ULAN
COAL

GLENCORE

14 May 2020

Seq no. 32/20

Dr Gang Li
Principal Subsidence Engineer
Department of Planning, Infrastructure and Environment – Resources Regulator
PO Box 344
Hunter Region Mail Centre NSW 2310

**CC: DPIE, DPI - Water, ESS, Mine Subsidence Board**

Dear Mr Li,

**Re: LWW5 End of Panel Report for Ulan Underground Mine**

Subsidence Management Plan (SMP) Approval (File No.09/5344) for Longwalls (LW) LW27 - LW29 and LWW4 & LWW5 was issued to Ulan Coal Mines Pty Limited (UCMPL) on 29 May 2013. Secondary extraction of LWW5 commenced on 18 December 2018 and was completed on 22 January 2020 at the Ulan Underground Mine.

Condition 18 of the SMP Approval requires preparation of an End of Panel Report (EoP), within 4 months of the completion of each longwall. This EoP Report is provided to meet the requirements of Condition 18 of the SMP Approval, including:

- A summary of the subsidence and environmental monitoring results for LWW5;
- An analysis of these monitoring results against the relevant:
    - Impact assessment criteria;
    - Monitoring results from previous panels; and
    - Predictions in the SMP.
- A review of any trends in the monitoring results over the life of the activity; and
- A description of actions taken to ensure adequate management of any potential subsidence impacts due to longwall mining.

This EoP Report is copied to the compliance section of the NSW Department of Planning, Industry and Environment (DPIE), NSW Department of Primary Industries – Water (DPI-Water), The Environment, Energy and Science (ESS) Group (formerly the NSW Office of Environment and Heritage) and The Mine Subsidence Advisory, in accordance with Condition 18 of the SMP approval.

LWW5 concludes longwall mining activities within the approved SMP application area for Longwalls (LW) LW27 - LW29 and LWW4 & LWW5 and therefore concludes the requirement for end of panel reporting by Condition 18 of the SMP Approval (File No.09/5344). Please contact Lucy Stuart on (02) 6372 5308, if you have any questions.

Yours Sincerely,

**Robyn Stoney**
**Environment and Community Manager**
**Ulan Coal Mines Pty Limited**
**Attachment A: End of Panel Report LWW5 – Ulan Underground Mine**

## 1.0 Introduction

Subsidence Management Plan (SMP) Approval (File No.09/5344) permits longwall mining methods in (LW) LW27 - LW29 and LWW4 & LWW5 at the Ulan Underground Mine (formally, Ulan No.3 Underground Mine). The Ulan Underground Mine is a component of the approved Ulan Coal Mine Complex, under Project Approval (PA08_0184).

In accordance with Condition 18 of the SMP Approval[1], Ulan Coal Mines Pty Limited (UCMPL) is required to prepare an End of Panel Report (EoP) within 4 months of the completion date of each longwall. Secondary extraction of LWW5 commenced on 18 December 2018 and was completed on 22 January 2020 at the Ulan Underground Mine.

This EoP Report for LWW5 is structured as follows:

**Section 2.0**: Provides a summary of the **Subsidence Monitoring**;

**Section 3.0**: Provides a summary of the **Assessment of Subsidence Performance Measures;**

**Section 4.0**: Provides a summary of the **Environmental Monitoring;**

**Section 5.0:** Provides a summary of **Public Safety Management**;

**Section 6.0:** Provides a summary of **Built Feature Management**; and

**Section 7.0:** Provides a summary of **Private Property Monitoring**.

**Appendices:** The EoP Report for LWW5 is supported by the following specialist reports:

- **Appendix 1:** *Ulan Underground Mine: Longwall W5 End of Panel Subsidence Report (SCT, April 2020)*
- **Appendix 2:** *Ulan Annual Groundwater Review 2019 (AGE, April 2020)*
- **Appendix 3:** *UCML Floristic Monitoring 2019 Annual Report (ELA, March 2020), UCML Aquatic Ecological Monitoring Report 2019 (ELA, March 2020) ,Microbat Monitoring of the Ulan Coal Mine Lease during 2019 (FBN, March 2020)*

Additional post-mining monitoring results, biodiversity monitoring results, and environmental monitoring results, as required by *Subsidence Management and Extraction Plan (ULN SD PLN 0024)*[2] (the SMP/EP), are also provided within the Annual Review (AR)[3], submitted annually at the end of March. UCMPL provide copies of the AR on its website: www.ulancoal.com.au.

UCMPL have prepared and implemented the approved Extraction Plan for LW30 & LWW6-LWW8[4] (this Extraction Plan) at the Ulan Underground Mine. All future reporting and management requirements will be in accordance with this Extraction Plan.

[1] Subsidence Management Plan Approval (File No.09/5344) Ulan Colliery Longwall 27-29, Longwall W4 & W5

[2] *Subsidence Management and Extraction Plan (ULN SD PLN 0024) dated May 2013 (Version 6) for five longwall (LW) mining panels within Ulan No. 3 (i.e. LW 27-29 and W4-W5), which was submitted in accordance with Schedule 3, Condition 26 of PA 08-01 84.*

[3] Condition 3, Schedule 5 of PA08-0184

[4] Approved on the 19 August 2019

## 2.0 Subsidence Monitoring

The subsidence monitoring[5] program for LWW5 includes survey monitoring, groundwater and surface water monitoring, biodiversity and heritage monitoring, built features and private property monitoring. Survey monitoring for LWW5 was completed along the H line[6] (**Figure 1**). The results of the survey monitoring were assessed by SCT (**Appendix 1**). Subsidence monitoring also included monthly/opportunistic observations recorded by UCMPL before and during secondary extraction (**Figure 3**), specialist reports (**Appendix 1-3**) and a site inspection by Ken Mills (Principal Geotechnical Engineer for SCT) on the 16 and 17 January 2020.

SCT confirmed the measured subsidence effects from mining LWW5 are of the expected form and the magnitude (**Table 1**), similar to those measures over previous panels in the western domain of Ulan Underground and consistent with those forecast in SCT (2009) for the subsidence assessment for the 2009 Ulan Coal Continued Operation Environmental Assessment and SMP/EP. The full discussion of the subsidence effects monitoring for LWW5 is provided by SCT in **Appendix 1**.

**Table 1 Actual Versus Predicted Subsidence Parameters for LWW5**

| Parameter | Predicted | Actual (LWW5) |
|---|---|---|
| Maximum Subsidence (m) | 1.6 | 1.27 |
| Maximum Tilt (mm/m) | 10 - 20 | 20 |
| Horizontal (Tensile) Strain (mm/m) | 5 - 15 | 4 |
| Horizontal (Compression) Strain (mm/m) | 5 - 15 | 8 |

The surface above LWW5 straddles the Great Diving Range with the western portion draining to the west into tributaries of Mona Creek while the eastern section drains to the Ulan Creek. Three drainage lines on the Mona Creek catchment are located at the west with a single drainage line flowing to Ulan Creek over the eastern part of LWW5. Theses creeks in the upper reaches of both catchments are first and second order and ephemeral in nature. The surface terrain above LWW5 comprises approximately 55% cleared land used for grazing purposes with the remainder semi-cleared or undeveloped bushland (SCT, 2020).

The majority of the land above LWW5 is owned by UCMPL. Approximately 2.8ha in the north-western corner of the panel is located on private property. The private property is approximately 2% of the total area of the panel (**Figure 2**). The landform over the eastern part of LWW5 is dominated by the outcrop of Jurassic strata leading to gently undulating terrain. The landform in the western part of the panel is dominated by the outcrop of Triassic sandstone leading to steeper terrain, drainage line gullies and sandstone formations. Aboriginal heritage sites above LWW5 are located over the western half of the panel and include artefact scatters sites, isolated finds and rock shelters (SCT, 2020) (**Figure 2**).

UCMPL owned surface infrastructure and built features above LWW5 include the Bobadeen Homestead and associated outbuildings in the east, several farm dams, stock fencing, water pipelines, transmission lines, pivot irrigation and a number of internal access tracks and unsealed roads. There is no public access above LWW5.

[5] As required by the *Subsidence Management and Extraction Plan (ULN SD PLN 0024)*
[6] The H Line is the main subsidence line that crosses LWW5 (**Figure 1**)

The mining impacts observed by SCT during the site inspection in January 2020 noted that surface infrastructure and built features above LWW5 were generally minor in nature and less than the impacts forecast (SCT, 2020).

Impacts from mining are most perceptible near the start of the panel including on the private property. Surface cracks occur parallel to the panel edges. The observed surface cracks and within the Application Area, outside of the panel footprint of the panel. Cracking outside of the panel footprint at the start of LWW5 is expected because of the topography in this area. Larger horizontal movements expected at the start of all panels are coincident with terrain sloping in the direction of mining at the start of LWW5. This combination of effects leads to larger cracks at the start of the panel and cracks apparent outside of the panel footprint (SCT, 2020). Following rainfall and flow in the drainage line over the start of the panel a number of erosion holes have also developed. The presence of this, and the need to conduct remediation was advised the DPIE on 17 April 2020. A follow up report will be provided in due course.

Surface cracks were also evident along the panel edges on hard surfaces such as roads and compacted areas around farm sheds (SCT, 2020). Surface cracks observed were generally less than 50-100mm wide. There were no perceptible impacts to the Bobadeen Homestead. Impacts to Aboriginal heritage rock shelter sites and sandstone formations mores generally are minor with no rock falls recorded and only minor perceptible cracking event at three of eighteen locations (SCT, 2020).

Heritage sites at Mona Creek, Brokenback and the Talbragar Fish Fossil Reserve are remote from the mining of LWW5. The closest of these are the Mona Creek heritage sites, approximately 1.1 kilometres north of the start of panel LWW5. An inspection of the Mona Creek sites was undertaken by South East Archaeology Pty Ltd on 15 Jan 2019, approximately 1 month after the commencement of longwall mining within panel LWW5. No changes to the rock shelters as a result of subsidence were observed. No impacts were observed in the Brokenback Conservation Area or the Talbragar Fish Fossil Reserve during the surface inspection by SCT on the 16 and 17 January 2020.

As recommended by SCT, the subsidence effect monitoring program will continue along the H Line (**Figure 1**) for at least 2km ahead of the active longwall panel.

**Figure 1 – Location of the H Line Relative to LWW5 (SCT, 2020)**

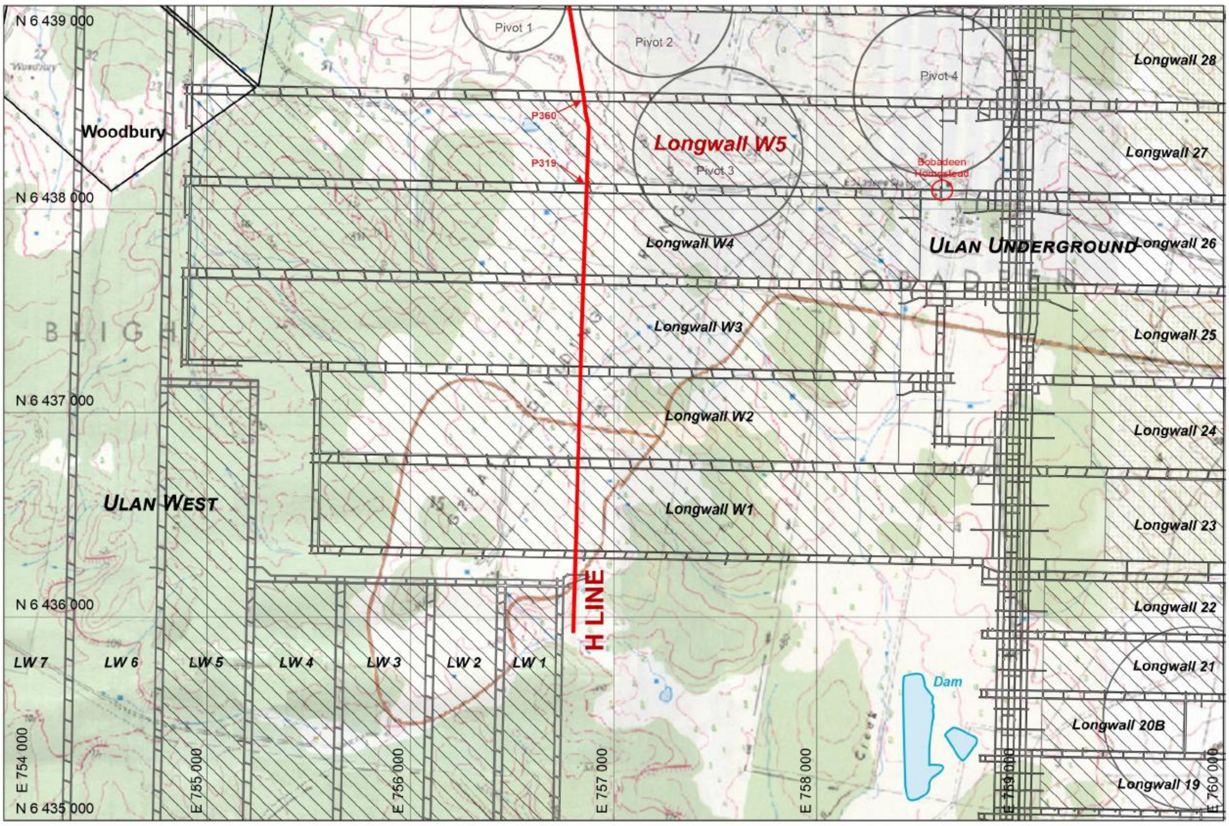



Figure 1: Site plan showing Longwall W5 and H Line relative to mine workings superimposed on 1:25,000 series topographic map.

