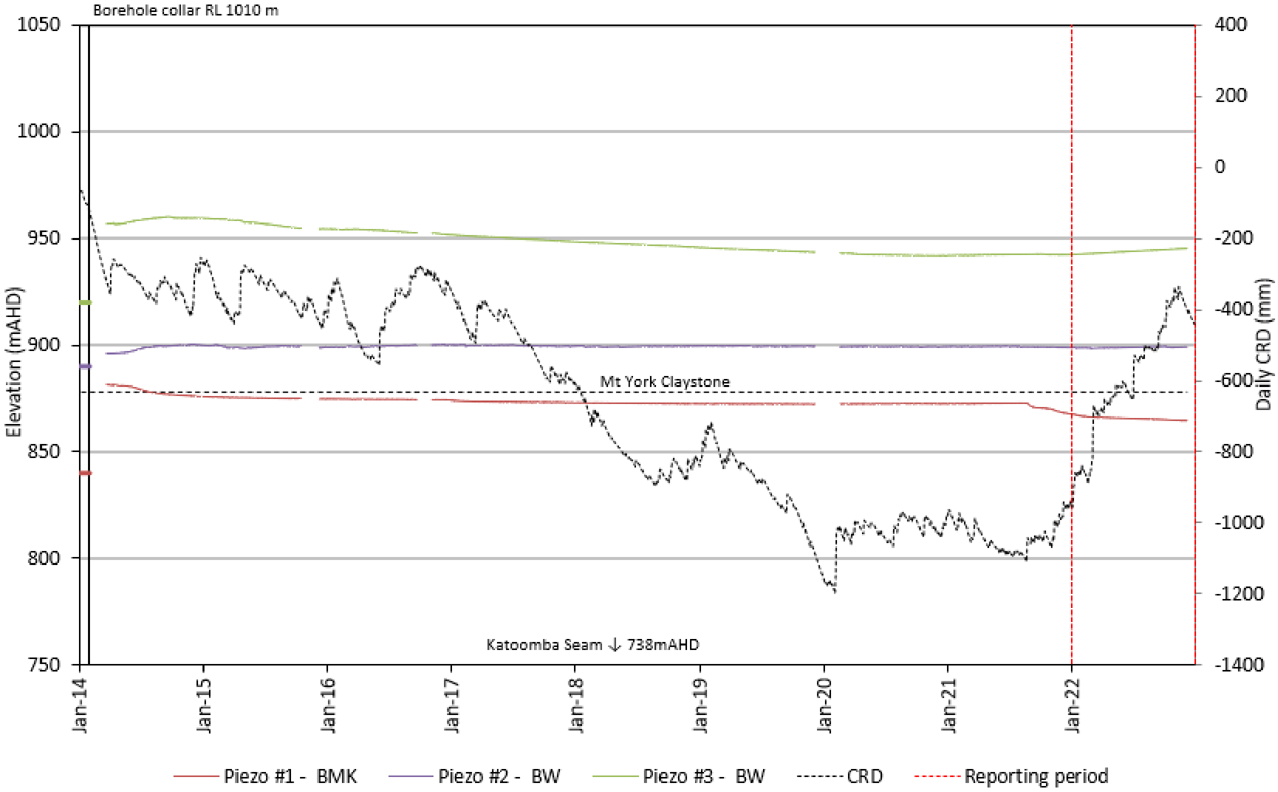


Figure 4.26 CLRP19 VWP hydrograph

4.3.14 CLRP22

The hydrograph for CLR22 is presented in Figure 4.27. CLRP22 has been undermined by Panel 910 in March 2019 and April 2020. Piezo #1 shows an initial depressurisation response of approximately 4 m in April 2020 due to pillar extraction and sequent failure in December 2020.

In September 2022 active mining of Panel 906 was approximately 500 m west of CLRP22. Piezo #2 remained stable with a slight increase in piezometric pressure, no mining impacts were observed.

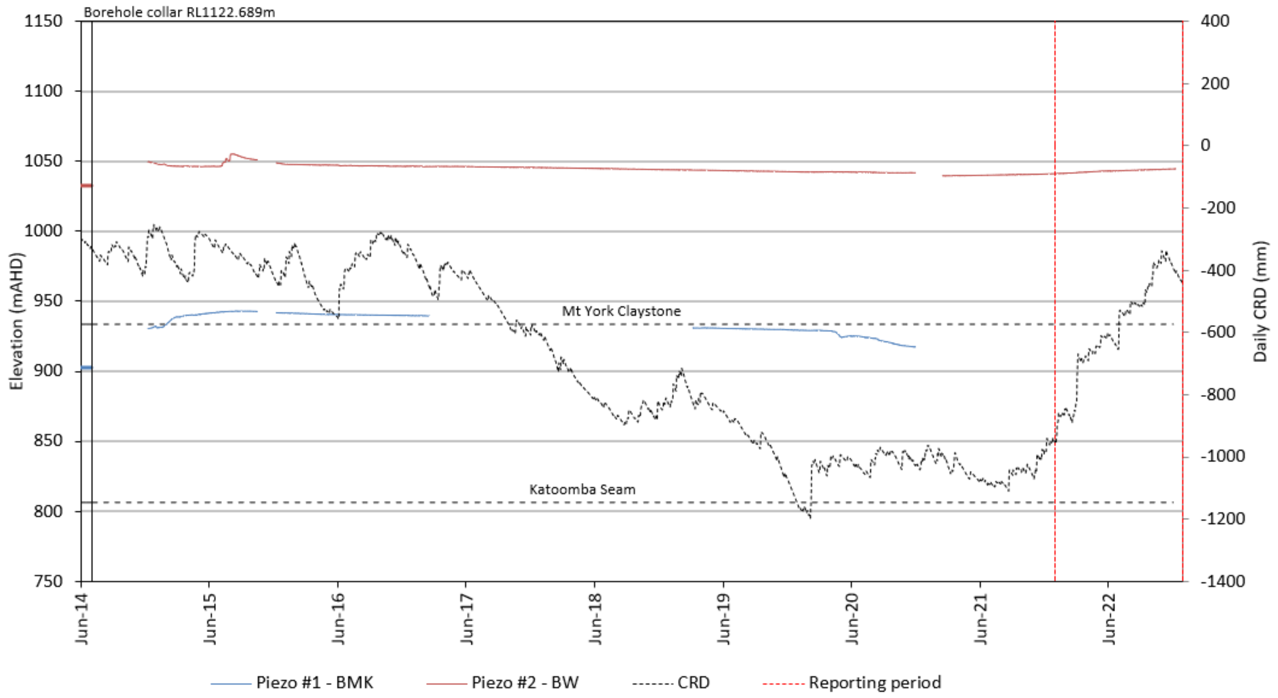


Figure 4.27 CLRP22 VWP hydrograph

4.3.15 CLRP27

The hydrograph for CLRP27 is presented in Figure 4.28. CLRP27 overlies panel 910 and was installed in January 2021.

In September 2022 active mining of Panel 906 was approximately 150 m east of CLRP27. No mining impacts were observed. Limited data is available from late September 2022 due to a logger malfunction. All remaining piezometers show stable trends. Some data has been omitted (Piezo #5 and #2) due to erroneous data.

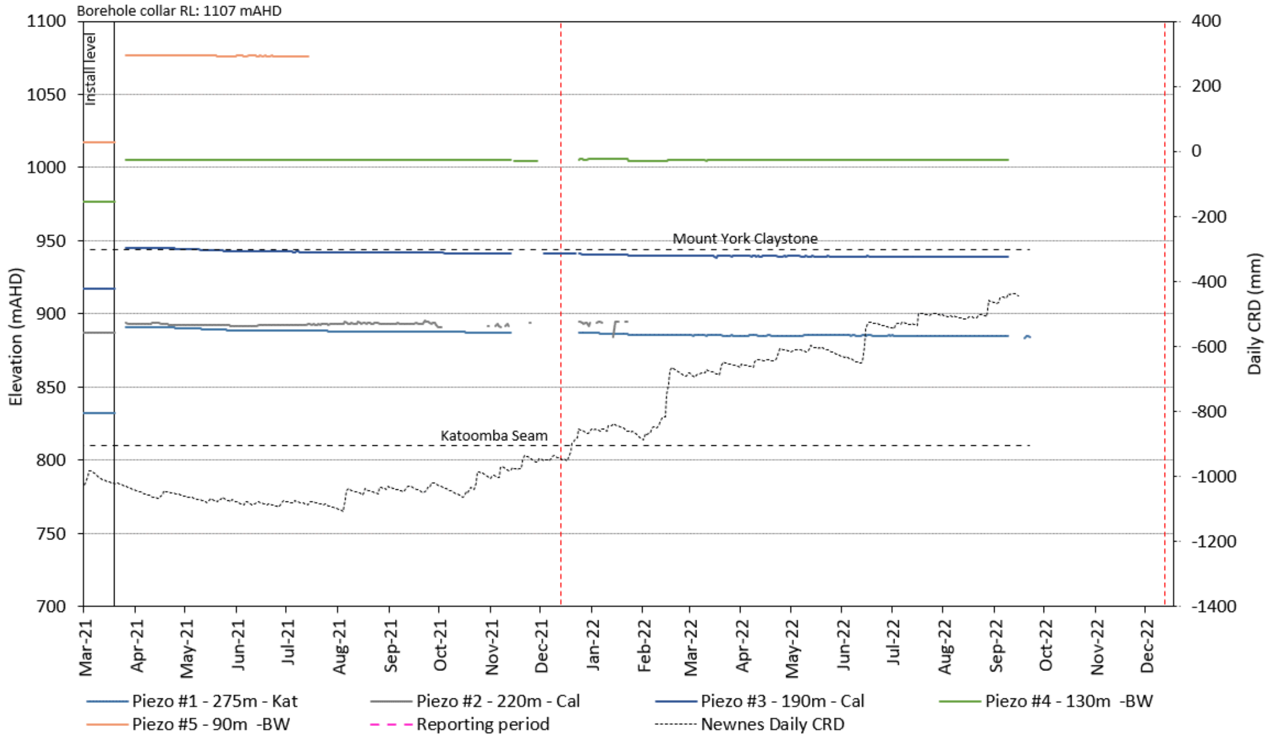


Figure 4.28 CLRP27 VWP hydrograph

4.3.16 CLRP29

The hydrograph for CLRP29 is presented on Figure 4.29. CLRP29 is north of the current mining lease above an unmined area and was installed in May 2020.

During the reporting period, no active mining occurred near CLRP29. All Piezometers display increasing trends.

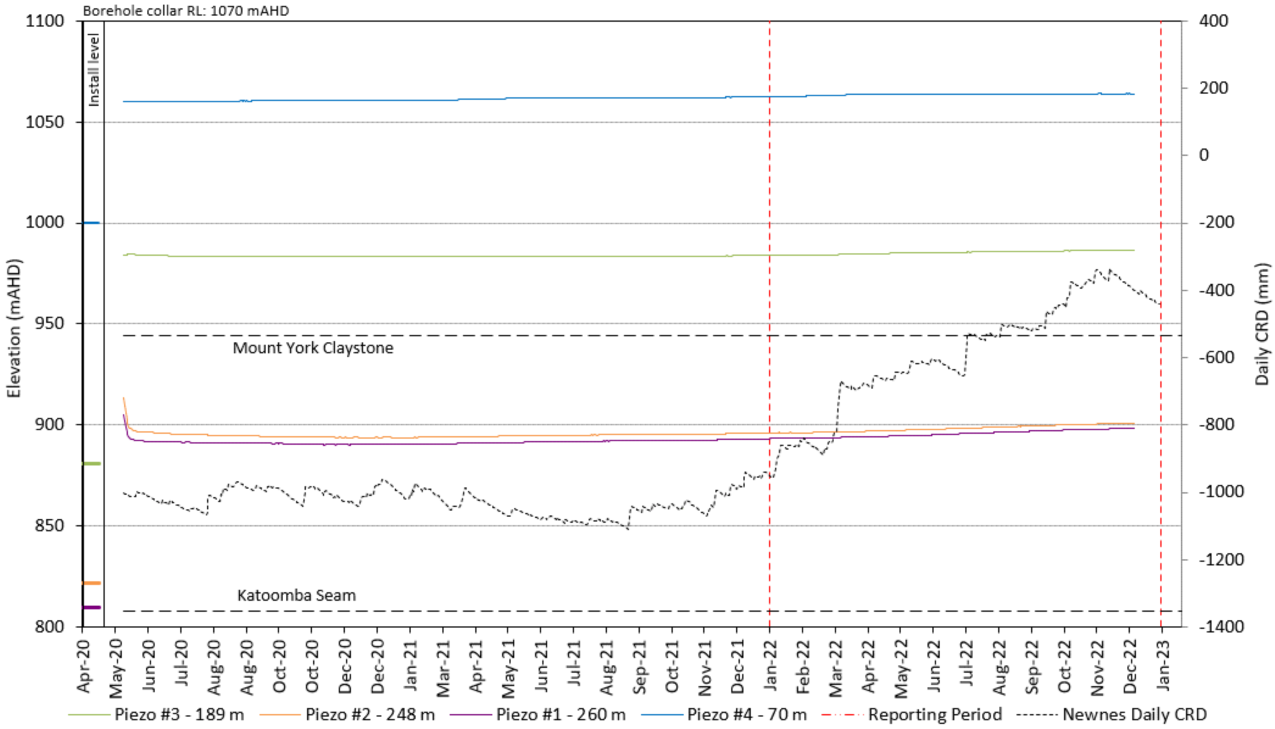


Figure 4.29 CLRP29 VWP hydrograph

4.3.17 CLRP33

The hydrograph for CLR33 is presented in Figure 4.30. CLRP33 is north of the current mining lease above an unmined area and was installed in May 2020. A data gap is present for most of 2021 due to logger issues. A new logger was installed in October 2021.

From mid-October 2021 Piezo #1 (287 m) has shown an increasing piezometric pressure. Remaining piezometers are stable, consistent with previous observations.

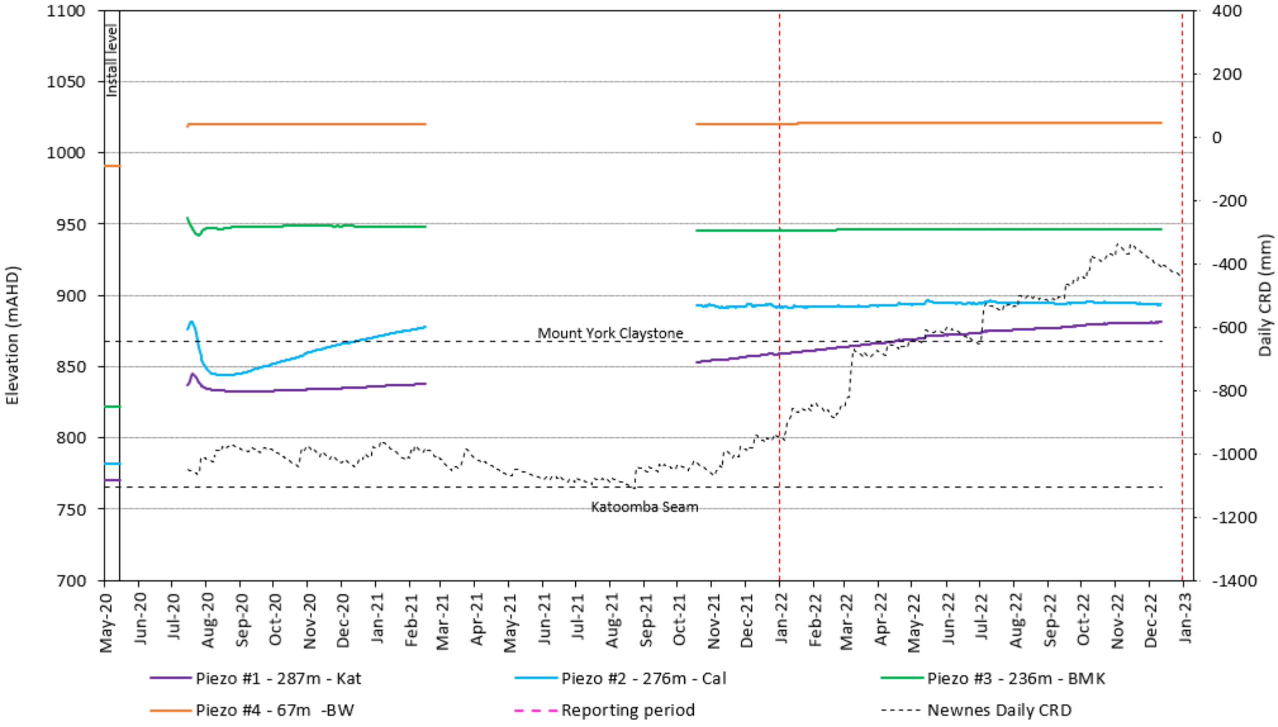


Figure 4.30 CLRP33 VWP hydrograph

4.3.18 CC114

The hydrograph for CC114 is presented in Figure 4.31. CC114 is approximately 700 m south of Panel 330, outside of planned mining development. A new logger was installed in October 2021 due to reliability issues.

During the reporting period there was no active mining near CC114. Since October 2021, piezometric pressures have resumed stable trends consistent with previous observations. Increases in piezometric pressures were observed across all piezos, corresponding to an increasing CRD.

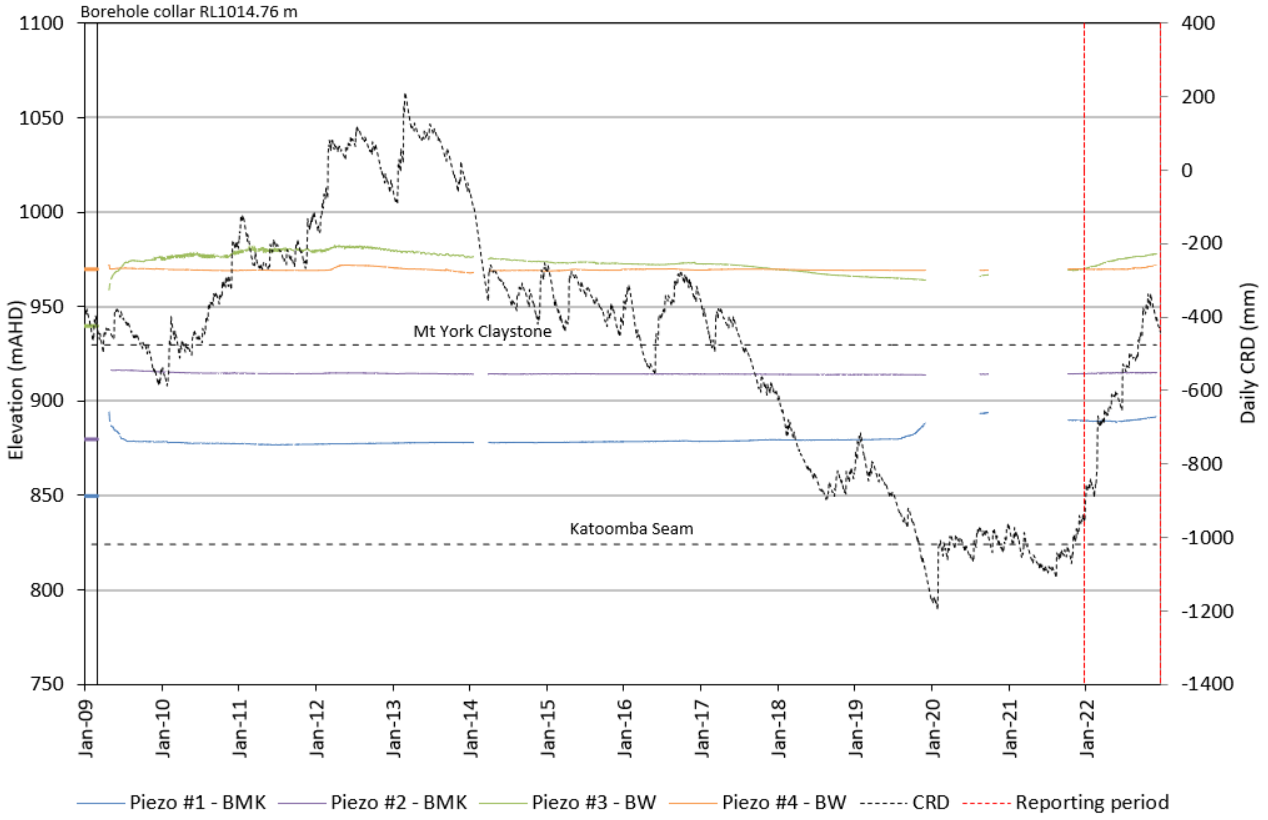


Figure 4.31 CC114 VWP hydrograph

4.3.19 CC115

The hydrograph for CC115 is presented in Figure 4.32. CC115 was undermined by Panel 812 and all Piezos showed depressurisation due to the first workings in June 2013. Further depressurisation was observed in May 2016 following pillar extraction. A depressurisation response in Piezos #1, #2 and #3 (below the MYC) was observed in in August 2021 due to mining of Panel 818A.

Following initial depressurisation observed in 2021, Piezos #2 and #3 showed an increasing trend from early February 2022 towards previously observed pressures. Piezos #1 and #4 displayed an increasing trend consistent with the CRD.

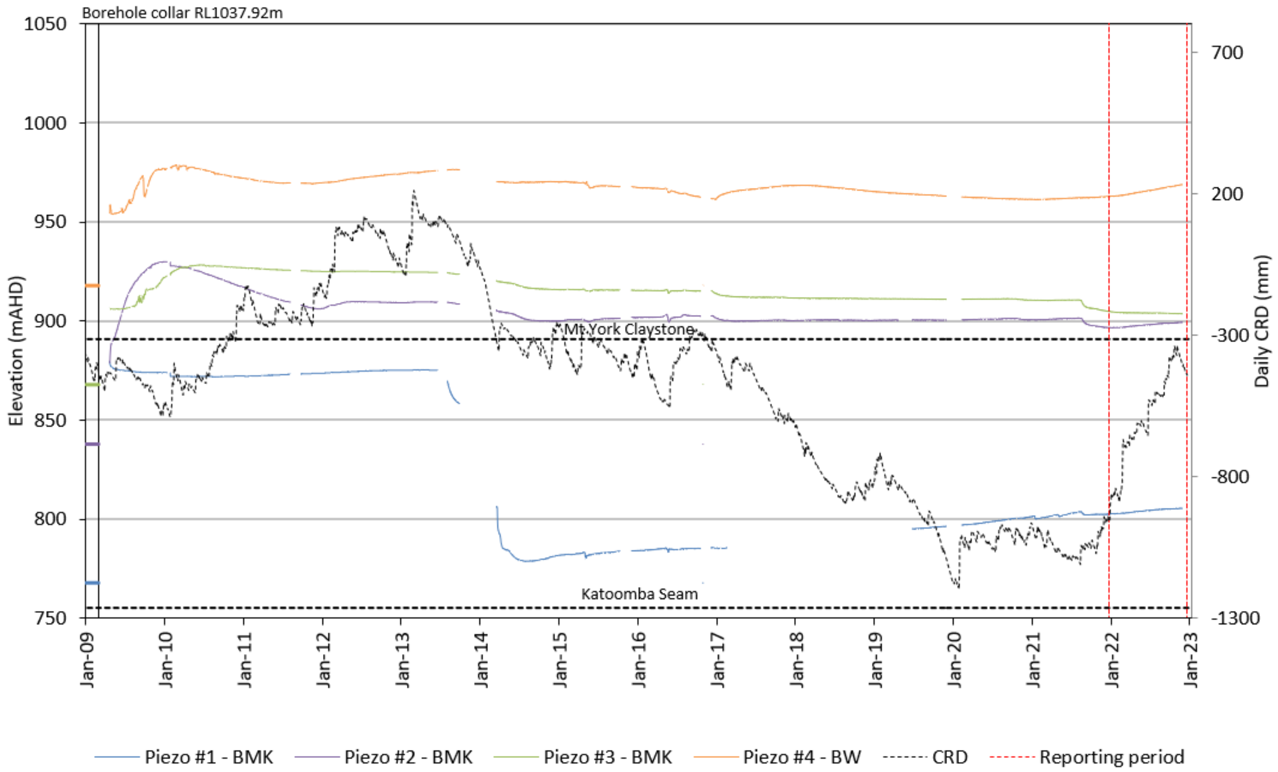


Figure 4.32 CC115 VWP hydrograph

5 Summary

The findings of this report are summarised in Table 5.1. The highlighted conditions are those defined in the Trigger Action Response Plan found in the Clarence Water Management Plan (Centennial, 2021).

Table 5.1 2022 Groundwater level summary

Monitoring zone	Comments	Condition (TARP)
Swamp monitoring piezometers	The groundwater level at PSE1, PSE2 and PG2 are below the trigger level, detailed in Table 6.2 of the WMP (Centennial, 2021). There has been no significant fall in piezometric pressure and normal TARP conditions are met. Continuation of trends that are consistent with historical observations or climatic influence were observed at all other swamp monitoring piezometers.	Condition: Normal
Open borehole standpipe piezometers	The groundwater level at CLRP10 was below the trigger level, detailed in Table 6.3 of the WMP (Centennial, 2021), from early August 2019 until late April 2022. There is no indication of mining related impacts, and the exceedance can be attributed to climatic influence. Continuation of trends that are consistent with historical observations or climatic influence were observed at all other standpipe piezometers.	Condition: Normal
VWPs	Piezometric pressure was below the trigger level in VWP piezos at CLRP2, CLRP18 and CLRP22, detailed in Table 6.4 of the WMP (Centennial, 2021). These exceedances are a continuation of historic observations with some piezos returning to a non-trigger state due to above average rainfall. Piezometric pressure in piezo #1 at CLRP19 is below the trigger level as, detailed in Table 6.4 of the WMP (Centennial 2021). A depressurisation response in August 2021 was observed due to the mining of Panel 818A. Piezo #1 displayed a continued decline in piezometric pressure throughout the reporting period. Continuation of trends that are consistent with historical observations or climatic influence were observed at all other VWPs.	Condition: Normal

5.1 Recommendations

It is recommended that the trigger levels defined in Table 6.2 to Table 6.4 of the WMP (Centennial 2021) be reviewed and updated to account for more recent groundwater level data.

References

Centennial. (2017). *800 Area SMP Variation 4.* Centennial Coal.

Centennial. (2021). *Clarence Colliery – MP-2041 Water Management Plan.* Centennial Coal.

Jacobs. (2019). *Groundwater Impact Assessment, Angus Place Amended Project.* prepared by Jacobs Group (Australia) Pty Ltd for Centennial Angus Place Pty Ltd.

McHugh. (2014). *The geology of the shrub swamps within Angus place, Springvale and the Springvale Mine extension project areas.* prepared by E.A. McHugh Geological and Petrographic Services for Centennial Coal Pty Ltd, September 2014.

McHugh. (2018). *The geology of the shrub swamps within Angus place, Springvale and the Springvale Mine extension project areas.* prepared by E.A. McHugh Geological and Petrographic Services for Centennial Coal Pty Ltd, September 2018.