**Figure 2 – Locations of Private Property, Cliff Lines and Heritage Sites above LWW5 (SCT, 2020)**

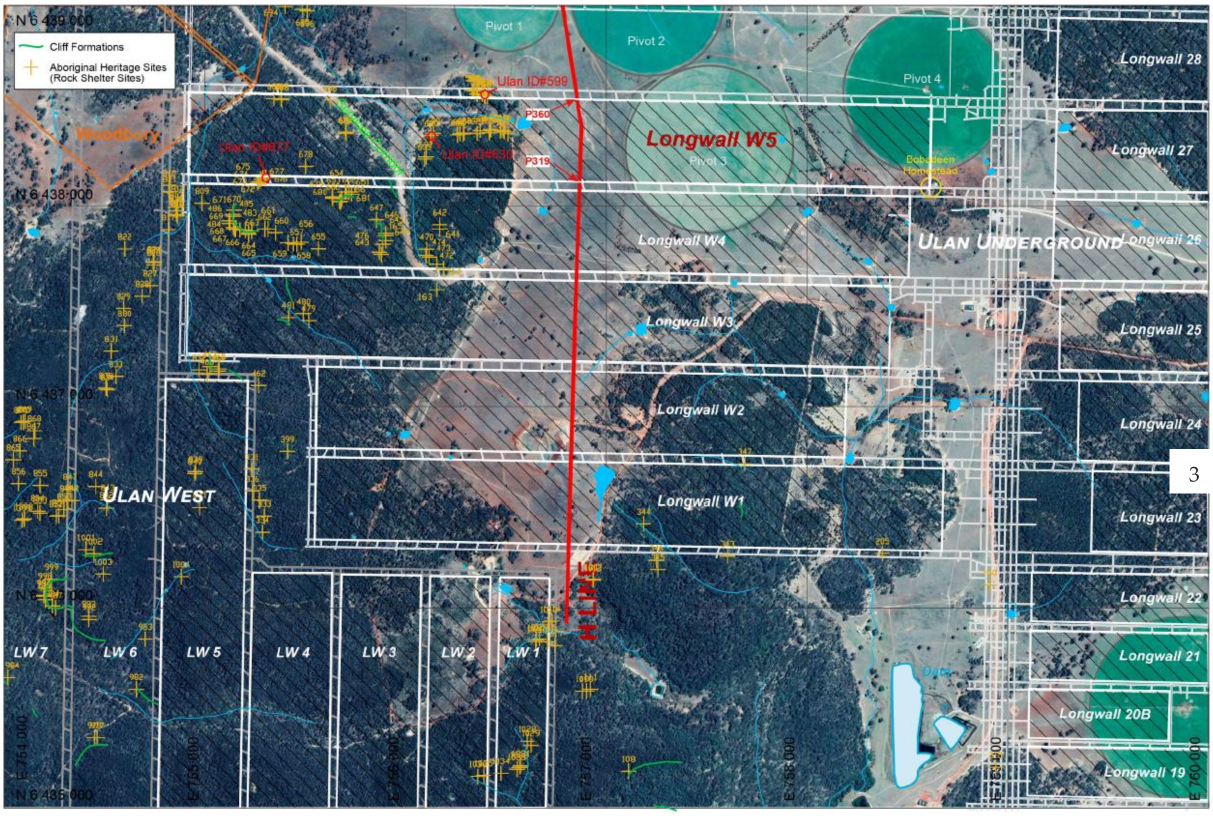
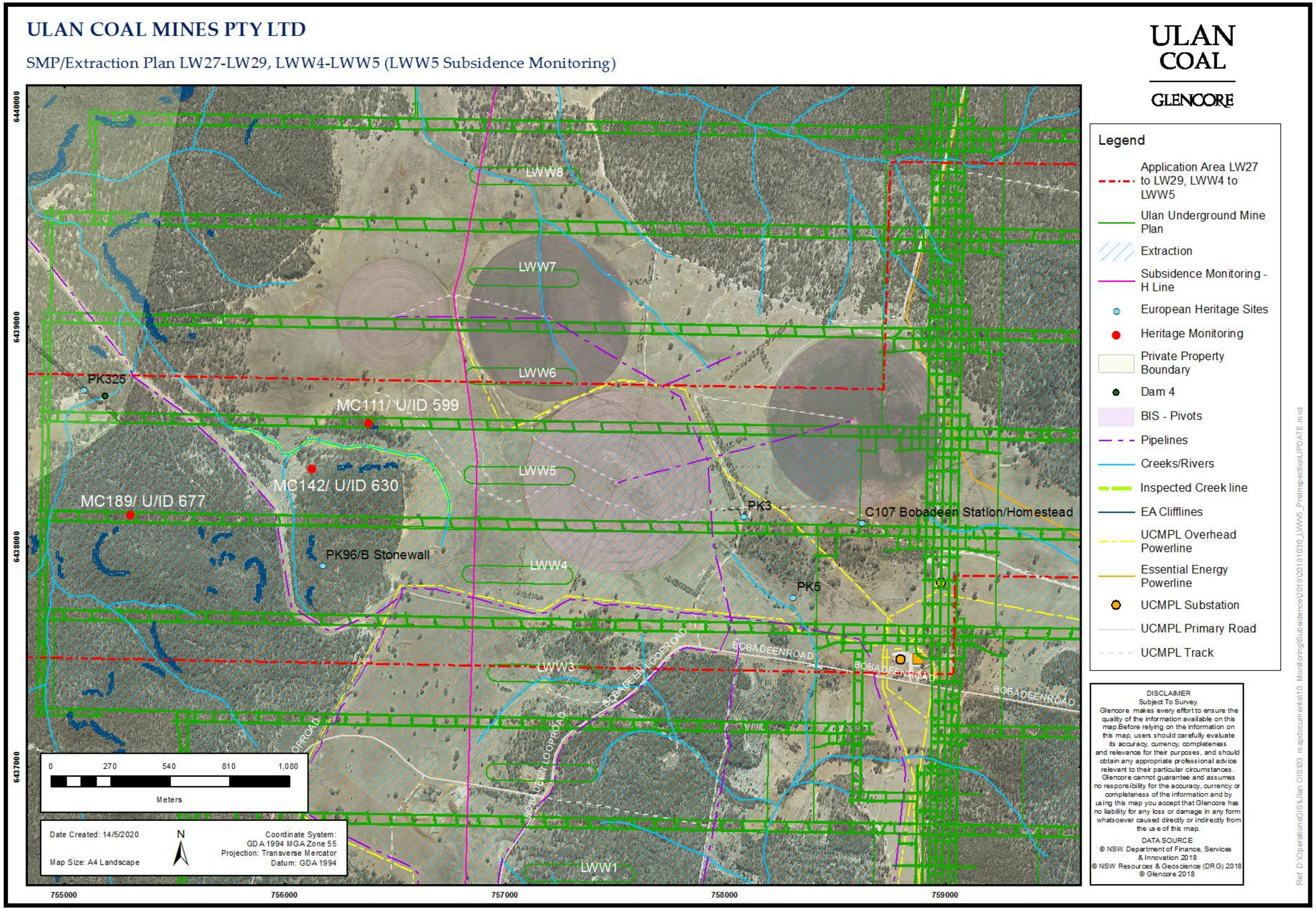



Figure 2: Site plan showing Longwall W5, H Line and Aboriginal rock shelter sites relative to mine workings superimposed onto a Google Earth image.

**Figure 3 – LWW5 Natural, Heritage and Built Features Inspected and Monitored by UCMPL**



## 3.0 Assessment of Subsidence Performance Measures

In accordance with Condition 24 of Schedule 3 of the PA08_0184, UCMPL must ensure that there is no exceedance of the subsidence impact performance measures listed in Table 14. The performance measures specified in Table 14 of Condition 24 of Schedule 3 of the PA08_0184 are listed in **Table 2**. The assessment of subsidence performance measures (**Table 2**) for LWW5 is consistent with the definitions in Section 2.3 (Table 2.3.1) of the *Subsidence Management and Extraction Plan (ULN SD PLN 0024)*.

**Table 2 Assessment of Subsidence Performance Measures**

| | | **Assessment definitions as provided in the SMP/EP (May 2013)** | **Subsidence Performance Measure Exceeded (yes/no)** |
|---|---|---|---|
| **Water** | | | |
| Ulan, Mona & Cockabutta Creeks | No greater environmental consequences than predicted in the EA | No significant changes to the extent of surface water ponding and no diversion of flows from creek alignment. Cockabutta Creek is not located within the Application Area. | No<br>Refer to **Appendix 1^** & **Section 2^** & **Section 4..2** |
| **Biodiversity** | | | |
| Threatened species, populations, habitat or ecological communities | Negligible impact | Negligible impact on vegetation and associated fauna habitat. | No<br>Refer to **Section 4.3** # * |
| **Land** | | | |
| Cliffs in the Brokenback Conservation Area | Nil environmental consequences | Nil subsidence impacts on cliff lines located within the Brokenback Conservation Area. | No<br>Refer to **Appendix 1^** & **Section 2^** |
| Other cliffs | Minor environmental consequences | Less than 20% of the total length of cliffs (and associated overhangs) within the mining area will experience mining induced rock fall. | |
| **Heritage** | | | |
| Aboriginal sites | Nil impact in the Brokenback Conservation Area (CA), Grinding Groove Conservation Area; and on Mona Creek/~~Cockabutta Creek~~*** Rock Shelter Sites | Nil subsidence impacts on identified Aboriginal heritage sites within the Brokenback Conservation Area, Grinding Groove Conservation Areas; and on Mona Creek/ ~~Cockabutta Creek~~ Rock Shelter Sites. | No<br>Refer to **Appendix 1^** & **Section 2^** & **Section 4.4** |
| Talbragar Fish Fossil Reserve | Negligible impact | Mining subsidence movements will be accommodated without significant disturbance to the fish fossil beds. | |
| Other Heritage Sites | No greater impact than predicted in the EA | Indirect impacts will be associated with ground surface impacts through underground mining induced subsidence within the application area. | |
| **Built Features** | | | |
| All built features | Safe, serviceable and repairable unless the owner agrees otherwise in writing | Two private properties are located in the application area. These will be maintained in a safe, serviceable and repairable condition, unless the owner and the MSB agree otherwise. Impacts on services (e.g. transmission lines) will be managed in consultation with the service provider. | No<br>Refer to **Appendix 1^** & **Section 2^** & **Section 4.1**** & **Section 7** |
| **Public Safety** | | | |
| Public Safety | No additional risk due to mining | | No<br>Refer to **Section 5** |

**Notes:** ^ Assessment undertaken by SCT # Assessment undertaken by ELA * Assessment made by Fly by Night
** Assessment of Private Bores made by AGE. *** Subsidence performance measures for protection of the Cockabutta Creek removed from the project approval in March 2016 with approval of MOD3.

# 4.0 Environmental Monitoring

## 4.1 Groundwater Monitoring

Groundwater monitoring for LWW5 was undertaken in accordance with the SMP/EP and the approved *Groundwater Monitoring Program (GWMP)*, a requirement of the *Water Management Plan (WMP)*. The GWMP describes the program to monitor trends in groundwater levels, assess groundwater depressurisation and associated groundwater inflows against modelled predictions and identify any impact on private licensed bores. It includes monitoring of the following elements of the alluvial and hardrock/coal measures aquifers in the region:

- Alluvial, Triassic, coal seam and interburden aquifers;
- Baseflows to the Goulburn and Talbragar Rivers and associated creeks;
- Groundwater bores, springs and seeps on privately owned land; and
- 'The Drip', a groundwater dependant natural site, east of the operations.

An assessment of the groundwater monitoring results from the North Monitoring Network[7] (NMN), for the 2019 calendar year was undertaken by Australasian Groundwater and Environmental Consultants Pty Ltd (AGE). The Annual Groundwater Monitoring Review - 2019 (AGE, 2020) (**Appendix 2**) concluded:

*Groundwater level monitoring was conducted in accordance with the GWMP during 2019. Monitoring bores, intersecting Jurassic sediments, recorded relatively stable groundwater levels, indicating no mine related impacts. Monitoring bores and VWPs intersecting Triassic units over 2 km from the mine recorded relatively stable groundwater levels. Monitoring bores intersecting the Triassic units within 1 km of the mine area recorded less than a 1 m decline in groundwater levels. These observed changes align with model predictions. Groundwater within the Permian coal measures generally declined over the monitoring period, in line with model predictions. Groundwater levels observed in monitored private bores have remained stable with no marked decline during 2019 monitoring period.*

*This review notes that whilst some SWGWRP triggers have been exceeded for the dissolved metals analysed (and with exception of iron), all bores recorded concentrations within acceptable limits under the ANZECC (2000) short term irrigation and stock water guidelines.*

*Water levels in Triassic and Permian units is monitored at key locations (PZ24, PZ29, TAL-1 and TAL-2) to inform ongoing assessment of baseflow loss to the Talbragar and Goulburn Rivers. In 2019, water levels at these locations were either stable or slightly declined line. These declines were in line with the predictions made in the groundwater model. This indicates that any reduction in baseflow remains within approved limits. In addition, water quality at The Drip continues to exhibit proportions of major ions that are different to those collected from other Triassic sediments in the rest of the monitoring network, suggesting influence from a different recharge source for The Drip.*

*During 2019, no complaints were received from private landholders regarding their bores. A number of private bores (PB05, PB08, PB09, PB10, PB11, PB14, PB17, PB21, PB26, PB30, PB31, PB32 and PB33) are predicted to experience groundwater level drawdowns in excess of 2 m. Of these bores, those that were monitored in 2019 were PB08, PB09, PB10, PB11, PB14, PB21, PB30, PB32 and PB33. Where obtained, recorded groundwater levels in these bores (PB08 and PB30) were in line with available historic levels for each bore and SWGWRP triggers were not exceeded. The remaining private bores, not predicted to be impacted, also recorded groundwater levels in line with historical levels.*

[7] The NMN was established over several years to monitor groundwater levels and quality in the Permian Coal Measures and Mesozoic Sandstones within and outside the mine lease.

## 4.2 Surface Water Monitoring

Surface water monitoring for LWW5 was undertaken in accordance with the SMP/EP and the approved *Surface Water Monitoring Program (SWMP)*, a component of the WMP, which details the integrated surface water monitoring strategy to measure and assess changes in stream health (including base flows) and channel stability that could be attributable to mining activities. It also establishes the monitoring and reporting requirements to enable water quality and quantity trends to be reported against EPL 394 conditions.

The surface water quality results applicable to LWW5 are monitoring sites SW10 and SW03. Medium-term results for SW03 and SW10 are provided in **Table 3**. Inspections and monitoring of a tributary of Mona Creek (**Figure 3** and **Table 4**) above LWW5 was also completed by UCMPL.

SW10 is located in Mona Creek[8], a fourth order, ephemeral stream which flows through cleared grazing land in the north-western section of the Project Approval boundary, outside the influence of mining activities in a north-westerly direction, towards the Talbragar River. Flows in Mona Creek are triggered during storm events or after prolonged rainfall and pools of permanent or semi-permanent water are present in the downstream reaches.

SW03 is located in Ulan Creek[9], approximately 5m upstream of LDP6 and sampled from a semi-permanent pool within the creek. Ulan Creek is a fourth order stream flowing in a southerly then easterly direction, though the Project Approval boundary before joining the Goulburn River. Ulan Creek is an ephemeral creek system with flows occurring during storm events or after prolonged rainfall. Downstream from SW03, creek flows are augmented by discharge from LDP6.

**Table 3 Surface Water Quality Results 2016-2019**

| SW10 | EC(µS/cm) | pH | TSS (mg/L) | SW03 | EC(µS/cm) | pH | TSS (mg/L) |
|---|---|---|---|---|---|---|---|
| 2016 Results | | | | 2016 Results | | | |
| Max | **413** | 7.6 | 46 | Max | **1220** | **8.2** | **117** |
| Min | 273 | 7.5 | 12 | Min | 115 | 6.9 | 3 |
| Ave | 323 | 7.6 | 35 | Ave | 670 | 7.6 | 50 |
| 2017 Results | | | | 2017 Results | | | |
| Max | ^ | ^ | ^ | Max | **1470** | **8.4** | 1 |
| Min | ^ | ^ | ^ | Min | **699** | 7.6 | 7 |
| Ave | ^ | ^ | ^ | Ave | 885.5 | 8.0 | 3 |
| 2018 Results* | | | | 2018 Results | | | |
| Max | 46 | 6.6 | **700** | Max | **1735** | **8.51** | **416** |
| Min | 38 | **6.1** | **300** | Min | 542 | 7.1 | 1 |
| Ave | 42 | 6.4 | **500** | Ave | **1460** | 7.8 | 44.08 |
| 2019 Results | | | | 2019 Results | | | |
| Max | 76 | 6.5 | **308** | Max | **1450** | **8** | 40 |
| Min | 41 | **6.4** | **47** | Min | 737 | 7.4 | <1 |
| Ave | 58.5 | 6.45 | **177.5** | Ave | 912.5 | 7.75 | 19.2 |

Notes: **Bold** results are outside the adopted trigger values[10] for key water quality parameters. ^No water samples taken January to July 2017 due to no flow in Mona Creek. *Two water samples available in 2018 due to dry conditions.

SW10 is an ephemeral stream, with no flow unless during heavy/extended rainfall. The elevated Total Suspended Solids (TSS) in samples collected from SW10 in 2018 and 2019 are associated heavy rainfall events (> 30mm in 24hr) and the subsequent first flush through the system resulting in increased TSS. Low rainfall during 2019 has resulted in no flow at other times of the year. The erosion holes became apparent

8 Mona Creek is not situated above LWW5. Flowlines pass over the western end of LWW5 in the Mona Creek catchment area.

9 Ulan Creek is not situated above LWW5. One flow line passes over the eastern end of LWW5 in the Ulan Creek catchment area.

10 Interim trigger values based on ANZECC (2000) default trigger values for lowland rivers in NSW. Site-specific trigger values will be developed as monitoring data becomes available.

in the flow line that reports to Mona Creek after the significant rainfall event on 17 February 2020. Hence they did not contribute to the turbidity that was measured at SW10 in 2018 and 2019. SW03 is upstream of LDP 6 and potential mining impacts. It is a semi–permanent pool of water, which again only flows after heavy or extended rainfall. The elevated results of pH and EC are due to periods of little to no rainfall, followed by heavy rain and are not subsidence related. SW03 is susceptible to pH and EC fluctuations depending on the flow regime at the time of sampling.

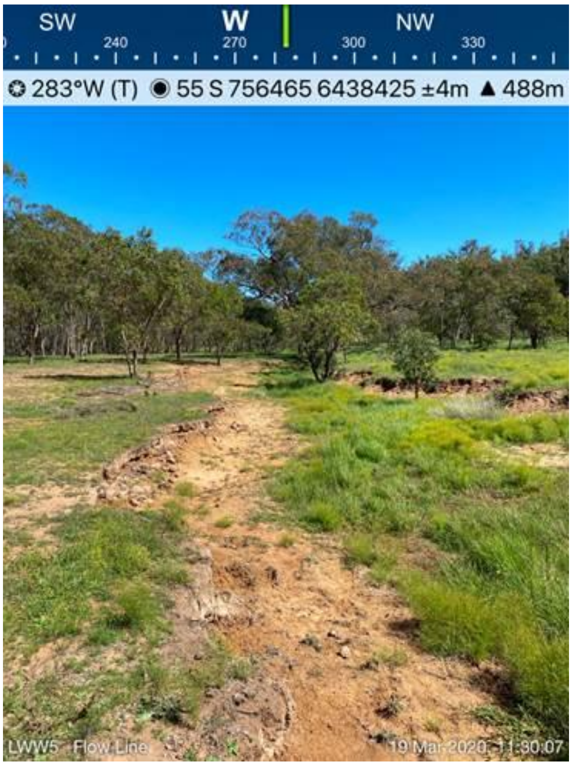
The 2019 annual aquatic fauna monitoring program was undertaken by Eco Logical Australia (**Appendix 3**) and includes monitoring of aquatic macro-invertebrate and undertaking riparian habitat assessments in Ulan Creek and Mona Creek. The 2019 annual aquatic fauna monitoring program by ELA concluded:

*The 2019 monitoring event occurred during prolonged drought conditions. Therefore, only nine of fourteen sites had enough water for the full suite of ecological samples to be collected. Due to the low rainfall in the lead up to sampling, flow at most sites was dominated by discharged mine water.*

*Aquatic macroinvertebrate taxonomic richness recorded in 2019 ranged from 12 to 17 taxa identified at sites upstream of UCC discharge locations and 14 to 20 taxa identified at downstream sites. SIGNAL2 scores ranged from 3.29 to 3.60 at upstream sites and 3.00 to 4.41 at downstream sites. These results indicate that aquatic macroinvertebrate communities apparently correlate to water flow and riparian condition, and both measures are reflective of disturbed systems, consistent with historical regional land-use practices. It is this historical disturbance, in conjunction with climatic conditions, which remain the key factors influencing macroinvertebrate communities. The presence of mine discharge water in the streams has allowed aquatic macroinvertebrate communities to persist in the landscape despite the drought.*

Further discussions regarding surface water and groundwater monitoring results are provided in 2019 Annual Review at: https://www.ulancoal.com.au/en/publications/Pages/annual-reports.aspx

**Table 4: Tributaries of Mona Creek - Pre & Post Mining Inspections LWW5**

| Pre-Mining Inspections LWW5 | Post Mining Inspections LWW5 |
|---|---|
|   |  <br>**Notes:** No surface cracking noted along flow line, however recent signs of erosion noted along the bank edge and most likely due to the 140mm rainfall event recorded in the Bobadeen area on the 17 February 2020. |

<table>
<tr><th>Pre-Mining Inspections LWW5</th><th>Post Mining Inspections LWW5</th></tr>
<tr><td>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**Notes:** No surface cracking noted along flow line, however recent signs of erosion noted and most likely due to the 140mm rainfall event recorded in the Bobadeen area on the 17 February 2020.
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**Notes:** No surface cracking noted along flow line and farm dam wall. Dam almost at capacity and most likely due to the 140mm rainfall event recorded in the Bobadeen area on the 17 February 2020.

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### 4.3 Biodiversity Monitoring

Biodiversity monitoring for LWW5 was undertaken in accordance with the SMP/EP and the approved *Biodiversity Management Plan (BMP)*. The BMP describes the ecological management strategies, procedures, controls and monitoring programs that are to be implemented for the management of flora and fauna within the Project Area. Reports of biodiversity monitoring for 2019 prepared by Eco Logical Australia (ELA) and Fly By Night Bat Surveys (FBN) are provided in (**Appendix 3**).

**Floristic Based Subsidence Monitoring**

Twenty (20) new Floristics Based Subsidence (FBS) sites located at longwall panels Ulan West (UW) LW6 and Ulan Underground (UG) LWW6 were established in autumn 2019. A total of 40 previously established sites along UW LW4, UG LWW4, UW LW5 and UG LWW5 also underwent monitoring in 2019.

Native species richness data collected from seven FBS monitoring sites shows no clear trends and does not indicate subsidence-related impacts on plant biodiversity for any site. Variation between years is consistent with observations at other BioMetric plots at the site and most likely explained by seasonal variation.

**Microbat Monitoring**

Microbat monitoring was undertaken at 20 general monitoring sites, eight control sites that have not been undermined by longwalls, twenty-four sites above the first seven panels of Ulan West and three sites above three panels of Ulan Underground.

Fifteen microbat species were recorded in total at the general fauna sites during the 2019 surveys. This is similar to that recorded during previous monitoring. The number of species recorded at each site varied from five to eleven.

Six species were captured in harp traps, the Large-eared Pied Bat (*Chalinolobus dwyeri*), Chocolate Wattled Bat (*Chalinolobus morio*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Gould's Long-eared Bat (*Nyctophilus gouldi*), Southern Freetail Bat (*Mormopterus planiceps*) and Little Forest Bat (*Vespadelus vulturnus*).

Monitoring at the targeted microbat sites during 2019 has provided information on the continued presence and abundance of the three target bat species within these areas. The Large-eared Pied Bat was captured at one and recorded from call at fifteen impact sites and captured at one and recorded from echolocation call at seven of the eight control sites. Capture of lactating females at UGLWW3, UG1 and SG7 confirmed continued breeding in these areas. In the case of SG7 this represented the first evidence of breeding at the Spring Gully Domain since 2004.

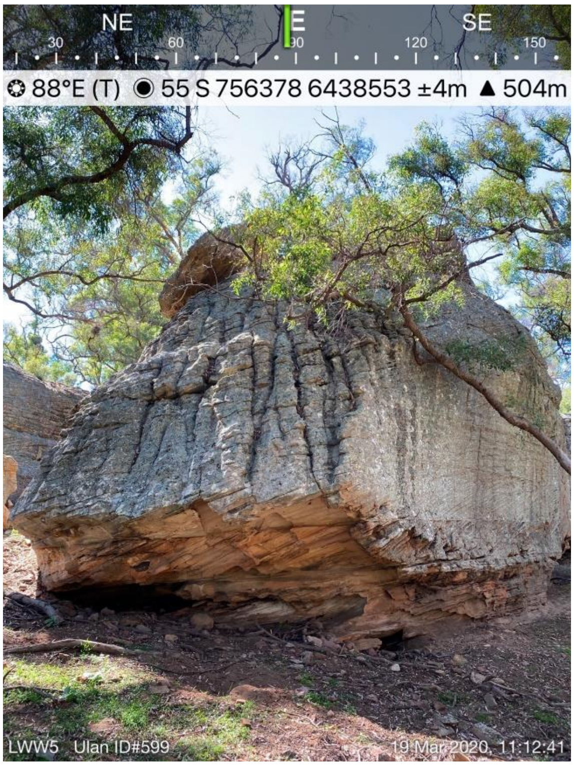
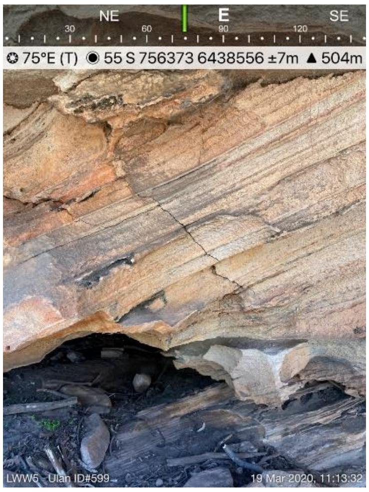
Additional data is available for target species: the Large-eared Pied Bat; Eastern Horseshoe Bat; and Large Bent-winged Bat longwall panels within the application area for the Ulan West Extraction Plan for LW1 to 6. Analysis of the data showed six examples of both decreased and increased activity of target microbat species at monitoring sites over previously mined longwall panels compared with activity prior to mining and control sites. The decreased results trigger an investigation consistent with the requirements of the Ulan West LW1 to LW6 BMP. The investigation will be undertaken in 2020.

Further discussions regarding biodiversity monitoring results are provided in 2019 Annual Review at: https://www.ulancoal.com.au/en/publications/Pages/annual-reports.aspx

## 4.4 Heritage Monitoring

Heritage monitoring for LWW5 was undertaken in accordance with the SMP/EP and the approved *Heritage Management Plan (HMP). The HMP* defines procedures for management and mitigation of impacts on Aboriginal, European and natural heritage. Surface inspections above LWW5 were undertaken prior to the commencement of the longwall retreating, to establish the baseline condition of a number rock shelters and the Bobadeen Homestead for qualitative post mining comparison. The monitoring methodology utilised physical inspections and photographic recordings of selected known rock shelters[11] along cliff lines and European heritage sites above LWW5 (**Figure 3**). No rock shelters above panel LWW5 were selected for test excavation and salvage.

**Table 5 Pre & Post Mining Inspections Rock Shelter ID#599 (LWW5)**

| Pre-Mining Inspections LWW5 | Post Mining Inspections LWW5 |
|---|---|
|  | <br><br>**Notes:** No rock falls, only very minor cracking was perceptible within the rock shelter. |

[11] *Selection of rock shelters above LWW5 as identified in the Subsidence Management and Extraction Plan (ULN SD PLN 0024)*

**Table 6 Pre & Post Mining Inspections Rock Shelter ID#630 (LWW5)**

<table>
<tr><th>Pre-Mining Inspections LWW5</th><th>Post Mining Inspections LWW5</th></tr>
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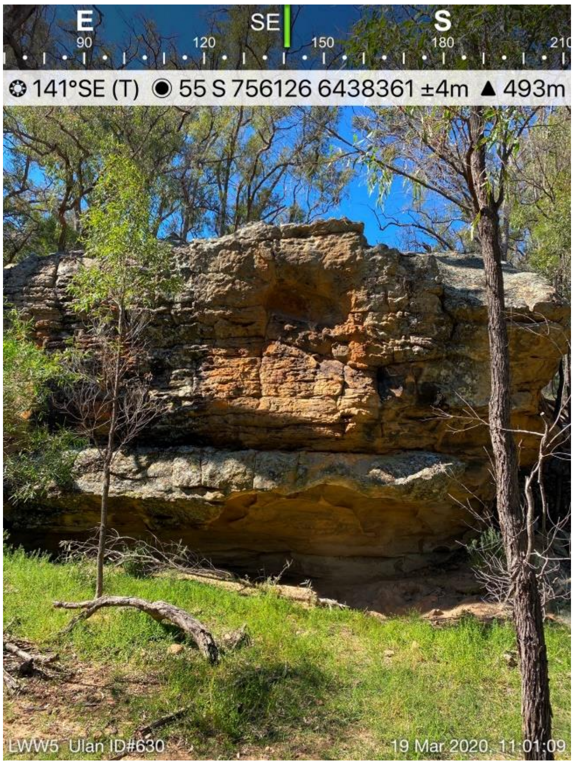


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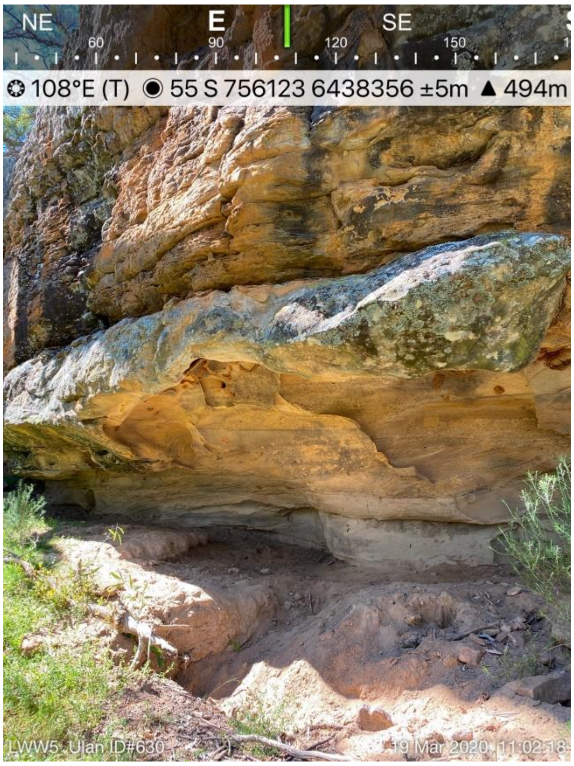


**Notes:** No rock falls & no perceptible change to rock shelter when compared to pre-mining condition.

</td></tr>
</table>

**Table 7 Pre & Post Mining Inspections Rock Shelter ID#677 (LWW5)**

<table>
<tr><th>Pre-Mining Inspections LWW5</th><th>Post Mining Inspections LWW5</th></tr>
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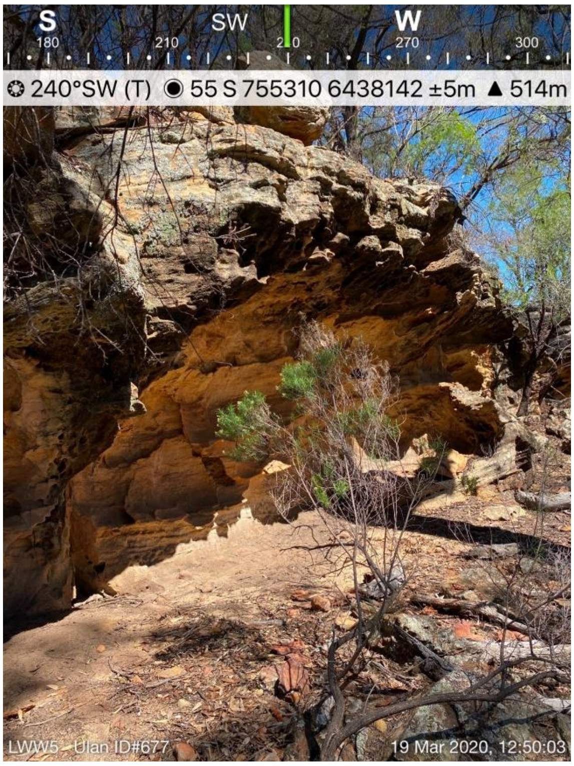

Notes: No rock falls & no perceptible change to rock shelter when compared to pre-mining condition.
</td></tr>
</table>

**Table 8 Pre & Post Mining Inspections Bobadeen Homestead**

<table>
<tr><th>Pre-Mining Inspections LWW5</th><th>Post Mining Inspections LWW5</th></tr>
<tr><td>
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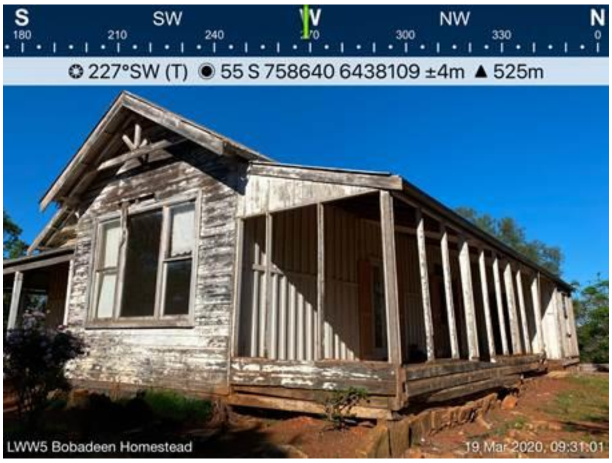
</td><td>
<br>**Notes:** No perceptible change to structures when compared to pre-mining condition.</td></tr>
</table>

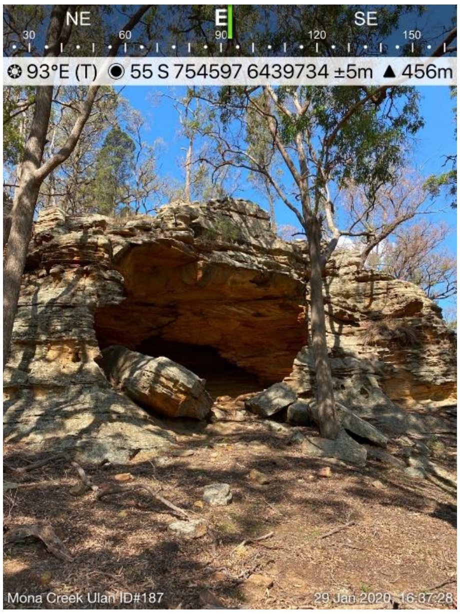
Longwall mining at the Ulan Underground Mine did not occur near the Brokenback Conservation Area, Mona Creek (**Table 9**), Rockshelter Sites or the Talbragar Fish Fossil Reserve (**Table 9**) and Grinding Groove Conservation Areas. The closest of these are the Mona Creek heritage sites, approximately 1.1 kilometres North of the start of panel LWW5. An inspection of the Mona Creek sites was undertaken by South East Archeaology Pty Ltd on 15 Jan 2019, approximately 1 month after the commencement of longwall mining within panel LWW5. No changes to the rock shelters as a result of subsidence were observed. SCT (**Appendix 1**) concluded:

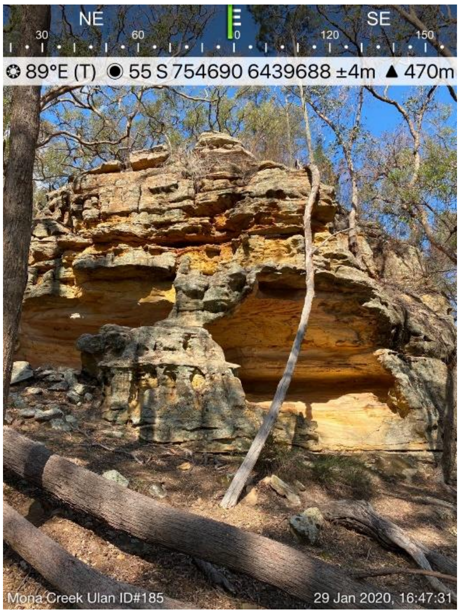
*Conservation areas for Aboriginal heritage sites at Mona Creek, Brokenback and Cockabutta Creek and the Talbragar Fish Fossil Reserve are all remote from the mining of LWW5. No impacts were observed in the Brokenback Conservation Area or the Talbragar Fish Fossil Reserve during the surface inspection by SCT on the 16 and 17 January 2020.*

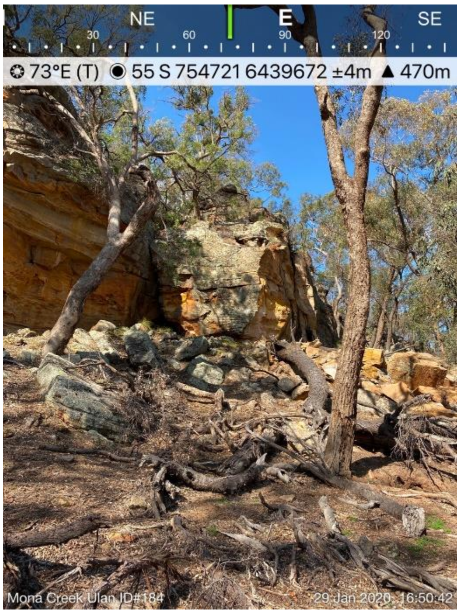
There have been no identified impacts to date in these areas as a result of potential mining induced subsidence from the Ulan Underground Mine. An assessment of the Mona Creek rock shelters in early 2019 by SCT concluded that a rock fall was not mining related.