Appendix A
Mining Progress 2022

creating opportunities

LEGEND

- EXISTING BOREHOLE / PIEZOMETERS
- COLLIERY HOLDING BOUNDARY
- NEWNES PLATEAU HANGING SWAMP
- NEWNES PLATEAU SHRUB SWAMP
- SWAMP PIEZOMETERS
- SURFACE DRAINAGE
- RIVERS\CREEKS
- ROADS\TRACKS
- FAULT
- STRIKE SLIP FAULT
- MODERATE ROOF ZONE
- STRUCTURED ROOF ZONE
- INTRUSION

NOTE:

1. The workings and scale shown on this plan are **indicative only**
2. Mine workings pre 2005 - refer to hard copy Mine Working Plan (in I.S.G.format)
3. Current mine workings - refer to digital mine working plan
4. Any queries on the workings - refer to the survey department at Clarence Colliery
5. The workings for the month that are shown (coloured hatching) are correct to the best of my knowledge (Mine Surveyor - Karl Harisson)

DATE	03.01.2023
SEAM	KATOOMBA
REFERENCE	
N:\Plans\EOM\2022\Monthly & Quarterly_prodn_2022.dwg	
SCALE	DIAGRAM

PRODUCTION FOR 2022 SHOWN MONTHLY

ENVIRONMENTAL REPORT

CENTENNIAL CLARENCE

DRG. No. CL2095

Appendix B
Clarence monitoring network

creating opportunities

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
CS1	Swamp	243769	6293815	1052.53	Nov 2013 – Oct 2018	-	1.14	Clarence Swamp
CS2	Swamp	243784	6293633	1066.96	Dec 2013 -Sep 2014	-	6.10	Clarence Swamp
CS3	Swamp	243770	6293725	1061.32	Dec 2013 – Sep 2014	-	5.56	Clarence Swamp
MW05	Swamp	243790	6293809	1053.7	Dec 2013 – present	-	5.59	Clarence Swamp
HS1	Swamp	243417	6294656	1053.7	Jul 2015 – present	-	10.80	Banks Wall Sandstone – Hanson Swamp
HS2	Swamp	243417	6294656	1053.7	Jul 2015 – present	-	3.91	Alluvial sand – Hanson Swamp
HS3	Swamp	243151	6294345	1069	Jul 2015 – present	-	0.98	Hanson Swamp
HV1	Swamp	241550	6292993	1094.94	Dec 2009 – Dec 2013	700 Area SMP	1.55	Happy Valley Swamp
HV2	Swamp	241839	6297077	1120	Dec 2009 – Nov 2013	700 Area SMP	1.70	Happy Valley Swamp
HVU1	Swamp	242590	6295590	1147.63	Dec 2009 – present	700 Area SMP	1.40	Happy Valley Swamp Upper
HVU2	Swamp	242424	6295520	1140.07	Dec 2009 – Nov 2013	700 Area SMP	1.10	Happy Valley Swamp Upper
PSE1	Swamp	241821	6299287	*1035**	Mar 2017 – present	West of 900 Area	1.30	Paddys Swamp East
PSE2	Swamp	241380	6298610	*1085**	Mar 2017 – present	West of 900 Area	2.32	Paddys Swamp east
OS1	Swamp	247829	6297096	*1059**	Dec 2017 – present	north of Area 800	1.83	Oleria Swamp
PG1	Swamp	242721	6300456	1036	Aug 2019 – present	900 Area	1.64	Pagoda Swamp
PG2	Swamp	242777	6300278	1032	Aug 2019 – present	900 Area	1.95	Pagoda Swamp
MU1	Swamp	TBC	TBC	TBC	Aug 2022 – present	–	1.45	Murrays Swamp
MU2	Swamp	TBC	TBC	TBC	Aug 2022 – present	–	2.28	Murrays Swamp

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
UD1	Swamp	TBC	TBC	TBC	Sept 2022 – present	–	1.56	Upper Dingo swamp
UD2	Swamp	TBC	TBC	TBC	Sept 2022 – present	–	1.12	Upper Dingo swamp
BN1	Swamp	245759	6302536	TBC	Nov 2022 – present	–	1.62	Bungleboori North
BN2	Swamp	246154	6303406	TBC	Nov 2022 – present	–	0.92	Bungleboori North
BSE1	Swamp	242146	6300691	TBC	Aug 2022 – present	–	1.45	Bungleboori South East Swamp
BSE2	Swamp	242280	6300541	TBC	Aug 2022 – present	–	1.10	Bungleboori South East Swamp
PHS1	Swamp	241949	6299627	TBC	Aug 2022 – present	–	1.88	Paddy’s Hanging Swamp
PHS2	Swamp	241826	6299710	TBC	Aug 2022 – present	–	0.90	Paddy’s Hanging Swamp
PA1	Standpipe	TBC	TBC	TBC	Dec 2022 – present	–	12.80	–
PA2	Standpipe	TBC	TBC	TBC	Dec 2022 – present	–	17.58	–
PA3	Standpipe	TBC	TBC	TBC	Dec 2022 – present	–	12.59	–
CLRP4	Standpipe	243204	6293153	1068.71	May 2008 – present	South of mining areas	17.98	Banks Wall Sandstone
CLRP5	Standpipe	242517	6297686	1110.92	May 2008 – present	700 Area AMP, north of 700 Area Panels	51.03	Banks Wall Sandstone
CLRP7	Standpipe	242181	6293863	1133.88	May 2008 – present	700 Area SMP, above 702/704 Panels	40.97	Banks Wall Sandstone
CLRP8	Standpipe	242351	6291961	1130	Jul 2009 – Dec 2018	Clarence Township	28.0	Banks Wall Sandstone
CLRP10	Standpipe	242355	6297148	1138.51	May 2008 – present	700 Area SMP, above 706 Panel	60.06	Banks Wall Sandstone
CLRP15	Standpipe	240907	6294871	1113.15	Jul 2012 – present	Lithgow No.2 Dam	116.2	Burra-Moko Head formation/Caley formation

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
CLRP28	Standpipe	243223	6302025	1090.48	May 2020 - present	North of 900 Area	45.0	Banks Wall Sandstone
CLRP31	Standpipe	244354	6302760	1050.77	May 2020 - present	North of 900 Area	30.0	Banks Wall Sandstone
CC113	Standpipe	241691	6293105	1140.25	May 2008 – Feb 2014	700 Area	37.38	Banks Wall Sandstone
CLRP1	VWP	245424	6295662	1002.97	Aug 2004 - present	Eastern Area SMP, within 330 Area	175	Katoomba Seam
							150	Burra-Moko Head Formation/Caley Formation
							100	Banks Wall Sandstone
							60	Banks Wall Sandstone
CLRP2	VWP	246465	6301421	1029.92	Aug 2004 – present	Eastern Area SMP, above 611E Panel	276	Katoomba Seam (Inactive since Aug 2007)
							190	Banks Wall Sandstone
							130	Banks Wall Sandstone
							70	Banks Wall Sandstone
CLRP3	VWP	246343	6299274	1037.21	Jan 2007 – present	Eastern Area SMP, above 612 Panel	198	Burra-Moko Head Formation
							138	Banks Wall Sandstone
							85	Banks Wall Sandstone
CLRP6	VWP	242638	6296369	1121.28	Jun 2008 – present	700 Area SMP, above 702/704 Panels	160	Burra-Moko Head Formation/Caley Formation- inactive since Sep 2010
							100	Banks Wall Sandstone
							60	Banks Wall Sandstone
CLRP11	VWP	240540	6296221	1110.96	Aug 2011 – present	700 West SMP Area	165	Burra-Moko Head Formation

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
							134.5	Burra-Moko Head Formation
							74.5	Banks Wall Sandstone
							61	Banks Wall Sandstone
CLRP12	VWP	240359	6297392	1146.80	Nov 2010 – May 2020	700 West SMP Area	230	Burra-Moko Head Formation
							180	Burra-Moko Head Formation
							120	Banks Wall Sandstone
							100	Banks Wall Sandstone
CLRP13	VWP	247674	6295052	1043.15	Nov 2010 – present	800 Area SMP Area	240	Burra-Moko Head Formation
							210	Burra-Moko Head Formation
							140	Banks Wall Sandstone
							110	Banks Wall Sandstone
							80	Banks Wall Sandstone
CLRP14	VWP	246524	6296235	1056.73	Apr 2011- present	800 Area SMP Area	220	Burra-Moko Head Formation
							185	Burra-Moko Head Formation (no data since Aug 2014)
							130	Banks Wall Sandstone (no data since Aug 2014)
							100	Banks Wall Sandstone
CLRP15	VWP	240912	6294870	1113.15	June 2014 – present	Lithgow No.2 Dam	160	Burra-Moko Head Formation

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
							130	Burra-Moko Head Formation
							90	Banks Wall Sandstone
							60	Banks Wall Sandstone
CLRP16	VWP	240400	6294981	1050.80	Apr 2011 – present	Lithgow No.2 Dam	115	Burra-Moko Head Formation
							70	Burra-Moko Head Formation
CLRP17	VWP	247607	6295623	1047.98	Mar 2014 – present	800 Area SMP	200	Burra-Moko Head Formation
							170	Burra-Moko Head Formation
							70	Banks Wall Sandstone
CLRP18	VWP	243124	6301413	1118.77	Dec 2014 – present	900 Area SMP	230	Burra-Moko Head Formation/Caley Formation
							75	Banks Wall Sandstone
CLRP19	VWP	249419	6295862	1010	Mar 2014 – present	800 Area SMP	170	Burra-Moko Head Formation
							120	Burra-Moko Head Formation
							90	Banks Wall Sandstone
CLRP22	VWP	243397	6300617	1122.69	Dec 2014 – present	900 Area SMP	220	Burra-Moko Head Formation
							90	Banks Wall Sandstone
CLRP27	VWP	242577	6300787	1110.0	March 2021 - present	North of 900 Area	275	Above Katoomba seam
							220	Caley formation
							190	Burra Moho Head Formation

Table B.1 Clarence Colliery groundwater monitoring network

Site ID	Installation type	Easting	Northing (GDA94 zone 56)	Surface Elevation (mAHD)	Data period	Area	Install Depth (mbgl)	Lithology
							130	Banks Wall Sandstone
							90	Banks Wall sandstone
CLRP29	VWP	242285	6302783	1070*	May 2020 - present	North of 900 Area	260	Katoomba Seam
							248	Caley Formation
							189	Burra-Moko Head Formation
							70	Banks Wall Sandstone
CLRP33	VWP	246372	6302594	1058*	Jul 2020 - present	North of 900 Area	287	Katoomba Seam
							276	Caley Formation
							236	Burra-Moko Head Formation
							67	Banks Wall Sandstone
CC114	VWP	245407	6295092	1014.76	Apr 2009 – present	700 West/800 Area background	165	Burra-Moko Head Formation
							135	Burra-Moko Head Formation
							75	Banks Wall Sandstone
							45	Banks Wall Sandstone
CC115	VWP	248478	6295951	1037.92	Apr 2009 – present	700 West/800 Area background	270	Burra-Moko Head Formation
							200	Burra-Moko Head Formation
							170	Banks Wall Sandstone
							120	Banks Wall Sandstone (dry since Mar 2014)

* Surface elevation measurements recorded with handheld GPS unit

Appendix C

Trigger action response plan

EMM
creating opportunities

Groundwater monitoring

Aspect	Normal	Stage 1	Stage 2	Notifications
Groundwater level	Groundwater level is greater than the groundwater level triggers specified in Table 6-2. **Response: Continue groundwater monitoring program**	**Trigger:** Groundwater level falls below the groundwater level triggers specified in Table 6-2 at one or more monitoring locations. **Response: Undertake investigation to determine if the change in groundwater level is due to mining-related activity.**	**Trigger:** Investigation into Stage 1 trigger identifies that change in groundwater quality is due to mining related activity. Community complaint to Clarence Colliery regarding groundwater levels. **Response: Undertake investigation to determine if the change in groundwater level is due to mining-related activity.** **Verify whether monitoring results are consistent with hydrogeological model predictions.** **If impacts on GDEs are unacceptable, then mitigation measures will be considered.** **Loss of water supply to any adjacent landholder will need to be replaced by Clarence Colliery.**	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2: Notify relevant agencies in accordance with PIRMP requirements or if material harm has occurred.**
Groundwater quality	Monitoring results do not exceed groundwater quality trigger values listed in Table 6-5. **Response: Continue groundwater monitoring program**	**Trigger:** Monitoring results above Stage 1 trigger value listed in Table 6-5 for at least one parameter for two consecutive sampling events. **Response: Undertake investigation to determine if the change in groundwater quality is due to mining-related activity.**	**Trigger:** Monitoring above Stage 2 trigger value listed in Table 6-5 for at least one parameter at one or more monitoring locations. Investigation into Stage 1 trigger identifies that change in groundwater quality is due to mining-related activity.	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2: Notify relevant agencies in accordance with PIRMP**

Aspect	Normal	Stage 1	Stage 2	Notifications
			Community complaint to Clarence Colliery regarding groundwater quality. **Response: Undertake investigation to determine if the change in groundwater quality is due to mining-related activity.** **If environmental impacts are unacceptable and/or if the beneficial use of the groundwater changes, remediation options will be considered.** **Loss of water supply to any adjacent landholder will need to be replaced by Clarence Colliery.**	**requirements or if material harm has occurred.**
Piezometric Head Change	**Trigger:** No significant fall in piezometric height of aquifers above Mt York Claystone **Response: Continue groundwater monitoring program**	**Trigger:** A 'stepped' mining related, 5 m piezometric head loss in any aquifer above the Mt York Claystone **Response: Field surface inspection by Environmental Officer to determine any evidence of surface cracking. Undertake geotechnical/hydrogeological investigation of the cause. Continue Groundwater Monitoring Program with additional monitoring as required.** **Report monitoring results in accordance with 10BL165053 and 10BL165054**	**Trigger:** 1. A 'stepped', mining related, 10 m piezometric head loss in any aquifer above the Mt York Claystone. 2. Loss of bore water supply from the near surface aquifer utilised by Clarence Village, based on the 5 m 'stepped', mining related criteria. **Response: Undertake geotechnical/hydrogeological investigation of the cause. Report to the Principal subsidence engineer on action to rectify.** **Implement engineering solutions (Appendix K) as appropriate.**	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. Consult with DEP, NOW and Trade & Investment, potentially affected landowners and/or existing or future tenants. **Stage 2: Immediately notify DPIE, DPIEW and Trade & Investments,**

Aspect	Normal	Stage 1	Stage 2	Notifications
			Change mine plan as required to prevent further subsidence effects. **If loss of bore water supply determined to be a result of mining operations by Centennial Coal, replace the water supply to the village residents (Appendix K).** **Continue Groundwater Monitoring Program with additional monitoring as required.** **Report monitoring results in accordance with 10BL165053 and 10BL165054.**	**potentially affected landowners & existing or future tenants.**
Dewatering volumes	**Trigger:** Dewatering volume for 82 c/t pump and 79 c/t pump below 6,623 ML over 12-month period **Response: Continue groundwater monitoring program**	**Trigger:** Dewatering volume for 82 c/t pump and/or 79 c/t pump greater than 3,260 ML over 6-month period **Response: Determine reason for greater than expected dewatering volumes. If likely to continue, consult with NOW and apply for WAL variation to increase allowable volumes.** **Undertake review of hydrogeological model predictions for groundwater inflows into the mine. The hydrogeological model and site water balance model will be updated if necessary.**	**Trigger:** Dewatering volume for 82 c/t pump (10BL165053) and/or 79 c/t pump (10BL165054) greater than 6,623 ML over 12-month period. **Response: Determine reason for greater than expected dewatering volumes. If likely to continue, consult with NOW and apply for WAL variation to increase allowable volumes** **Undertake review of hydrogeological model predictions for groundwater inflows into the mine. The hydrogeological model and site water balance model will be updated if necessary.** **Additional groundwater WALs will be obtained if necessary.**	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2: Immediately notify DPIEW**

Aspect	Normal	Stage 1	Stage 2	Notifications
Swamp and Pagoda / Cliff line Damage Visual monitoring	**Trigger:** No visible surface cracking **Trigger:** Surface cracking <5 cm wide on top of cliff line, minor visible cracking on cliff face or rock fall or isolated block **Response: Monitor quarterly over next 12 months**	**Trigger:** Surface cracking visible in swamp **Trigger:** Surface cracking 5-10 cm on cliff line, substantial visible cracking on rock face or rock fall of greater than 100 m^3. **Response: Monitor quarterly over next 12 months. Undertake geotechnical and groundwater investigation as required. Redesign extraction of future panels to avoid damage where investigations show trigger has been exceeded due to mining activities. Suitable qualified external consultant to inspect and judge need for further action/cause.**	**Trigger:** Surface cracking resulting in visible water loss from streams **Trigger:** Surface cracking >10 cm wide major damage to cliff face or rock fall of >100 m^3 **Response: Report to Principal subsidence Engineer on action to rectify. Suitable qualified external consultant to inspect and judge need for further action/cause.**	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2: Immediately notify DPIE, DPIEW and Trade & Investment**
Swamp water level	**Trigger:** No significant fall in piezometric height of surface aquifers **Response: Monitor quarterly over next 12 months**	**Trigger:** 10% loss of saturated head within surface aquifers outside of climatic response behaviour **Response: Monitor over next 12 months. Check instrumentation/installations** **Undertake geotechnical and groundwater investigations as required.** **Redesign extraction of future panels to avoid damage where investigations show trigger has been exceeded due to mining activities.**	**Trigger:** Total loss of groundwater **Response: Report to the Principal Subsidence Engineer on action to rectify. Undertake seasonal flora monitoring.**	**Stage 1:** Notify Environment and Community Coordinator/Mine Manager. **Stage 2: Immediately notify DPIE, DPIEW, and Trade & Investment**

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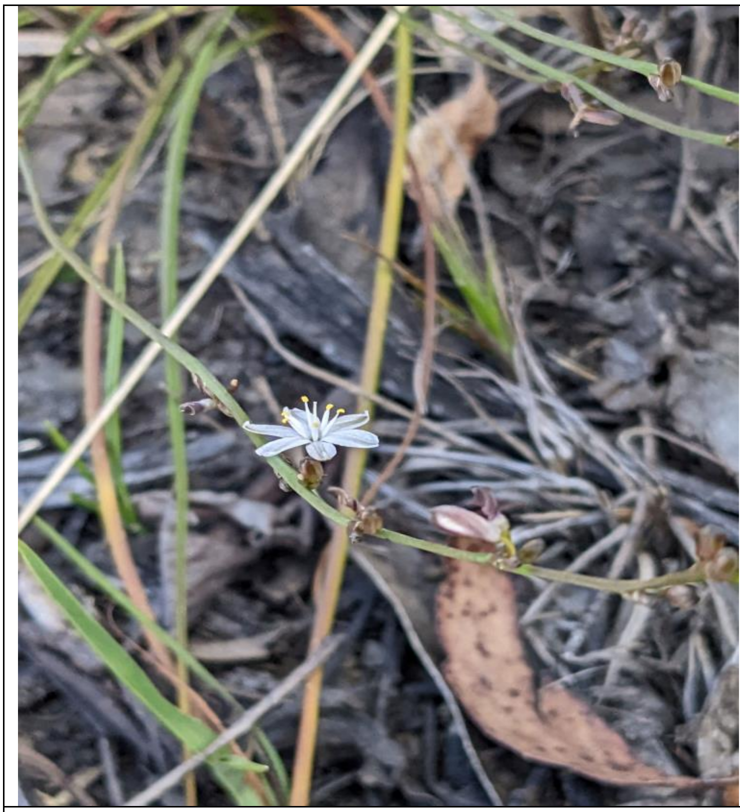
CLARENCE COLLIERY REHABILITATION

MONITORING ASSESSMENT

MARCH 2023



The endangered species, Caesia parviflora var. minor at RHB 2 rehabilitation transect

Report prepared for Centennial Coal

by

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REHABILITATION MONITORING 2022
CLARENCE COLLIERY
MARCH 2023

1.0 INTRODUCTION

Clarence Colliery is an underground coal mining operation owned by Centennial Coal and located within the New South Wales (**NSW**) Western Coalfields, approximately 10 kilometres (**km**) east of Lithgow. Coal is extracted from the Katoomba Seam using the board and pillar partial extraction method, supplying coal to both domestic and export markets (Koru Environmental 2022).

Clarence currently operates under three development consents: IRM.GE.76 and DA 174/93 granted by the former Greater Lithgow County Council, and DA 504-00 granted in 2005 by the (now) NSW Department of Planning, Industry and the Environment under the *Environmental Planning and Assessment Act 1979*. The latter allows Clarence to extract up to three million tonnes of run of mine coal per year until 31 December 2026 (Koru Environmental 2022).

Monitoring of rehabilitated areas at Clarence commenced in 2012 and has been implemented annually by AECOM (2012-2017) and Koru Environmental (2018, 2019, 2020). Monitoring has been implemented to satisfy the requirements of:

• The current Mining Operations Plan 2018-2022 (**MOP**); and

• Relevant conditions contained within the respective development consents.

Rehabilitation monitoring methods were revised and amended in 2018 with the aim to improve the relevance and adequacy of collected datasets; with the result that some of the monitoring data collected prior to 2018 was unable to be directly compared and analysed against data collected from 2018 onwards. At that time, it was considered that historic rehabilitation monitoring data remained relevant and valuable in terms of documenting rehabilitation performance condition over time. This continues to be a valid consideration.

The 2018 monitoring methods were designed to address the objectives completion criteria defined in the MOP (2018-2022) for Clarence rehabilitation. The data derived from the monitoring program were capable of assessing the effectiveness of rehabilitation techniques and practices, and of providing strategies for improvement.

The monitoring program had the aim of achieving sustainable post mining vegetation communities which are aligned to the agreed post mining land use for the Clarence mining lease areas.

In July 2022 Centennial Coal adopted a new Rehabilitation Management Plan (RMP) for Clarence Colliery. (Centennial 2022). The RMP includes new procedures for monitoring, including new control plots and use of Biodiversity Assessment Method (BAM) plot design. Whilst the RMP refers to the history of rehabilitation monitoring at Clarence, it does not reference recent monitoring reports, including the 2021 Koru Environmental report. This has meant it appears unaware that an additional monitoring transect RHB 6A was established within the REA 6 area in 2019. It is unclear how adoption of BAM procedures aligns to the monitoring conducted between 2012 and 2021.

In 2022 monitoring was conducted by Roger Lembit of Gingra Ecological Surveys on a stand-in basis as Koru Environmental Pty Ltd were unavailable. The process by which Gingra Ecological Surveys sought to ensure retention of the value of past monitoring events with the implementation of the new RMP is addressed in the following section.

2.0 METHODS

The 2022 monitoring survey involved the established six rehabilitation monitoring sites and three control (analogue) sites used in recent years by Koru Environmental. Their details are listed in Table 1. The proposed indicative rehabilitation monitoring site was not surveyed due to doubts about its suitability as it lies close to a significant infestation of Pampas Grass (*Cortaderia selloana*) and may be subject to edge effects from the haul road for the adjacent Clarence Sand Quarry operated by Hanson.

The monitoring approach melded the previous methodology used by Koru Environmental with the BAM method identified in the 2022 RMP.

Each monitoring site consists of a standardised 50 m long transect, with nested 10 m x 30 m plot and 1 m x 1 m quadrats. All sites have been permanently marked at the start and end points of the 50 m line, and their geographical coordinates recorded using a GPS. To achieve a 400 m^2 BAM plot based on the established transect configuration, a 40 m x 10 m rectangle was used, using the transect origin as the central point at one end of the BAM plot.

There are 10 small quadrats located at 5 m intervals alternately along the transect line. These quadrats are used to estimate ground cover characteristics and floristics.

The large quadrat commences at the 10 m mark along the transect. This quadrat is used for data relating to woody species (shrubs and trees), including floristic composition and height and stem diameter of all woody plants with a height of at least 1.3 m.

Standard BAM data was collected for the 40 x 10 m BAM plot, full floristics, estimates of cover and abundance for each species. Extent of woody debris was also recorded for most plots.

Table 1. Clarence Colliery Rehabilitation Monitoring Transects

PLOT	STATUS	EASTING	NORTHING
RHB 1	Rehab	244291	6294105
RHB 2	Rehab	244563	6293796
RHB 3A	Rehab	244665	6294303
RHB 3B	Rehab	244752	6294210
RHB 4B	Rehab	244299	6293670
RHB 6A	Rehab	243889	6293733
ANA 1	Analogue	244632	6293686
ANA 2	Analogue	244659	6294391
ANA 3	Analogue	244521	6294450

3.0 RECENT WEATHER

Data for the Lithgow weather station show that 2022 was a year of record rainfall with particularly wet months in January, March and July. This followed above average rainfall years in 2020 and 2021. This has meant that the soil profile has contained adequate water for plant growth from February 2020 onwards.

Conditions were dry and mild to warm during the survey period.

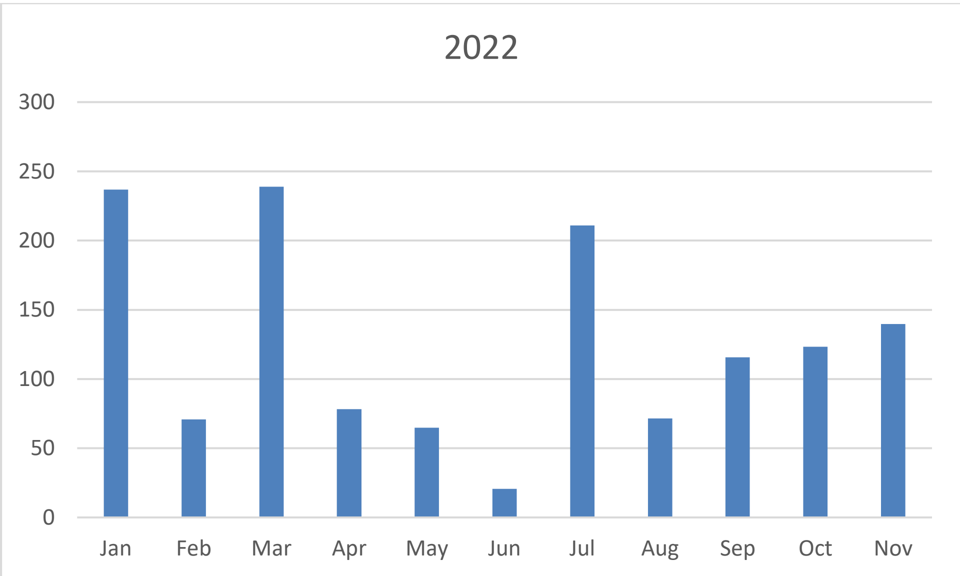

Figure 1. 2022 Rainfall Data (mm) Jan – Nov.

4.0 RESULTS

4.1 Soils and Erosion

No significant new erosion features were observed across the rehabilitation area, despite record rainfall over the preceding year. The issue reported by Koru Environmental based on the 2021 survey was again observed – the evidence of areas of surface erosion associated with bare ground at transects RHB 3A and RHB 4B. In 2022 sheet erosion was also observed at RHB 3B. This erosion is of low impact and not considered significant.

Soil stability is consistent with that reported for the 2021 survey (Koru Environmental) with a stable land surface.

4.2 Ground Cover Protection

Koru Environmental (2022) reported ground cover protection figures separating bare ground, live vegetation (plants, mosses and lichens) and other cover (litter, timber, rock). The results for ground cover protection are provided in Figure 2.

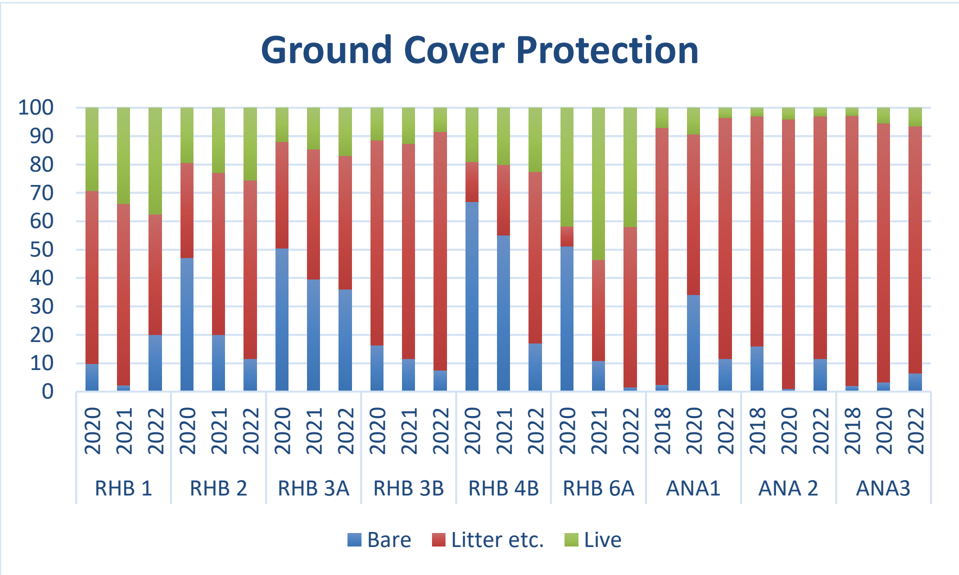

Figure 2. Ground cover protection for Clarence rehabilitation areas.

Koru Environmental identified a ground cover protection figure of 60% as meeting the completion criterion for this parameter. Ground cover protection is the sum of litter, timber and live vegetation including vascular plants, mosses and lichen. In 2022 all rehabilitation transects had achieved the completion criterion level. The transect with the lowest ground cover protection score was RHB 3A where the score was 64%.

Vegetative cover had increased at 4 of the 6 rehabilitation transects. At RHB 3B and RHB 6A, there was a decline, but an associated increase in litter cover.

Ground cover protection at the analogue sites typically exceeds 80% and in 2022 the average for the analogue sites was 91%.

4.3 Woody Species – Tree Stem Densities

In 2022 all woody plants at least 1.3 m high with a stem diameter of 5.0 cm or greater were recorded within a 30 m x 10 m sub-plot along each transect, consistent with the recent past practice of Koru Environmental.

As they reported in 2022 stem densities at the analogue sites in 2020 (applying a ±20% variance), the benchmark range is considered to be 320-680 stems/ha. The range recorded for analogue sites in December 2022 was 430-570 stems/ha, within the middle of the benchmark range.

The full range of stem densities recorded at Clarence in 2022 is recorded in Table 2.

Table 2. Woody Plant Stem Densities in December 2022

	RHB 1	RHB 2	RHB 3A	RHB 3B	RHB 4B	RHB 6A	ANA 1	ANA 2	ANA 3
Stems	4	6	10	14	3	0	13	13	17
Stem/Ha	133	200	333	467	100	0	433	433	567

Both RHB 3A and RHB 3B transects had stem densities within the benchmark range in 2022. RHB 1, RHB 2 and RHB 4B had lower than benchmark stem densities. As suggested by Koru Environmental (2022) it is likely that intervention will be required at these locations to ensure the tree layer achieves mine completion criteria.

4.4 Woody Plants – Species Richness

Woody species richness recorded within the large (30 m x 10 m) quadrats is reported in Figure 3. Species richness of woody species in analogue sites ranged from 9 to 11 species with four eucalypt species within each large quadrat. Species richness in rehabilitation sites ranged from 4 to 12 species. The number of eucalypt species within rehabilitation transects ranged from 1 to 4 species. At RHB 4B, just one eucalypt species was recorded, while 3 other rehabilitation sites had just 2 eucalypt species. Just RHB 2 and RHB 3A had adequate levels of eucalypt species diversity.

No exotic woody species were present at any of the transects.

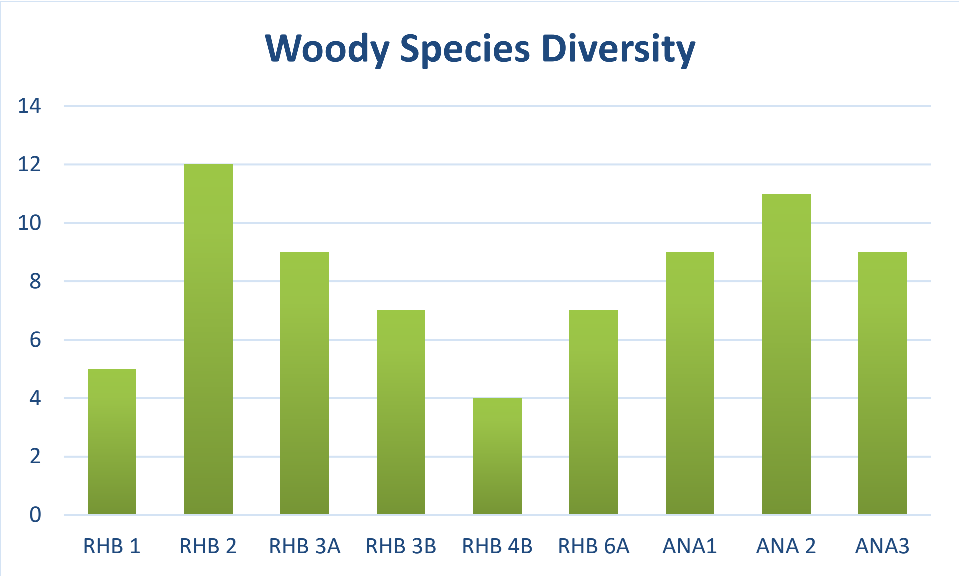

Figure 3. Woody species richness at Clarence Colliery transects.