**Table 9 Post Mining Inspections of Mona Creek Rock Shelters & Talbragar Fish Fossil Reserve**

**Post Mining Inspections LWW5**





**Notes:** No perceptible mining impacts identified

## 5.0 Public Safety

The SMP/EP describes the appropriate management protocols to minimise public safety risks from potential impacts resulting from mine subsidence. The surface area above LWW5 is restricted through fencing, signage and locked gates. There were no public safety incidents recorded by UCMPL as a result of mining LWW5.

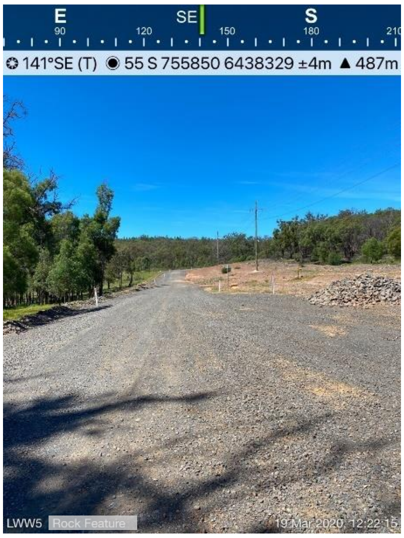
## 6.0 Built Features

The SMP/EP describes the appropriate management protocols to minimise potential impacts to built features resulting from mine subsidence. As discussed in **Section 2**, UCMPL owned surface infrastructure and built features above LWW5 include several farm dams, stock fencing, water pipelines, transmission lines, pivot irrigation and a number of internal access tracks and unsealed roads. The mining impacts observed during a site visit by SCT to natural and built features are generally minor in nature and less than the impacts forecast in SCT (2009) and in the SMP/EP (SCT, 2020).

**Table 10 Post Mining Inspections of UCMPL Built Features**

**Post Mining Inspections LWW5**





**Notes:** No perceptible change to built features when compared to pre-mining condition. Minor surface cracking noted in close proximity of farm shed, internal roads and powerline easements. No surface cracking noted in the vicinity of farm dam along flow line.

## 7.0 Private Property

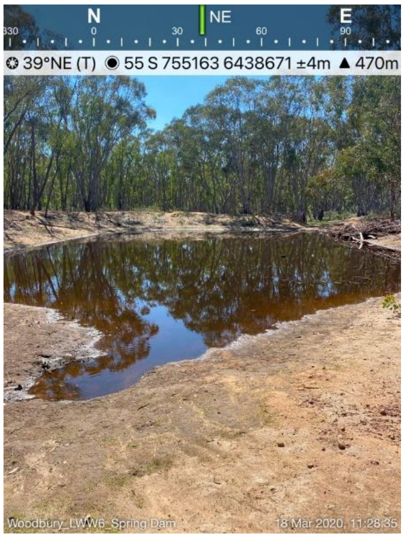
Approximately 2.8ha in the north-western corner of the LWW5 panel is located on private property. The private property is approximately 2% of the total area of the longwall panel (**Figure 2**). Subsidence impacts on privately owned land at the start of the panel are consistent with expectation (**Table 11**). A spring fed dam on the private property (Dam 4) located within the subsidence affectation area of LWW5 appears to have been impacted. The impacts were identified in October 2019, during active mining of LWW5 in proximity to this dam. A coincidence of mining induced cracking, a drainage line and recent heavy rainfall events, approximately 14 months after the area was mined has led to flow into subsidence cracks and localised erosion of surface soils. The details of the impacts are being assessed separately together with a suitable remediation strategy (SCT, 2020).

**Table 11 Private Property Monitoring**

**Post Mining Inspections LWW5**





**References:**


- *Ulan Underground Mine: Longwall W5 End of Panel Subsidence Report (SCT, April 2020)*
- *Ulan Annual Groundwater Review 2019 (AGE, April 2020)*
- *UCML Floristic Monitoring 2019 Annual Report (ELA, March 2020)*
- *UCML Aquatic Ecological Monitoring Report 2019 (ELA, March 2020)*
- *Microbat Monitoring of the Ulan Coal Mine Lease during 2019 (FBN, March 2020)*

# APPENDIX 1

Strata Control Technology

**ULAN COAL MINES PTY LTD**

Ulan Underground Mine: Longwall W5
End of Panel Subsidence Report

**ULA5114**

Mining Research and Consulting Group

**SCT Operations Pty Ltd** PO Box 824 Wollongong NSW 2520 Australia
Phone: +61 2 4222 2777 Email: sctnsw@sct.gs Website: www.sct.gs
ABN 23 078 328 953

**REPORT TO** Lucy Stuart
Environment and Community Coordinator
Ulan Coal Mines Pty Ltd
Private Mail Bag 3006
MUDGEE NSW 2850

**TITLE** Ulan Underground Mine: Longwall W5
End of Panel Subsidence Report:

**REPORT NO** ULA5114_Rev 1

**PREPARED BY** Ken Mills
Stephen Wilson

**DATE** 19 April 2020

Stephen Wilson
Mine Planner

| Report No | Version | Date |
|---|---|---|
| ULA5114 | 1 | 31 March 2020 |
| ULA5114 | 2 | 14 April 2020 |
| ULA5114 | Revision 1 | 19 April 2020 |
| | | |
| | | |

Ken Mills
Principal Geotechnical Engineer

## SUMMARY

Ulan Coal Mines Pty Ltd (UCMPL) owns and operates Ulan Underground (UUG) mine approximately 25km northeast of Gulgong in the Central West of NSW. UCMPL recently finished mining Longwall W5 at UUG. UCMPL commissioned SCT Operations Pty Ltd (SCT) to review the subsidence monitoring and surface impacts from mining Longwall W5 and prepare an end of panel report to meet the requirement of the integrated Subsidence Management Plan (SMP) and Extraction Plan (EP). This report presents our review of the subsidence monitoring and mining impacts for Longwall W5 and comparisons against relevant impact assessment criteria.

Our review indicates that the subsidence effects from the mining of Longwall W5 are consistent with expectation. The magnitudes of the primary subsidence parameters are consistent with those forecast for this panel and similar to those measured over previous panels in the western domain of UUG. Subsidence impacts observed during a site visit to the area are consistent with expectation and less than forecast.

Maximum vertical subsidence measured above Longwall W5 is 1.27m and less than the maximum 1.6m forecast. Maximum tilt is 20mm/m and at the upper end of the 10-20mm/m range forecast. Maximum strain is 4mm/m in compression and 8mm/m in tension and towards the lower end of the 5-15mm/m range forecast.

The impacts are likely to be compliant with the impact criteria in the SMP Approval conditions for watercourses, groundwater, habitats, conservation areas, buildings, structures, roads and heritage sites. Subsidence impacts and environmental consequences to features are also expected to be less than the criteria specified in the subsidence performance measures of Project Approval 08_0184 for water, biodiversity, land, heritage, built features and public safety. Specific compliance for water and biodiversity needs to be confirmed by other specialists.

Subsidence impacts to natural and built features on land owned by UCMPL are generally minor in nature and less than forecast. Cracking of the surface is evident in some places, generally near the panel edges but impacts from mining are imperceptible over large areas of the panel footprint. Impacts to Aboriginal heritage rock shelters and sandstone formations are less than forecast.

Subsidence impacts on privately owned land at the start of the panel are consistent with expectation. A coincidence of mining induced cracking, a drainage line and recent heavy rainfall events, approximately 14 months after the area was mined, has led to flow into subsidence cracks and localised erosion of surface soils. The details of these impacts are being assessed separately together with a suitable remediation strategy.

Continuation of the subsidence monitoring in the western domain of UUG is recommended. This report represents the final end of panel report required by the SMP/EP for Longwalls 27-29 and W4-W5.

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# 1. INTRODUCTION

Ulan Coal Mines Pty Ltd (UCMPL), formerly Ulan Coal Mines Ltd, operates the Ulan Underground (UUG) and Ulan West (UW) mines within the Ulan Complex, approximately 25km northeast of Gulgong in the Central West of NSW. UCMPL recently completed mining Longwall W5, the fifth longwall panel in the western domain at UUG. UCMPL commissioned SCT Operations Pty Ltd (SCT) to review and analyse the subsidence monitoring data for Longwall W5 and prepare a subsidence report suitable to meet the end of panel reporting requirements of the SMP/EP for this panel. This report presents our review and assessment of the subsidence monitoring conducted for Longwall W5 and our review of subsidence impacts based on site visit and reports by UCMPL personnel.

The report is structured to provide:

- conclusions and recommendations
- a general site description
- analysis of the subsidence measurements and monitoring
- observations of subsidence impacts
- comparisons of measured subsidence effects and observed impacts against forecasts with comparisons against:
    - relevant impact assessment criteria
    - monitoring over previous panels
    - subsidence predictions in the SMP/EP for Longwall W5
    - subsidence performance measures of Project Approval (PA08_0184).

# 2. CONCLUSIONS AND RECOMMENDATIONS

The measured subsidence effects from mining Longwall W5 are of the expected form and magnitude, similar to those measured over previous panels in the western domain of UUG and consistent with those forecast in SCT (2009) for the subsidence assessment for the Ulan Coal Continued Operations Environmental Assessment and used as the basis for the SMP/EP for this panel.

Table 1 summaries the primary subsidence parameters for Longwall W5 compared to the maxima forecast in the SMP/EP for the overburden range in this panel of 170-270m.

**Table 1: Comparison of primary subsidence parameters for Longwall W5 with forecast parameters.**

| LWW5 | Measured | Forecast |
|---|---|---|
| Vertical subsidence (m) | 1.27 | 1.6 |
| Tilt (mm/m) | 20 | 10-20 |
| Compressive Strain (mm/m) | 4 | 5-15 |
| Tensile Strain (mm/m) | 8 | 5-15 |

Table 2 summaries the secondary primary subsidence parameters for Longwall W5 compared to the forecast values of these parameters.

**Table 2: Comparison of secondary subsidence parameters for Longwall W5 with forecast parameters.**

| LWW5 | Measured | Forecast |
|---|---|---|
| Chain Pillar Subsidence (mm) | **250** | 800 |
| Goaf Edge Subsidence (mm) | **160** | 200-300 |
| Angle of Draw (°) | **46** | 30-50 |
| Horizontal movement (mm) | **500** | 400-500 |

Subsidence impacts to natural and built features observed during a site visit to the area above Longwall W5 were generally minor in nature and less than the impacts forecast in the SMP/EP.

Impacts from mining are most perceptible near the start of the panel, including on the Woodbury property, as surface cracks and potholes and along the panel edges on hard surfaces such as roads and compacted areas around farm sheds. Recent unusually heavy rainfall events have contributed to erosion of surface material across the area above Longwall W5 including into subsidence cracks at the start of the panel.

Pre and post mining surveys of surface features undertaken by UCMPL indicates impacts to Bobadeen Homestead, Aboriginal heritage rock shelter sites and sandstone formations, flow (drainage) lines, farm dams and mining and farm related infrastructure are either very minor or imperceptible.

Impacts to Aboriginal heritage rock shelter sites and sandstone formations are generally minor and less than forecast.

The effects of erosion from recent heavy rainfall events are evident as potholes along flow lines.

Measurements of subsidence effects and observations of subsidence impacts indicate that the effects from the mining of Longwall W5 are less than forecast and the impacts are likely to be compliant with the impact criteria in the SMP Approval conditions for watercourses, groundwater, habitats, conservation areas, buildings, structures, roads and heritage sites. Conservation areas for Aboriginal heritage sites at Mona Creek, Brokenback and Cockabutta Creeks and the Talbragar Fish Fossil Reserve are still remote from the mining area and were not perceptibly impacted.

Subsidence impacts and environmental consequences to other features or items are expected to be less than the criteria in the subsidence performance measures of PA08_0184 for water, biodiversity, land, heritage, built features and public safety, notwithstanding assessment for water and biodiversity impacts by other specialists. Table 3 summarises the subsidence performance measures outlined in Table 14 of Ulan Coal Continued Operations Project Approval 08_0184, and the likely status of compliance.

**Table 3: Subsidence performance measures and likely compliance status.**

| ***Subsidence Performance Measure*** | | ***Assessment of status of compliance*** |
|---|---|---|
| **Water** | | |
| Ulan, Mona & Cockabutta Creeks | No greater environmental consequences than predicted in EAs | Compliance expected as main channels of these creeks too remote to be impacted. |
| **Biodiversity** | | |
| Threatened species, populations, habitat or ecological communities | Negligible impact | Compliance expected because no greater subsidence effects compared to EAs and SMP/EPs (assessed by other specialists) |
| **Land** | | |
| Cliffs in the Brokenback Conservation Area | Nil environmental consequences | No impacts observed indicating compliance. Current mining remote from this area |
| Other Cliffs | Minor environmental consequences | Compliance expected - no cliff lines in Longwall W5 footprint |
| **Heritage** | | |
| Aboriginal Sites | Nil impact in the Brokenback Conservation Area, Grinding Groove Conservation Areas and Mona Creek Rock Shelters | Compliance expected. No impacts observed at Brokenback cliffs. Current mining remote so mining impacts not credible |
| Talbragar Fish Fossil Reserve | Negligible impact | Compliance expected. No impacts observed. Current mining remote so mining impacts not credible |
| Other Heritage Sites | No greater impact than predicted in EAs | Compliance expected (other specialists to assess) Subsidence effects are less than forecast in EP (updated since EAs). |
| **Built Features** | | |
| All built features | Safe, serviceable and repairable unless the owner agrees otherwise in writing | Compliance expected (impacts managed via provisions of BFMP) |
| **Public Safety** | | |
| Public Safety | No additional risk due to mining | Compliance expected (risk managed via controls in PSMP) |

The continuation of subsidence monitoring along H Line for at least 2km ahead of the active longwall panel is recommended. Ideally, a high-resolution survey of the full length of the line would be undertaken at the completion of each longwall panel. Surveying the section from 2km to the north of the current panel to more than half-way across the previous panel is recommended as a minimum.

## 3. SITE DESCRIPTION

Figure 1 shows a plan of the surface area above Longwall W5. The mine plan and the location of the main subsidence line, H Line, are superimposed onto a 1:25,000 series topographic map of the area.

Figure 2 shows similar details as Figure 1 with Aboriginal heritage rock shelter sites superimposed on a Google Earth image dated September 2018.

### 3.1 Surface Features and Aboriginal heritage sites

The surface above Longwall W5 straddles the Great Dividing Range with the western portion draining to the west into tributaries of Mona Creek while the eastern section drains to the Ulan Creek upstream of the Bobadeen Water Treatment Facility (BWTF). Three drainage lines of the Mona Creek catchment are located over the western section of Longwall W5. These drainage lines are first and second order streams. They are all ephemeral in nature. Two small farm dams are located on the drainage lines of Mona Creek tributaries.

The majority of the land above Longwall W5 is owned by UCMPL. Approximately 2.8ha in the north-western corner of the panel is located on private property referred to as Woodbury. This area is approximately 2% of the total area of the panel. Approximately 55% of the surface above Longwall W5 is cleared land used for grazing purposes with the remainder semi-cleared or undeveloped bushland. The section of private property is mainly cleared land.

The landform over the eastern part of Longwall W5 is dominated by the outcrop of Jurassic strata leading to gently undulating terrain. The landform in the western part of the panel is dominated by the outcrop of Triassic sandstone strata leading to steeper terrain, drainage line gullies and sandstone formations.

Aboriginal heritage sites above Longwall W5 are located over the western half of the panel and include artefact scatter sites, isolated find sites and rock shelters. There are 25 rock shelter sites associated with sandstone formations including artefact finds and potential archaeological deposits.

Mining related or farm infrastructure and built features owned by UCMPL above Longwall W5 includes:

- The Bobadeen Homestead and associated outbuildings in the east.
- Sections of Irrigation Pivot 3 and Pivot 4 in the east.

- Water pipelines and power transmission lines.
- Two shallow farm dams in the central section.
- Other farm infrastructure including agricultural land, access tracks or roads, fences, gates and sheds.
- A section of the recently constructed unsealed access road in the northwest with access controlled by UCMPL.
- A services corridor alongside the road including overhead powerlines and underground pipelines.

### 3.2 Mining Geometry and Timing

Longwall W5 created an extracted void that is nominally 410m wide (coal rib to rib) and 3697m long (including the 9m wide installation roadway). The longwall started in the west at CH3688m on 18 December 2018 and mined to the east finishing production at CH0m on 22 January 2020.

The Ulan Seam dips gently to the northeast, so variation in overburden depth is mainly a result of topographic changes. The overburden depth over Longwall W5 ranges from approximately 170m in the west to 230m in the middle and up to 260m at the eastern end of the panel.

UUG mines the D working section (DWS) in the Ulan Seam. In Longwall W5, the DWS typically ranges 2.9-3.1m in thickness.

### 3.3 Regulatory Context and Subsidence Forecasting

UUG and UW mines both operate under modified approval for the Ulan Coal Continued Operations (UCCO) Project 08_0184 (MOD4), originally determined in 2010.

SCT (2009) presented subsidence predictions to inform the UCCO Project Environmental Assessment (EA). SCT (2009) was prepared after the mining of Longwall W1 and Longwall 23 at UUG.

An integrated Subsidence Management Plan (SMP) / Extraction Plan (EP) for the secondary extraction of Longwalls 27-29 and W4-W5 was approved in 2013 using SCT (2009) as the basis for the subsidence forecasts. This subsidence report represents the final end of panel report required by the SMP/EP for Longwalls 27-29 and W4-W5.

## 4. SUBSIDENCE EFFECTS MONITORING

This section presents the subsidence effects measured and subsidence impacts observed from mining Longwall W5. These effects and impacts are discussed and compared with the forecasts made in the SMP/EP for Longwalls 27-29 and W4 and W5.

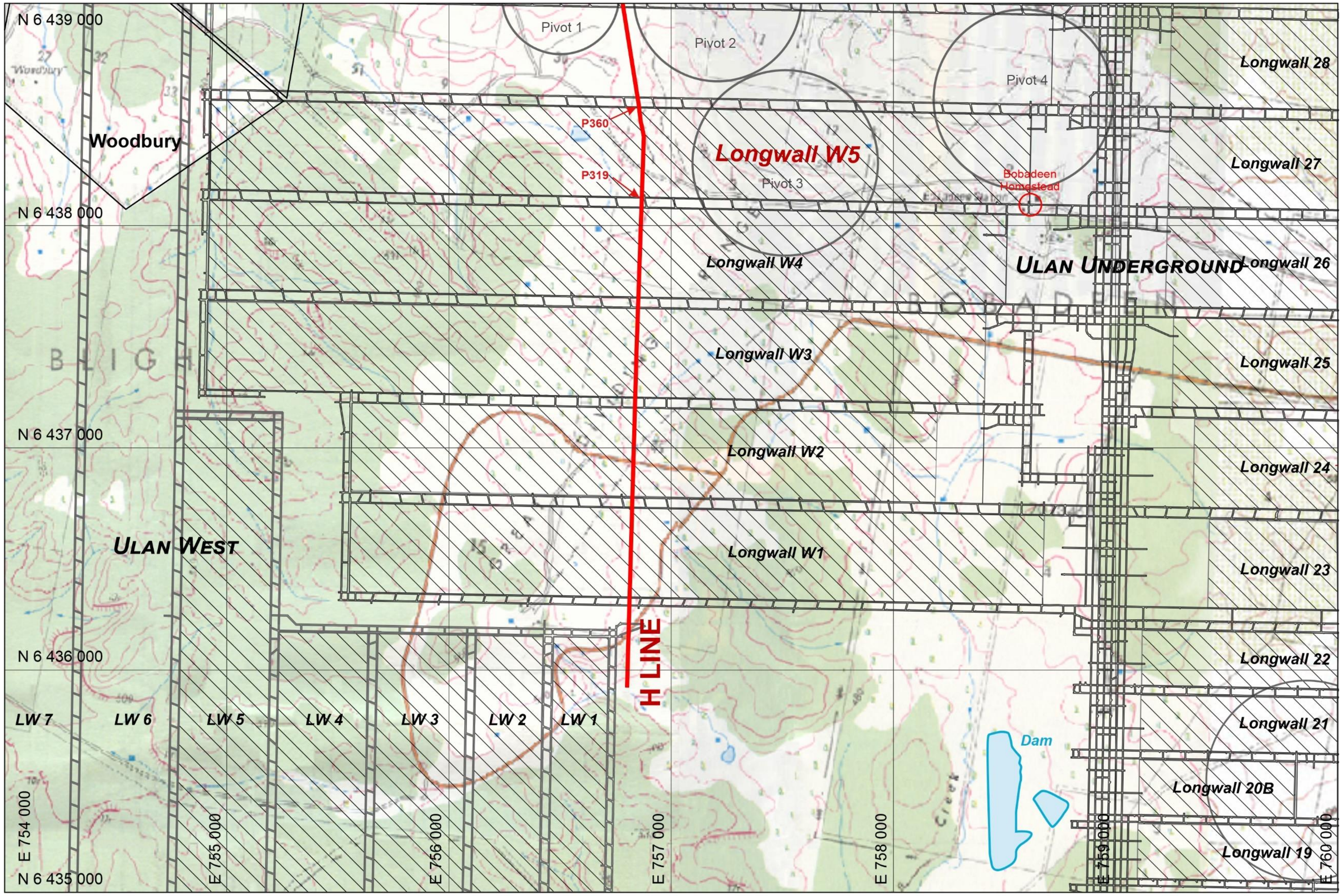


**Figure 1: Site plan showing Longwall W5 and H Line relative to mine workings superimposed on 1:25,000 series topographic map.**

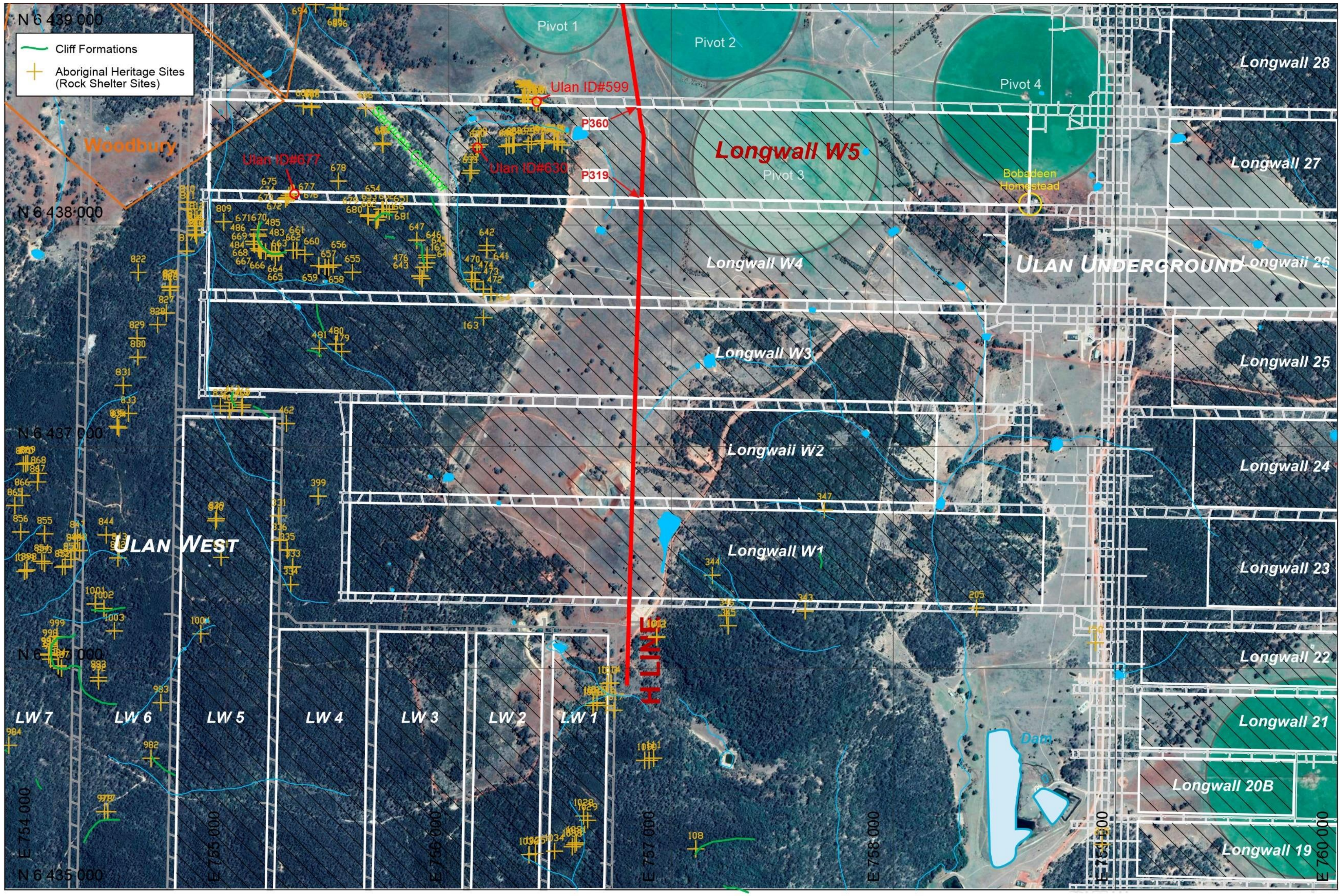


**Figure 2: Site plan showing Longwall W5, H Line and Aboriginal rock shelter sites relative to mine workings superimposed onto a Google Earth image.**

## 4.1 H Line

H Line is the main subsidence monitoring line for the western domain longwalls at UUG. The line traverses the longwall panels from south to north almost perpendicular to the panel direction. Figure 3 shows the grazing land along H Line above Longwall W5.

H Line crosses Longwall W5 between CH1763m and CH1740m. Longwall W5 mined directly below H Line between 5 July and 8 July 2019. The overburden depth along H Line over Longwall W5 varies from 220m to 225m. The mining height at this location is reported as 2.9m.

H Line was initially installed in 2008 prior to the mining of Longwall W1 and was subsequently extended to the north to allow far-field horizontal subsidence movements to continue to be measured. The line was recently extended to the lease boundary, 1.7km to the north of Longwall W8, with the baseline survey of the new marks undertaken in conjunction with the Longwall W5 end of panel survey.

The depth varies along H Line from approximately 200m at the start of the line to the south of Longwall W1, increasing to 240m over Longwall W3 and then remaining in the range 210-230m up to Longwall W8.

## 4.2 Primary Subsidence Parameters

Figure 4 shows a summary of subsidence effects for each of the longwall panels mined in the western domain including Longwall W5.

Table 4 details the monitoring results for the primary subsidence parameters along H Line for each of these panels at the time of each end of panel survey.

**Table 4: Maximum subsidence over Longwall W5 and previous panels.**

| Subsidence Parameter | LWW1 | LWW2 | LWW3 | LWW4 | LWW5 |
|---|---|---|---|---|---|
| Vertical subsidence (m) | 1.3 | 1.35 | 1.54 | 1.47 | 1.27 |
| Tilt (mm/m) | 14 | 27 | 15 | 20 | 20 |
| Compressive Strain (mm/m) | 5 | 7 | 6 | 7 | 4 |
| Tensile Strain (mm/m) | 3 | 4 | 4 | 6 | 8 |

A single survey was conducted on H Line on 6 February 2020 after mining in Longwall W5 had finished. This survey extended from near the southern edge of Longwall W4, over Longwall W5 and to the northern end of the established line more than 1.1km beyond the goaf edge of Longwall W5.

The 2.9m mining height in the vicinity of H Line is consistent with the mining height assumed for the subsidence assessment presented in SCT (2009).

Maximum vertical subsidence measured above Longwall W5 is 1.27m. This value is less than the maximum 1.6m forecast in the SMP/EP for Longwalls 27-29 and W4 and W5.

**Figure 3: Surface along H Line.**

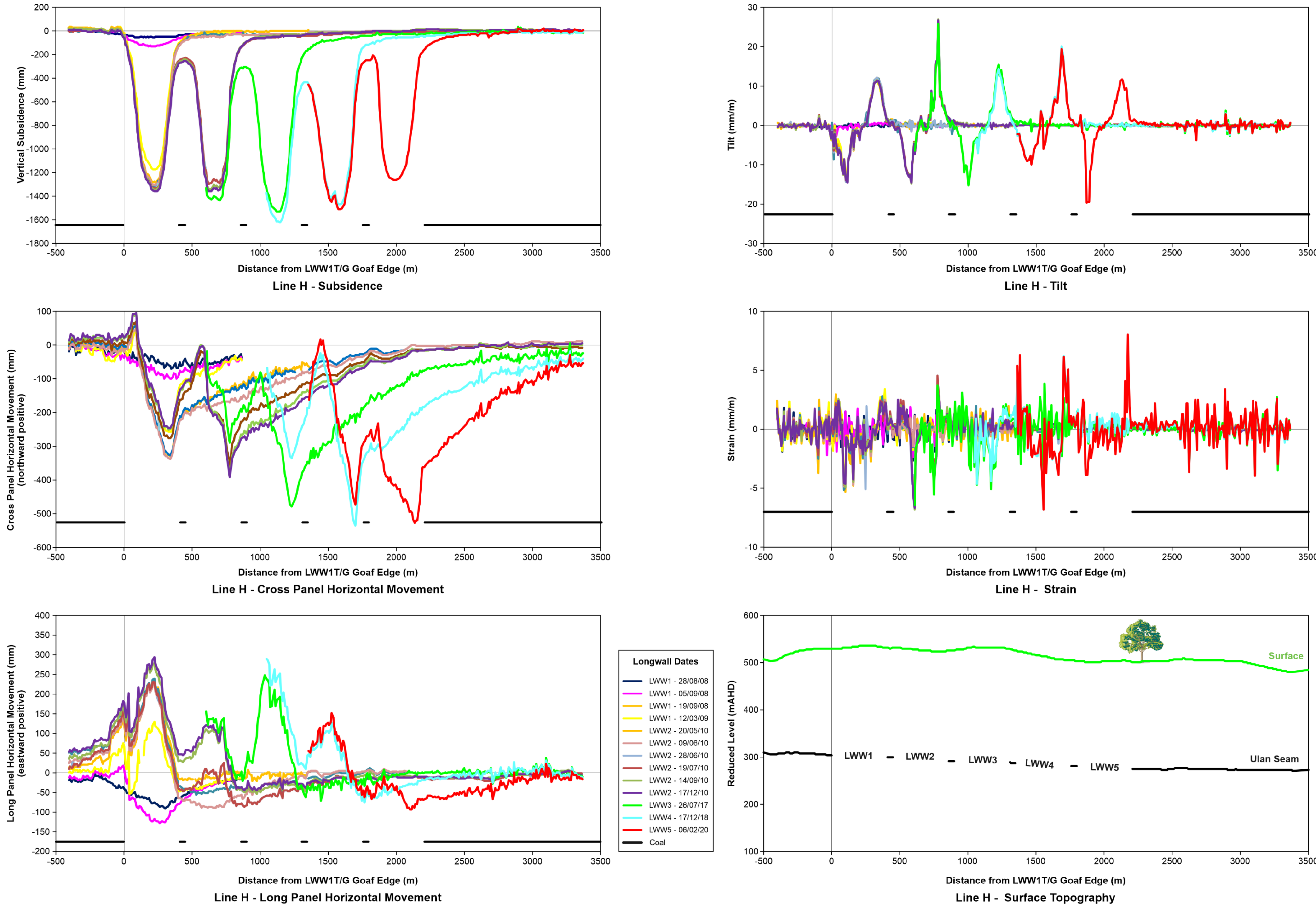


**Figure 4: Subsidence summary of the main parameters of subsidence from the monitoring on H Line at the completion of Longwall W5.**

Maximum vertical subsidence measured above the first three panels in the western domain has increased across each successive panel. Vertical subsidence over the inter-panel chain pillars also increased. Maximum subsidence over Longwalls W4 and W5 has reduced so that maximum subsidence over Longwall W5 is similar to the maximum subsidence measured over Longwall W1.

The variations in maximum subsidence correlate with variation in overburden depth but may also be due to cyclicity of maximum subsidence with distance along each panel. This cyclicity is apparent in the caving behaviour of the Triassic Sandstones. The maximum subsidence observed over any given panel depends on where the subsidence line happens to be in relation to the subsidence cycle.

The vertical subsidence profile over Longwall W5 does not display any significant bias associated with horizontal stress concentrations, indicating that the major horizontal stress is approximately perpendicular to the panel axis where H Line crosses Longwall W5.

Maximum tilt measured over Longwall W5 is 20mm/m. This value is at the upper end of the 10-20mm/m range forecast in SCT (2009), the SMP/EP for overburden depths of 150m to 300m.

Maximum strain measured over Longwall W5 was 4mm/m in compression and 8mm/m in tension. These values are toward the lower end of the 5-15mm/m range of maximum strains forecast in the SMP/EP.

### 4.3 Secondary Subsidence Parameters

A widely distributed survey control network located well outside the active mining area has allowed small, far field horizontal subsidence movements to be measured on H Line with a high degree of confidence. These small far-field horizontal movements have allowed broad scale ground displacements to be studied to provide insight into the mechanics of overburden behaviour around longwall panels.

The improved survey technique has allowed the magnitude of measured ground movements, particularly outside the panel footprint, to be measured more accurately. The magnitudes of secondary subsidence parameters such as goaf edge subsidence, angle of draw to 20mm and horizontal movements have increased as a result of the improved survey technique. These movements were occurring prior to the improvements in survey technique but were previously not able to be detected. The increases are not considered to represent a change in ground behaviour.