4.5 Plant Species Diversity

Appendix A includes a list of plant species recorded within the small and large quadrats to maintain consistency with plant species records presented in the past by Koru Environmental. Appendix B provides data for the BAM plots, discussed in more detail in a following section of this report.

A total of 80 plant species were detected within the Koru quadrats in 2022 including 69 native species and 11 exotic species. The proportion of native species for the rehabilitation transects was 86%, with 14% of species being exotics. The proportion of total ground layer plant cover represented by native and exotic species within the rehabilitation transects is shown in Figure 4 below. No exotic species were recorded within the analogue quadrats.

The discovery of a small population of the endangered plant species Caesia parviflora var. minor at transect RHB2 was a significant finding. This is the first time this species has been recorded at a mine rehabilitation site. The source of seed for this plant is not known definitively but is thought to have been retained within topsoil spread across this rehabilitation area, with seed germination responding to the wet period from 2020-2022.

The native plant species composition of the rehabilitation areas is trending towards that of analogue sites. The presence of a number of difficult to propagate species such as members of the Ericaceae family including *Brachyloma daphnoides*, *Epacris pulchella*, *Leucopogon lanceolatus* and *Monotoca scoparia* is an indicator of the success of rehabilitation.

The root parasite, *Leptomeria acida*, was also present. Seeds of this difficult to propagate species may have been transported to the area by fruit-eating birds.

4.6 Weeds

Nineteen exotic species were recorded within transects across the rehabilitation area. Two species of those species are considered to be of concern; African Lovegrass (*Eragrostis curvula*) and Pampas Grass (*Cortaderia selloana*). Another species of concern Blackberry (*Rubus anglocandicans*) was observed opportunistically in the area.

Table 3 presents some figures on weed cover and diversity from the monitoring transects in 2022.

Table 3. Weed Cover and Diversity 2022

	RHB 1	RHB 2	RHB 3A	RHB 3B	RHB 4B	RHB 6A	ANA 1	ANA 2	ANA 3
Cover	0.4	0	0	2	0.9	26.9	0	0	0
Species	4	0	0	1	2	6	0	0	0
BAM plot species	14	0	1	1	4	7	0	0	0
BAM Cover	5.2	0	0.1	1.0	0.4	25.6	0	0	0

Pampas Grass is a weed of concern in the Clarence area and on the Newnes Plateau. It generates thousands of seeds which may be wind dispersed and can spread across large areas in a relatively short period of time. It has persisted along the Clarence Access Road, and the Clarence Sand Quarry but is also present at the Zig Zag Railway and in patches of the former pine plantation on the Newnes Plateau. It has been the subject of sporadic efforts to control outbreaks, including work by Clarence Colliery.

Spot spraying of Pampas Grass plants across the rehabilitation area is recommended as a high priority.

African Lovegrass is an invasive perennial grass which has increased significantly in abundance and range over the past 40 years. It is capable of invading disturbed lands and spreading along roads and tracks. There is concern about its role in altering fire regimes in grasslands. In the REA 6 area where the RHB 6 transect is located African Lovegrass has an approximate average cover of 25%. At this level of cover it is suppressing more desirable native ground covers and poses a potential threat to shrub and tree species should a bushfire take a run through the area.

African Lovegrass is a Central Tablelands weed of community concern.

Control of African Lovegrass within the REA 6 area should be seen as a high priority. An early onset of cold weather would reduce the likelihood of effective control. Spot spraying in early spring should be undertaken, with follow up herbicide application in response to growth flushes after rainfall, Repeat spot spraying will be necessary in spring 2024 and 2025. Any non-target impacts on desirable native ground layer species should be recorded with the intention of supplementary seeding to restore cover on patches of bare, exposed soil.

Information on African Lovegrass ecology and control is available from the following webpage:

https://weeds.dpi.nsw.gov.au/Weeds/AfricanLovegrass

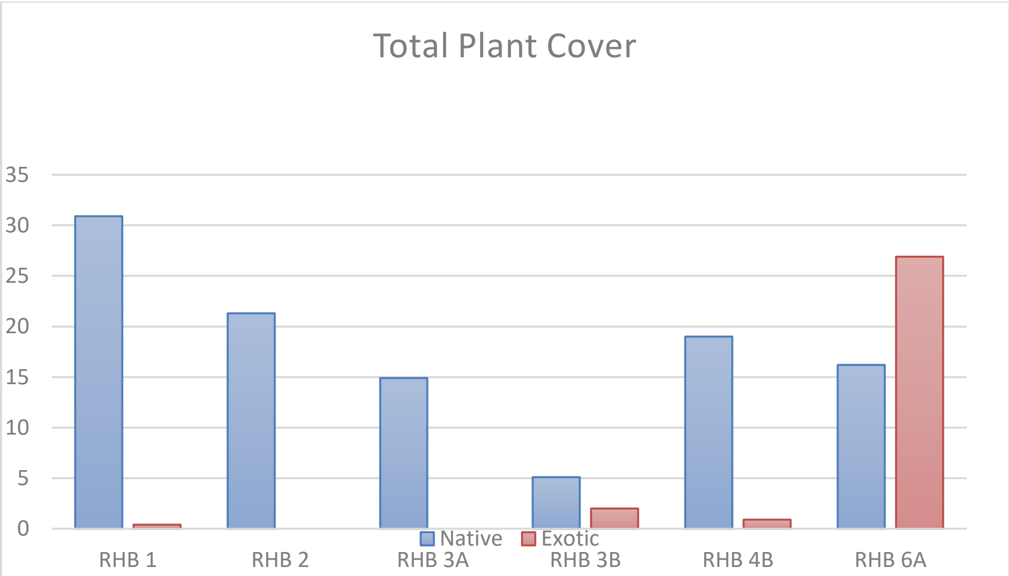

Figure 4. Native and Exotic Gound Layer Plant Cover 2022.

4.7 BAM Plots

The RMP anticipates that information available from application of the Biodiversity Assessment Methodology (BAM) can be used to assess rehabilitation success in relation to parameters including: regeneration of tree, shrub and ground layer species, floristic diversity, vegetation structure. Regrettably the RMP did not consider recent monitoring reports and methodology, nor established parameters relating to rehabilitation success from experience over the past ten years.

Table 4 presents information collected from the BAM plots relating to overall species richness and for each plant stratum. Taller Acacias such as Green Wattle (*Acacia decurrens*) and Silver Wattle (*Acacia dealbata*) have been defined as trees for the purpose of this analysis. As stated previously cover and abundance scores for plant species recorded at each BAM plot is included in Appendix B.

Table 4. BAM Plot Summary Data

	RHB 1	RHB 2	RHB 3A	RHB 3B	RHB 4B	RHB 6A	ANA 1	ANA 2	ANA 3
Native Species Richness	51	44	35	38	37	28	38	37	36
Native Tree Species	1	5	4	3	1	2	4	5	3
Native Shrub Species	19	15	16	11	11	8	12	19	16
Native Ground Layer Species	31	24	15	24	25	18	22	13	17

Table 13 of the RMP presents draft completion criteria for a number of parameters. For vegetation composition the RMP suggests that the presence of 1 tree species, 2 shrub species and 6 ground layer species characteristic of the target vegetation type represents an adequate degree of floristic diversity to meet a completion criterion.

The BAM data collected in 2022 shows that half of rehabilitation plots meet this criterion with the number of tree, shrub and ground layer species being comparable to analogue plots. At RHB 1, RHB 4B and RHB 6, tree diversity was low, which may indicate a need for supplementary seeding or planting of tubestock to improve eucalypt diversity. Shrub and ground layer diversity was at least adequate at all rehabilitation plots with levels comparable to or exceeding those at the analogue plots.

5.0 FAUNA HABITAT CHARACTERISTICS

The rehabilitation area currently provides woodland habitat of varying age and structure suitable for the bird species which inhabit the bushland areas surrounding the mine. The proximity of this more intact bushland means that a range of woodland birds were recorded opportunistically during the field survey, including Australian Magpie, Australian Raven, Pied Currawong, Crimson Rosella, Yellow-Tailed Black Cockatoo, Superb Lyrebird, White-throated Treecreeper, White-eared Honeyeater, , Rufous Whistler, Superb Fairy-wren and Grey Shrike-thrush.

The area also supports native mammals with Eastern Grey Kangaroo scats being observed during the field survey.

6.0 DISCUSSION

The adoption of the new RMP needed to better integrate previous monitoring work at Clarence to retain the value of past work and provide for a more complete analysis of the trajectory of the rehabilitation areas. That would be consistent with best practice adaptive monitoring as outlined in Lindenmayer & Likens (2010).

This survey and report have sought to meld the two approaches in order achieve this end.

Following the practice of the 2022 Koru Environmental report, this section will concentrate on issues which have emerged in the past twelve months. It should be assumed that recommended actions from earlier Koru Environmental reports remain valid.

Eucalypt regeneration is below benchmark at REA 1, REA 4 and REA 6. RHB 1, RHB 2 and RHB 4B had lower than benchmark stem densities. Supplementary spreading of eucalypt seed or planting of tubestock is recommended to achieve benchmark levels.

Whilst there was evidence of Pampas Grass control across the rehabilitation area, ongoing control is necessary to stay on top of outbreaks of this weed. Additional spot spraying of Pampas Grass is recommended across the rehabilitation areas.

The high abundance of African Lovegrass at REA 6 is a high priority for timing action to reduce prevalence and allow native ground covers to occupy the niche now taken up by this invasive perennial grass. Spot spraying in early spring is recommended, with follow up herbicide application in response to growth flushes after rainfall. The recommended herbicides for control by spot spraying are flupropanate and glyphosate.

Advice from the Department of Primary Industries indicates that it may be possible to suppress seed set of African Lovegrass at a time when native grasses are not flowering by application of Paraquat at a rate to 300-500 ml per hectare. Spraying needs to occur when flowerheads of African Lovegrass plants are emerging. Further detailed records of flowering times of native grasses are needed to reduce the chance of non-target impacts when applying this control method.

Repeat spot spraying will be necessary in spring 2024 and 2025. Any non-target impacts on desirable native ground layer species should be recorded with the intention of supplementary seeding with native grass seed to restore cover on patches of bare, exposed soil.

A small population of the endangered plant species *Caesia parviflora* var. *minor* was found at transect RHB2. This is the first time this species has been recorded at a mine rehabilitation site and is a significant finding. The source of seed for this plant is not known definitively but is thought to have been retained within topsoil spread across this rehabilitation area, with seed germination responding to the wet period from 2020-2022.

The native plant species composition of the rehabilitation areas is trending towards that of analogue sites. The presence of a number of difficult to propagate species such as members of the Ericaceae family including *Brachyloma daphnoides*, *Epacris pulchella*, *Leucopogon lanceolatus* and *Monotoca scoparia* is an indicator of the success of rehabilitation.

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27 March 2023

APPENDIX A1. Plant Species List, Clarence Colliery Rehabilitation quadrats, December 2022.

Species Name	RHB 1	RHB 2	RHB 3A	RHB 3B	RHB 4B	RHB 6A
Native Plants						
Acacia dealbata		x			x	
Acacia decurrens		x				
Acacia obtusifolia		x	x	x	x	x
Acacia terminalis		x	x		x	x
Amperea xiphoclada				0.1	0.5	
Aristida ramosa	6.6				0.1	
Austrostipa pubescens	6.6	4.6	0.1	0.1		1.0
Baloskion australe			0.1			
Banksia ericifolia	x					
Bossiaea heterophylla			0.1			
Cassinia aculeata						x
Caustis flexuosa			1.1	0.2		
Chordifex fastigiatus	0.1					
Coronidium scorpioides		0.1				0.1
Cyathochaeta diandra				0.1		
Cynodon dactylon					0.5	4.5
Dampiera stricta	0.1					
Daviesia alata			0.1			
Daviesia latifolia		x				x
Dianella revoluta		0.3				
Dichelachne inaequiglumis	4.0					
Entolasia stricta	2.7	4.0	0.7	1.6	9.0	1.2
Eragrostis brownii	0.1					
Eucalyptus dives	x					
Eucalyptus ligustrina			x			
Eucalyptus mannifera		x				
Eucalyptus piperita			x	x		x
Eucalyptus radiata					x	
Eucalyptus sclerophylla	x	x	x			
Eucalyptus sieberi		x	x	x		
Eucalyptus sp.						x
Euchiton sphaericus	0.1					
Geranium solanderi					0.6	0.1
Gonocarpus tetragynus	0.1				0.1	0.1
Grevillea laurifolia						1.0
Hybanthus monopetalus			0.1	0.1		
Juncus continuus						0.1
Juncus usitatus	0.1					
Lachnagrostis filiformis	0.1					
Laxmannia gracilis	0.1		0.1			
Lepidosperma laterale	0.1					
Leptomeria acida				x		

Leptospermum polygalifolium		x				x
Leptospermum sphaerocarpum	x					
Leptospermum trinervium	x	x	x	x		
Lomandra cylindrica			0.1			
Lomandra filiformis subsp. coriacea	2.1					
Lomandra glauca		0.1		0.1		
Lomandra longifolia		3.5			2.0	1.3
Lomandra multiflora				0.1		
Lomatia silaifolia		x				
Microlaena stipoides	5.0	1.1	5.5	0.1	2.0	5.6
Opercularia varia	0.1					
Patersonia glabrata		0.1	0.1	0.1		
Patersonia longifolia	2.5		0.1			
Persoonia levis			x	x		
Platysace linearifolia	0.1		0.1	0.1		
Poa sieberiana subsp. sieberiana		1.5				1.1
Pomaderris andromedifolia		x				
Pomax umbellata				0.1		
Rhytidosporum procumbens	0.1					
Rytidosperma fulvum				2.0		
Rytidosperma pallidum		2.5	6.6	0.1	4.0	
Senecio diaschides					0.1	
Schoenus villosus		3.5		0.1		
Thysanotus sp.	0.1					
Veronica plebeia						0.1
Xanthosia stellata	0.1			0.1		
Wahlenbergia stricta					0.1	
Exotic Plants						
* Acetosella vulgaris						0.1
* Conyza sp.	0.1					0.1
* Cortaderia selloana				2.0		
* Echium vulgare					0.3	
* Eragrostis curvula						26.5
* Gamochaeta sp.	0.1					
* Hypochaeris radicata					0.6	
* Silene gallica	0.1					
* Verbascum virgatum						0.1
* Verbena bonariensis						0.1
* Vulpia sp.	0.1					

NOTES

x Recorded

Numbers relate to those species recorded during the ground cover assessments, the value representing the average cover for each species

APPENDIX A2. Plant Species List, Clarence Colliery Analogue quadrats, December 2022.

Species Name	ANA 1	ANA 2	ANA 3
Native Plants			
Acacia obtusifolia			x
Acacia terminalis	x	x	
Aristida ramosa	0.1		
Austrostipa pubescens	0.1		0.1
Baloskion australe		0.1	
Banksia spinulosa	x	x	
Billardiera scandens		0.1	
Caustis flexuosa	0.1	0.6	0.1
Dampiera stricta	0.2	0.1	
Daviesia latifolia			x
Dianella revoluta	0.1		0.1
Dillwynia retorta		x	
Entolasia stricta	0.1	0.1	2.3
Eucalyptus ligustrina		x	
Eucalyptus piperita	x	x	x
Eucalyptus sclerophylla	x	x	x
Eucalyptus sieberi	x	x	x
Eucalyptus sparsifolia	x		x
Gompholobium huegelii		0.1	
Gonocarpus tetragynus	0.1		
Goodenia bellidifolia	0.1	0.1	
Haemodorum planifolium	0.1		
Leptospermum sphaerocarpum		x	x
Leptospermum trinervium	x	x	x
Lepyrodia gracilis	0.1		
Lomandra cylindrica	0.2	0.1	0.1
Lomandra filiformis subsp. coriacea	0.1		
Lomandra glauca	0.1	0.1	0.1
Lomandra multiflora	0.1		
Mirbelia platyloboides	0.1		
Patersonia glabrata	0.2	2.1	0.1
Patersonia sericea			0.1
Persoonia laurina		x	
Persoonia levis	x	x	x
Platysace linearifolia	0.2	0.1	
Pomax umbellata			0.1
Poranthera microphylla			0.1
Rytidosperma pallidum	2.3	0.6	3.3
Schoenus villosus	0.2		
Thysanotus sp.			0.1
Xanthosia pilosa			0.1
Xanthosia stellata	0.1	0.1	

NOTES

x Recorded

Numbers relate to those species recorded during the ground cover assessments, the value representing the average cover for each species

APPENDIX B. Plant cover/abundance scores from BAM plots. December 2023.

Transect RHB 1

Scientific Name	C	A
Amperea xiphoclada	0.1	20
Aristida ramosa	1	2000
Austrostipa pubescens	1	1000
Banksia ericifolia	0.1	10
Banksia spinulosa	0.1	1
Billardiera scandens	0.1	10
Brachyloma daphnoides	0.1	100
Callistemon citrinus	0.5	1
Cassinia arcuata	0.1	1
Chordifex fastigiatus	0.1	5
Cryptandra amara	0.1	5
Cynoglossum australe	0.1	1
Dampiera stricta	0.1	10
Dianella revoluta	0.1	50
Entolasia stricta	1	2000
Epacris pulchella	0.1	50
Eragrostis brownii	0.1	200
Eucalyptus sclerophylla	5	20
Euchiton sphaericus	0.1	500
Hakea dactyloides	0.1	1
Hakea laevipes	0.1	1
Hakea sericea	0.1	5
Hybanthus monopetalus	0.1	10
Isopogon anemonifolius	1	50
Juncus usitatus	0.1	50
Lachnagrostis filiformis	0.1	20
Lepidosperma laterale	0.1	20
Leptomeria acida	0.1	1
Leptospermum polygalifolium	0.1	10
Leptospermum sphaericum	0.2	10
Leptospermum trinervium	1	50
Lomandra filiformis subsp. coriacea	1	2000
Microlaena stipoides	1	2000
Mirbelia platyloboides	0.1	10
Mitrasacme polymorpha	0.1	20
Monotoca scoparia	0.1	50
Patersonia glabrata	0.1	10
Patersonia longifolia	0.1	20
Persoonia myrtilloides	0.1	1
Petrophile pulchella	0.1	1
Phyllota squarrosa	0.1	10
Platysace linearifolia	0.1	50

Poa sieberiana subsp. cyanophylla	0.1	10
Rhytidosporum procumbens	0.1	50
Senecio minimus	0.2	100
Senecio quadridentatus	0.1	20
Stackhousia monogyna	0.1	20
Styphelia tubiflora	0.1	1
Thelymitra ixioides	0.1	5
Thysanotus sp.	0.1	1
Xanthosia stellata	0.1	100
Acetosella vulgaris *	0.1	100
Cerastium glomeratum *	0.1	50
Conyza sp. *	0.1	100
Eragrostis curvula *	0.1	1
Gamochaeta purpurea *	0.1	100
Gamochaeta sp. *	0.1	500
Hypochaeris radicata *	0.1	20
Silene gallica *	0.1	50
Solanum nigrum *	2	500
Sonchus asper *	0.1	1
Sonchus oleraceus *	0.1	10
Trifolium dubium *	0.1	20
Verbena bonariensis *	0.1	50
Vulpia myuros *	2	2000

Transect RHB 2

Scientific Name	**C**	**A**
Acacia dealbata	1	10
Acacia decurrens	0.1	1
Acacia obtusifolia	1	50
Acacia terminalis	0.5	50
Austrostipa pubescens	1	500
Banksia marginata	0.1	1
Billardiera scandens	0.1	10
Caesia parviflora var. minor	0.1	2
Coronidium scorpioides	0.1	100
Dampiera stricta	0.1	20
Daviesia latifolia	0.5	20
Dianella revoluta	0.1	100
Entolasia stricta	5	2000
Eucalyptus mannifera	1	5
Eucalyptus piperita	0.1	1
Eucalyptus sieberi	0.5	3
Gahnia sieberiana	0.5	10
Grevillea laurifolia	0.1	20
Isopogon anemonifolius	0.1	10
Lepidosperma laterale	0.1	1
Leptomeria acida	0.1	10
Leptospermum polygalifolium	1	20
Leptospermum trinervium	20	2000
Leucopogon lanceolatus	0.1	10
Leucopogon muticus	0.1	5
Lomandra cylindrica	0.1	10
Lomandra filiformis subsp. coriacea	0.1	10
Lomandra glauca	0.1	50
Lomandra longifolia	2	500
Lomatia silaifolia	0.1	20
Microlaena stipoides	0.2	100
Monotoca scoparia	0.1	20
Patersonia glabrata	0.1	50
Patersonia longifolia	0.1	10
Patersonia sericea	0.1	1
Phyllota squarrosa	0.1	50
Poa sieberiana subsp. cyanophylla	1	500
Poa sieberiana subsp. sieberiana	0.5	500
Polyscias sambucifolius 'long'	0.2	20
Pomaderris andromedifolia	1	50
Poranthera microphylla	0.1	1
Rytidosperma pallidum	1	100
Schoenus villosus	0.1	100
Stackhousia monogyna	0.1	20

Stylidium graminifolium	0.1	1

Transect RHB 3A

Scientific Name	**C**	**A**
Acacia obtusifolia	0.1	10
Acacia terminalis	0.5	20
Austrostipa pubescens	0.1	100
Baloskion australe	0.1	100
Billardiera scandens	0.1	10
Boronia microphylla	0.1	1
Brachyloma daphnoides	0.1	10
Caustis flexuosa	0.5	500
Daviesia acicularis	0.1	1
Daviesia alata	0.1	10
Entolasia stricta	0.1	500
Eucalyptus ligustrina	0.1	1
Eucalyptus piperita	2	20
Eucalyptus sclerophylla	2	20
Eucalyptus sieberi	10	10
Hibbertia obtusifolia	0.1	5
Hybanthus monopetalus	0.1	3
Isopogon anemonifolius	0.1	1
Leptospermum sphaericum	0.2	20
Leptospermum trinervium	3	100
Lomatia silaifolia	0.2	100
Microlaena stipoides	5	1000
Mirbelia platyloboides	0.1	100
Mitrasacme polymorpha	0.1	5
Monotoca scoparia	0.2	100
Patersonia longifolia	0.1	50
Patersonia sericea	0.1	1
Persoonia levis	0.1	5
Persoonia myrtilloides	0.1	1
Petrophile canescens	0.1	5
Phyllota squarrosa	0.1	10
Platysace linearifolia	0.1	100
Poranthera microphylla	0.1	3
Rhytidosporum procumbens	0.1	10
Rytidosperma pallidum	25	1000
Cortaderia selloana *	0.1	1

Transect RHB 3B

Scientific Name	C	A
Acacia ulicifolia	0.1	5
Allocasuarina nana	0.1	1
Amperea xiphoclada	0.1	100
Austrostipa pubescens	0.5	100
Banksia cunninghamiana	0.1	1
Billardiera scandens	0.1	1
Caustis flexuosa	1	1000
Comesperma ericinum	0.1	1
Dianella prunina	0.1	50
Entolasia stricta	0.5	500
Epacris pulchella	0.1	100
Eucalyptus piperita	3	20
Eucalyptus sclerophylla	1	5
Eucalyptus sieberi	10	50
Gahnia microstachya	0.1	1
Grevillea laurifolia	0.1	1
Hybanthus monopetalus	0.1	20
Isopogon anemonifolius	0.5	10
Leptomeria acida	0.1	1
Leptospermum sphaericum	0.5	20
Leptospermum trinervium	5	50
Lomandra glauca	0.1	100
Lomandra multiflora	0.1	10
Lomatia silaifolia	0.1	5
Microlaena stipoides	0.1	100
Mirbelia platyloboides	0.1	20
Monotoca scoparia	0.1	50
Patersonia glabrata	0.1	100
Persoonia levis	0.1	1
Petrophile canescens	0.1	20
Pimelea linifolia	0.1	1
Platysace linearifolia	0.2	500
Pomax umbellata	0.1	100
Pteridium esculentum	0.1	20
Rytidosperma pallidum	0.1	50
Rytidosperma sp.	1	100
Schoenus villosus	0.1	50
Xanthosia stellata	0.1	50
Cortaderia selloana *	1	100

Transect RHB 4B

Scientific Name	C	A
Acacia dealbata	30	500
Acacia obtusifolia	10	500
Acacia terminalis	10	500
Acacia ulicifolia	0.1	5
Amperea xiphoclada	0.2	500
Austrostipa pubescens	0.1	100
Billardiera scandens	0.1	50
Callistemon citrinus	0.1	3
Carex inversa	0.1	1
Cassinia aculeata	0.1	20
Cryptandra amara	0.1	5
Dampiera stricta	0.1	20
Daviesia latifolia	1	50
Deyeuxia sp.	0.1	5
Entolasia stricta	5	2000
Gahnia sieberiana	0.1	1
Geranium solanderi	0.1	100
Gonocarpus tetragynus	0.1	50
Grevillea laurifolia	0.1	5
Hakea sericea	0.1	2
Hardenbergia violacea	0.1	1
Juncus usitatus	0.1	1
Lomandra filiformis subsp. coriacea	0.1	5
Lomandra longifolia	0.1	10
Microlaena stipoides	5	1000
Mirbelia platyloboides	0.1	5
Olearia erubescens	0.1	1
Opercularia aspera	0.1	1
Opercularia varia	0.1	10
Patersonia glabrata	0.1	5
Patersonia sericea	0.1	1
Persoonia myrtilloides	0.1	5
Polyscias sambucifolius 'long'	0.1	5
Poranthera microphylla	0.1	10
Rytidosperma fulvum	0.5	500
Senecio quadridentatus	0.1	50
Wahlenbergia stricta	0.1	10
Conyza sp. *	0.1	500
Gamochaeta calviceps	0.1	20
Hypochaeris radicata *	0.1	500
Verbascum virgatum *	0.1	20

Transect RHB 6

Scientific Name	C	A
Acacia obtusifolia	5	100
Acacia terminalis	0.1	20
Austrostipa pubescens	0.1	50
Billardiera scandens	0.1	20
Callistemon citrinus	0.1	1
Cassinia aculeata	0.5	20
Comesperma ericinum	0.1	1
Coronidium scorpioides	0.1	100
Cynodon dactylon	5	2000
Daviesia latifolia	0.1	20
Dichelachne inaequiglumis	0.1	20
Echinopogon ovatus	0.1	5
Entolasia stricta	0.1	100
Eucalyptus macrorhyncha	0.1	1
Eucalyptus piperita	0.1	5
Geranium solanderi	0.1	100
Gonocarpus tetragynus	0.1	10
Grevillea laurifolia	0.1	20
Hardenbergia violacea	0.1	10
Juncus continuus	0.1	20
Leptospermum continentale	0.2	5
Leptospermum polygalifolium	10	100
Lomandra longifolia	5	1000
Microlaena stipoides	1	1000
Poa labillardierei	0.1	20
Poa sieberiana subsp. sieberiana	1	1000
Veronica plebeia	0.1	5
Wahlenbergia gracilis	0.1	10
Acetosella vulgaris *	0.1	100
Conyza sp. *	0.1	100
Eragrostis curvula *	25	2000
Hypericum perforatum *	0.1	20
Oenothera stricta*	0.1	1
Verbascum virgatum *	0.1	100
Verbena bonariensis *	0.1	20

Transect ANA 1

Scientific Name	C	A
Aristida ramosa	0.1	10
Austrostipa pubescens	0.1	10
Banksia spinulosa	0.1	5
Boronia microphylla	0.1	20
Dampiera stricta	0.1	100
Dianella revoluta	0.5	500
Dillwynia retorta	0.1	1
Entolasia stricta	0.1	100
Eucalyptus piperita	1	1
Eucalyptus sclerophylla	5	20
Eucalyptus sieberi	10	5
Eucalyptus sparsifolia	1	5
Gonocarpus tetragynus	0.2	500
Goodenia bellidifolia	0.1	100
Haemodorum planifolium	0.1	10
Hakea laevipes	0.1	20
Isopogon anemonifolius	0.1	20
Lepidosperma filiforme	0.1	1
Leptospermum trinervium	5	50
Lepyrodia gracilis	0.1	20
Lomandra cylindrica	0.2	1000
Lomandra filiformis subsp. coriacea	1	2000
Lomandra glauca	0.1	100
Lomandra multiflora	0.1	10
Lomatia silaifolia	0.1	10
Mirbelia platyloboides	0.1	20
Patersonia glabrata	0.1	20
Patersonia longifolia	0.1	20
Persoonia laurina	0.1	1
Persoonia levis	0.1	1
Platysace linearifolia	0.5	500
Rytidosperma pallidum	10	2000
Schoenus villosus	0.2	500
Styphelia tubiflora	0.1	1
Telopea speciosissima	0.1	1
Thelymitra ixioides	0.1	1
Thysanotus sp.	0.1	5
Xanthosia stellata	0.1	100