Vertical subsidence over the Longwall W4 to W5 inter-panel chain pillar is approximately 250mm at the completion of Longwall W5. This value is consistent with expectations for a depth of 220m but less than the maximum 800mm forecast in SCT (2009) for depths up to 300m. Subsidence above the Longwall W4 to W5 inter-panel chain pillar is similar to the subsidence above the Longwall W1 to W2 chain pillar but less than the maximum 430mm measured on H Line over the Longwall W3 to W4 chain pillar.

Goaf edge subsidence of approximately 160mm was measured above the northern edge of Longwall W5. This value of goaf edge subsidence is similar to the goaf edge subsidence measured at the Longwall W2 and W4 goaf edges but less than the 230mm measured at the Longwall W3 goaf edge. All these values are consistent with the 200-300mm goaf edge subsidence forecast in SCT (2009).

Angles of draw are sensitive to survey tolerance and are therefore somewhat interpretative. The angle of draw for Longwall W5 is estimated to be approximately 46° after consideration of survey tolerance. This value is within the range of 30-50° forecast in the SMP/EP but less than the 65° angles of draw observed after Longwall W3 and W4 were mined.

Horizontal movements above Longwall W5 panel reached a maximum of approximately 500mm. This value is similar to the maximum horizontal movements observed over Longwalls W3 and W4, and consistent with the 500mm forecast in the SMP/EP. The horizontal movements are of similar magnitude and character to the horizontal movements observed over recent longwall panels.

Since PA08_0184 was granted, ongoing subsidence monitoring has improved the understanding of subsidence behaviour at the Ulan Complex. This understanding also includes unconventional subsidence phenomena. As opportunities arise through Project Approval modification or extraction plan processes updated forecasts of subsidence effects are being incorporated in impact assessments.

The forecast magnitude of goaf edge subsidence, angle of draw and maximum horizontal movements were increased in the SMP/EP from those presented in SCT (2009) to reflect the improvements in survey technique. These greater subsidence effects are not considered to be of any significance in terms of subsidence impact. They are imperceptible for all practical purposes and occur so gradually that they do not typically impact surface features. Similar movements are likely to have been occurring for most of the time mining has occurred at the Ulan Complex, but the surveying methods used prior to Longwall W1 and Longwall 23 were not able to detect them.

### 4.4 Far-field Horizontal Movements and Horizontal Stress Relief

Figure 5 shows the cross panel horizontal movements measured on H Line at the completion of Longwalls W1-W5 plotted as a function of distance relative to the northern goaf edge of Longwall W5. The overburden depths at the goaf edge of these five panels range from 220m to 240m. Horizontal movements measured relative to the goaf edges of Longwalls 26, 27, 28 and 29 in the eastern domain at UUG are also plotted for reference. The overburden depth above these eastern domain panels ranges from 240m to 300m.

The horizontal movements measured over the goaf and panel edge of Longwall W5 are almost the same as those measured for Longwalls W4 and W3 and less than the those measured over Longwalls 26-29 where the overburden depth is greater.

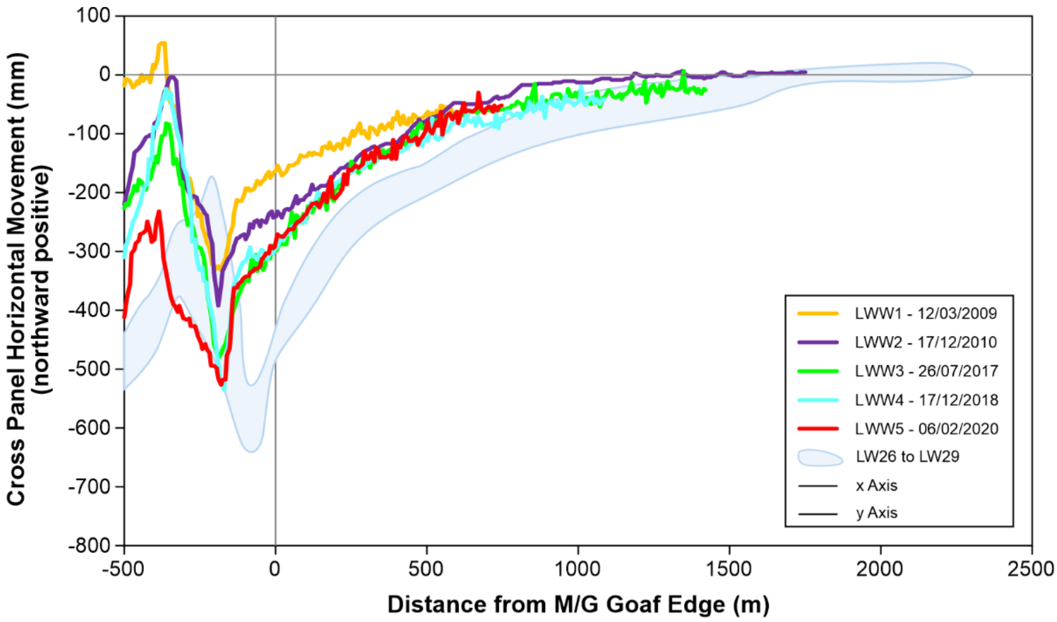


**Figure 5: Cross panel horizontal movements measured on H Line at the end of Longwall W1, W2, W3, W4 and W5.**

These measurements indicate a consistent pattern of horizontal displacement that increases in magnitude with overburden depth. The horizontal displacement profile implies that the far-field horizontal movements are a consequence of horizontal stress relief toward the extracted panels. As the overburden depth increases, the magnitude of horizontal stress increases so the magnitude of stress relief is greater. The greater stresses cause the larger magnitude displacements to extend for a greater distance outside the mining area.

The process that slows and eventually stops the far-field movement involves shear resistance developed on a basal shear plane. Gradually the stress relief that occurs at the goaf edge is balanced by frictional shear resistance on this basal shear plane. Frictional shear resistance appears to be low at Ulan, so far-field movements are evident to distances of the order of 1.5km to 1.8km from the goaf edge in areas where the overburden depth is 250m to 300m.

## 4.5 Unconventional Subsidence Behaviour

No unconventional subsidence effects were observed from the mining of Longwall W5. A compression override or ripple caused by horizontal shearing on a bedding plane was previously observed above Longwall W4. This feature has since been remediated and no extension to the previously disturbed ground or similar feature was observed above Longwall W5.

# 5. OBSERVATIONS OF SUBSIDENCE IMPACTS

This section discusses the subsidence impacts observed from the mining of Longwall W5. The impacts observed are compared with forecasts of impacts made in SCT (2009) and used as the basis for the UUCO Project EA and the SMP/EP forecasts. SCT understands that other specialists have undertaken monitoring of surface and sub-surface features and will independently prepare reports addressing the relevant impact assessment criteria and subsidence performance measures of PA08_0184.

SCT made a site visit to inspect the surface area above Longwall W5 on 16 and 17 January 2020 when the panel was near the finish line and in 'bolt-up'. The site visit included an inspection along H Line and other areas above Longwall W5 including roads and powerlines, Pivot 3 Irrigator, the section of private property (Woodbury) above the start line, and the Bobadeen Homestead precinct near the finish line of the panel.

Subsidence impacts to natural and built features observed during a site visit are generally minor in nature and less than the impacts forecast in SCT (2009) and in the SMP/EP.

Impacts from mining are most perceptible near the start of the panel, including on the Woodbury property. Surface cracks occur parallel to the panel edges. Most of these cracks are within the footprint of the panel. Cracking evident outside the panel footprint at the start of Longwall W5 is expected because of the topography in this area. Larger horizontal movements expected at the start of all panels are coincident with terrain sloping in the direction of mining at the start of Longwall W5. This combination of effects leads to larger cracks at the start of the panel and cracks apparent outside the panel footprint.

Surface cracks are also evident along the panel edges on hard surfaces such as roads and compacted areas around farm sheds.

Impacts to Aboriginal heritage rock shelter sites and sandstone formations more generally are minor with no rock falls recorded and only minor perceptible cracking evident at three of 18 locations (UCMPL 2020).

Subsidence impacts or environmental consequences to other features or items are expected to be less than the criteria for water, biodiversity, land, heritage, built features and public safety in the subsidence performance measures of PA08_0184, based on observations, monitoring and the primary subsidence effects being less than forecast in the UCCO EA, notwithstanding assessment of water and biodiversity impacts by other specialists.

Additional impacts associated with unusually heavy rainfall events in February and April 2020 following an extended drought are considered in this report even though these events occurred well after mining in the area was completed. Overland flow in a drainage line that has interacted with subsidence cracks above the start of the panel has led to localised surface erosion on the Woodbury property. Work to develop a remediation strategy is planned after consultation with the landowner, but an overview of the impacts is presented.

## 5.1 Impacts on UCMPL Property

Surface cracks observed during site visits were generally less than 50-100mm wide and most are located near panel edges. The low frequency of cracks observed is consistent with expectation based on experience in the adjacent panels.

Figure 6 shows a crack, parallel to and inside the northern panel edge of Longwall W5 where it crosses H Line.

**Figure 6: Surface crack that crosses H Line.**

Figure 7 shows similar cracking, near the northern side of Longwall W5 further to the east, that crosses Irrigation Road below the single pole overhead powerline at this location. No significant impacts or consequences to these built features were reported.

Minor cracking was also observed above the southern side of Longwall 5 at the hay shed 500m to the west of the Bobadeen Homestead site. Figure 8 shows the cracking parallel to and approximately 40m in from the southern panel edge at the hay shed location. There were no perceptible impacts to the hay shed structure.

**Figure 7: Cracking adjacent to Irrigation Road.**

**a) Cracking near foundation.**

**b) Overview of hay shed structure.**

**Figure 8: Impacts to Bobadeen Hay Shed.**

UCMPL (2020) reports on pre and post mining monitoring of surface features above the panel footprint as required by the SMP approval conditions for Longwalls 27-29 and W4-W5. This monitoring includes the pre and post mining condition of buildings in the Bobadeen Homestead precinct, Aboriginal heritage rock shelter sites and sandstone formations, flow (drainage) lines, farm dams and mining related or farm infrastructure. The post mining inspections for Longwall W5 were completed on 19 March 2020 after a significant (140mm) rainfall event on 17 February 2020.

No perceptible impacts from longwall mining were recorded to the Bobadeen Homestead and associated outbuildings.

The SMP/EP specifies the following three Aboriginal heritage sites are to be monitored during mining of Longwall W5:

- Ulan ID#599 (MC111), is located approximately 15m outside the northern panel edge.
- Ulan ID#630 (MC142), is located over the centre of Longwall W5.
- Ulan ID#677 (MC189), is located approximately 10m outside the southern panel edge above the Longwall W4-W5 chain pillar.

These three sites are rock shelters with artefacts. Their locations are shown in Figure 2.

No rock falls were observed, and only very minor cracking was perceptible at Site 599. No rock falls or perceptible cracking were observed at Sites 630 and 677.

Another 15 sandstone formations were also monitored. These also host rock shelter sites. Three of these are near Site 599 on the northern edge of the panel and twelve are immediately to the east of Site 630 above the centre of Longwall W5. No rock falls were recorded at any of the 15 locations monitored, and only very minor perceptible cracking or a slight change to the previous cracking was noted at two locations.

These impacts are less than the forecast in SCT (2009). Rock falls were forecast on up to 20% of the length of cliff formations located directly over mined areas and perceptible impacts were forecast along 70% of the length of cliff formations mined under or located within 0.4 times depth of the panel edge.

No perceptible impacts to the drainage line (tributary of Mona Creek) and associated farm dams were observed. However, increased erosion, most likely from the heavy rainfall event was noted in several locations. The two dams that have been mined under by Longwall W5 were reported as at near capacity following the rainfall event. Some significant erosion was recorded on some drainage lines, but this erosion is unlikely to be directly related to subsidence impacts.

The appearance of the surface cracking was noted to have changed after the rainfall event. The width of cracks was noticeably wider especially in sandy soil areas where erosion or slumping of the near surface material had fallen into the cracks.

Mining related infrastructure or built features and farm infrastructure owned by UCMPL appeared to be unaffected by mining subsidence. This infrastructure includes powerlines, pipelines and buried cables, agricultural land, irrigation equipment, fences and water troughs. Minor cracking near the panel edge was reported on the access road within the new services corridor to the northwest. No other impacts were observed along this corridor.

Minor impacts were also reported to the Pivot 3 irrigator during the active subsidence period as forecast in SCT (2018a). The horizontal movements resulted in temporary changes to the alignment and tracking of transit wheels during the transient period of subsidence movements. Tracking has since rectified itself once the longwall moved past the pivot.

Conservation areas for Aboriginal heritage sites at Mona Creek, Brokenback and Cockabutta Creek and the Talbragar Fish Fossil Reserve are all remote from the mining of Longwall W5. These areas are not expected to have experienced any perceptible impacts. No impacts were observed in the Brokenback Conservation Area or at the Talbragar Fish Fossil Reserve during surface inspections on 16 and 17 January 2020.

Subsidence impacts and environmental consequences to other features or items are expected to be less than the criteria for water, biodiversity, land, heritage, built features and public safety in the subsidence performance measures of PA08_0184, based on observations, monitoring and the primary subsidence effects being less than forecast in the UCCO EA, notwithstanding assessment of water and biodiversity impacts by other specialists.

## 5.2 Impacts to Private Property

The section of the Woodbury property above Longwall W5 was inspected on 17 January 2020 in company with the landholder. The impacts observed were consistent with expectation and less than the maximum forecast in SCT (2009) and in the SMP/EP.

Figure 9 shows a general view of the surface above Longwall W5. The farm dam embankment just east of the start line of the panel is in the middle ground on the left in the photograph. Cracking was observed near the panel edges both inside and outside the panel edge. The sandy soil was observed to slump into cracks in some places giving the appearance of "potholes". Figure 10 shows an example of this type of impact.

The width of cracks parallel to the start line of Longwall W5 are expected to be larger than elsewhere along the panel because of the subsidence mechanics that generate horizontal movement. Crack width at the start of Longwall W5 is further magnified by the surface terrain sloping in the direction of mining. The largest horizontal movements occur at the start of longwall panels with the direction of movement in the direction of mining.

**Figure 9: General view of section of 'Woodbury' property above Longwall W5.**

**Figure 10: Cracking near northern edge of Longwall W5.**

Cracks that form above the start line of longwall panels are permanent and usually larger than elsewhere. The interaction of subsidence and sloping terrain causes horizontal movements to develop in a downslope direction. This effect is greatest when mining from high ground towards lower ground. The combination of sloping terrain in the direction of mining at the start of a longwall panel leads to the type of cracking shown in Figure 11.

a) Looking South.

b) Looking North.

Figure 11: Cracking in sloping terrain near start line of Longwall W5.

The two farm dams above or adjacent to the area mined by Longwall W5 had very low levels of standing water. The low water levels observed are likely to have been a combination of mining impacts and the drought conditions at the time of inspections. It is understood that UCMPL will remediate these impacts to the satisfaction of the landholder as detailed in the Private Property Subsidence Management Plan (PPSMP).

The start of Longwall W5 is located below an ephemeral drainage line that eventually flows into Mona Creek. Potholes were observed along this drainage line during the site visit on 17 January 2020. Sandy soil had eroded into a subsidence crack during a period of overland flow along the drainage line. Two heavy rainfall events in February and April 2020 have caused further erosion and an increase in the size of the potholes observed. Figure 12 shows overland flow entering subsidence cracks and the resulting erosion. A strategy of regrading the eroded areas and moving the drainage line to avoid a recurrence is expected to be effective in controlling further erosion.

## 6. REFERENCES

SCT 2009 "Part 3A Subsidence Assessment Ulan Coal – Continued Operations" – SCT Report ULA3367 - 14 August 2009.

SCT 2016 "Subsidence Assessment for Extraction Plan LW30 and LWW6 – LWW8 at Ulan Underground Mine" SCT Report ULA4560 - 28 September 2016.

SCT 2018a "Ulan Underground Mine: Subsidence Assessment for Irrigation Pivot 3" - SCT Letter Report ULA4917 – 31 August 2018.

SCT 2018b "Ulan Underground Mine: Subsidence Assessment for Bobadeen Homestead" - SCT Letter Report ULA4916_Rev1 – 14 December 2018.

SMP/EP 2016 "Ulan Coal Subsidence Management and Extraction Plan" - ULN SD PLN 0024 - Version: 5 - Effective 24/09/2012 – Dated May 2016.

UCMPL 2020 "Pre & Post Mining Inspection LWW5 Ulan Underground Mine".

**a) Example of flow into a subsidence crack during an overland flow event.**

**b) Example of erosion along a drainage line following an overland flow event.**

**Figure 12: Erosion associated with interaction of overland flow and subsidence cracks.**

# APPENDIX 2

Australasian Groundwater and
Environmental Consultants Pty Ltd

Report on

# Ulan Annual Groundwater Review 2019

Prepared for
Ulan Coal Mines Pty Limited

Project No. G1985D April 2020
www.ageconsultants.com.au ABN 64 080 238 642

# Document details and history

## *Document details*

| | |
|---|---|
| **Project number** | G1985D |
| **Document title** | Ulan Mine Annual Groundwater Review 2019 |
| **Site address** | Ulan Mine |
| **File name** | G1985D Ulan Mine Annual Groundwater Review 2019 v01.04.docx |

## *Document status and review*

| Edition | Comments | Author | Authorised by | Date |
|---|---|---|---|---|
| v01.04 | Final | PAR | DWI | 08/04/2020 |
| | | | | |



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*Appendix B* North Monitoring Network VWP hydrographs

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*Appendix D* Private monitoring bores

*Appendix E* Groundwater model (MOD4) level predictions v observed

*Report on*

# Ulan Mine
# Annual Groundwater Review 2019

## 1 Introduction

Ulan Coal Mine Complex (Ulan Mine) is operated by Ulan Coal Mines Pty Limited (UCMPL. The Ulan Mine is located in the central west of New South Wales near the town of Ulan, approximately 38 km north-northeast of Mudgee. Ulan Mine was first assessed under Part 3A of the *Environmental Planning & Assessment Act 1979* (EP&A Act) and approved on 15 November 2010. Routine groundwater monitoring is undertaken at Ulan Mine as part of the conditions of the project approval (PA 08_0184), which was last updated in July 2019 (Modification 4). The groundwater monitoring program is outlined in the Ulan Groundwater Monitoring Program (GWMP) that was updated in May 2019.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) were commissioned by UCML to prepare this annual groundwater review for the 2019 monitoring period/calendar year. The annual groundwater review has been prepared to address Schedule 5 (Environmental Management, Reporting and Auditing) and the statements of commitments listed in Appendix 9, Section 6.4.1 to Section 6.4.6 of PA 08_0184.

## 2 Objectives and scope of work

The GWMP incorporates monitoring in accordance with the conditions of approval at the Ulan Mine site, and on properties adjacent to Ulan Mine. Tasks undertaken over the 2019 monitoring period included:

1. manual measurement of groundwater water levels in the monitoring network;
2. downloading of electronic water level loggers; and
3. collection ofgroundwater samples for field and laboratory analysis.

The objective of this report is to review and present the groundwater monitoring results and analyses for the 2019 monitoring period.

# 3 Project approval conditions

Condition 39 of PA 08_0184 requires that Ulan Mine conducts groundwater monitoring program whilst Appendix 9 lists the commitments made by UCMPL.

Commitments specific to groundwater are stipulated under Sections 6.4.1 to 6.4.6 of Appendix 9.

Table 3.1 details the PA 08_0184 conditions and commitments relevant to this review, a short summary of findings from this review, and reference to the sections of this review where full details are provided.

**Table 3.1 Project approval conditions**

| Project approval conditions | 2019 Annual groundwater review |
|---|---|
| **39.** The Groundwater Monitoring Program must include: | |
| b) a program to augment the baseline data over the life of the project; | **Section 6**<br>Ulan Mine has four active monitoring networks, the North Monitoring Network (NMN), Bobadeen Monitoring Network (BMN), Pleuger Monitoring Network (PMN) and the Private Bore Monitoring Network. Groundwater monitoring in these networks adds to the baseline data of the project. |
| c) groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts; | **Section 6.3**<br>Ulan Mine has established groundwater quality and level triggers for NMN, BMN and the Private Bore Monitoring Network as part of its Surface Water and Groundwater Response Plan.<br>**Appendix E**<br>Observed drawdown results are tabulated and compared to the approved groundwater model predicted heads |
| d) a program to monitor and/or validate:<br>○ groundwater inflows to the open cut and underground mining operations; | **Section 8.1** |
| ○ a program to monitor and/or validate the impacts of the project on the:<br>▪ alluvial aquifer<br>▪ Triassic aquifers<br>▪ coal seam aquifer<br>▪ interburden aquifers | **Section 6**<br>Monitoring bores in the NMN, BMN and PMN installed to monitor the Triassic, coal seam and interburden aquifers. The site monitoring program and monitoring bore details are outlined in detail in the GWMP. |
| ▪ baseflows to the Goulburn and Talbragar Rivers and associated creeks; | **Section 7.5** |
| ▪ any groundwater bores, springs and seeps on privately-owned land; and | **Section 7.4**<br>Twenty-five identified privately owned bores were monitored in 2019. There were no identified impacts |

| Project approval conditions | 2019 Annual groundwater review |
|---|---|
| ▪ the 'Drip'. | **Section 7.5**<br>Analysis of the water quality results indicate The Drip water quality exhibits a different proportion of major ions (different water type) and metals compared to the Triassic sediments away from the cliff exposure. Indicating the influence of a different recharge source. |
| ○ the seepage/leachate from any tailings dams, water storages or backfilled voids on site. | **Section 7.2 and Section 7.3**<br>Monitoring of potential seepage from Bobadeen Dam and the Bobadeen Irrigation Scheme is captured by the BMN. Seepage from backfilled voids is captured by the PMN.<br>No adverse changes in water levels or water quality were observed for either monitoring network.<br>The GWMP does not include any actively monitored bores positioned around the East Pit tailings storage. |
| **6.4.1** The GWMP will include:<br>• Continued measurement of groundwater levels, pressures and water quality within the existing regional network of monitoring bores and an expanded network as underground mining progresses to the north and west, specifically considering: | **Section 7**<br>Where access allows, the NMN, BMN, PMN and Private Bore Monitoring Network were all monitored during 2019 at the frequency outlined in the GWMP. |
| ○ depressurisation monitoring of at least three multi-level piezometer strings equipped with vibrating wire transducers (or equivalent) and distributed within the Permian-Triassic strata; | **Section 6.2.2 and Section 7.1.1.1**<br>Most VWPs remained functional during the 2019 monitoring period. The currently monitored NMN intersects all key hydrogeological units. VWP and monitoring bores are progressively installed as the mine moves north and west |
| ○ strata hydraulic conductivity measurement on rock core obtained at these above noted piezometer locations; | **Ulan Annual Review 2018** Error! Reference source not found.<br>Hydraulic conductivity measurement on rock core from hole DDH561 was provided as Appendix in the Ulan Mine Annual Review 2018. |
| ○ daily or more frequent monitoring of pore pressures and piezometric elevations by installed auto recorders in selected new piezometers. | **Section 6.2.2 and Section 7.1.1.1**<br>Several VWP installations are in place and recording across the site |
| • Groundwater monitoring will include:<br>○ monthly monitoring of basic water quality parameters pH and EC in pumped mine water. | **Section 7.3**<br>Pumped groundwater quality is sampled from the PMN and pumped into the mine water system. No adverse impacts were identified. |

| Project approval conditions | 2019 Annual groundwater review |
|---|---|
| ○ six monthly monitoring of pH and EC in the regional monitoring network. | **Section 7.1**<br>Regional groundwater monitoring was completed in the NMN which covers the area surrounding the mine.<br>Where access is allowed, all site groundwater monitoring and sampling frequencies are outlined in the GWMP |
| ○ annual measurement of total dissolved solids (TDS) and speciation of water samples in selected piezometers to support identification of mixing of groundwater types. | **Section 7.1.2 and Section 7.5**<br>Annual groundwater samples for speciation were collected from the NMN and The Drip. |
| ○ graphical plotting of basic water quality parameters and identification of trend lines and statistics including mean and standard deviation calculated quarterly. Comparison of trends with rainfall and any other identifiable processes that may influence such trends. | **Appendix A, Appendix C and Appendix D**<br>Timeseries charts are presented for:<br>• NMN in Appendix A;<br>• PMN in Appendix C; and<br>• Private Bores in Appendix D. |
| • The monitoring network and monitoring programme will be reviewed on an annual basis to determine ongoing suitability and any proposed changes will be discussed in the annual review of monitoring results. | The groundwater monitoring network at Ulan Mine is extensive and a program is in place to install groundwater monitoring infrastructure as the mine progresses. |
| **6.4.2**<br>The results of groundwater monitoring and a comparison of measured and predicted impacts will be reported in the annual review required by the project approval conditions. | **Section 7.1 and Appendix E**<br>The 2019 observed groundwater drawdown was compared to predicted levels. The review indicates the model predictions are generally in line with observed changes during 2019 |
| **6.4.3**<br>Impacts on the privately owned licensed bores identified as being potentially affected, will be assessed by monitoring and in the event that any utilised privately owned bore is significantly adversely affected, an alternative water supply will be provided by UCML until such time as the bore is re-established or replaced, or appropriate compensation established, in accordance with project approval requirements. | **Section 7.4**<br>There were no adversely affected private bores identified in this review. Ulan Mine continues to monitor private bores annually (when accessible) or more frequently if requested by a landholder. |
| **6.4.4**<br>The groundwater monitoring results will be analysed (graphically and statistically) as new results become available i.e. quarterly or six monthly. In addition, a monitoring review and verification process will be established as part of the Water Management Plan process, to verify regional groundwater losses as necessary to refine groundwater mitigation strategies. | **Section 7**<br>Groundwater levels and water quality are reviewed by Ulan Mine staff as they occur. Any data anomalies or trends are investigated. An annual groundwater review is completed to identify any adverse impacts that will help refine the groundwater management plans. |

| Project approval conditions | 2019 Annual groundwater review |
|---|---|
| **6.4.5**<br>Identification of any changes or long-term trends in groundwater outside the predicted impacts will result in an investigation to determine if the trend is a result of the Project operations and if so, identify management strategies to be implemented to address the identified issues as per UCML's Internal TARP process (T – trigger; A – Action; R – response; P – Plan). | **Section 7.1, Appendix A, B, Appendix C, Appendix D, and Appendix E**<br>Groundwater levels within the NMN generally matched predicted trends for all bores. |

# 4 Background

## 4.1 Geology

Ulan Mine is located within the western limit of the Sydney Basin, and at the southern end of the Gunnedah Sub-basin. The stratigraphic sequence across the mine area comprises Permian Illawarra Coal Measures, Triassic Narrabeen Group and Jurassic Pilliga sandstone (Table 4.1). Tertiary volcanics and Quaternary sediments are also present in localised areas around the site. The Permian and Triassic strata are largely stratified and uniformly dip towards the north-east at a shallow angle (between 1 and 3 degrees).

**Table 4.1 Summary of site stratigraphy**

| Age | Unit | Description |
|---|---|---|
| **Quaternary** | - | Alluvium/colluvium – comprising soil, silt, clay, sand and gravel |
| **Tertiary** | - | Alluvium (palaeochannels)<br>Weathered basalts |
| **Jurassic** | Pilliga sandstone<br>Purlewaugh Siltstone | Coarse grained quartzose sandstone, lithic sandstone, conglomerates, claystone and shale |
| **Triassic** | Wollar Sandstone (Narrabeen Group equivalent) | Quartzose and lithic sandstone, conglomerates and claystone |
| **Permian** | Illawarra Coal Measures | Interbedded claystones, siltstones, sandstones (fine to coarse grained) and coal seams |

## 4.2 Mine activities

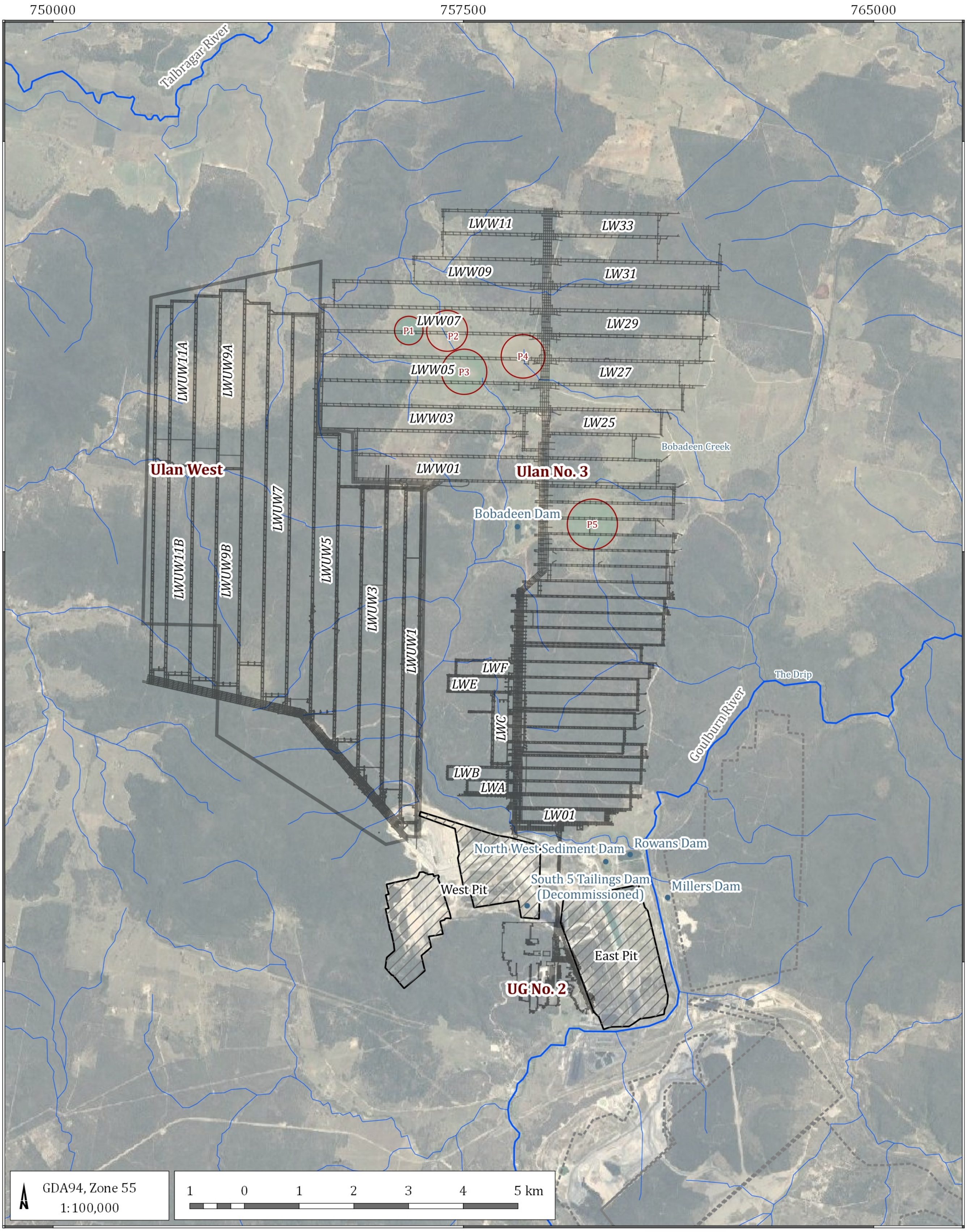
The Ulan Mine has a long history of open-cut and underground mining dating back to the 1920's. Currently, underground mining is active within Ulan No. 3 and Ulan West Underground (Figure 4.1). During 2019 Ulan No.3 completed the extraction of LWW5 and heading development of LWW6 and commenced development of LWW7.

Mining commenced at Ulan West Underground around 2012 and will progress in a westerly direction until 2031. During 2019, mining was active within the Ulan West Underground in longwall panel LW5 and headings development commenced for LW6.

Historic underground mining within the Ulan Coal Complex also occurred at Underground No. 2 until 1983.

Open cut mining occurred at East Pit until 2008. Mining at West Pit occurred from 2012 until 2016 when it entered care and maintenance; however, mining in West Pit is approved until 2031. East Pit is currently used for tailings storage. Tailings were also stored within South 5 Tailings Dam until around 2011, and within West Pit (Barrier Pit) between 2012 and 2016.

There are several water storage dams at Ulan Mine, including East Pit, North West Sediment Dam, Bobadeen Dam and Rowans Dam that store underground mine water. This water is treated at either the Bobadeen Water Treatment Facility, or the North West Sediment Dam Treatment Facility. Treated water is then blended and either used for operations, irrigation or discharged. Potable water is abstracted from PB1C (WAL41492), treated at the Miller Water Treatment Facility and used to meet site requirements. The rate of abstraction from PB1C is approximately 50 ML/year.




LEGEND

- Major drainage
- Minor drainage
- Ulan underground
- Ulan open cut
- Moolarben mine area
- Bobadeen Irrigation System (P1 - P5)

Ulan Annual GW Review 2019 (G1985D)

**Mine area**

AGE

DATE 16/03/2020

FIGURE No: **4.1**


Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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# 5 Rainfall data

Rainfall data has been collected at Ulan Mine on a daily basis since 2013. Rainfall patterns during 2019 were compared with long term averages derived from SILO data[1]. Whilst rainfall in January (135.1 mm) and March (88.9 mm) exceeded long term averages (72.3 mm and 56.0 mm respectively), the remainder of 2019 experienced below average rainfall. Overall, 2019 total rainfall was 50% of the long term average annual rainfall.

Table 5.1 presents the Ulan Mine 2019 average monthly rainfall and long term average SILO data.