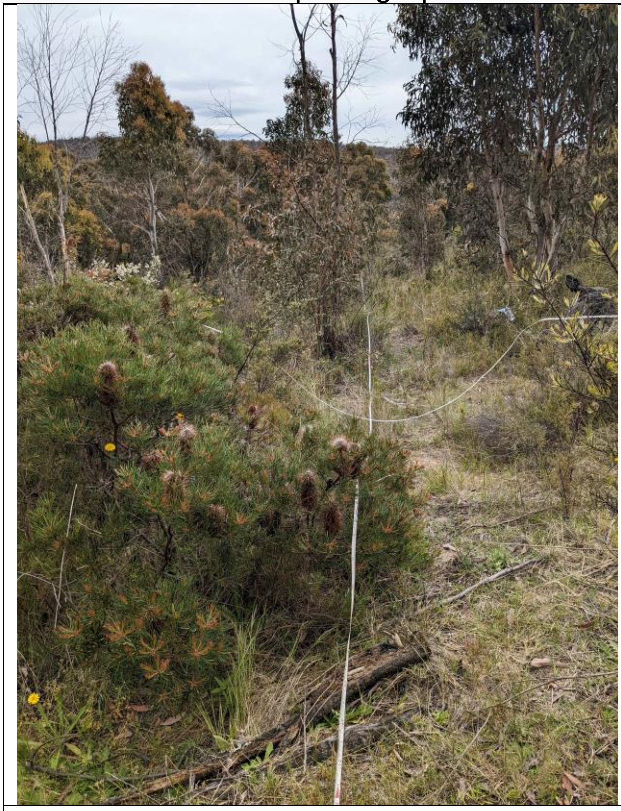
Transect ANA 2

Scientific Name	C	A
Acacia asparagoides	0.1	10
Acacia terminalis	1	100
Acacia ulicifolia	0.1	20
Banksia marginata	0.1	1
Banksia spinulosa	0.1	10
Boronia microphylla	0.1	50
Bossiaea heterophylla	0.1	1
Caustis flexuosa	0.5	2000
Daviesia latifolia	0.1	5
Dillwynia retorta	0.1	10
Entolasia stricta	0.5	100
Eucalyptus ligustrina	1	10
Eucalyptus piperita	10	50
Eucalyptus radiata	0.1	1
Eucalyptus sclerophylla	5	20
Eucalyptus sieberi	10	20
Gompholobium huegelii	0.1	5
Goodenia bellidifolia	0.1	50
Hovea heterophylla	0.1	1
Hybanthus monopetalus	0.1	10
Isopogon anemonifolius	0.1	10
Leptomeria acida	0.2	20
Leptospermum sphaericum	5	100
Leptospermum trinervium	5	100
Lomandra cylindrica	0.1	100
Lomandra filiformis subsp. coriacea	0.1	20
Lomandra glauca	0.1	10
Lomatia silaifolia	0.1	20
Mitrasacme polymorpha	0.1	10
Monotoca scoparia	0.1	50
Patersonia glabrata	0.5	500
Persoonia laurina	0.1	1
Persoonia levis	0.1	10
Petrophile canescens	0.1	1
Platysace linearifolia	0.1	20
Rytidosperma pallidum	0.1	50
Xanthosia stellata	0.1	50

Transect ANA 3

Scientific Name	C	A
Acacia terminalis	0.1	10
Acacia ulicifolia	0.1	5
Amperea xiphoclada	0.1	1
Austrostipa pubescens	0.1	100
Banksia marginata	0.1	1
Banksia spinulosa	0.1	5
Boronia microphylla	0.1	10
Caustis flexuosa	1	1000
Daviesia latifolia	0.1	10
Dianella revoluta	1	500
Entolasia stricta	5	2000
Eucalyptus sclerophylla	10	20
Eucalyptus sieberi	3	10
Eucalyptus sparsifolia	5	5
Hakea laevipes	0.5	10
Isopogon anemonifolius	0.1	10
Leptomeria acida	0.1	10
Leptospermum sphaericum	1	50
Leptospermum trinervium	3	50
Lomandra cylindrica	0.5	500
Lomandra glauca	0.5	500
Lomandra longifolia	0.1	1
Microlaena stipoides	0.1	50
Monotoca scoparia	1	100
Patersonia glabrata	0.2	100
Patersonia sericea	0.1	10
Persoonia laurina	0.1	1
Persoonia levis	0.1	1
Petrophile canescens	0.1	5
Platysace linearifolia	0.1	50
Pomax umbellata	0.1	10
Poranthera microphylla	0.1	5
Pultenaea scabra	0.1	1
Rytidosperma pallidum	10	2000
Thysanotus sp.	0.1	10
Xanthosia pilosa	0.1	10

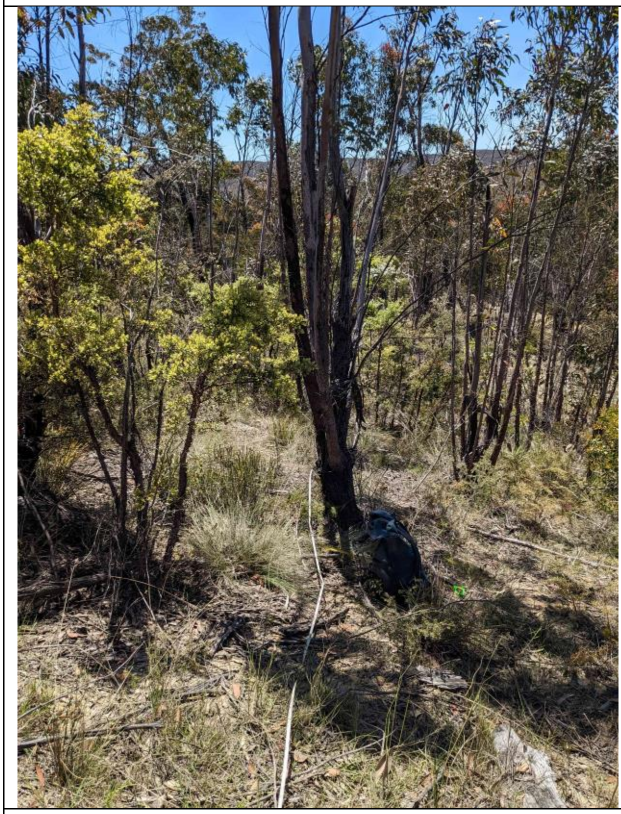
APPENDIX C. Site photographs December 2022.

	
C1. RHB 1 from start	**C2.** RHB 1 from end

	
C3. RHB 2 from start	**C4.** RHB 2 from end

C5. RHB 3A from start

C6. RHB 3A from end



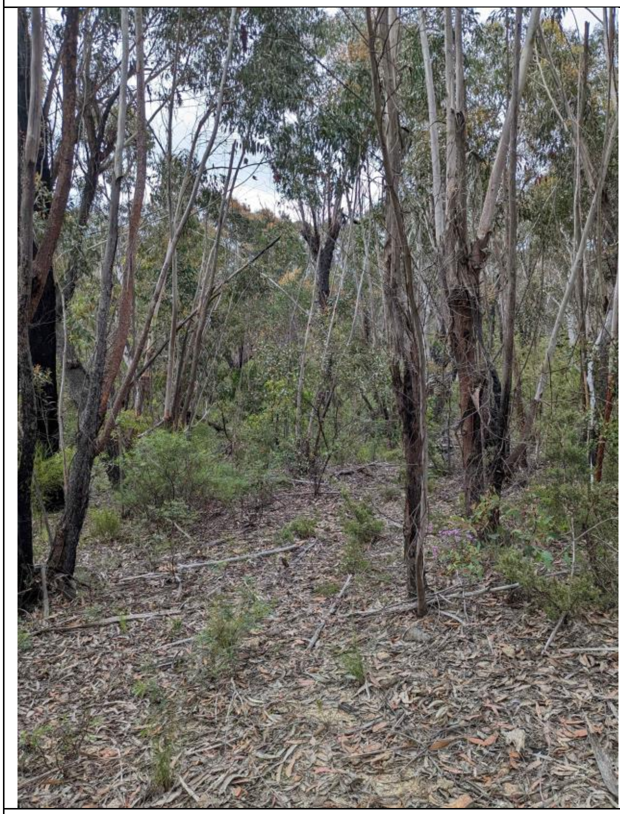
C7. RHB 3B from start

C8. RHB 3B from end

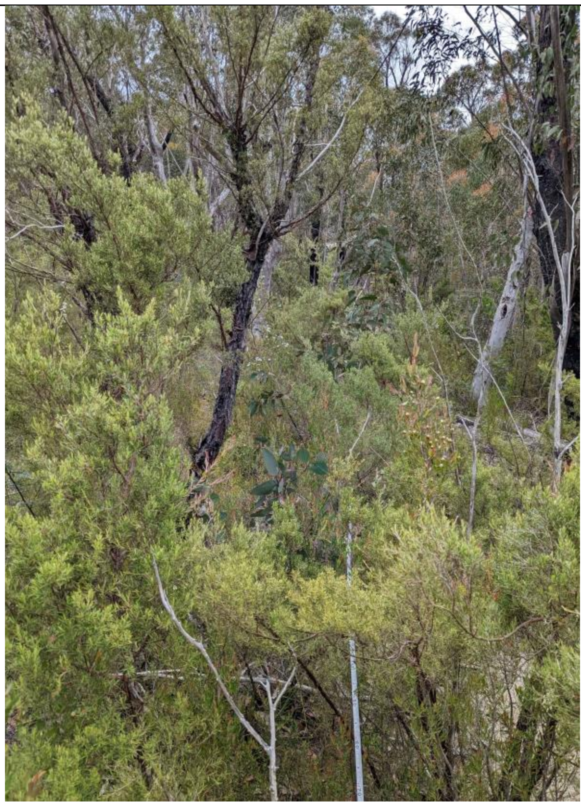
	
C9. RHB 4B from start	**C10.** RHB 4B from end
	
C11. RHB 6 from start	**C12.** RHB 6 -not recorded

C13. ANA 1 from start

C14. ANA 1 from end



C15. ANA 2 from start



C16. ANA 2 from end

	
C17. ANA 3 from start	**C18.** ANA 3 from end

CENTENNIAL COAL CLARENCE COLLIERY

Reject Emplacement Area 4 Rehabilitation Trial
Annual Monitoring

Prepared for:

Clarence Colliery Pty Ltd
Centennial Western Accounts
Locked Bag 1002
WALLERAWANG NSW 2845

SLR Ref: 630.12944-R01
Version No: -v2.0
March 2023

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BASIS OF REPORT

DOCUMENT CONTROL

Reference	Date	Prepared	Checked	Authorised
630.12944-R01-v2.0	16 March 2023	Hannah Centra, Jarrid Beeton	Jeremy Pepper, Fiona Iolini	Jeremy Pepper
630.12944-R01-v1.0	2 March 2023	Hannah Centra, Jarrid Beeton	Jeremy Pepper, Fiona Iolini	Jeremy Pepper

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APPENDICES

1 Introduction

1.1 Background

The Clarence Colliery is an underground coal mine located approximately 10 km east of Lithgow, NSW (see Figure 1). SLR Consulting Australia Pty Ltd (SLR) has been commissioned by Clarence Colliery Pty Ltd (Clarence) to implement a rehabilitation trial within Reject Emplacement Area 4 (REA 4) at the colliery. The rehabilitation trial forms part of a 'High Risk Activity Notification' process to allow for operational activities in preparation for the rehabilitation and decommissioning of REA 3. The trial was developed by SLR with assistance from Centennial Coal and the Bush Doctor Pty Ltd and the rehabilitation works were implemented in October 2019. For more details on the development and justifications for the trial refer to Clarence Colliery REA 2 and REA 4 Rehabilitation Trials (SLR 2018). The results of the rehabilitation trial at Clarence Colliery will be used to identify suitable methods for the future rehabilitation of REA 3.

The locality of REA 4 and the rehabilitation trial areas are illustrated on Figure 2. Ecological and erosion monitoring was to occur within the REA4 area on a quarterly basis to track the progress of the trial (see SLR 2018). The results of the soil loss monitoring using the profile meter correlate well with the RUSLE results from the 2020 annual monitoring, which provided confidence in long-term performance prediction. The profile meter soil loss monitoring program is adequate to verify the erosion modelling and identify areas of concern while the ground cover is being established. Following adequate ground cover establishment in the trial area in 2020 and 2021, visual monitoring of ground cover status becomes more relevant to the long-term stability of the landform. Quarterly aerial LiDAR surveys are being conducted at Clarence and will be used to assist in the visual inspection of ground cover and landform changes.

Monitoring reports are delivered annually to capture the following:

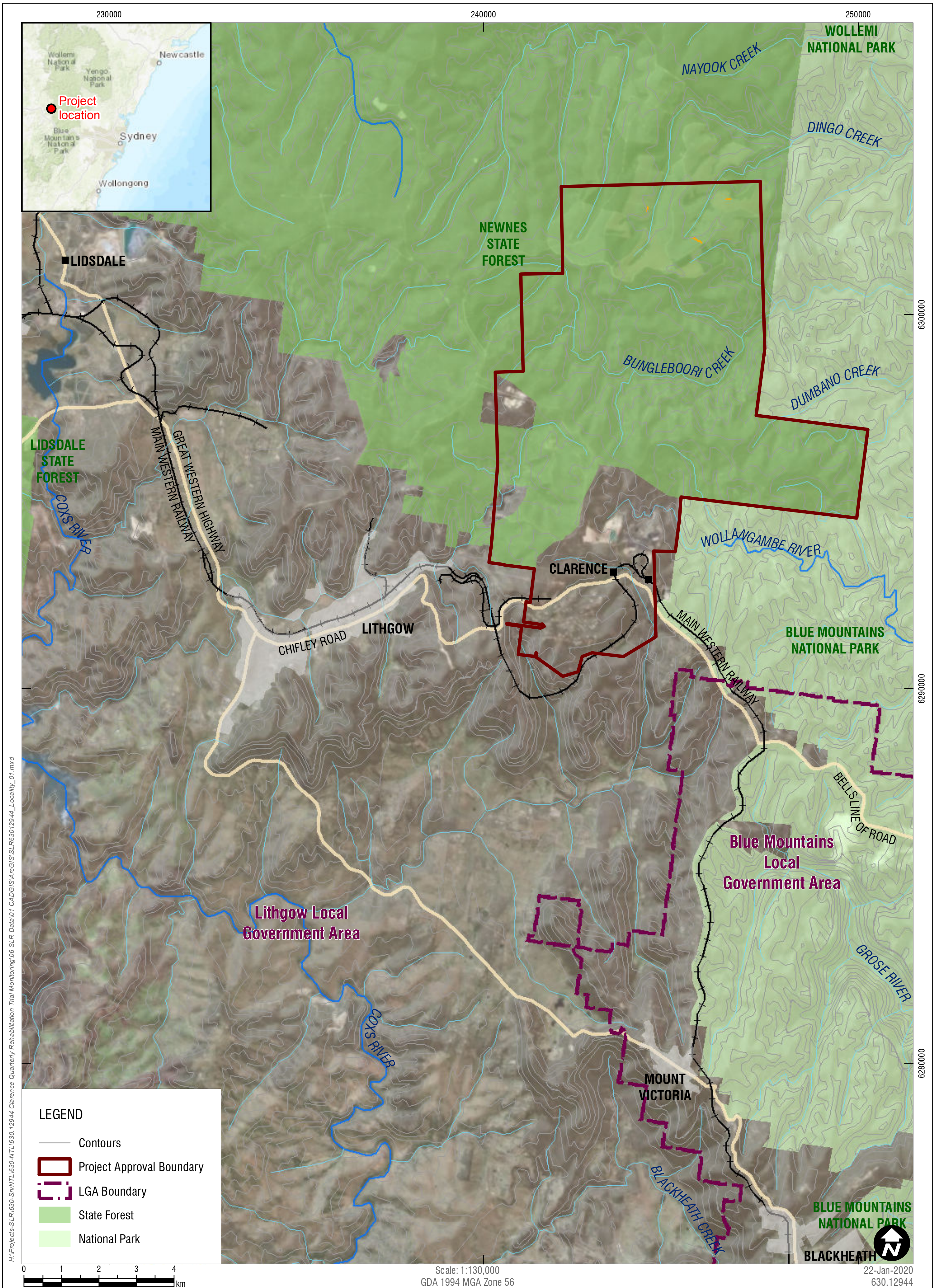
- Estimated soil loss from each trial area, with a comparison to the average soil loss rates (year 1 only)
- Ecological trends
- Assessment of rehabilitation performance against prescribed criteria (as set out in the Clarence Mining Operations Plan 'MOP')
- Recommendations for any necessary remedial works and/or changes to treatment that provide cost effective improvements to rehabilitation performance

This report describes the methods and results of the annual monitoring survey undertaken within REA4 in December 2022. For a summary of the establishment of the rehabilitation trials refer to Clarence Rehabilitation Trials –Rehabilitation Report (SLR 2020).

1.2 Rehabilitation Trial Objectives and Outcomes

The objectives and outcomes of the rehabilitation trial are:

- To measure and compare the success of different rehabilitation treatments (growth medium, erosion control, planting method) across seven trial sites, using Ecosystem Function Analysis and Profile Metre Monitoring Methods
- To identify suitable methods for the rehabilitation of REA 3 that are cost effective and will satisfy rehabilitation objectives of the MOP (Centennial Coal 2019)
- To fulfil requirements of the 'High Risk Activity Notification' process



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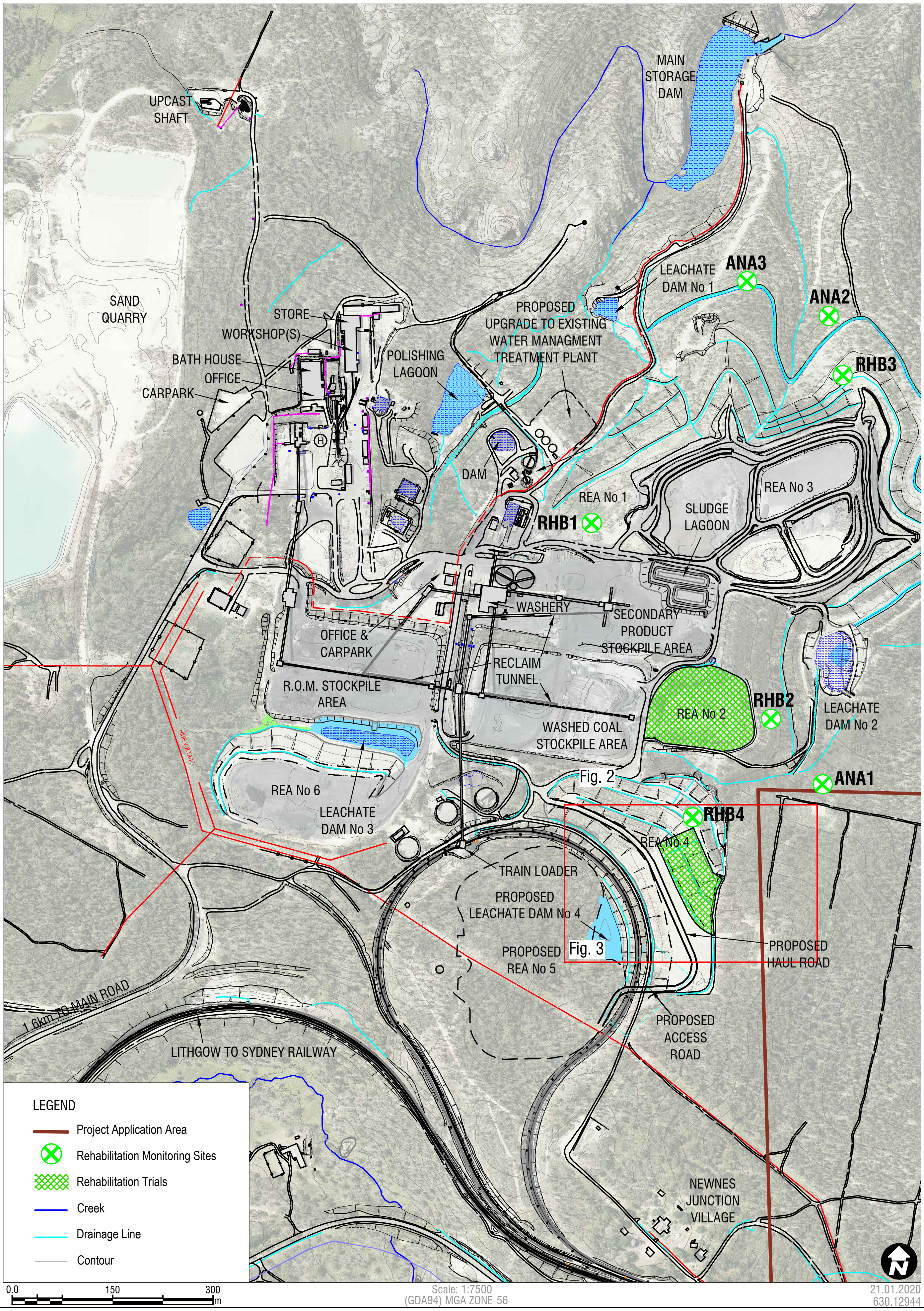
Locality

FIGURE 1



H:\Projects-SLR\630-SrvNTL\630-NTL\630.12944 Clarence Quarterly Rehabilitation Trial Monitoring\06 SLR Data\01 CADGIS\CAD\Workings\SLR63012944_F02_V01_Site Layout_200121.dwg

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Site Layout

FIGURE 2

1.3 MOP Completion Criteria

Rehabilitation reform, through the replacement of existing MOPs with the introduction of the Rehabilitation Management Plans (RMP) was implemented across all Centennial Coal mine sites in NSW including Clarence Colliery in 2022. However, as the Clarence REA4 Trial is a short-term program it will continue in line with the Clarence Colliery MOP methods and completion criteria.

All rehabilitated areas across Clarence Colliery are being returned to a final land use of native woodland/forest (Centennial Coal 2019).

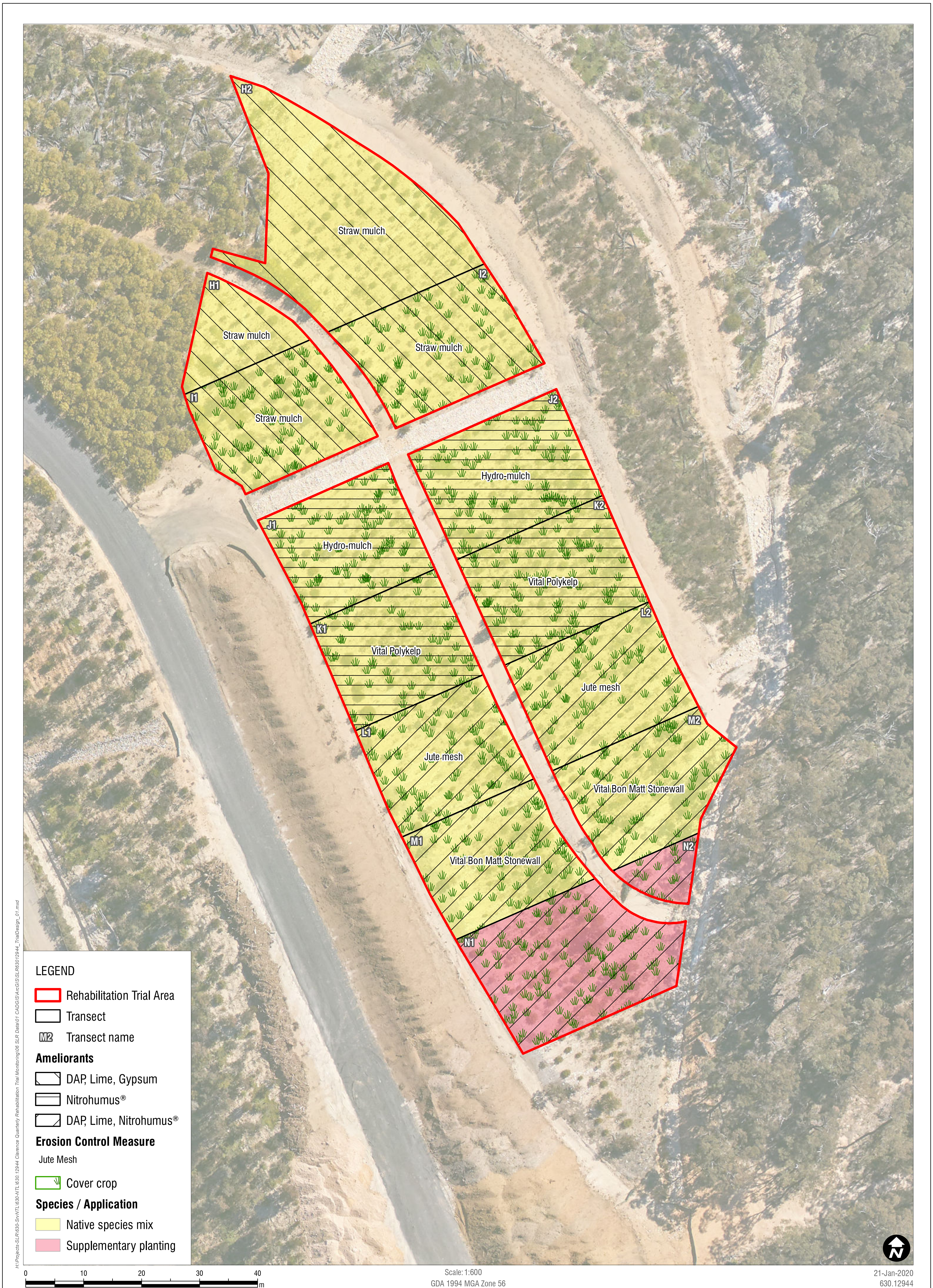
The final completion criteria for 'Rehabilitation Area - Woodland', as defined by the MOP domains, are as follows:

- Habitat complexity score is >4.0 - ≤6.0
- Species are capable of setting viable seed, flowering or otherwise reproducing, with evidence of second generation of tree/shrub species
- Evidence of active use of habitat provided during rehabilitation, such as nest boxes and logs and signs of natural generation of shelter sources, including leaf litter
- Nutrient cycling and recycling processes are occurring as evidenced by the presence of a litter layer, mycorrhizae and/or other microsymbionts
- Continue rehabilitation monitoring until self-sustaining levels are confirmed
- More than 75 % of trees are healthy and growing, as indicated by long-term rehabilitation monitoring
- Rehabilitation monitoring confirms woodland rehabilitation areas provide a range of structural habitats (eg eucalypts, shrubs, ground cover, developing litter layer etc.)
- Total woody species richness differs 10 - 20% from analogue sites
- Less than 40% bare ground cover
- The dominant species found within rehabilitation sites are found in analogue sites

1.4 Details of the Trial Treatment

Treatments were applied on REA 4 during October 2019. Figure 3 displays the trial design, Table 1 details the treatments applied to the seven transects at REA 4, Table 2 includes species of plants used in the rehab and Photo 1 shows the condition of REA 4 at the time of the third year monitoring survey (December 2022).

For a detailed justification of each product/ application rates/ volumes refer to Clarence Colliery REA 2 and REA 4 Rehabilitation Trials (SLR 2018a) and Clarence Rehabilitation Trials - Rehabilitation Report (SLR 2020).



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Trial Design

FIGURE 3

Table 1 Trial Treatments for REA 4

Site ID	Growth Medium	Aspect	Erosion Control Measure	Species/Application
H	DAP, Lime Gypsum	NNE	Straw Mulch	Native species mix
I	DAP, Lime Gypsum	NE	Straw Mulch, cover crop	Native species mix
J	Nitro humus®	NE	Hydro-mulch, cover crop	Native species mix
K	Nitro humus®	NE	Vital Polykelp, cover crop	Native species mix
L	DAP, Lime, Nitro humus®	NE	Jute Mesh, cover crop	Native species mix
M	DAP, Lime, Nitro humus®	NE	Vital Bon Matt Stonewall, cover crop	Native species mix
N	DAP, Lime, Nitro humus®	NE	None (deep rip & cover crop)	Supplementary planting

Table 2 Flora Species used in Rehabilitation

Stratum	Species Name	Common Name
Trees	Eucalyptus dalrympleana	Mountain Gum
	Eucalyptus dives	Broad-leaved Peppermint
	Eucalyptus mannifera	Brittle Gum
	Eucalyptus oreades	Blue Mountains Ash
	Eucalyptus piperita	Sydney Peppermint
	Eucalyptus radiata	Narrow-leaved Peppermint
	Eucalyptus sclerophylla	Narrow-leaved Scribbly Gum
	Eucalyptus sieberi	Silvertop Ash
	Eucalyptus stricta	Blue Mountains Mallee Ash
Shrubs	Allocasuarina nana	Dwarf She-oak
	Gahnia filifolia	-
	Leucopogon lanceolatus	-
	Epacris pulchella	Wallum Heath
	Amperea xiphoclada	Broom Spurge
	Daviesia latifolia	Hop Bitter-pea
	Daviesia ulicifolia	Gorse Bitter Pea
	Dillwynia elegans	-
	Phyllota squarrosa	Dense Phyllota
	Acacia obtusifolia	Blunt Leaf Wattle
	Acacia dorothea	Dorothy's Wattle
	Acacia longifolia	Sydney Golden Wattle
	Acacia rubida	Red-stemmed Wattle
	Acacia terminalis subsp. angustifolia	Sunshine Wattle
	Acacia ulicifolia	Prickly Moses
	Leptospermum brevipes	Slender Tea-tree
	Leptospermum continentale	Prickly Tea-tree
	Leptospermum grandifolium	Woolly Teatree
	Leptospermum polygalifolium	Tantoon
	Leptospermum trinervium	Flaky-barked Tea-tree
	Hakea dactyloides	Finger Hakea
	Hakea laevipes subsp. laevipes	-
	Petrophile pedunculata	Conesticks

Stratum	Species Name	Common Name
	Petrophile pulchella	Conesticks
	Telopea speciosissima	Waratah
	Boronia microphylla	Small Leaved Boronia
Groundcovers	Patersonia glabrata	Leafy Purple-flag
	Patersonia sericea	Silky Purple-flag
	Dianella longifolia	Blueberry Lily
	Austrostipa scabra subsp. falcata	Speargrass
	Entolasia stricta	Wiry Panic
	Microlaena stipoides	Weeping Grass
	Poa labillardierei	Tussock
	Poa sieberiana	Snowgrass
	Rytidosperma erianthum	-

Photo 1 General Nature and Condition of REA 4 at Year Three (22 December 2022)

1.5 Details of the Monitoring Surveys

The monitoring surveys are to be undertaken annually from 2019 and were supported by simple monitoring inspections undertaken at each quarter for the first year. Details of the monitoring surveys undertaken to date are presented in Table 3.

Table 3 Details of the Monitoring Surveys

Survey type	Dates	Techniques	Survey Personnel
Baseline EFA, Erosion	02-03 December 2019	EFA and profile metre monitoring	Fiona Iolini, Samuel McDonald
Erosion Quarterly 1	14 January 2020	Profile metre monitoring	Centennial surveyor
EFA Quarterly 1	22 April 2020	Photo, habitat complexity and general health monitoring	Fiona Iolini
Erosion Quarterly 2	04 May 2020	Profile metre monitoring	Centennial surveyor
EFA Quarterly 2	03 June 2020	Photo, habitat complexity and general health monitoring	Fiona Iolini
EFA Quarterly 3	22 September 2020	Photo, habitat complexity and general health monitoring	Samuel McDonald
EFA Annual 2020	09-11 December 2020	EFA and flora quadrats	Fiona Iolini, Caitlin Cross
Erosion Annual 2020	24 February 2021	Profile metre monitoring	Centennial surveyor
EFA Annual 2021	15-17 December 2021	EFA and flora quadrats, analogue	Fiona Iolini, Jarrid Beeton
EFA Annual 2022	21-22 December 2022	EFA and flora quadrats, analogue	Jarrid Beeton, Hannah Centra

1.6 Staff Qualifications and Roles

The roles and qualifications of all staff responsible for preparation of this report are listed in Table 4.

Table 4 SLR Staff Roles and Qualifications

Staff name and title	Qualifications and training	Role
Jeremy Pepper Technical Director	Bachelor of Science (Hons Class 1) University of NSW 1996 Cert II Bushland Regeneration, TAFE NSW Cert III Horticulture (Arboriculture), TAFE NSW BAM accredited assessor (#BAAS17104)	Project Director and report authorisation
Fiona Iolini Associate Ecologist	Bachelor of Environmental Science and Management, University of Newcastle 2007 Cert III Conservation and Land Management, TAFE NSW 2015 BAM accredited assessor (#BAAS19042)	Project Manager, field assessment, report review
Jarrid Beeton Project Ecologist	Bachelor of Environmental Science and Management, University of Newcastle, 2018 Dip. Conservation and Land Management, TAFE NSW	Field assessment, report preparation
Hannah Centra Project Ecologist	Bachelor of Environmental Science and Management, University and Newcastle, 2021	Field assessment, report preparation
Jeremy Goffeau Senior GIS Analyst	Master of Applied Science (Spatial Information Services), University of Sydney, 2012 Bachelor of Applied Science (Majors in Environmental Studies, GIS and Geology), University of Tasmania, 2010	GIS data management and figure preparation

2 Methods

2.1 Ecosystem Function Analysis

Ecosystem function analysis (EFA) is a field monitoring process that uses simple indicators to assess how well a landscape is working as an ecological system. It is a scientifically verified method that can be used to monitor mine rehabilitation in a much more quantitative way than in the past. It can also be used for early detection of rehabilitation failure, hence allowing a change in remediation technique.

EFA is composed of four parts (Tongway & Hindley 2004):

- Landscape function analysis (LFA)
- Vegetation and structure composition
- Habitat complexity
- Erosion and rill assessment

SLR employed the LFA, habitat complexity and erosion and rill assessment components of EFA during the baseline and first year assessments and will add vegetation and structure composition monitoring at a later stage (once the shrub and canopy layers have established). Groundcover protection and floristics were also collected from year one of the monitoring.

The LFA technique uses simple field indicators to monitor stability, water infiltration and nutrient cycling of the landscape and soil, each of which has a distinct significance for landscape function monitoring, as outlined below. It is a field-based monitoring procedure that assesses a linear transect that is positioned vertically down the slope and ranges from 50-100 m in length depending on the complexity/uniformity of the environment. The assessment uses rapidly assessed, simple visual indicators, to determine how well a landscape functions as a biophysical system. LFA assesses the fate of vital resources such as water, topsoil and organic matter, and identifies both potential accelerated losses and processes that retain those resources. The quality and fate of the resources are compared over time against the relevant reference sites and the success criteria.

The interpretation framework of the LFA provides three numeric values (indices): soil stability, infiltration of water and the cycling of nutrients. Indices are compared with appropriately selected reference sites, representing the most and the least disturbed examples of the landscape type being evaluated. Indices are incorporated into a value for the whole landscape and the application of this value is used to generate comparative graphs between rehabilitation sites of different age and a response curve which relates landscape condition to changes in landscape condition over time.

Results of EFA analysis can be compared to analogue sites within areas of similar vegetation types or landforms to be replicated. The first round of analogue data was collected for comparison to the trial in 2021.

Details of the EFA methods used are included in Appendix A. The location of each gradsect has been marked using wooden pegs at the top and bottom of the slope and coordinates for the pegs are included in the results section. The location of each gradsect is presented in Figure 4 The location of the analogue site (MU29 Analogue 1) is presented in Figure 5.

0 10 20 30 40 m

Scale: 1:750
GDA 1994 MGA Zone 56

22-Jan-2020
630.12440

* Note: Representative only.
Not true to size.

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Ecological and Erosion Control Monitoring Sites

FIGURE 4

0 50 100 m

Scale: 1:5,000 at A4
GDA 1994 MGA Zone 56

24-Feb-2022
630.12944.00200 (0003)

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SLR

Data Source:
Nearmap Satellite Imagery 2021

Vegetation Mapping and Analogue Site Location

FIGURE 5

3 Results

3.1 Trial Site H (straw mulch)

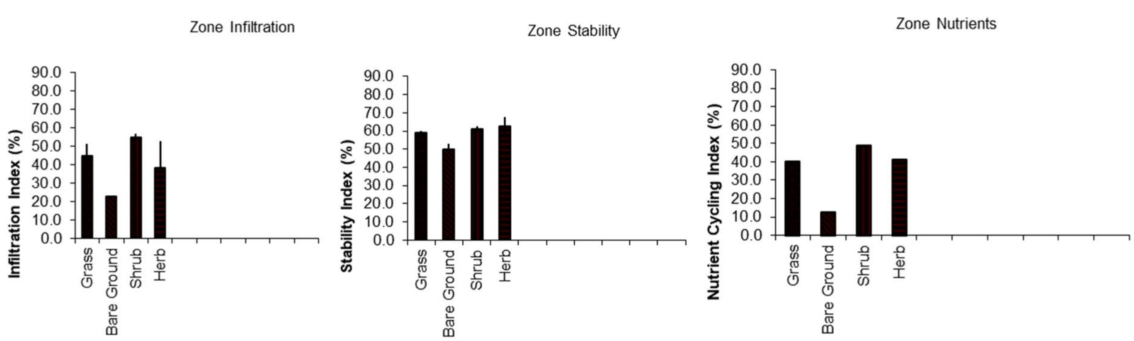
Site H contains a native species mix and is treated with Lime Gypsum, with straw mulch for erosion control. The LFA site description values for Site H are summarised in Table 5. The Site H gradsect was organised into the following four zones: grass, bare ground, shrub and herb. The LFA Landscape Organisation data, including photographs representing each zone, is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site H are shown in Figure 6. At 3.7, the habitat complexity results (see Appendix D) remain below the target habitat value of 4-6. No rills were recorded at Site H in 2022.

Ground cover protection is good with a 7.8% cover of bare ground. Floristic quadrat data for Site H detected 28 flora species, including 26 natives and two exotics. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 5 Site Description Factors at Site H, December 2022

Site descriptor	Description
Position (GPS):	244381.969 E, 6293611.902 N (top peg); 244415.1233 E, 6293644.906 N (bottom peg).
Transect compass bearing	045° (top peg)
Position in landscape	Upper slope
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 33°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Stable
Comments	Sandy road through middle. Log emplacement at bottom of slope. Rills recorded during previous monitoring periods currently have a good cover of vegetation and are no longer active while showing signs of self-recovery.

Figure 6 Infiltration, Stability and Nutrients at Site H in 2022



3.2 Trial Site I (straw mulch, cover crop)

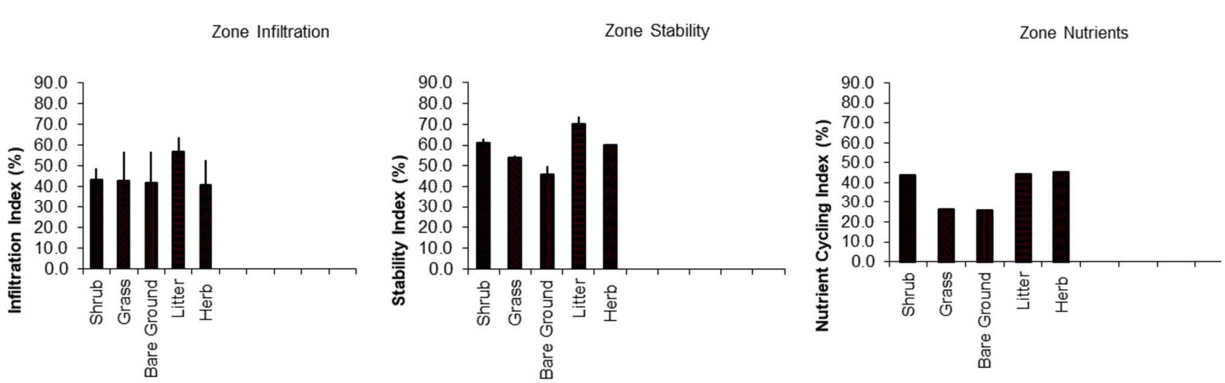
Site I contains a native species mix and was treated with DAP and Lime Gypsum, with straw mulch and cover crop for erosion control. The LFA site description values for Site I are summarised in Table 6. The Site I gradsect was organised into the following five zones: bare ground, grass, herb, shrub and litter. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site I are included in Figure 7. At a score of 5.7, the habitat complexity results (see Appendix D) are good and are at the target habitat value of 4-6, representing a complex habitat system. No rills have been recorded at Site I.

Ground cover protection is moderate to good with only a 16.7% cover of bare ground. Floristic quadrat data for Site I detected 27 flora species, including 26 natives and one exotic. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 6 Site Description Factors at Site I, December 2022

Site descriptor	Description
Position (GPS):	244389.9149 E, 6293596.589 N (top peg). 244431.3003 E, 6293624.415N (bottom peg).
Transect compass bearing	055° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 33°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Stable
Comments	Sandy road through middle. Log emplacement at top and bottom of slope. No rills. Large areas of bare soil. Several Acacia shrubs, mainly Acacia longifolia throughout site are showing signs of poor health and beginning to die.

Figure 7 Infiltration, Stability and Nutrients at Site I in 2022



3.3 Trial Site J (hydro-mulch, cover crop)

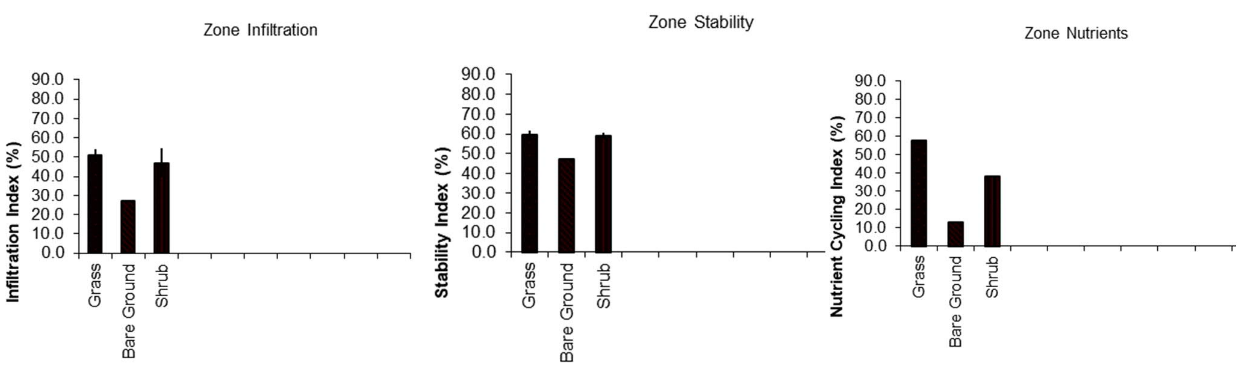
Site J contains a native species mix and was treated with Nitro humus®, with hydro-mulch and cover crop for erosion control. The LFA site description values for Site J are summarised in Table 7. The Site J gradsect was organised into the following four zones: bare ground, grass and shrub. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site J are in Figure 8. At 3.7, the habitat complexity results (see Appendix D) remain below the target habitat value of 4-6. No rills have been recorded at Site J.

Ground cover protection is good with only an 10.5 % cover of bare ground. Floristic quadrat data for Site J detected 29 flora species, including 28 natives and one exotic. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 7 Site Description Factors at Site J, December 2022

Site descriptor	Description
Position (GPS):	244402.2309 E, 6293579.969 N (top peg); 244448.1121 E, 6293597.908 N (bottom peg).
Transect compass bearing	070° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 35°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Very stable
Comments	Soil contains rock and mulch debris. Sandy road through middle with rock wall on high side. Rock riprap along north edge. Log emplacement top and bottom of slope. No rills. Some minor insect attack on tops of leaves.

Figure 8 Infiltration, Stability and Nutrients at Site J in 2022



3.4 Trial Site K (vital polykelp, cover crop)

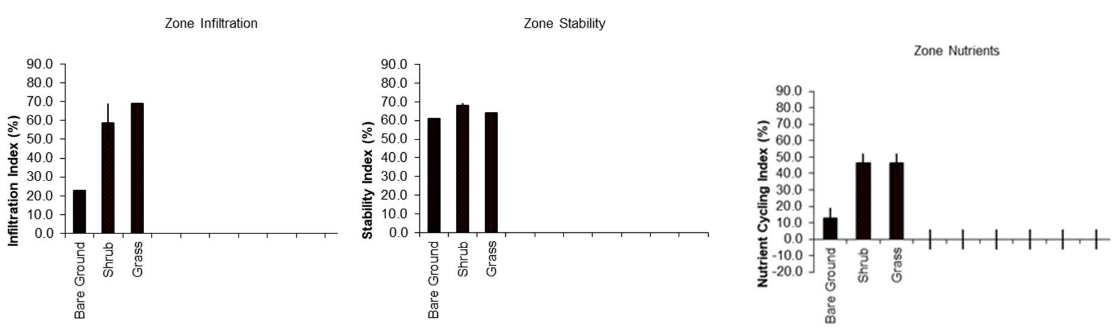
Site K contains a native species mix and was treated with Nitro humus®, with vital polykelp and cover crop for erosion control. The LFA site description values for Site K are summarised in Table 8. The Site K gradsect was organised into the following three zones: bare ground, grass, and shrub. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site K are included in Figure 9. At a score of 5, the habitat complexity results (see Appendix D) are good and are at the target habitat value of 4-6, representing a complex habitat system. No rills have been recorded at Site K.

Ground cover protection is good with only a 6.4 % cover of bare ground. Floristic quadrat data for Site K detected 26 flora species, including 23 natives and three exotics. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 8 Site Description Factors at Site K, December 2022

Site descriptor	Description
Position (GPS):	244402.2309 E, 6293579.969 N (top peg); 244448.1121 E, 6293597.908 N (bottom peg).
Transect compass bearing	070° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 35°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Very stable
Comments	Soil contains rock and mulch debris. Sandy road through middle with rock wall on high side. Rock riprap along north edge. Log emplacement top and bottom of slope. No rills.

Figure 9 Infiltration, Stability and Nutrients at Site K in 2022



3.5 Trial Site L (jute mesh, cover crop)

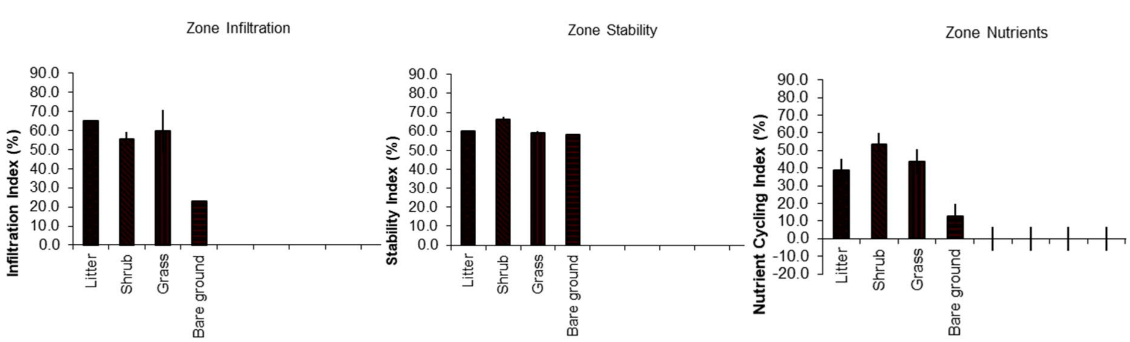
Site L contains a native species mix and was treated DAP, Lime and Nitro humus®, with jute mesh and cover crop for erosion control. The LFA site description values for Site L are summarised in Table 9. The Site L gradsect was organised into the following four zones: bare ground, grass, shrub and litter. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site L are included Figure 10. At a score of 3.7, the habitat complexity results (see Appendix D) remain below the target habitat value of 4-6. No rills have been recorded at Site L.

Ground cover protection is good with only a 3.5 % cover of bare ground. Floristic quadrat data for Site L detected 25 flora species, including 22 natives and three exotics. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 9 Site Description Factors at Site L, December 2022

Site descriptor	Description
Position (GPS):	244419.0146 E, 6293540.394 N (top peg); 244462.9902 E, 6293562.566 N (bottom peg).
Transect compass bearing	062° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019)
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 33°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Very stable
Comments	Sandy road through middle with rock wall on high side. Log emplacement at top and bottom of slope. No rills. Pampas Grass weed established at road edge. Bare strip noted in the past has good cover of grasses and shrubs (Daviesia latifolia and Ozothamnus diosmifolius).

Figure 10 Infiltration, Stability and Nutrients at Site L in 2022



3.6 Trial Site M (vital bon matt stonewall, cover crop)

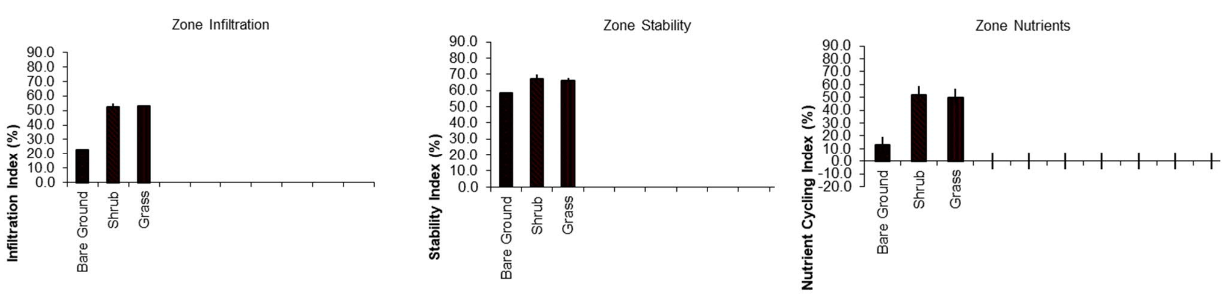
Site M contains a native species mix and was treated DAP, Lime and Nitro humus®, with vital bon matt stonewall and cover crop for erosion control. The LFA site description values for Site M are summarised in Table 10. The Site M gradsect was organised into the following three zones: bare ground, grass, and shrub. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site M are included in Figure 11. At a score of 5, the habitat complexity results (see Appendix D) are good and are at the target habitat value of 4-6, representing a complex habitat system. No rills have been recorded at Site L.

Ground cover protection is good with only a 3.7% cover of bare ground. Floristic quadrat data for Site M detected 24 flora species, including 19 natives and five exotics. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 10 Site Description Factors at Site M, December 2022

Site descriptor	Description
Position (GPS):	244425.6361 E, 6293526.8 N (top peg); 244468.3386 E, 6293548.46 N (bottom peg).
Transect compass bearing	064° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 33°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Stable
Comments	Sandy road through middle. Exposed fill and rock wall on high side of road. Small amount of log emplacement at top and bottom of slope. No rills. Several Acacia shrubs, mainly Acacia longifolia throughout site are showing signs of poor health and beginning to die.

Figure 11 Infiltration, Stability and Nutrients at Site M in 2022



3.7 Trial Site N (no treatment, cover crop)

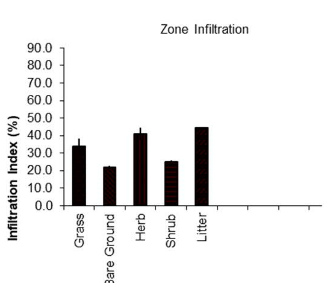
Site N does not contain a native species mix (it will be planted out with native species) and was treated with DAP, Lime and Nitro humus®, with deep ripping and cover crop for erosion control. The LFA site description values for Site N are summarised in Table 11. The Site N gradsect was organised into the following five zones: bare ground, grass, herb, litter and shrub. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for Site N are included in Figure 12. At a score of 4.3, the habitat complexity results (see Appendix D) are good and are at the target habitat value of 4-6, representing a complex habitat system. No rills were recorded at Site N in 2022.

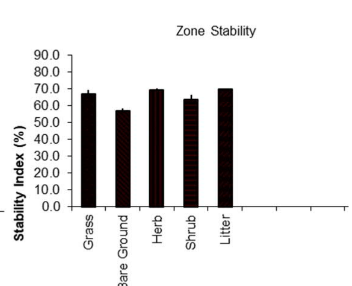
Ground cover protection is good with a 11.8% cover of bare ground. Floristic quadrat data for Site N detected 29 flora species, including 23 natives and six exotics. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

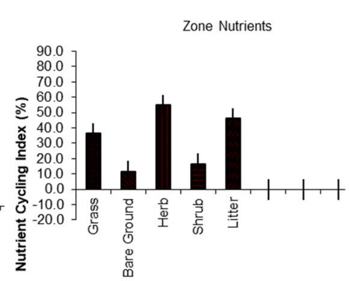
Table 11 Site Description Factors at Site N, December 2022

Site descriptor	Description
Position (GPS)	244436.0081 E, 6293505.556 N (top peg); 244471.4818 E, 6293528.703 N (bottom peg).
Transect compass bearing	058° (top peg)
Position in landscape	Upper
Lithology	Narrabeen Group – quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe and Medlow Bath landscapes. Black/Brown-Orthic Tenosol (SLR 2018b).
Slope	Steep 33°
Aspect	North-east facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest (target).
Land use	Woodland/mine spoil
State of soil surface	Stable
Comments	Sandy road through middle. Non-formed at edge resulting in hard surface. Exposed fill at upper and lower road edge. Rock wall at upper road edge with sediment fence. Minimal log emplacement at top slope. Rills recorded during previous monitoring periods currently have a good cover of vegetation and are no longer active while showing signs of self-recovery. Several Acacia shrubs, mainly Acacia longifolia throughout site are showing signs of poor health and beginning to die.

Figure 12 Infiltration, Stability and Nutrients at Site N in 2022







3.8 MU29 Analogue Site 1

The analogue site (MU29 Analogue 1) is located in an area of native bushland to the north of the Clarence Colliery administration building (see Figure 5). The flora composition conforms to vegetation community MU29 Sandstone Slopes Sydney Peppermint Shrubby Forest (DEC 2006), the target vegetation community of the REA 4 trial plots.

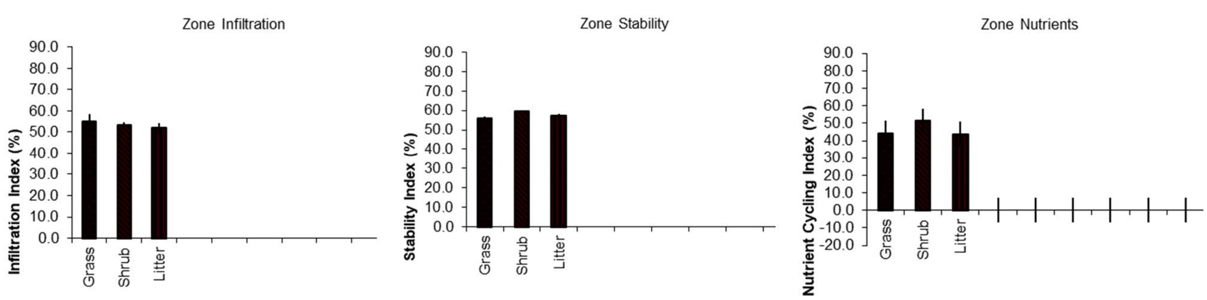
The LFA site description values for MU29 Analogue 1 are summarised in Table 12. The MU29 Analogue 1 gradsect was organised into the following three zones: litter, grass and shrub. The LFA Landscape Organisation data, including photographs representing each patch type is presented in Appendix B. LFA soil surface assessment results are included in Appendix C and the indices (stability, infiltration and nutrient cycling) for MU29 Analogue 1 are included in Figure 13. Habitat complexity results are good and are at the expected score of 8.7, representing a complex habitat system (see Appendix D). The site does not contain rills.

Ground cover protection is very good with a 0.2 % cover of bare ground. Floristic quadrat data for MU29 Analogue 1 detected 31 flora species, all of which are native with no exotic species. Quadrat data for ground cover protection and floristics is included in Appendix E and Appendix F.

Table 12 Site Description Factors at MU29 Analogue 1, December 2022

Site descriptor	Description
Position (GPS)	243830.4573 E, 6294505.716 N (top peg); 243873.8491 E, 6294503.6 N (bottom peg).
Transect compass bearing	100° (top peg)
Position in landscape	Mid slope
Lithology	Narrabeen Group - quartz/quartz-lithic sandstone interbedded with claystone, shale and occasional conglomerate/ironstone (OEH 2019).
Soils	Wollangambe landscapes (OEH 2019).
Slope	NA
Aspect	East southeast facing
Vegetation type	Sandstone Slopes Sydney Peppermint Shrubby Forest.
Land use	Woodland
State of soil surface	Stable
Comments	Analogue site in good condition with minimal exotic coverage and minimal bare ground.

Figure 13 Infiltration, Stability and Nutrients at MU29 Analogue 1 in 2022



4 ANALYSIS AND DISCUSSION

4.1 Ecosystem Function Analysis

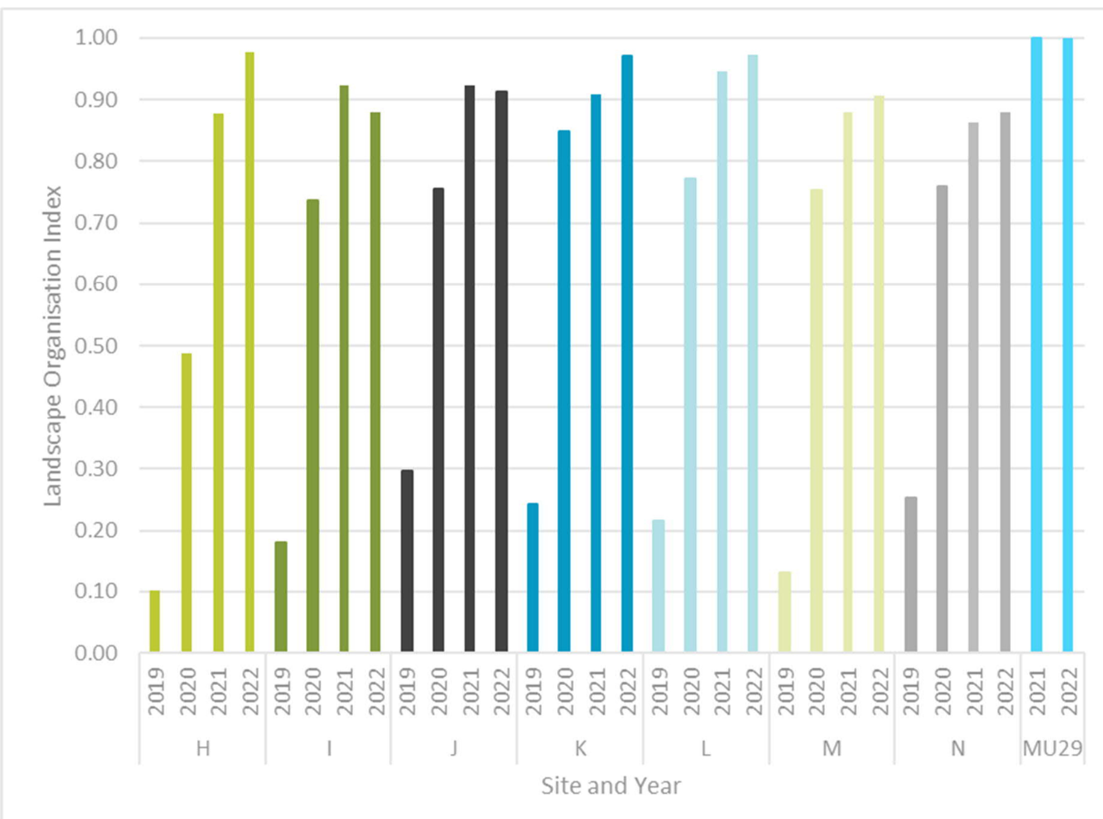
4.1.1 LFA Data Site Comparisons

As described in the MOP (Centennial Coal 2019) the LFA results describe the functionality of the landscape as a biophysical system by providing an assessment of the landscape organisation (through the landscape organisation index and patch area index) and of the soil surface condition (through the soil surface condition indices).

Overall, a soil landscape that is on a trajectory to sustainability in the context of vegetative cover and soil stability would have high landscape organisation index and patch area index values (ie close to one indicating good vegetation cover - while lower values indicate higher occurrence of bare ground) and high soil surface condition indices scores (out of 100) (Centennial Coal 2019).

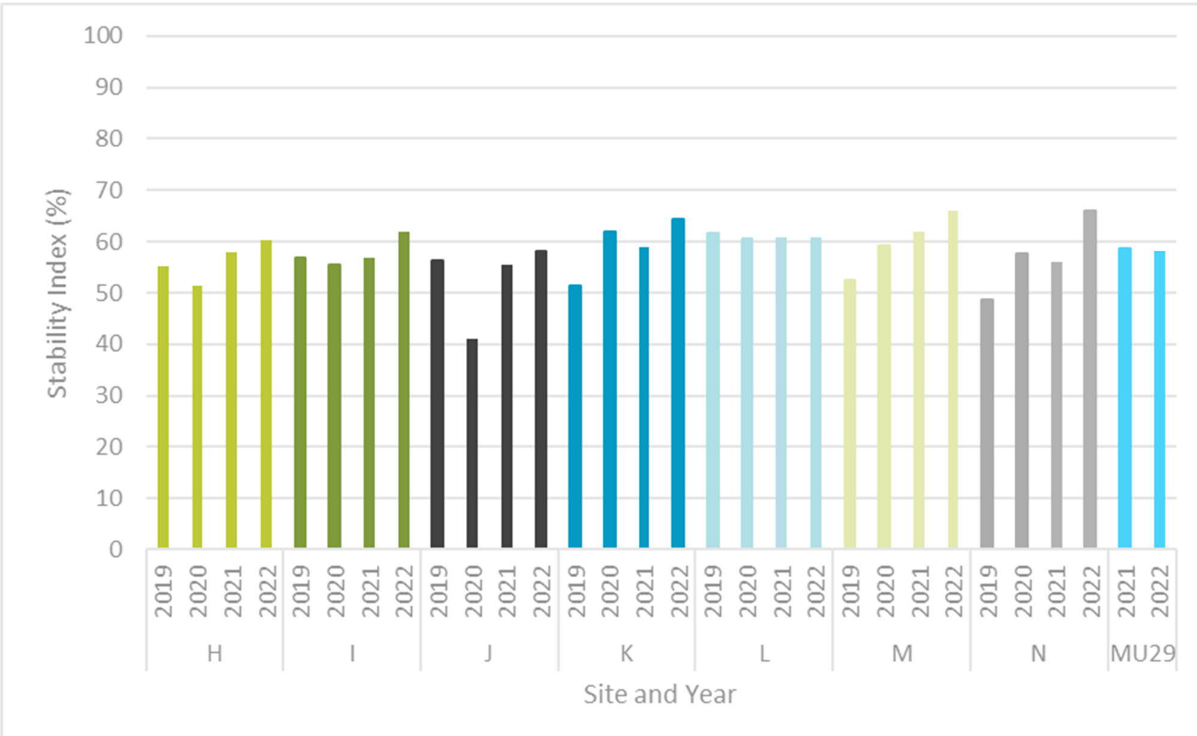
The landscape organisation index has increased substantially since baseline, as presented in Figure 14. With respect to Landscape Organisation, all rehabilitation sites are performing well with Site H (straw mulch) recording the highest at 0.98 and Site N (no treatment, cover crop) and Site I (straw mulch, cover crop) recording the lowest at 0.88. Although all rehabilitation sites performed highly, all are below the landscape organisation index of the analogue site (MU29 Analogue 1) of 1.00.

Figure 14 Landscape Function Analysis: Landscape Organisation Index



The stability index has remained relatively consistent since baseline however, overall declined slightly at site L and increased slightly at H, I, J, K, M and N (Figure 15). With respect to the stability index, Site N (no treatment, cover crop) is currently performing the best at 66.1 %, whilst Site J (hydro-mulch with cover crop) is performing the worst at 58.1 %. While all sites are currently performing slightly better than the analogue site (MU29 Analogue 1).

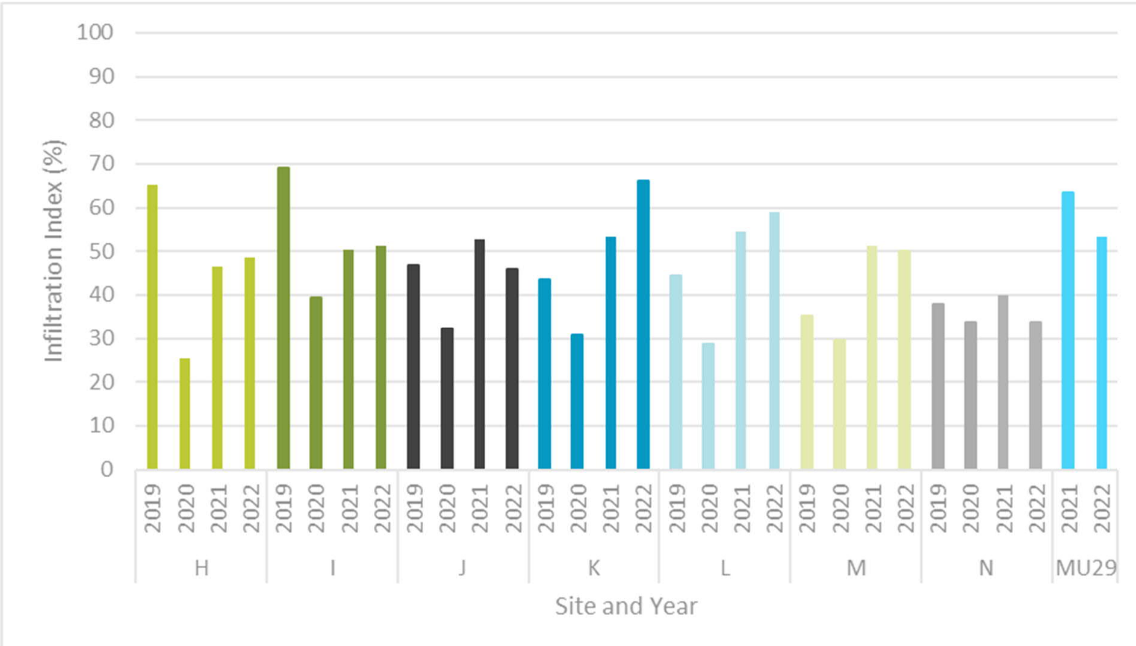
Figure 15 Landscape Function Analysis: Stability Index



The infiltration index has recorded an increase across Sites H, I, K, and L since 2021, however the 2022 results are lower than the previous year's results at Site J, M, and N. Sites H, I, J and N are lower than the baseline results, while Sites K, L and M all recorded higher results than that of the baseline, as presented in Figure 16.

Site K (vital polykelp, cover crop) is currently performing the best with the highest infiltration index of 66.2 %, while Site N (no treatment, cover-crop) is performing the poorest with an infiltration index of 33.7 %. All sites, with the exception of Sites K and L are currently performing poorer than MU29 Analogue 1 (53.3 %). The infiltration index of MU29 Analogue 1 has dropped considerably than that of the 2021 results (63.3%).

Figure 16 Landscape Function Analysis: Infiltration Index



The nutrient cycling index has experienced an overall increase since baseline, but has decreased significantly at most sites, with the exception of Sites H and I, since 2021, as presented in Figure 17. Site I (Straw mulch, cover crop) is currently performing the best with a nutrient cycling index of 64.5 %, whilst Site N (no treatment, cover crop) is performing the poorest with 37.2 %. Site I and M are currently performing better than MU29 Analogue 1 (46.9 %).

Figure 17 Landscape Function Analysis: Nutrient Cycling Index

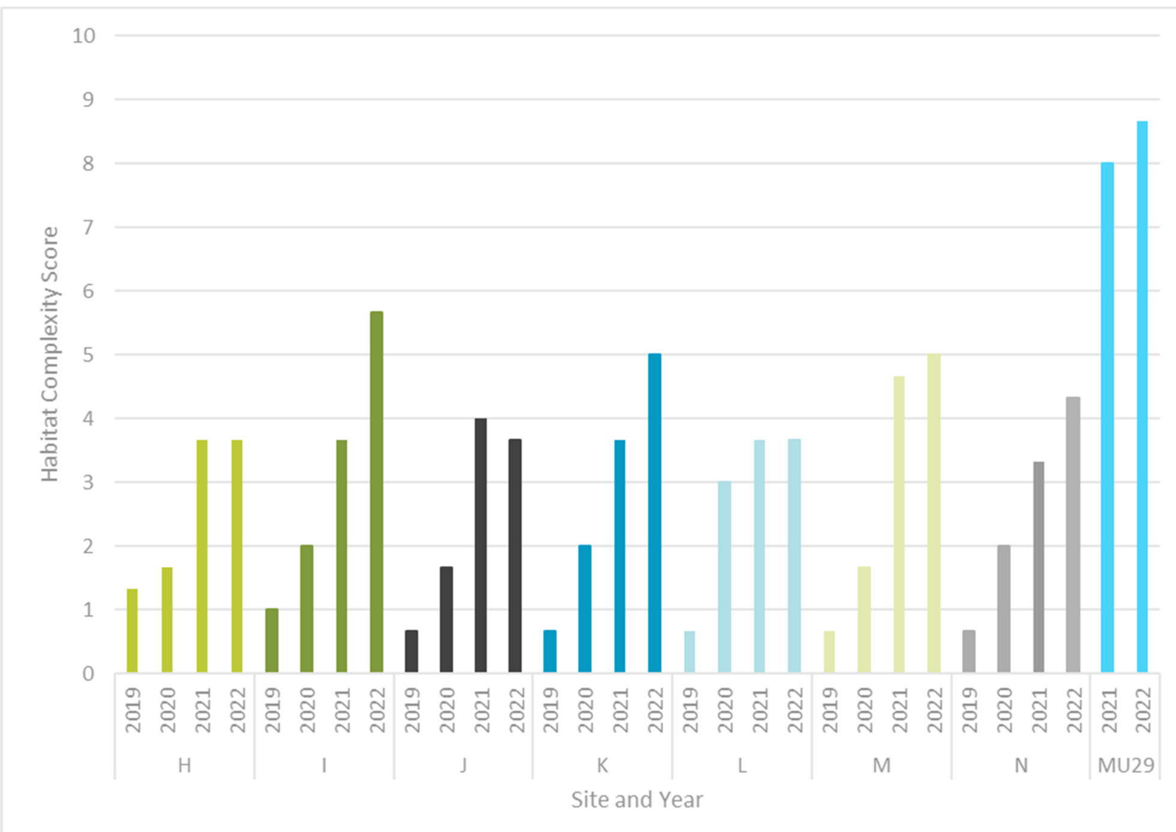
4.1.2 Habitat Complexity

The higher the complexity score, the more macro-habitats are available for flora and fauna in the area. An ecosystem with a habitat complexity score > 8 is generally considered complex and as providing a range of micro-habitats as available to fauna (Centennial Coal 2019).

The habitat complexity continues to increase significantly across all trial plots since the baseline survey. The average habitat complexity score per site ranged from 0.7 to 1.3 at baseline, 1.7 to 3 in 2020, 3.3 to 4.67 in 2021, and is currently ranging between 3.7 at Sites H (straw mulch), J (hydro-mulch, with cover crop), and L (jute mesh with cover crop) and 5.7 at Site I (straw mulch with cover crop). As presented in Figure 18 majority of sites, with the exception of Sites H, J and L all fall within the habitat complexity range (4-6). With a score of 8.7 the analogue site (MU29 Analogue 1) also falls within the “complex habitat” range.

The increase in habitat complexity values can be attributed to increased ground herbage and shrub cover as the plants grow, as well as consideration of the proximity of the dam at sites L-N. Records of zero at 25 m reflect the presence of the road at this interval and this is likely bringing the overall habitat complexity down at each of the rehabilitation sites (Appendix D).

Figure 18 Habitat Complexity



4.1.3 Rill Assessment

There were no rills detected during the 2022 annual monitoring survey. Six rills were detected in the 2021 survey (one at Site N and five at Site H); however all previously recoded rills showed signs of strong recovery, with good revegetation coverage in 2022 and were observed to be no longer active (Photo 2).

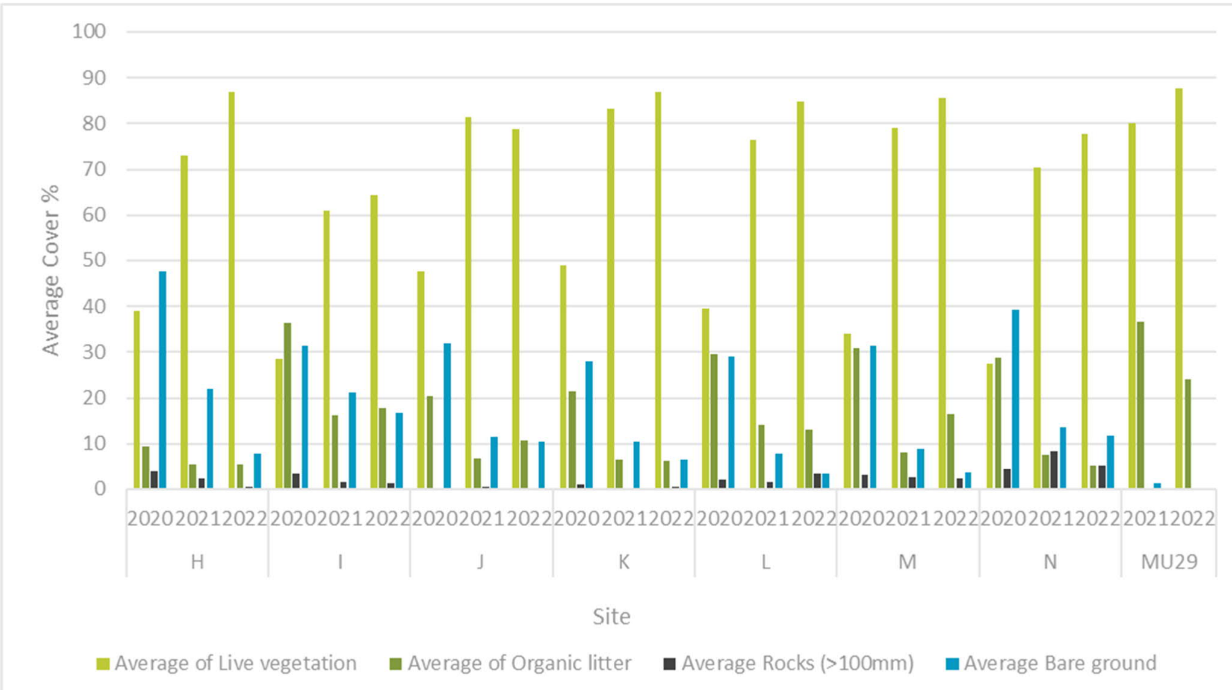
Photo 2 Revegetation assisting the recovery of a former rill at Site H

4.1.4 Groundcover Protection and Floristics

Groundcover protection is moderate to good, with only 3.7 to 16.7 % bare ground recorded across the rehabilitation sites in 2022 (see Figure 19). Live vegetation contributes most highly to groundcover protection, followed by litter and lastly rock. Of the rehabilitation sites, live vegetation cover is currently performing the best at Site H (straw mulch) at 86.9% and the worst at Site I (straw mulch, cover crop) at 64.4 %. The analogue site (MU29 Analogue 1) recorded the highest coverage of litter and the lowest bare ground cover.

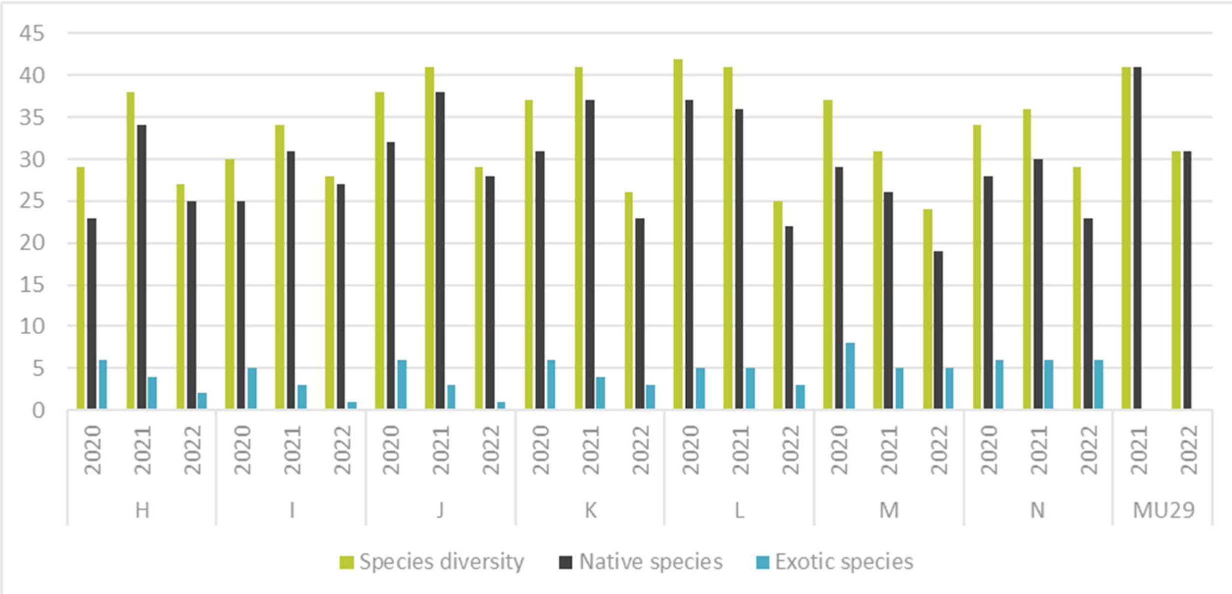
In comparison to the 2021 monitoring event, all rehabilitation sites saw an increase in live vegetation cover and a decrease in bare ground cover, with the exception of Site J that had a slight decrease in live vegetation. Variations in organic litter was seen across each site. Sites H, I, J and M all increased, while Sites K, L, and N all had decreased organic litter values since 2021. A decrease was also shown in rock cover, with the exception of Site K and L which had very minor increases in rock cover (see Figure 19). This is likely due to increases in live vegetation cover meaning that rocks are less obvious, and breakdown of the Millet cover crop.

Figure 19 Groundcover Protection



The diversity of native species is performing well at all rehabilitation sites, with Site H (straw mulch), I (straw mulch with cover crop) and Site J (hydro-mulch with cover crop) performing the best and Site M (vital bon matt stonewall with cover crop) performing the worst (see Figure 20). The diversity of exotic species is fairly consistent, but Site N (no treatment with cover crop) recorded the highest diversity of exotics. The analogue site (MU29 Analogue 1) recorded the highest number of native species (31) and did not record any exotic species. Species diversity has decreased across all rehabilitation sites between 2021 and 2022. However, no site showed an increase in exotic species with sites H, I, J, K and L all recording a significant decrease while sites M and N remain stable (see Figure 20).

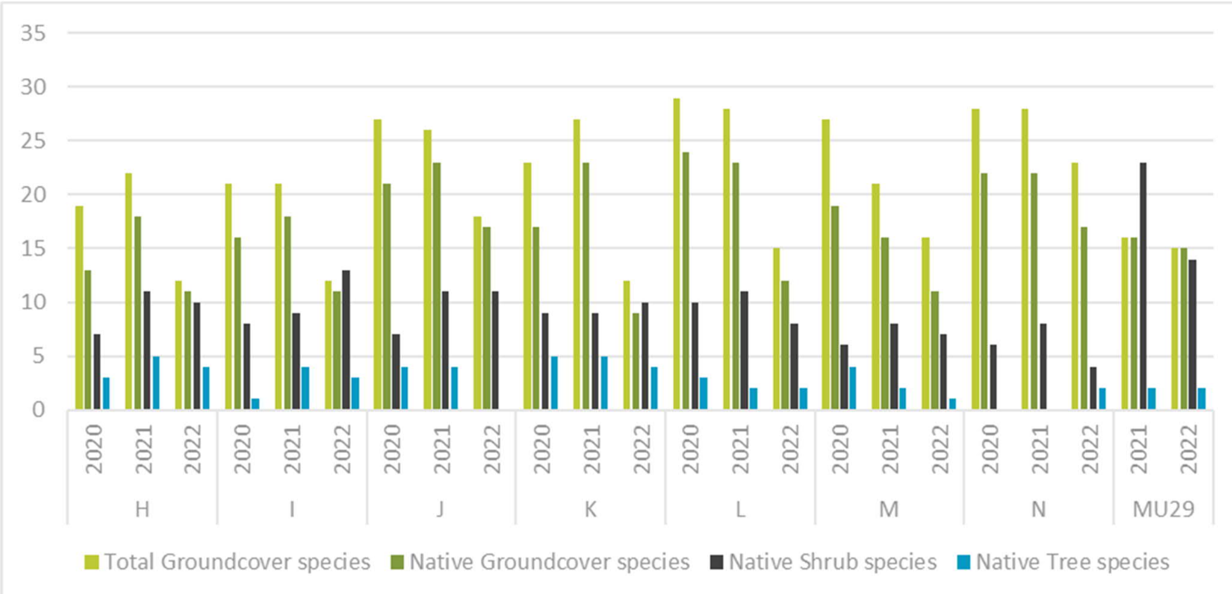
Figure 20 Floristics - Species Diversity



Native species diversity is higher in the groundcover layer, followed by the shrub layer and then tree layer at most of the rehabilitation sites, with the exception of Sites H, I and K that show a higher native species diversity in the shrub layer (see Figure 21). All sites display native trees recorded, with the exception of Site J recording no trees, a decrease since 2021 rehabilitation monitoring. This is the first year since commencement of monitoring that site N (no treatment with cover top) has recorded native trees. The analogue site (MU29 Analogue 1) recorded the highest native species richness within the shrub layer, sites J and N recorded the highest native species richness within the ground layer and sites H and K recorded the highest native species richness with the tree layer. The native species diversity within the ground and tree layers was typically greater at the rehabilitation sites than the analogue site, but the shrub layer diversity was higher at the analogue site.

Diversity of plant species has various increases and decreases across all sites in each stratum between 2021 and 2022 monitoring events. The shrub stratum has seen an increase or remained stable across sites H, I, J and K, and a decrease in site L, M, N and the analogue site MU29. The native groundcover stratum saw a decrease across all sites. While native tree species either decreased or remained stable at most sites, with the exception of site N recording an increase (see Figure 21).

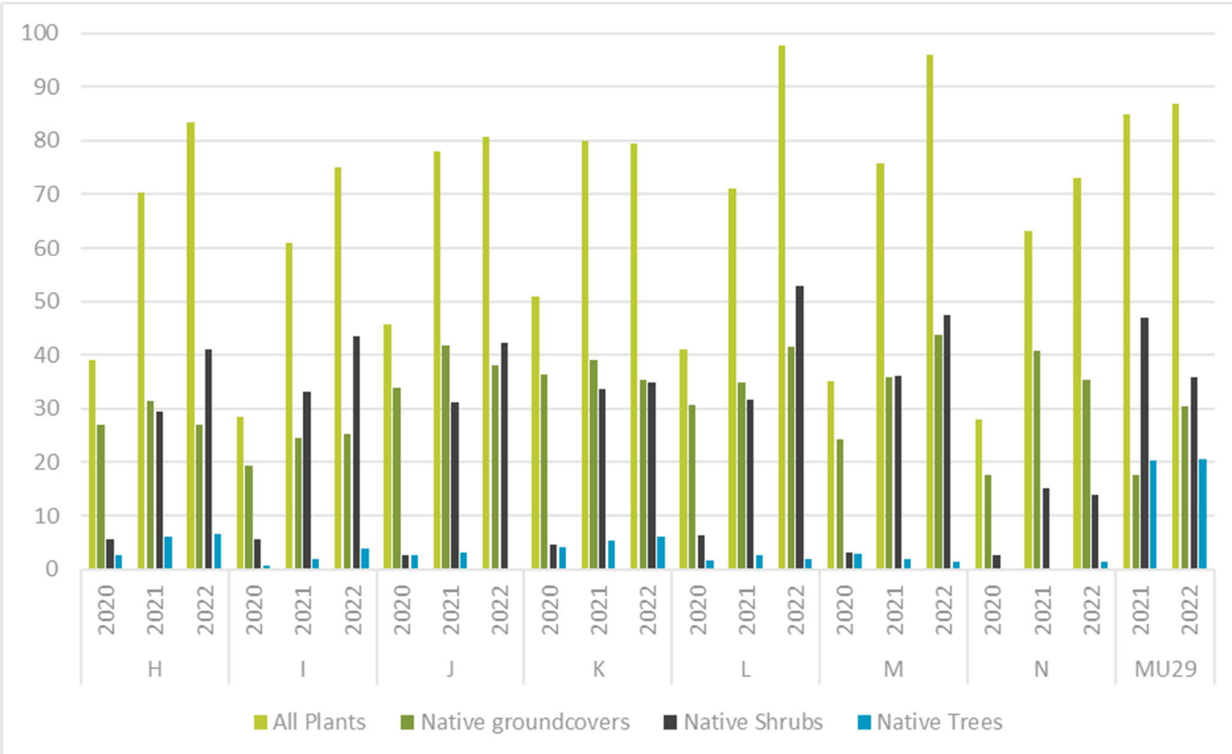
Figure 21 Floristics - Native Species Diversity per stratum



Total plant cover during the 2022 monitoring event across the rehabilitation sites is highest at Site L (jute mesh with cover crop) and lowest at N (no treatment with cover crop) (see Figure 22). Per stratum, shrub cover across most sites saw the highest improvement across all sites, however Site N (no treatment, cover crop) was the lowest at 14 % cover. Native groundcover coverage is mixed with Site M (vital bon matt stonewall with cover crop) recording the highest (44 %) and Site I (straw mulch with cover crop recording the lowest coverage (25 %). Tree cover is low across all sites with Site H (straw much, no cover crop) recording the highest cover (7 %) and Site J scoring the lowest with no trees. Cover at the analogue site (MU29 Analogue 1) is highest within the shrub layer followed by ground cover and trees.

In comparison to the 2021 monitoring event, all rehabilitation sites have shown an increase in total plant coverage along with a major increase in native shrub coverage across most sites. Native groundcover recorded mixed values with a decrease at most sites, with the exception of sites L, M and MU29. Tree cover remained relatively stable with a small increase across most sites, however, Site L (jute mesh with cover crop) and J (hydro mesh with cover crop) showed a minor decrease and a major increase was recorded at Site N (2%) since the commencement of the monitoring (see Figure 22).

Figure 22 Floristics - Percentage Cover per stratum



4.2 Assessment of Overall Performance by Site

Overall Site H (straw mulch without cover crop) performed well with improving scores across most EFA variables. Site H performed the best across landscape organisation and recorded significant increases in performance across the stability index, infiltration index, nutrient cycling score but still low scores for habitat complexity. The site saw a significant increase in performance since 2021 with respect to groundcover protection. Native floristic diversity and cover at Site H were also low to average in comparison to other sites. A significant amount of erosion was previously recorded at Site H, with five rills recorded in 2021. Indeed, Site H was the only site with considerable erosion, and therefore it can be inferred that the cover crop is essential in controlling erosion during the establishment period.

Site I (straw mulch with cover crop) performed slightly poorer than other sites with lower scores for most EFA variables (landscape organisation, infiltration index, habitat complexity), although nutrient cycling was higher than other sites in 2022. Site I recorded the third highest native flora species diversity but the lowest cover. There have been no erosion or rills recorded at Site I since commencement of the monitoring program.

Site J (hydro-mulch with cover crop) performed average in respect to most LFA values and recorded the lowest stability result. However, native floristic species diversity was the highest of the rehabilitation sites, and cover of natives also performed well. There have been no erosion or rills recorded at Site J since commencement of the monitoring program.

Site K (vital polykelp with cover crop) showed good performance with high scores for several LFA attributes (second highest infiltration and third highest stability, nutrient cycling and habitat complexity). The site also performed well in relation to ground cover protection, having the third lowest area of bare ground and one of the highest covers of live vegetation. Native species diversity is the fourth highest, and tree species diversity is the highest diversity on par with Site H. There have been no erosion or rills noted at Site K since commencement of the monitoring program.

Site L (jute mesh with cover crop) performed highly across most LFA scores (second highest in landscape organisation and infiltration) while habitat complexity and floristic values were on par with other sites. Groundcover protection at Site L was the highest of all rehabilitation sites as the site recorded the lowest bare ground cover. There have been no erosion or rills recorded at Site L since commencement of the monitoring program.

Site M (vital bon matt stonewall with cover crop) had strong performance across most LFA scores (second highest stability and nutrient cycling) along with the second highest habitat complexity score and second lowest groundcover protection of all rehabilitation sites. However, the site recorded the lowest diversity of native plant species. There have been no erosion or rills recorded at Site M since commencement of the monitoring program.

Site N (no treatment with cover crop) performed poorly in comparison to other rehabilitation sites, with LFA scores, groundcover protection and native flora cover recording lower scores than most sites. Site N recorded the lowest index for landscape organisation, infiltration and nutrient cycling. Groundcover protection was poor compared to the other sites, with the second highest score for bare ground and lowest score for live vegetation cover. Native species diversity was one of the higher of the rehabilitation sites but there was a lower diversity of shrubs. Native species cover was lower than all other sites however 2022 was the first year to record tree growth. A small rill was previously recorded at the middle of the slope has evidence of self-recovery through the growth of vegetation and is no longer active.

4.3 Assessment of Rehabilitation against MOP Completion Criteria

An assessment of the MOP completion criteria at the time of the 2022 survey is provided in Table 13.

As with any newly established rehabilitation, MOP completion criteria are not likely to be met in the REA 4 trial area at year three of the trial. Over time it is expected that it will be possible to observe trends in results towards MOP completion criteria. However, two completion criteria, being bare ground and reproduction have already been met at all rehabilitation sites, and habitat complexity has been met at Sites I, K, M and N. This indicates that the trial is progressing well.

Table 13 Assessment of Rehabilitation against the MOP Completion Criteria

Completion Criteria	Status
Habitat complexity score is ≥4.0 - ≤6.0.	Met at Sites I, K, M and N.
Species are capable of setting viable seed, flowering or otherwise reproducing. Evidence of second generation of tree/shrub species.	Met at all sites
Evidence of active use of habitat provided during rehabilitation such as nest boxes, and logs and signs of natural generation of shelter sources including leaf litter.	Met at Sites I, J, L, M and N
Nutrient cycling and recycling processes are occurring as evidenced by the presence of a litter layer, mycorrhizae and/or other microsymbionts.	Met at Sites I, J, L, M and N
Continue rehabilitation monitoring until self-sustaining levels are confirmed.	Not met
More than 75% of trees are healthy and growing as indicated by long term rehabilitation monitoring.	Met at all Sites
Rehabilitation monitoring confirms woodland rehabilitation areas provide a range of structural habitats (eg eucalypts, shrubs, ground cover, developing litter layer etc.).	Met at all Sites
Total woody species richness differs 10 - 20% from analogue sites.#	Not met
Less than 40% bare ground cover.	Met at all sites
The dominant species found within rehabilitation sites are found in analogue sites.*	Not met

Source: Table 20 of Clarence Colliery MOP (Centennial Coal 2019)

#Range of species diversity for woody species (ie tree and shrub) target in 2021 is 20 to 22.5.

*Dominant species recorded at the analogue site in 2022 (species that recorded above 2% cover) are Eucalyptus piperita, Eucalyptus radiata Daviesia latifolia, , , Xanthosia pilosa, Acacia longifolia, Banksia spinulosa, Epacris pulchella, Lomatia silaifolia and Grevillea laurifolia. Species recorded at the rehabilitation sites include: Eucalyptus piperita was recorded at Site I only, Eucalyptus radiata was recorded at sites I and K. . Acacia longifolia was recorded at all sites. Lomatia silaifolia was recorded at site K. Grevillea laurifolia was recorded at Site L only.

4.4 Assessment of MOP Rehabilitation Maintenance

The MOP identifies the requirement for rehabilitation maintenance. An assessment of the rehabilitation at the time of the 2022 survey against potential corrective actions from the MOP is provided in Table 14. The assessment has determined that there are no corrective actions required at most sites, and only minor repair of the sediment fence at Site N is required. This is a positive result and indicates that the trial has been well established and is progressing well.

Table 14 Potential Corrective Actions to Consider in Accordance With MOP

Corrective Action	Status
Re-seeding and, where necessary, re-topsoiling and/or the application of specialised treatments such as composted mulch or bio-solids to areas with poor vegetation establishment.	Not required
Installation of tree guards around planted seedlings or construction of temporary fencing suitable for excluding native and feral fauna species should grazing by animals be excessive.	Not required
Replacement of drainage controls if they are found to be inadequate for their intended purpose or compromised by vegetation or wildlife.	Not required
De-silting or repair of sediment control structures.	Site N
Where monitoring indicates the presence of excessive weeds or the potential for noxious weed infestation, necessary precautions to prevent the development of weeds within the rehabilitated areas will be undertaken.	Not required

*Source: Section 7.9 of Clarence Colliery MOP (Centennial Coal 2019)

5 Conclusions and Recommendations

This report presents data collected along a series of gradsects established within each trial plot in accordance with EFA monitoring techniques. Monitoring data collected at year three (2022) has been compared to baseline data from 2019 and data from year one (2020) and year two (2021), enabling comparison of several rehabilitation techniques (growth medium, erosion control and supplementary planting) applied at the seven trial plots.

Results of the surveys suggest that Site K (vital polykelp with cover crop) and Site L (jute mesh, cover crop) are currently performing the best, and Site H (straw mulch without cover crop) and Site N (no treatment, cover crop) are performing the worst.

The EFA data continues to return a strong improvement from the previous results, however, most of the components are below the values required to meet MOP completion criteria. Additionally, the trial plots are generally stable and there are currently minimal remediation actions recommended. The next annual monitoring survey will be required in November-December 2023.

It is recommended that the analogue site is re-surveyed in future annual monitoring events, to allow comparison of results to areas of natural bushland (and target vegetation for the rehabilitation) over time.

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Appendix A:
EFA Methods

A1 LFA SOIL SURFACE ASSESSMENT

A 1.1 Rainsplash protection

The objective is to assess the degree to which physical surface cover and projected plant cover ameliorate the effect of raindrops impacting on the soil surface. Assess the projected percentage cover of perennial vegetation to a height of 0.5 m, plus rocks > 2 cm and woody material > 1 cm in diameter or other long-lived, immoveable objects. These objects intercept and break up raindrops, making them less erosive and less liable to form soil physical crusts. This indicator relates to the Stability Index.

Table A1 Rainsplash protection

Projected cover	Class	Interpretation
1% or less	1	No rainsplash protection
1 to 15%	2	Low rainsplash protection
15 to 30%	3	Moderate rainsplash protection
30 to 50%	4	High rainsplash protection
More than 50%	5	Very high rainsplash protection

A 1.2 Perennial grass basal, tree/shrub canopy cover

The objective is to estimate the "basal cover" of perennial grass and/or the density of canopy cover of trees and shrubs. This indicator assesses the contribution of the below-ground biomass of perennial vegetation in contributing to nutrient cycling and infiltration processes (example). Grass cover is assessed by summing the butt lengths (example) of perennial grass plants in the query zone. Tree and shrub cover is defined from the cover and density of the canopy overhanging the query zone. (McDonald et al, p 66-71 has photo-references). The contribution of annual plants is included under litter.

Table A2 Perennial grass basal tree/shrub canopy cover

Basal and canopy cover	Class	Interpretation
1% or less	1	No below ground contribution
1 to 10%	2	Low below ground contribution
10 to 20%	3	Moderate below ground contribution
More than 20%	4	High below ground contribution

A 1.3 Litter cover, origin & incorporation

The objective is to assess the amount, origin and degree of decomposition of plant litter. "Litter" refers to annual grasses and ephemeral herbage (both standing and detached) as well as detached leaves, stems, twigs, fruit, dung, etc. The position of litter in the overall landscape also assists in defining fertile patches. Plant litter accumulation is strongly related to the carbon, nitrogen and other elements stored in the surface soil layers and acquired by decomposition processes. Note: recent fire usually eliminates litter, temporally disadvantaging the nutrient cycling index as it relies strongly on the litter indicator. Unless the effect of the fire itself is being assessed a period of at least one growing season should elapse before assessing burnt sites. There are three properties of litter that need to be assessed in the following order: the cover; the origin of the litter; and the decomposition.

Table A3 Litter cover

% Cover of plant litter*	Class
<10	1
10-25	2
25-50	3
50-75	4
75-100	5
100 up to 20 mm thick	6
100, 21-70 mm thick	7
100, 70-120 mm thick	8
100, 120-170 mm thick	9
100, > 170 mm thick	10

*When litter is more than 100% cover, the depth is assessed by compressing it with the flat of your hand to remove "air-gaps"

Table A4 Litter transport

Interpretation	Example
Local (l)	derived from plants growing in very close proximity to the query zone and showing no signs of transport/deposition by wind or water flows and transported
Transported (t)	litter has clear signs of being washed or blown to the current location.

Table A5 Litter decomposition

Interpretation	Example
Nil decomposition (n)	the litter is loosely spread on the surface with few signs of decomposition and incorporation.
Slight decomposition (s)	litter is broken down into small fragments and intimately in contact with soil; some fragments may be partially buried.
Moderate decomposition (m)	litter is in several distinct layers; some fungal attack is visible; the layer next to the soil is somewhat humified; some darkening of the soil to a depth of less than 10 mm
Extensive decomposition (e)	litter has at least 3 layers or stages in decomposition ranging from fresh material on top to 20 mm or more of comprehensively humified (very dark, with no identifiable fragments) at the soil-litter interface; mineral soil may have significant organic darkening in excess of 10 mm.

A 1.4 Soil biological crust cover

The objective is to assess the cover of cryptogams visible on the soil surface. "Cryptogam" is a generic term that includes algae, fungi, lichens, mosses and liverworts. Fruiting bodies of mycorrhizas would be included. When these are present, they indicate soil surface stability and elevated levels of available nutrients in the surface layers of soil. They are known to exchange minerals and water with vascular plants in return for carbohydrates.

Typically, they colonise soils with pre-existing stable physical crusts, though not exclusively. They tend to impart flexibility to the physical crust, due to the ramification of hyphae through the surface few mm. Cryptogams may be early colonisers of recovering soil surfaces but may decline as vascular plant cover increases. Typically, they need high light levels to persist and are seldom found under dense, particularly woody, litter. They have been observed under light grassy litter. Open, crusted soils are their typical habitat.

The soil surface may need close inspection to assess the presence of cryptogams. Adding a little water and observing the "greening" of cryptogams over a period of 10 –20 seconds can be very useful. Some cryptogams are "detached" from the soil surface after long periods of desiccation, but cover is assessed normally.

Table A6 Cryptogram cover

Cryptogram cover	Class	Interpretation
Not applicable	0	No stable crust present
1% or less	1	No contribution
1 to 10%	2	Slight contribution
10 to 50%	3	Moderate contribution
More than 50%	4	Extensive contribution

A 1.5 Crust brokenness

The objective is to assess to what extent the surface crust is broken, leaving loosely attached soil material available for erosion. A crust is defined as a physical surface layer that overlies sub-crust material. Soils with physical crusts in good condition are crusts that are smooth and conforms to the gentle undulations in the soil surface. These good condition crusts yield little soil material in a runoff event.

However, crusts can become unstable, brittle and easily disturbed by grazing animals, the materials becoming available for wind or water erosion. Polygonal cracking of the crust without curled edges is not considered broken and scores 4, the maximum value. Typically, sections of crust are lost, forming a micro-crater (example) that may be filled with loose alluvium. Both the area of and severity of broken crust needs to be assessed.

Table A7 Crust brokenness

Crust brokenness	Class
No crust present	0
Crust present but extensively broken	1
Crust present but moderately broken	2
Crust present but slightly broken	3
Crust present but intact, smooth	4

A 1.6 Erosion type & severity

The objective is to assess the type and severity of recent/current soil erosion ie soil loss from the query zone. Erosion in this context refers to accelerated erosion caused by the interaction of management and climatic events, rather than the background levels of geologic erosion.

There are five distinct types of soil erosion that are caused by water and/or wind action. It is useful to note which type or types are active and how serious is the soil loss. This involves both the aerial extent and the severity. The conventions of McDonald et al 1990 p 92-96 are used. A number of images are presented to assist accurate classification. Sometimes the erosion occurred at some time in the past and spontaneous restoration has since taken place. For example; rill edges may be rounded or terracettes may have cryptogam colonisation. In these cases, reduce the severity by one class.

Table A8 Erosion

Class	Severity
1	Severe
2	Moderate
3	Slight
4	Insignificant

A 1.7 Deposited materials

The objective is to assess the nature and amount of alluvium transported to and deposited on the query zone. The presence of soil and litter materials on the query zone indicates the availability for transport of resources from upslope sources in the landscape and implies some instability. Silts, sands and gravels usually comprise the alluvium. Absence does not necessarily imply a lack of deposition, as erosion may sweep all these materials out of the system. Alluvial fans can become quite stable and productive, depending on the stress and disturbance impacting on the surface. An alluvial fan may become a productive patch within a short time if the right seasonal conditions occur. The amount or volume of deposited material is more important than the simple cover.

Hummocking is an indication of the movement large quantities of materials by wind. It is not to be confused with pedestalling which is the eroding away of material around plants and other objects. It is most often associated with adjacent scalding. Hummocking is confined to soils with sandy-textured surface layers and is the result of re-sorting of sand by wind, which accumulates around obstructions, often to depths of many centimetres, or even metres. The soil in the hummock is unconsolidated, and if sectioned reveals layers of accumulated soil (inter-bedding) and/or organic matter. The soil in pedestals is coherent and has no sign of layering. A consequence of hummocking is that fine-grained materials and litter maybe widely dispersed during windy phases and are lost to the system. It is rare in the tropical grasslands.

Table A9 Deposited material

Deposited material	Class
Extensive amount available Greater than 50% cover several cm deep	1
Moderate amount of material available 20 to 50% cover	2
Slight amount of material available 5% to 20% cover	3
None or small amount of material available 0-5% cover	4

A 1.8 Soil surface roughness

The objective is to assess the surface roughness for its capacity to capture and retain mobile resources such as water, propagules, topsoil and organic matter. Surface roughness may be due to soil surface microtopography which retain flowing resources (depressions, gilgais etc) or to high grass plant density such that water flows are highly convoluted at the 5-cm horizontal scale. High surface roughness slows outflow rates, permitting a longer time for infiltration and may comprise a safe site for the lodgement of propagules and litter. Soil surface relief that does not facilitate resource retention attracts low scores. The spatial expression of roughness off the strict line transect may provide context and assist in the assessment. On minesites with bank and trough formations, the depth of the trough is the relevant depth to record (look at the integrity of the trough; if bank broken within 10 metres downgrade class value, according to loss of water holding ability (often this is class 4 or 5).

Table A10 Surface roughness

Surface roughness	Class
<3 mm relief in soil surface smooth	1
Shallow depressions 3-8 mm relief; low retention	2
Deeper depressions 8-25 mm, dense tussock grasslands; moderate retention	3
Deep depressions that have a visible base; large retention	4
Very deep depressions or cracks >100mm; extensive retention	5

A 1.9 Surface resistance to disturbance

The objective is to assess the ease with which the soil can be mechanically disturbed to yield material suitable for erosion by wind or water. This assessment should only be done on dry soil, as all moist soils are soft. All the criteria below assume dry soil. A very hard soil surface implies high mechanical strength, but very low infiltration, due to low porosity and massive crusting or hard setting. This is taken into account by the Excel template which weights the indicator appropriately. Crust flexibility and coherence are assessed, as per the table. Note that classification here is not necessarily intuitive: barren scald surfaces receive a 4.

Table A11 Surface resistance to disturbance

Surface nature	Class	Interpretation
Non -brittle	5	Shows some "springiness" when pressed with finger, typically with A0 layer; or Surface is a self-mulching clay; or Surface has no physical crust and is under a dense perennial grass sward (ie not just an isolated plant).
Crust is very hard and brittle	4	Needs a metal implement to break the surface, forming amorphous fragments or powder. The sub-crust is also very hard, coherent and brittle.
Moderately hard	3	Surface has a physical crust and moderately hard, needing a plastic tool (eg pen-top) to pierce, breaking into amorphous fragments or powder; the sub-crust is coherent.
Easily broken	2	Surface is easily penetrated with finger pressure (to about first knuckle joint). Surface may have a weak physical crust and sub-crust is non-coherent eg sandy.
Loose sandy surface	1	Surface is not crusted, easily penetrated by finger pressure to about second knuckle joint. Sub-surface is non-coherent.

A 1.10 Slake test

The objective of this test is to assess the stability of natural soil fragments to rapid wetting. The test needs to be done on each landscape stratum type identified. Stable soil fragments maintain their cohesion when wet, implying low water erosion potential.

The test is performed by gently immersing air-dry soil fragments of about 1-cm cube size in rainwater and observing the response over a period of a minute or so. Water quality is important. Saline water is unsuitable. The soil crust must remain uppermost after immersion. The fragment can be obtained with a chisel or knife blade, breaking the fragment with the fingers to the appropriate size. Some soils with high organic matter levels may float in the water. Usually, these are stable (Class 4). Soils that do not permit coherent fragments to be picked up and tested (eg loose sands) should be scored as "not applicable" (a zero in the spreadsheet).

Table A12 Slake test

Observed behaviour	Class	Interpretation
Not Applicable	0	No coherent fragments available eg sand
Very unstable	1	Fragment collapses in less than 5 seconds
Unstable	2	Fragment substantially collapses 5-10 seconds; a thin surface crust remains. >50% of the sub-crust material slumps
Moderately stable	3	Surface crust remains intact with some slumping of the sub-crust but less than 50%
Very stable	4	Whole fragment remains intact with no swelling

A 1.11 Texture

The objectives of this test are to classify the texture of the surface soil, and relate this to permeability. This procedure is an initial measurement at the establishment of the site, and does not require being repeated at each monitoring event. It is done with a pedologists' moist bolus test, and a simplified 4 point scale.

The field technique is described by McDonald et al 1990. Take a sample of soil from a depth of 0-5 cm that will comfortably fit into the palm of the hand. Moisten the soil with water, a little at a time, and knead until the ball of soil, so formed, just fails to stick to the fingers. Add more soil or water to attain this condition, known as the sticky point, which approximates field capacity for that soil. Continue kneading and moistening until there is no apparent change in the soil ball, usually 1-2 minutes. The behaviour of the soil ball, or bolus, and the ribbon it produces by pressing out between the thumb and forefinger characterizes the field texture. The flow-chart in figure 33 enables soil texture to be quickly determined.

Table A13 Texture

Texture	Class
Silty clay to heavy clay (very slow infiltration rate)	1
Sandy clay loam to sandy clay (slow infiltration rate)	2
Sandy loam to silt loam (moderate infiltration rate)	3
Sandy to clayey sand (high infiltration rate)	4

A2 HABITAT COMPLEXITY

Visual method for scoring habitat complexity from forest structure for eucalypt dominated forests (adapted from Newsome and Catling, 1979). Habitat complexity is assessed along a 50 m transect line at zero, 25 and 50 m intervals according to Tongway & Hindley (2004). Scores at these points are then averaged to determine the habitat complexity score for the site.

Table A14 Habitat Complexity

Structure score	0	1	2	3
Tree Canopy (%)	0	<30	30-70	>70
Shrub Canopy (%)	0	<30	30-70	>70
Ground Herbage	Sparse <0.5m	Sparse >0.5m	Dense < 0.5m	Dense >0.5m
Logs, rocks, debris etc (%)	0	<30	30-70	>70
Soil Moisture	dry	moist	permanent water adjacent	water-logged

A 3 RILL ASSESSMENT

The technique for rill assessment involves collection of the following data where a rill is observed.

Table A15 Rill assessment

Transect	L/O Transect distance (m)	Start of rill edge (m)	Finish of rill edge (m)	Rill depth (m)	Rill bed nature	Comment

A3 GROUND COVER PROTECTION AND FLORISTICS

Groundcover protection and floristics are assessed within $1m^2$ quadrats placed at 5m intervals along a 50 m transect line (the 'gradsect'). The percentage cover live vegetation (projected), organic litter, rocks >100mm and bare ground are visually estimated. All ground cover species (grasses, forbs, sub-shrubs, etc.) are identified and recorded, and assigned a percentage cover score.

Appendix B:

LFA Organisation Data

Table B1 LFA Landscape Organisation Data for Site H in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.7	30	Patch	Grass
0.7	1.1	50	Interpatch	Bare Ground
1.1	7.2	200	Patch	Shrub
7.2	8.4	100	Patch	Grass
8.4	10.1	500	Patch	Shrub
10.1	14.1	40	Patch	Herb
14.1	15.5	500	Patch	Shrub
15.5	20.4	200	Patch	Grass
20.4	21.2	300	Interpatch	Bare Ground
21.2	22.7	300	Patch	Grass
22.7	25	300	Patch	Herb
25	33	300	Patch	Shrub
33	36.2	200	Patch	Grass
36.2	39.5	200	Patch	Shrub
39.5	43.7	200	Patch	Grass
43.7	50	100	Patch	Shrub

Table B2 LFA Organisation Data for Site H - examples of patches in 2022

Bare ground	Shrub	Herb	Grass
			
21m	8m	25m	40m

Table B3 LFA Landscape Organisation Data for Site I in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.6	70	Patch	Shrub
0.6	2.4	100	Patch	Litter
2.4	4.2	150	Patch	Shrub
4.2	6.4	200	Patch	Litter
6.4	7	200	Patch	Log
7	9.2	80	Patch	Litter
9.2	12.4	150	Patch	Shrub
12.4	13.2	50	Patch	Herb
13.2	16	500	Patch	Shrub
16	16.3	60	Patch	Log
16.3	25.1	500	Patch	Shrub
25.1	25.9	200	Interpatch	Bare Ground
25.9	26.1	200	Interpatch	Log
26.1	28.9	30	Patch	Jute Mesh
28.9	33.6	90	Patch	Shrub
33.6	38.7	100	Patch	Grass
38.7	40.6	40	Patch	Shrub
40.6	41.8	40	Interpatch	Bare Ground
41.8	47.9	200	Patch	Shrub
47.9	49.9	20	Patch	Grass
49.9	50	40	Patch	Herb

Table B4 LFA Organisation Data for Site I - examples of patches in 2022

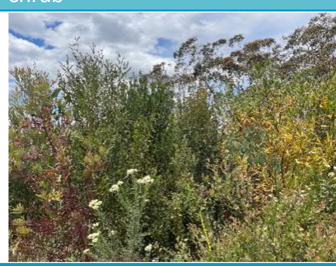
Log	Shrub	Herb	Bare ground
			
7m	10m		25m

Table B5 LFA Landscape Organisation Data for Site J in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	1.5	40	Patch	Grass
1.5	2.1	60	Patch	Shrub
2.1	3.2	60	Patch	Grass
3.2	3.9	60	Patch	Shrub
3.9	4.9	30	Patch	Grass
4.9	5.2	100	Interpatch	Log
5.2	8.5	120	Patch	Shrub
8.5	13.4	70	Patch	Grass
13.4	22.5	300	Patch	Shrub
22.5	23.6	200	Interpatch	Rock
23.6	27.8	200	Interpatch	Bare Ground
27.8	50	500	Patch	Shrub

Table B6 LFA Organisation Data for Site J - examples of patches in 2022

Shrub	Bare ground	Grass
		
30m	25m	3.5m

Table B7 LFA Landscape Organisation Data for Site K in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.1	500	Patch	Shrub
0.1	20.9	200	Patch	Grass
20.9	24.1	2000	Interpatch	Rock
24.1	24.8	200	Interpatch	Bare Ground
24.8	50	500	Patch	Shrub

Table B8 LFA Organisation Data for Site K - examples of patches in 2022

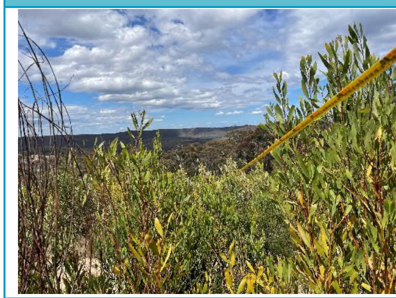
<table>
<tr><th>Shrub</th><th>Grass</th></tr>
<tr><td></td><td></td></tr>
<tr><td>0m</td><td>11.6m</td></tr>
</table>

Table B9 LFA Landscape Organisation Data for Site L in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.4	30	Interpatch	Bare ground
0.4	9.3	500	Patch	Shrub
9.3	13.4	30	Patch	Litter
13.4	15.5	100	Patch	Grass
15.5	18	200	Patch	Shrub
18	21	60	Patch	Grass
21	24	500	Patch	Shrub
24	25.2	500	Interpatch	Rock
25.2	28	500	Interpatch	Bare Ground
28	45	500	Patch	Shrub
45	46.1	100	Patch	Grass
46.1	50	500	Patch	Shrub

Table B10 LFA Organisation Data for Site L - examples of patches in 2022

Litter	Shrub	Bare ground
		
10m	7m	25m

Table B11 LFA Landscape Organisation Data for Site M in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.8	20	Interpatch	Bare Ground
0.8	11.2	400	Patch	Shrub
11.2	18.3	200	Patch	Grass
18.3	22	200	Patch	Shrub
22	23.2	40	Patch	Grass
23.2	24	100	Interpatch	Log
24	26.5	200	Interpatch	Rock
26.5	28.8	200	Interpatch	Bare Ground
28.8	50	500	Patch	Shrub

Table B12 LFA Organisation Data for Site M - examples of patches in 2022

Grass	Rock	Bare ground
		
12m	25m	0m

Table B13 LFA Landscape Organisation Data for Site N in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.9	30	Interpatch	Bare Ground
0.9	2.1	10	Patch	Grass
2.1	2.7	30	Patch	Herb
2.7	3.3	100	Patch	Grass
3.3	3.5	30	Interpatch	Log
3.5	3.9	30	Patch	Herb
3.9	4.1	150	Patch	Log
4.1	8.4	50	Patch	Grass
8.4	9.1	20	Patch	Litter
9.1	11.8	30	Patch	Grass
11.8	14.2	100	Patch	Herb
14.2	19.8	200	Patch	Grass
19.8	25	100	Patch	Herb
25	27.2	150	Patch	Shrub
27.2	27.8	200	Patch	Grass
27.8	29.7	500	Patch	Shrub
29.7	30.9	2000	Interpatch	Rock
30.9	36.5	200	Interpatch	Bare Ground
36.5	39.5	200	Patch	Grass
39.5	41.3	200	Patch	Herb
41.3	42.5	30	Patch	Shrub
42.5	44	20	Patch	Grass
44	50	40	Patch	Herb

Table B14 LFA Organisation Data for Site N - examples of patches in 2022

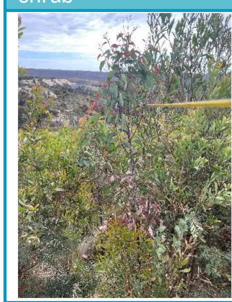
Shrub	Grass	Bare ground
		
25m	3m	0m

Table B15 LFA Landscape Organisation Data for MU29 Analogue 1 in 2022

Patch Start Distance (m)	Patch End Distance (m)	Patch Width (cm)	Patch / interpatch Identity	Notes
0	0.5	100	Patch	Litter
0.5	6.8	80	Interpatch	Tree
6.8	7.8	100	Patch	Litter
7.8	9.4	150	Patch	Shrub
9.4	10.7	100	Patch	Grass
10.7	11.5	100	Patch	Litter
11.5	15.4	200	Patch	Grass
15.4	16.3	100	Patch	Grass
16.3	17.8	80	Patch	Litter
17.8	20.3	100	Patch	Shrub
20.3	23.2	100	Patch	Litter
23.2	27.7	300	Patch	Shrub
27.7	32	100	Patch	Litter
32	35	70	Patch	Grass
35	39.6	200	Patch	Shrub
39.6	39.8	40	Interpatch	Log
39.8	41.4	80	Patch	Litter
41.4	44.1	200	Patch	Shrub
44.1	44.9	100	Interpatch	Log
44.9	46.6	40	Patch	Litter
46.6	47.1	20	Patch	Shrub
47.1	47.8	30	Patch	Litter
47.8	49.3	30	Patch	Grass
49.3	50	80	Interpatch	Tree

Table B16 LFA Organisation Data for MU29 Analogue 1 - examples of patches in 2022

Shrub	Litter
	
25m	7m

Appendix C:

Soil Surface Assessment Data

Table C1 Soil Surface Assessment Data at Site H in 2022

Start Distance (m)	0.7	1.1	7.2	8.4	10.1	14.1	15.5	20.4	21.2	22.7	25	33	36.2	39.5
Notes	G	BG	Sh	Gr	Sh	H	Sh	Gr	BG	G	H	Sh	Gr	Sh
Rainsplash Protection (1-5)	2	1	4	3	4	3	4	3	1	3	2	4	3	4
t/s canopy cover (1-4)	2	2	4	3	3	2	3	2	1	2	2	3	3	3
Litter (1-10)	1	1	2	2	2	3	2	2	1	1	1	2	2	2
Soil Biological crust (0, 1-4)	0	0	1	3	0	4	1	2	0	0	4	1	2	1
Crust broken-ness (0, 1-4)	3	2	3	3	3	3	3	3	2	3	3	3	3	3
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	3	4	4	4	4	4
Deposited materials (1-4)	3	3	3	3	3	3	3	3	2	3	3	3	3	3
Surface Roughness (1-5)	2	2	2	2	2	2	2	2	3	2	2	2	2	2
Resistance to disturbance	4	4	3	3	3	3	3	3	4	3	3	3	3	3
Slake test (0, 1-4)	4	4	4	4	4	4	4	4	4	4	3	3	3	3
Texture (1-4)	3	3	3	4	4	3	3	3	3	3	2	3	3	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass

Table C2 Soil Surface Assessment Data at Site I in 2022

Start Distance (m)	0.6	2.4	4.2	6.4	25.9	33.6	38.7	40.6	41.8	47.9	49.9	50
Notes	Sh	L	Sh	L	BG	Sh	G	Sh	BG	Sh	G	H
Rainsplash Protection (1-5)	3	2	3	2	1	3	2	3	1	3	2	2
t/s canopy cover (1-4)	3	1	3	1	1	3	2	3	1	3	2	1
Litter (1-10)	4	8	3	6	1	1	2	1	2	4	1	1
Soil Biological crust (0, 1-4)	0	0	2	0	0	0	1	0	1	2	1	4
Crust broken-ness (0, 1-4)	3	2	3	2	1	3	3	2	2	3	3	3
Erosion & Severity (1-4)	4	4	4	4	3	4	4	4	4	4	4	4
Deposited materials (1-4)	3	3	3	3	2	3	3	3	3	3	3	3
Surface Roughness (1-5)	3	3	2	3	3	2	2	2	3	2	2	3
Resistance to disturbance	4	4	4	2	3	3	3	3	3	3	3	3
Slake test (0, 1-4)	4	4	4	4	4	4	4	3	4	3	4	4
Texture (1-4)	3	3	3	4	3	4	4	4	4	4	4	4

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass, L = Litter

Table C3 Soil Surface Assessment Data at Site J in 2022

Start Distance (m)	1.5	2.1	3.2	3.9	4.9	8.5	13.4	22.5	27.8	50
Notes	G	Sh	G	Sh	G	Sh	G	Sh	BG	Sh
Rainsplash Protection (1-5)	3	4	3	4	3	3	3	4	1	5
t/s canopy cover (1-4)	3	4	3	4	3	3	3	4	1	4
Litter (1-10)	2	1	4	1	2	4	3	3	1	3
Soil Biological crust (0, 1-4)	2	1	2	1	3	1	3	1	0	1
Crust broken-ness (0, 1-4)	2	3	2	3	0	3	3	2	3	2
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	4	4
Deposited materials (1-4)	3	3	3	3	3	3	3	3	2	3
Surface Roughness (1-5)	2	2	2	2	2	2	2	2	3	2
Resistance to disturbance	4	3	3	3	3	3	3	3	3	3
Slake test (0, 1-4)	2	3	3	3	3	4	4	4	3	4
Texture (1-4)	3	3	3	3	3	3	3	3	4	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass, L = Litter

Table C4 Soil Surface Assessment Data at Site K in 2022

Start Distance (m)	0.1	20.9	24.8	50
Notes	Sh	Gr	BG	Sh
Rainsplash Protection (1-5)	5	4	3	5
t/s canopy cover (1-4)	4	4	2	4
Litter (1-10)	3	4	1	4
Soil Biological crust (0, 1-4)	1	1	0	1
Crust broken-ness (0, 1-4)	0	0	3	0
Erosion & Severity (1-4)	4	4	4	4
Deposited materials (1-4)	4	4	3	4
Surface Roughness (1-5)	1	1	2	1
Resistance to disturbance	4	2	4	2
Slake test (0, 1-4)	4	4	4	4
Texture (1-4)	3	3	3	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass, L = Litter

Table C5 Soil Surface Assessment Data at Site L in 2022

Start Distance (m)	0.4	9.3	13.4	15.5	18	21	25.2	28	45	46.1	0.4	9.3	13.4
Notes	Sh	L	G	Sh	G	Sh	BG	Sh	G	Sh	Sh	L	G
Rainsplash Protection (1-5)	4	4	4	5	3	4	2	4	4	5	4	4	4
t/s canopy cover (1-4)	4	3	3	4	3	4	2	4	4	4	4	3	3
Litter (1-10)	3	4	3	2	2	3	1	4	4	3	3	4	3
Soil Biological crust (0, 1-4)	1	1	1	0	2	0	0	2	1	0	1	1	1
Crust broken-ness (0, 1-4)	1	1	1	0	1	1	4	1	1	0	1	1	1
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	4	4	4	4	4
Deposited materials (1-4)	4	4	4	4	4	4	2	4	4	4	4	4	4
Surface Roughness (1-5)	1	1	1	1	1	1	2	1	1	1	1	1	1
Resistance to disturbance	4	2	3	3	4	4	4	3	1	2	4	2	3
Slake test (0, 1-4)	4	4	4	4	4	4	4	4	4	4	4	4	4
Texture (1-4)	3	3	3	3	3	3	3	3	3	3	3	3	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass, L = Litter

Table C6 Soil Surface Assessment Data at Site M in 2022

Start Distance (m)	0.8	11.2	18.3	22	26.5	28.8	0.8	11.2	18.3	22	26.5
Notes	Sh	G	Sh	G	BG	Sh	Sh	G	Sh	G	BG
Rainsplash Protection (1-5)	5	4	4	4	2	5	5	4	4	4	2
t/s canopy cover (1-4)	4	3	3	3	1	4	4	3	3	3	1
Litter (1-10)	3	4	3	4	1	3	3	4	3	4	1
Soil Biological crust (0, 1-4)	2	2	2	3	0	0	2	2	2	3	0
Crust broken-ness (0, 1-4)	1	1	1	1	3	0	1	1	1	1	3
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	4	4	4
Deposited materials (1-4)	4	4	4	4	3	4	4	4	4	4	3
Surface Roughness (1-5)	1	1	1	1	3	1	1	1	1	1	3
Resistance to disturbance	4	3	3	3	4	3	4	3	3	3	4
Slake test (0, 1-4)	4	4	4	4	4	4	4	4	4	4	4
Texture (1-4)	3	3	3	3	3	3	3	3	3	3	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass, L = Litter

Table C7 Soil Surface Assessment Data at Site N in 2022

Start Distance (m)	2.1	2.7	3.3	3.9	8.4	27.8	29.7	36.5	39.5	41.3	42.5
Notes	G	H	G	H	G	G	Sh	BG	G	H	Sh
Rainsplash Protection (1-5)	3	3	3	3	4	4	3	2	4	4	5
t/s canopy cover (1-4)	3	3	2	3	3	4	3	2	4	3	4
Litter (1-10)	1	2	1	1	4	1	1	1	3	3	1
Soil Biological crust (0, 1-4)	2	4	3	4	4	0	0	0	2	4	1
Crust broken-ness (0, 1-4)	2	3	3	3	3	0	2	4	1	1	0
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	4	4	4
Deposited materials (1-4)	3	3	4	4	4	4	3	2	4	4	4
Surface Roughness (1-5)	1	1	1	1	1	1	3	1	1	1	1
Resistance to disturbance	4	4	4	4	4	4	4	4	4	4	4
Slake test (0, 1-4)	4	4	4	4	4	4	4	4	4	4	4
Texture (1-4)	3	3	3	3	3	3	3	3	3	3	3

BG = Bare ground, Sh = Shrub, H = Herb, G = Grass

Table C8 Soil Surface Assessment Data at MU29 Analogue 1 in 2022

Start Distance (m)	0.5	7.8	9.4	10.7	11.5	27.7	32	35	39.6	41.4	44.1	46.6
Notes	L	L	Sh	G	L	Sh	L	G	Sh	L	Sh	L
Rainsplash Protection (1-5)	2	2	3	3	2	4	3	3	4	3	4	3
t/s canopy cover (1-4)	3	2	3	2	2	3	3	3	3	3	4	3
Litter (1-10)	6	6	5	4	6	4	5	4	5	6	5	5
Soil Biological crust (0, 1-4)	2	1	3	1	1	1	1	1	1	1	1	1
Crust broken-ness (0, 1-4)	1	1	1	0	1	1	1	1	1	1	1	1
Erosion & Severity (1-4)	4	4	4	4	4	4	4	4	4	4	4	4
Deposited materials (1-4)	3	3	3	3	3	3	3	3	3	3	3	3
Surface Roughness (1-5)	2	2	2	2	2	2	2	2	2	2	2	2
Resistance to disturbance	3	3	3	3	3	3	3	3	3	3	3	3
Slake test (0, 1-4)	3	2	2	3	3	3	3	3	3	3	3	3
Texture (1-4)	3	3	3	3	3	3	3	3	3	3	3	3

BG = Sh = Shrub, H = Herb, L = Litter

Appendix D:
Habitat Complexity Data

Table D1 Habitat Complexity Data for All Sites in 2021

Site	Distance (m)	Tree Canopy (%)	Shrub Canopy (%)	Ground Herbage	Logs, rocks, debris (%)	Soil Moisture	Total	Average
LFA H	0	0	1	0	1	0	2	3.67
	25	0	1	2	1	0	4	
	50	0	3	0	2	0	5	
LFA I	0	0	3	0	3	0	6	5.67
	25	0	3	1	1	0	5	
	50	0	2	3	1	0	6	
LFA J	0	0	3	1	1	0	5	3.67
	25	0	0	0	1	0	1	
	50	0	3	0	2	0	5	
LFA K	0	0	3	0	3	0	6	5.00
	25	0	1	0	2	0	3	
	50	0	3	0	3	0	6	
LFA L	0	0	3	0	1	0	4	3.67
	25	0	1	0	2	0	3	
	50	0	3	0	1	0	4	
LFA M	0	0	3	1	1	0	5	5.00
	25	0	1	1	3	0	5	
	50	0	3	1	1	0	5	
LFA N	0	0	1	1	1	0	3	4.33
	25	0	2	2	1	0	5	
	50	0	2	2	1	0	5	
MU29 Analogue 1	0	2	2	0	3	1	8	8.67
	25	3	3	0	3	1	10	
	50	3	1	0	3	1	8	

Appendix E:
Ground Cover Protection Data

Table E1 Groundcover Protection at LFA H in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	90	80	95	70	95	95	90	86	86	82	86.9
Organic litter	5	10	10	5	2	3	7	4	5	5	5.6
Rocks (>100mm)	0	0	0	0	0	0	0	0	0	5	0.5
Bare ground	5	10	3	25	3	2	3	10	9	8	7.8

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E2 Groundcover Protection at LFA I in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	40	73	82	60	45	66	73	80	98	27	64.4
Organic litter	50	25	18	35	5	2	7	10	2	23	17.7
Rocks (>100mm)	0	0	0	0	5	2	5	0	0	0	1.2
Bare ground	10	2	0	5	45	30	15	10	0	50	16.7

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E3 Groundcover Protection at LFA J in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	60	65	95	100	22	86	91	95	100	75	78.9
Organic litter	35	30	3	0	0	14	9	5	0	10	10.6
Rocks (>100mm)	0	0	0	0	0	0	0	0	0	0	0
Bare ground	5	5	2	0	78	0	0	0	0	15	10.5

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E4 Groundcover Protection at LFA K in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	100	100	100	80	38	95	87	88	80	100	86.8
Organic litter	0	0	0	20	5	5	13	10	10	0	6.3
Rocks (>100mm)	0	0	0	0	5	0	0	0	0	0	0.5
Bare ground	0	0	0	0	52	0	0	2	10	0	6.4

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E5 Groundcover Protection at LFA L in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	78	100	87	76	60	83	95	80	88	100	84.7
Organic litter	30	30	10	14	5	7	20	5	10	0	13.1
Rocks (>100mm)	0	0	0	0	35	0	0	0	0	0	3.5
Bare ground	0	0	3	10	0	10	0	10	2	0	3.5

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E6 Groundcover Protection at LFA M in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	100	77	85	69	56	83	100	85	100	100	85.5
Organic litter	50	10	10	25	20	5	30	15	0	0	16.5
Rocks (>100mm)	0	3	0	0	20	0	0	0	0	0	2.3
Bare ground	0	10	5	6	4	12	0	0	0	0	3.7

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E7 Groundcover Protection at LFA N in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	80	70	87	85	92	57	40	89	83	93	77.6
Organic litter	5	5	5	10	5	5	5	9	2	2	5.3
Rocks (>100mm)	5	5	3	0	0	35	0	0	0	5	5.3
Bare ground	10	20	5	5	3	3	55	2	15	0	11.8

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table E8 Groundcover Protection at MU29 Analogue 1 in 2022

	1	2	3	4	5	6	7	8	9	10	Av
Live vegetation	78	70	85	53	199	65	86	90	77	75	87.8
Organic litter	23	30	15	47	20	35	14	10	21	25	24
Rocks (>100mm)	0	0	0	0	0	0	0	0	0	0	0
Bare ground	0	0	0	0	0	0	0	0	2	0	0.2

1-10 = ground protection data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average

Appendix F:
Floristic Data

Table F1 Floristic data at LFA H in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	10	0	0	10	0	0	0	20	25	6.5
N	N	Acacia paradoxa	0	0	0	0	0	0	5	0	0	0	0.5
N	N	Acacia rubida	40	0	60	0	0	60	40	30	0	0	23
E	N	Aira caryophyllea	0	0	0	0	70	0	0	0	0	0	7
N	Y	Allocasuarina nana	5	0	0	5	0	0	0	3	5	5	2.3
N	Y	Amperea xiphoclada	0	0	0	5	0	0	0	0	0	0	0.5
N	N	Austrostipa pubescens	0	0	0	5	0	0	0	10	10	0	2.5
N	N	Billardiera scandens	0	0	0	5	0	0	0	0	0	0	0.5
N	N	Cassina aculeata	0	0	5	10	0	0	5	0	5	0	2.5
N	Y	Daviesia latifolia	0	30	0	0	0	0	0	0	0	0	3
N	Y	Entolasia stricta	10	0	3	0	3	5	5	3	0	5	3.4
N	Y	Eucalyptus dalrympleana	0	0	0	0	0	0	0	5	0	0	0.5
N	Y	Eucalyptus dives	0	0	0	5	0	0	0	0	15	5	2.5
N	Y	Eucalyptus mannifera	0	5	0	5	0	0	0	0	0	0	1
N	N	Gonocarpus teucrioides	0	0	2	0	0	0	0	1	0	0	0.3
N	Y	Hakea dactyloides	0	0	0	0	0	0	0	30	30	0	6
N	Y	Hakea pachyphylla	0	0	0	10	0	10	0	0	0	10	3
N	N	Hydrocotyle laxiflora	0	0	0	0	0	0	0	0	0	2	0.2
E	N	Hypochaeris radicata	0	2	0	2	2	0	5	2	0	5	1.8
N	N	Isopogon spp.	0	0	0	0	0	0	5	0	0	0	0.5
N	N	Juncus continuus	0	0	0	5	5	0	0	0	0	0	1
N	N	Leptospermum continentale	0	0	0	0	0	0	0	0	0	5	0.5
N	Y	Leptospermum polygalifolium	0	0	0	5	0	0	0	2	5	0	1.2
N	N	Lomandra longifolia	5	3	5	3	0	0	0	0	0	5	2.1
N	Y	Poa labillardierei	0	0	0	0	5	0	10	0	0	5	2
N	Y	Poa sieberiana	30	30	20	15	0	20	10	0	10	10	14.5
N	Y	Rytidosperma erianthum	0	0	0	0	0	0	5	0	0	0	0.5
N	N	Wahlenbergia gracilis	0	0	0	0	0	0	0	0	1	0	0.1

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F2 Floristic data at LFA I in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	0	40	0	0	0	0	0	0	0	4
N	N	Acacia paradoxa	0	0	0	0	0	0	0	5	0	0	0.5
N	Y	Acacia terminalis	0	0	0	0	0	15	0	0	0	0	1.5
N	N	Acacia rubida	0	40	10	0	0	0	40	0	75	0	16.5
N	Y	Allocasuarina nana	0	2	5	0	0	0	5	0	0	0	1.2
N	N	Aspersula conferta	0	0	0	0	0	1	0	0	0	0	0.1
N	Y	Amperea xiphoclada	5	2	0	3	5	5	3	3	3	0	2.9
N	N	Austrostipa pubescens	5	0	0	0	10	0	0	0	0	0	1.5
N	N	Billardiera scandens	0	0	0	0	0	5	0	5	0	0	1
N	N	Cassina aculeata	0	0	0	10	2	5	0	1	5	5	2.8
N	Y	Entolasia stricta	0	0	0	5	0	5	3	3	0	3	1.9
N	Y	Eucalyptus dalrympleana	0	0	0	0	0	0	0	3	0	0	0.3
N	Y	Eucalyptus piperita	0	5	0	0	0	0	0	25	0	0	3
N	Y	Eucalyptus radiata	0	5	0	0	0	0	0	0	0	0	0.5
N	N	Gonocarpus teucrioides	0	2	0	0	0	0	0	5	0	1	0.8
N	Y	Hakea dactyloides	0	0	10	10	0	0	0	15	0	0	3.5
N	Y	Hakea pachyphylla	0	0	0	0	5	0	0	0	0	0	0.5
E	N	Hypochaeris radicata	5	1	0	5	3	5	5	0	0	1	2.5
N	N	Juncus continuus	0	0	0	0	0	0	0	5	0	5	1
N	N	Lachnagrostis filiformis	0	0	0	0	0	0	0	0	0	2	0.2
N	Y	Leptospermum polygalifolium	0	1	0	10	0	0	0	0	0	0	1.1
N	N	Lomandra filiformis	0	0	0	0	3	0	0	0	0	0	0.3
N	Y	Lomandra longifolia	5	0	2	5	2	0	5	3	0	5	2.7
N	N	Platysace linearifolia	0	0	0	0	0	5	0	0	0	0	0.5
N	Y	Poa sieberiana	20	15	25	15	0	0	19	19	15	5	13.3
N	Y	Rytidosperma erianthum	0	0	0	0	1.5	20	0	0	0	0	2.15

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F3 Floristic data at LFA J in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	0	0	50	0	10	0	25	0	0	8.5
N	Y	Acacia terminalis	0	0	20	10	0	0	0	0	0	5	3.5
N	N	Acacia paradoxa	0	10	0	0	0	0	0	0	0	0	0.5
N	N	Acacia rubida	0	0	0	0	0	10	60	5	40	0	16.5
N	Y	Allocasuarina nana	0	2	0	0	0	0	0	0	0	0	0.2
N	Y	Amperea xiphoclada	2	0	3	0	0	0	0	0	0	0	0.5
N	N	Austrostipa pubescens	0	0	2	0	0	0	0	0	0	0	0.2
N	Y	Austrostipa scabra subsp. falcata	0	0	0	5	0	0	0	0	0	0	0.5
N	N	Billardiera scandens	0	0	0	0	0	1	1	0	0	0	0.2
N	N	Cassina aculeata	15	0	30	10	0	0	10	0	0	20	8.5
N	N	Coronidium waddelliae	0	0	2	0	0	0	0	0	0	0	0.2
N	N	Cynodon dactylon	0	3	0	0	0	0	0	0	0	0	0.3
N	Y	Daviesia latifolia	0	0	5	0	3	0	5	5	0	0	1.8
N	Y	Entolasia stricta	3	2	5	0	3	0	0	0	0	0	1.3
N	N	Euchiton involucratus	0	0	1	0	0	0	0	0	0	0	0.1
N	N	Geranium homeanum	0	0	5	0	0	0	0	0	0	0	0.5
N	N	Gonocarpus micranthus	0	0	0	0	1	0	0	0	0	0	0.1
N	N	Gonocarpus teucrioides	0	2	0	0	0	0	0	0	0	0	0.2
N	Y	Hakea dactyloides	0	0	0	5	0	5	5	0	0	0	1.5
N	N	Hydrocotyle laxiflora	0	0	2	0	0	0	0	0	0	0	0.2
E	N	Hypochaeris radicata	2	1	0	0	0	0	0	0	0	0	0.3
N	N	Juncus continuus	20	0	5	0	0	0	0	0	0	0	2.5
N	N	Lachnagrostis filiformis	0	0	0	0	5	0	0	0	0	0	0.5
N	Y	Leptospermum continentale	0	0	0	5	0	0	0	0	0	10	1.5
N	Y	Leptospermum polygalifolium	3	10	0	0	0	0	0	0	5	0	1.8
N	Y	Lomandra longifolia	5	5	0	0	0	0	0	0	0	0	1
N	Y	Poa labillardierei	0	0	5	0	0	60	0	55	53	35	20.8
N	Y	Poa sieberiana	10	30	10	15	0	0	10	0	0	0	7.5
N	N	Veronica plebeia	0	0	0	1	10	0	0	5	0	5	2.1

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F4 Floristic data at LFA K in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	15	0	0	0	0	0	20	0	60	9.5
N	N	Acacia paradoxa	0	5	0	0	0	0	0	0	0	0	0.5
N	N	Acacia spp	15	0	20	0	0	60	25	0	10	0	0.5
N	Y	Amperea xiphoclada	0	0	0	0	0	0	0	8	0	0	0.8
N	N	Cassina aculeata	25	20	20	0	0	5	10	30	0	0	11
E	N	Conyza bonariensis	0	0	0	0	5	0	0	0	0	0	0.5
N	Y	Daviesia latifolia	10	5	0	0	0	0	0	0	0	0	1.5
N	N	Dianella caerulea	0	0	0	0	0	5	0	0	0	0	0.5
N	Y	Entolasia stricta	0	0	0	0	3	0	5	0	0	0	0.8
N	Y	Eucalyptus dalrympleana	0	0	0	0	0	0	0	10	0	0	1
N	Y	Eucalyptus mannifera	0	5	0	0	0	0	0	0	0	0	0.5
N	Y	Eucalyptus oreades	0	0	15	0	0	0	0	0	0	0	1.5
N	Y	Eucalyptus radiata	0	25	5	0	0	0	0	0	0	0	3
N	N	Euchiton involucratus	0	0	0	0	0	0	0	0	0	5	0.5
E	N	Gamochaeta purpurea	0	0	0	0	5	0	0	0	0	0	0.5
N	N	Geranium homeanum	0	0	0	0	0	0	0	0	25	0	2.5
N	Y	Hakea dactyloides	0	0	0	0	0	10	0	0	10	0	2
N	N	Hydrocotyle laxiflora	0	0	0	0	0	0	2	0	0	0	0.2
E	N	Hypochaeris radicata	0	0	0	0	25	0	0	0	0	0	2.5
N	Y	Leptospermum continentale	10	0	10	0	10	0	10	0	20	0	6
N	Y	Leptospermum polygalifolium	0	0	10	0	0	0	0	0	10	0	2
N	Y	Lomandra longifolia	0	0	0	0	0	0	5	0	0	0	0.5
N	N	Lomatia silaifolia	0	0	0	10	0	0	0	0	0	0	1
N	Y	Poa labillardierei	40	30	20	0	0	15	30	10	30	40	21.5
N	Y	Poa sieberiana	0	0	0	70	0	0	0	10	0	0	8
N	N	Veronica plebeia	0	0	0	0	0	0	0	3	0	5	0.8

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F5 Floristic data at LFA L in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	20	50	5	0	0	5	60	10	60	20	23
N	Y	Acacia terminalis	5	0	0	0	0	0	0	0	0	0	0.5
N	Y	Allocasuarina nana	3	0	0	0	0	0	0	0	0	0	0.3
N	N	Cassina aculeata	10	15	10	15	35	10	0	0	0	30	12.5
E	N	Centaurium erythraea	0	0	0	0	0	0	0	5	0	0	0.5
E	N	Conyza bonariensis	0	1	0	2	0	0	0	0	2	0	0.5
N	Y	Daviesia latifolia	5	0	0	0	0	15	0	0	0	0	2
N	Y	Eucalyptus mannifera	0	0	0	0	0	0	5	0	0	0	0.5
N	Y	Eucalyptus oreades	0	0	0	0	0	0	10	5	0	0	1.5
N	N	Euchiton involucratus	0	0	0	5	0	3	0	0	0	0	0.8
N	N	Euchiton sphaericus	0	0	0	0	0	0	0	0	1	0	0.1
N	N	Geranium homeanum	0	0	2	0	0	0	0	5	0	0	0.7
N	N	Grevillea laurifolia	0	0	0	0	5	0	0	0	0	0	0.5
N	Y	Hakea laevipes	0	0	0	0	0	0	0	0	10	0	1
N	N	Hydrocotyle laxiflora	5	0	0	0	0	0	0	0	0	0	0.5
E	N	Hypochaeris radicata	0	0	0	2	0	0	0	0	0	0	0.2
N	Y	Leptospermum continentale	0	0	0	2	0	0	0	15	0	20	3.7
N	Y	Leptospermum polygalifolium	5	0	10	20	15	10	10	20	5	5	10
N	Y	Lomandra longifolia	0	0	0	5	0	0	0	0	0	0	0.5
N	Y	Poa labillardierei	0	20	60	15	0	0	10	20	10	25	16
N	Y	Poa sieberiana	25	5	0	10	0	10	0	0	0	0	5
N	N	Pteridium esculentum	0	0	0	0	0	0	0	5	0	0	0.5
N	Y	Rytidosperma erianthum	0	0	0	0	5	30	0	0	0	0	3.5
N	N	Veronica plebeia	0	10	0	0	0	0	0	0	0	0	1
N	N	Viola hederacea	10	15	10	15	35	10	0	0	0	30	12.5

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F6 Floristic data at LFA M in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	80	0	0	0	0	0	50	30	60	50	27
N	Y	Acacia terminalis	20	0	0	0	0	0	0	5	0	0	2.5
N	N	Austrostipa pubescens	0	0	0	0	0	3	0	0	0	0	0.3
N	N	Cassina aculeata	0	10	20	0	0	0	20	0	0	0	5
E	N	Centaurium erythraea	0	0	0	2	0	0	0	0	0	0	0.2
E	N	Conyza bonariensis	0	0	0	3	0	0	0	0	0	0	0.3
N	Y	Daviesia latifolia	5	0	0	0	0	30	10	10	0	0	5.5
N	Y	Entolasia stricta	0	0	0	0	3	0	0	0	0	0	0.3
N	Y	Eucalyptus oreades	0	5	0	0	0	0	0	10	0	0	1.5
N	N	Euchiton involucratus	0	2	0	2	0	0	0	0	0	0	0.4
E	N	Gamochaeta purpurea	0	0	0	2	0	0	0	0	0	0	0.2
N	N	Geranium homeanum	0	0	0	5	0	0	0	0	0	0	0.5
N	N	Gonocarpus teucrioides	0	5	0	0	0	0	0	0	0	0	0.5
N	Y	Hakea laevipes	0	15	0	0	0	0	0	0	0	0	1.5
E	N	Hypochaeris radicata	0	0	0	0	15	0	0	0	0	0	1.5
N	N	Lachnagrostis filiformis	0	0	0	0	2	0	0	0	0	0	0.2
N	Y	Leptospermum polygalifolium	0	10	0	15	20	0	0	0	0	0	4.5
N	Y	Lomandra longifolia	0	15	0	5	0	0	0	0	0	0	2
N	Y	Poa labillardierei	20	20	60	30	0	0	0	0	0	0	13
N	Y	Poa sieberiana	0	5	0	0	0	0	40	30	60	60	19.5
N	N	Polyscias sambucifolia	0	0	5	0	0	0	5	0	5	0	1.5
N	Y	Rytidosperma erianthum	0	0	0	5	15	50	0	0	0	0	7
E	N	Trifolium glomeratum	0	0	0	0	10	0	0	0	0	0	1
N	N	Wahlenbergia gracilis	0	0	0	0	1	0	0	0	0	0	0.1
N	Y	Acacia longifolia	80	0	0	0	0	0	50	30	60	50	27
N	Y	Acacia terminalis	20	0	0	0	0	0	0	5	0	0	2.5
N	N	Austrostipa pubescens	0	0	0	0	0	3	0	0	0	0	0.3
N	N	Cassina aculeata	0	10	20	0	0	0	20	0	0	0	5
E	N	Centaurium erythraea	0	0	0	2	0	0	0	0	0	0	0.2
E	N	Conyza bonariensis	0	0	0	3	0	0	0	0	0	0	0.3
N	Y	Daviesia latifolia	5	0	0	0	0	30	10	10	0	0	5.5

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F7 Floristic data at LFA N in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	0	0	0	0	5	5	0	40	0	5
N	N	Asperula conferta	0	0	0	0	0	2	1	0	0	0	0.3
N	N	Austrostipa pubescens	0	25	10	5	0	0	0	0	0	0	4
N	N	Billardiera scandens	0	0	0	0	0	0	0	0	0	5	0.5
N	N	Cassina aculeata	0	0	10	0	0	0	0	0	0	0	1
E	N	Centaurium erythraea	2	0	0	0	3	0	10	0	0	0	1.5
E	N	Conyza bonariensis	2	2	5	2	2	0	0	0	0	0	1.3
N	N	Cynodon dactylon	0	0	5	0	0	0	0	0	0	0	0.5
N	Y	Entolasia stricta	5	3	0	5	2	2	2	0	5	3	2.7
N	N	Eucalyptus racemosa	0	0	0	0	0	0	0	0	5	0	0.5
N	N	Euchiton involucratus	0	0	0	0	0	0	0	3	3	0	0.6
E	N	Gamochaeta purpurea	0	2	5	5	0	0	0	2	0	0	1.4
N	N	Geranium homeanum	0	0	0	2	0	0	0	3	3	0	0.8
N	N	Hakea pachyphylla	0	0	0	0	0	0	0	0	2	0	0.2
N	N	Hydrocotyle laxiflora	2	1	5	0	0	0	0	0	0	0	0.8
E	N	Hypochaeris radicata	20	20	20	25	20	5	5	30	25	0	17
N	N	Juncus continuus	5	0	0	0	3	3	10	0	25	0	4.6
N	N	Lachnagrostis aemula	0	0	0	0	10	0	0	5	3	0	1.8
N	Y	Leptospermum polygalifolium	0	0	5	10	25	25	15	0	5	0	8.5
N	Y	Lomandra longifolia	2	2	20	10	15	0	0	10	0	0	5.9
E	N	Lysimachia arvensis	0	0	0	5	2	0	0	0	0	0	0.7
N	Y	Microlaena stipoides	0	0	0	0	0	0	0	10	0	0	1
N	N	Olearia erubescens	0	0	0	0	0	0	2	0	0	0	0.2
N	Y	Poa labillardierei	0	0	0	0	0	0	0	0	2	10	1.2
N	Y	Poa sieberiana	20	15	2	10	0	0	0	5	0	0	5.2
N	Y	Rytidosperma erianthum	0	0	0	5	0	15	5	0	0	20	4.5
E	N	Stenotaphrum secundatum	0	0	0	0	0	0	0	0	5	0	0.5
N	N	Veronica plebeia	0	0	0	0	0	0	0	5	0	0	0.5
N	N	Wahlenbergia gracilis	0	0	0	0	0	0	0	0	5	0	0.5

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

Table F8 Floristic data at MU29 Analogue 1 in 2022

Status	Planted (Y/N)	Species Name	1	2	3	4	5	6	7	8	9	10	Av
N	Y	Acacia longifolia	0	0	15	0	0	5	10	0	5	0	3.5
N	Y	Acacia terminalis	10	0	0	0	0	0	0	0	0	0	1
N	Y	Acacia ulicifolia	0	5	0	10	0	0	0	0	0	0	1.5
N	Y	Amperea xiphoclada	0	0	0	0	0	0	2	0	5	0	0.7
N	N	Austrostipa pubescens	0	5	0	0	0	0	0	0	0	0	0.5
N	N	Banksia spinulosa	0	0	0	0	50	5	10	0	0	0	6.5
N	N	Billardiera scandens	0	0	0	3	0	0	0	0	0	0	0.3
N	Y	Boronia microphylla	0	0	0	15	0	0	5	0	0	0	2
N	N	Caustis flexuosa	10	0	0	0	0	0	0	0	0	0	1
N	N	Comesperma ericinum	0	0	0	0	0	0	0	0	0	2	0.2
N	N	Dampiera stricta	5	0	5	5	5	5	3	2	0	0	3
N	Y	Daviesia latifolia	5	10	5	3	25	5	5	5	5	10	7.8
N	N	Dianella revoluta var. revoluta	0	0	0	0	0	0	2	0	0	0	0.2
N	N	Epacris pulchella	0	0	0	0	5	0	25	5	10	0	4.5
N	Y	Eucalyptus piperita	10	5	0	30	40	10	5	0	0	10	11
N	Y	Eucalyptus radiata	0	0	20	0	0	10	0	50	5	10	9.5
N	N	Gonocarpus teucrioides	0	10	0	0	0	0	5	5	0	0	2
N	N	Grevillea laurifolia	0	0	40	0	0	0	0	0	0	0	4
N	N	Hybanthus monopetalus	5	0	0	0	0	0	2	0	0	0	0.7
N	N	Lomandra filiformis	15	0	5	10	15	10	10	15	10	10	10
N	N	Lomatia silaifolia	0	20	0	0	0	10	0	0	0	0	3
N	N	Mitrasacme polymorpha	10	0	5	0	0	0	2	0	0	0	1.7
N	N	Monotoca scoparia	0	0	0	2	0	0	0	0	5	0	0.7
N	N	Opercularia hispida	5	0	0	0	0	0	0	0	0	0	0.5
N	N	Petrophile sessilis	0	0	0	0	0	5	0	0	0	0	0.5
N	N	Platysace linearifolia	0	10	0	0	2	0	0	0	0	0	1.2
N	Y	Poa sieberiana	0	0	5	0	0	0	0	0	0	0	0.5
N	N	Poranthera microphylla	3	0	0	0	0	0	0	0	0	0	0.3
N	N	Pteridium esculentum	0	5	0	0	0	5	5	5	15	20	5.5
N	N	Viola sieberiana	0	0	0	0	0	0	0	0	0	3	0.3
N	N	Xanthosia pilosa	0	0	5	5	5	10	0	3	0	0	2.8

N = Native, E = Exotic, Y = Yes, N = No, 1-10 = data sampled within 1m^2 plot at 5m intervals along 50m transect, Av = Average.

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