### Table 5.1 Monthly rainfall data

| Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SILO long-term average monthly rainfall (mm) | | | | | | | | | | | | |
| 72.3 | 64.0 | 56.0 | 42.4 | 44.3 | 49.4 | 47.4 | 44.4 | 45.7 | 54.1 | 59.0 | 66.3 | 645.4 |
| Ulan Mine 2019 rainfall (mm) | | | | | | | | | | | | |
| 135.1 | 2.7 | 88.9 | 0.2 | 17.0 | 9.4 | 5.0 | 6.9 | 26.7 | 9.4 | 18.6 | 4.4 | 324.3 |
| 2019 % of long-term average | | | | | | | | | | | | |
| 187% | 4% | 159% | 0% | 38% | 19% | 11% | 16% | 58% | 17% | 32% | 7% | 50% |

# 6 Monitoring network

Groundwater monitoring at Ulan Mine is undertaken in accordance with the GWMP. Information relating to Ulan Mine's groundwater monitoring activities in 2019 are provided in this section. Full details of the groundwater monitoring program and network including monitoring and sampling frequency, sample method and trigger levels for water levels and water quality are provided in the GWMP.

## 6.1 Monitoring bores

The monitoring bore network at Ulan Mine has been installed over a number of different campaigns since 1997. Full details of the groundwater monitoring network are detailed in the GWMP and locations are shown in Figure 6.1. Ulan Mine has four active monitoring networks, the North Monitoring Network (NMN), Bobadeen Monitoring Network (BMN), Pleuger Monitoring Network (PMN) and the Private Bore Monitoring Network.

The NMN is the largest monitoring network with bores, intersecting all key hydrogeological units except alluvium. The NMN comprises:

- 38 monitoring standpipes at 18 locations from which groundwater level and quality data is collected;
- One data logger R753A is installed to collect water level data; and
- eighteen vibrating wire piezometer (VWP) arrays locations with multiple sensors installed from which groundwater pressure data for the target strata is collected.

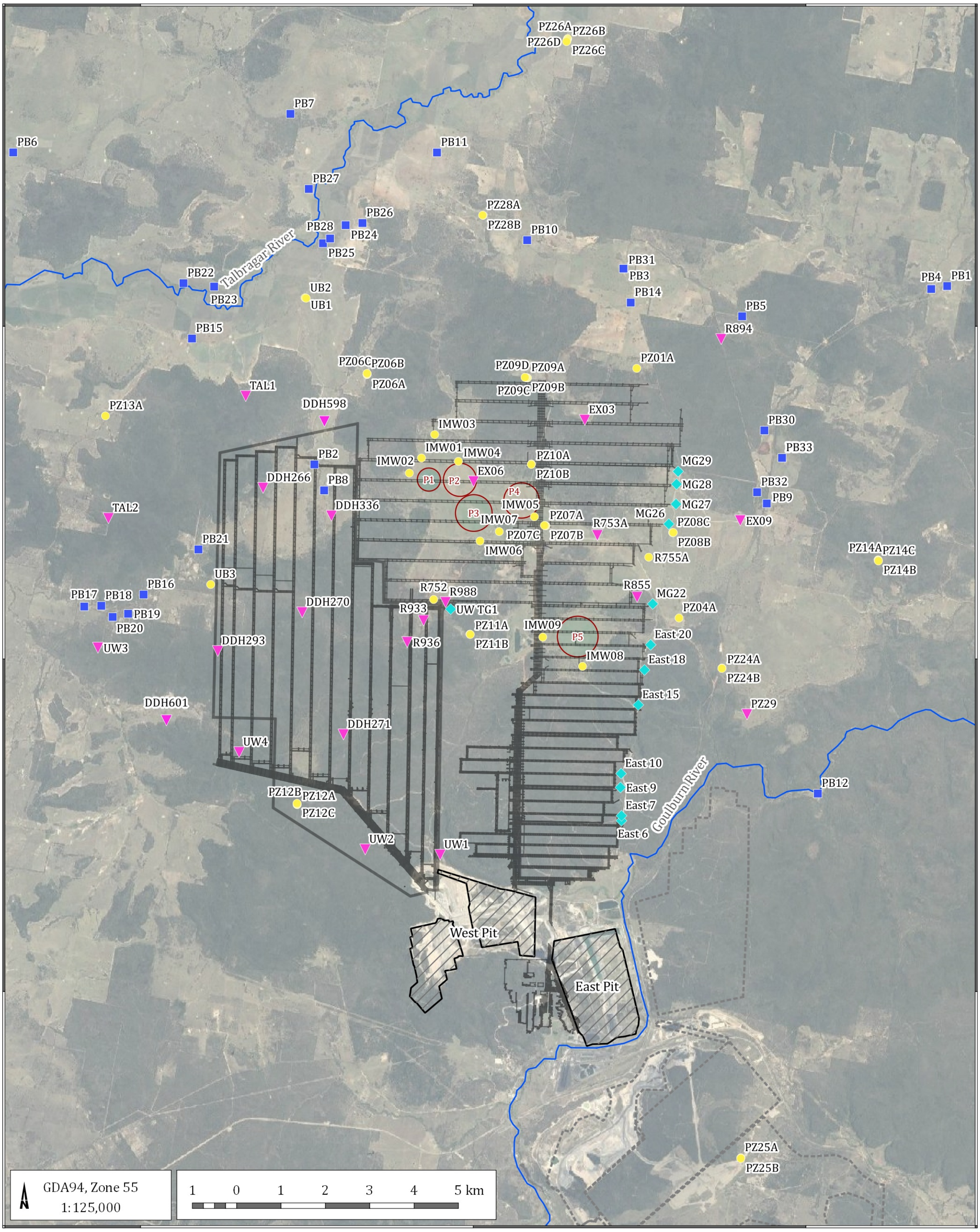
[1] Rainfall data is collected by BoM at station 62036 however there are significant gaps in this dataset. In order to obtain longer term climate information, rainfall data was sourced from the Scientific Information for Land Owners (SILO) database. SILO is operated by the Queensland Department of Environment and Science, with data contributions from BoM. The SILO generates a climate dataset via interpolation between neighbouring BoM stations to produce a continuous daily time series. The SILO dataset was for latitude -32.25 and longitude 149.70 from 1889 to present.

Additional VWP arrays were also installed at two new locations; Mona Creek (DDH598) and Ryan's (DDH601) in late 2019 with data from these VWP not included in this review.

The BMN comprises nine open standpipes (IMW01 to IMW09) in the vicinity of Bobadeen Dam and the Bobadeen Irrigation Scheme. The shallow monitoring bores intersect unconsolidated sediments within the upper catchments of Mona Creek, Ulan Creek, and Spring Gully Creek and monitor seepage from the BIS.

The PMN comprises active and decommissioned bores used to dewater the underground workings at Ulan Mine. In 2019, the PMN consisted of eight active dewatering bores (East 20, MG22, MG23, MG26, MG27, MG28, MG29 and UW-TG1) and six decommissioned dewatering bores (East 7, East 9, East 10, East 15, East 18 and MG21).

Where access is granted, private landholder bores (PB bores) are also monitored. However, there is limited information about the construction of these bores.




LEGEND

- Major drainage
- Ulan underground
- Ulan open cut
- Moolarben mine area
- Bobadeen Irrigation System (P1 - P5)

**Groundwater monitoring network**

- Abstraction
- Landholder
- Monitoring bore
- VWP

Ulan Annual GW Review 2019 (G1985D)

## Groundwater monitoring network

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FIGURE No: **6.1**


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## 6.2 Network status and condition

### 6.2.1 *Monitoring bores*

#### *NMN*

Due to access restrictions, monitoring bores PZ13A, PZ25A, PZ25B, PZ26A, PZ26B, PZ26C and PZ26D were not sampled during 2019. Access restrictions at monitoring bores PZ14A, PZ14B and PZ14C limited data collection to only the second half of 2019.

No sampling from NMN monitoring bores PZ08B, PZ12A and R752 was undertaken during 2019 as these bores were dry over this period. Groundwater conditions (insufficient yield) also prevented sampling during some 2019 monitoring rounds at PZ04A, PZ10B and PZ28A.

#### *BMN*

All BMN monitoring bores were recorded as being dry for all monitoring events during 2019.

#### *PMN*

Throughout 2019, monitoring was undertaken at PMN bore as follows:

- water level measurements at East 7, East 9, East 15, East 18, East 20 and MG21; and
- groundwater quality sampling from East 20, MG23, MG26, MG27, MG28, MG29 and UW-TG1.

#### *Private bores*

Annual groundwater level measurement and quality sampling was undertaken at 29 bores in the private bore monitoring network. Due to installed headworks (i.e pumps), water level measurements were only collected from 15 of the 29 bores.

### 6.2.2 *VWP*

Of the 14 NMN VWPs accessed, in 2019, ten (EX03, EX06, EX09, TAL1, TAL2, UW1, UW2, UW3, UW4 and PZ29 [The Drip]) were serviceable and provided data. Some disruption to data collection occurred at TAL1, UW1 and UW2 during 2019. As noted in Section 6.1, two additional VWP, Mona Creek and Ryans, were installed in late 2019.

Of the remaining VWPs, three (DDH266, DDH270 and R894) were reinstated in 2019 with data to be collected in 2020. The fourth VWP, DDH271, is out of service and will not be replaced as this location is expected to be mined through in 2020.

## 6.3 Trigger levels

### 6.3.1 *Site monitoring bores (NMN and BMN)*

The Environmental Assessment (EA) for Ulan Mine predicts complete dewatering of Triassic strata above all mine longwall panels, with depressurisation extending up to 5 km from the mine. Subsequently, trigger levels are not required to be developed for all Ulan Mine groundwater monitoring locations above the mined longwall panels, as the majority of these monitoring bores are predicted to become dry within the life of the mine. These monitoring locations include some NMN bores and VWP, and all PMN and BMN locations.

Groundwater levels for those NMN locations outside of the immediate mine footprint (PZ01, PZ04, PZ06, PZ08, PZ09, PZ12, PZ13, PZ14, PZ24, PZ25, PZ26, PZ28, PZ36, R755A, R894, TAL1, TAL2, UW2 and UW3), are compared against model predictions in accordance with the Ulan Mine Surface Water and Groundwater Response Plan (SWGWRP) to identify any deviations. Any lowering of groundwater levels beyond SWGWRP trigger levels will require investigation into the potential cause and implications.

The SWGWRP specifies a 10% divergence from historical groundwater quality as being triggers for NMN monitoring bores. Subsequently, 2019 groundwater quality data has been reviewed against the 80$^{th}$ percentile of historical data to identify changes in groundwater quality which may require further investigation.

### 6.3.2 *Site monitoring bores (PMN)*

Groundwater is abstracted from PMN dewatering bores to deliberately lower groundwater levels to allow for underground mining. Abstracted groundwater is then treated prior to site use, irrigation or discharge. As groundwater drawdown is intended and approved and abstracted water treated, trigger values for the PMN have not been adopted in this review.

### 6.3.3 *Private bores*

Trigger levels for the private bore monitoring network have been developed based on predicted drawdown and are provided in the SWGWRP. Those private bores that are predicted to experience groundwater level drawdown in excess of 2 m as the result of mining operations and those which are not.

2019 groundwater levels and groundwater quality results collected from the private bore monitoring network (where access permits data collection) have been compared against the SWGWRP trigger levels.

The SWGWRP trigger levels are as follows:

- ± 10% deviation from baseline data for those bores within the predicted 2 m drawdown area;
- ± 15% deviation from baseline data for those bores outside the predicted 2 m drawdown area;
- greater depressurisation than that predicted by numerical groundwater modelling; and
- complaint received from private landholder.

# 7 Monitoring results

The sections below present the 2019 monitoring results for each of the stratigraphic units present at Ulan Mine (refer Table 4.1).

## 7.1 North monitoring network

During the 2019 monitoring period and where access and groundwater conditions permitted (refer Section 6.3.1), groundwater levels were monitored on a quarterly basis, field water quality was sampled bi-annually and a full suite of chemical parameters was collected annually.

Hydrographs for NMN monitoring bores and VWPs are presented in Appendix A and Appendix B respectively. Comparisons with the model predictions are discussed in the following results sections with tabulated observed 2018 and 2019 and predicted drawdown presented in Appendix C.

### 7.1.1 *Groundwater levels*

#### *Tertiary basalt*

Monitoring bore R752 intersects Tertiary basalt. This monitoring bore was dry during the second half of 2018 and through all 2019 monitoring rounds. It is expected that the absence of groundwater levels at R752 is the result of low rainfall (refer Section 5).

#### *Jurassic sediments*

Quarterly groundwater levels for 2019 are presented in Table 7.1, which shows groundwater levels during 2019 in:

- PZ09D were relatively stable (+/- 0.1 m), similar to 2018 levels;
- PZ10B increased between quarter 2 and quarter 3 however this bore was dry in quarter 4.
- PZ14C (when access was permitted) were stable; and
- PZ28B were stable in 2019 after slightly decreasing in 2018.

Figure 7.1 shows the interpolated groundwater contours from monitoring bores and VWP in the Jurassic sediments. The contours clearly show that groundwater flow is south-easterly, away from the mine towards the Goulburn River.

**Table 7.1 Jurassic groundwater levels**

| Site | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| PZ09D | 62.1 | 62.2 | 62.2 | 62.1 |
| PZ10B | 33.6 | 34.6 | 30.7 | dry |
| PZ14C | no access | no access | 33.5 | 33.5 |
| PZ28B | 16.2 | 16.2 | 16.2 | 16.2 |

***Note:*** *ground water level in metres below reference point [GWL mBRP]*

#### *Triassic sediments*

The Triassic sediments directly overlie the Permian coal measures, which include those currently being mined. Table 7.2 presents the 2019 results of groundwater level measurements at NMN monitoring bores screened in this stratigraphy. As shown in Table 7.2, measured 2019 groundwater levels for PZ01A, PZ06C, PZ09C, PZ11B, PZ12C, PZ14B, PZ24B, PZ28A and R755A were generally stable (+/- 0.2 m). The relative stable groundwater levels measured in PZ01A, PZ06C, PZ24B and R755A during quarters 2, 3 and 4 are counter to the slight decreasing trend observed in 2018.

PZ10A, which is located directly above the northern section of the underground mine continued to experience groundwater decline of around 5 m over the 2019 monitoring period. This is in addition to a 3 m decline in 2018. This observed drawdown is at a greater rate than the predicted drawdown, and likely reflects differences in the modelled mine plan to the actual mining sequence/timing. PZ07C, which is also within the mine footprint also exhibited decreasing groundwater levels. However, the observed drawdown has not exceed predicted drawdown.

Declining groundwater levels at PZ04A and PZ08C, both east of the mine footprint, represent a continuing trend from 2018. During 2019, trigger levels at these monitoring bores were not exceeded. However, should the groundwater decline at PZ08C continue at current rates (0.7 m/year average over 2018 and 2019), it is likely that the trigger value for this monitoring bore will be exceeded in 2020.

Figure 7.2 shows the interpolated groundwater contours from monitoring bores in the Triassic sediments. The contours show that groundwater within the Triassic sediments is lowest in an area directly above the mine (PZ10A).

### Table 7.2 Triassic groundwater levels

| Site | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| PZ01A | 117.8 | 118.0 | 118.0 | 118.0 |
| PZ04A | 42.9 | dry | dry | 43.2 |
| PZ06C | 19.3 | 19.4 | 19.4 | 19.4 |
| PZ07C | 107.9 | 108.3 | 108.5 | 108.7 |
| PZ08C | 86.0 | 86.2 | 86.4 | 86.5 |
| PZ09C | 118.9 | 119.2 | 119.2 | 119.1 |
| PZ10A | 139.4 | 140.4 | 142.0 | 145.0 |
| PZ11B | 79.1 | 79.2 | 79.3 | 79.2 |
| PZ12C | 60.8 | 60.9 | 60.9 | 60.8 |
| PZ14B | no access | no access | 57.8 | 57.9 |
| PZ24B | 21.5 | 21.6 | 21.6 | 21.6 |
| PZ28A | dry | 48.3 | 48.3 | 48.2 |
| R752 | dry | dry | 44.1 | dry |
| R755A | 72.9 | 73.0 | 73.1 | 73.1 |

**Note:** *ground water level in metres below reference point [GWL mBRP]*

### *Permian coal measures*

Table 7.3 presents the results of 2019 groundwater level measurements for monitoring bores intersecting the Ulan Seam and the underlying Permian coal measures. Figure 7.3 shows the interpolated groundwater contours from monitoring bores in the Permian Coal Measures.

Declines in groundwater levels over the course of 2019 are evident at PZ06A, PZ06B, PZ07A, PZ07B, PZ09A, PZ09B, PZ12B and PZ24A and reflect trends observed in the 2018 data. Declining groundwater levels in this stratigraphic unit is not unexpected as the process of underground mining reduces groundwater pressures within the target coal seam (Ulan seam) and hydraulically connected aquifers (Permian coal measures). A summary for those monitoring bores outside of the mine footprint, which exhibited declining groundwater levels is as follows:

- PZ06A: Lower Permian coal measures - whilst observed drawdown exceeds predictions, the trigger value was not exceeded;
- PZ06B, PZ09B, PZ12B and PZ24A: Ulan Seam - observed drawdown less than predicted and the trigger values were not exceeded; and
- PZ09A: Lower Permian coal measures - observed drawdown less than predicted and the trigger value was not exceeded.

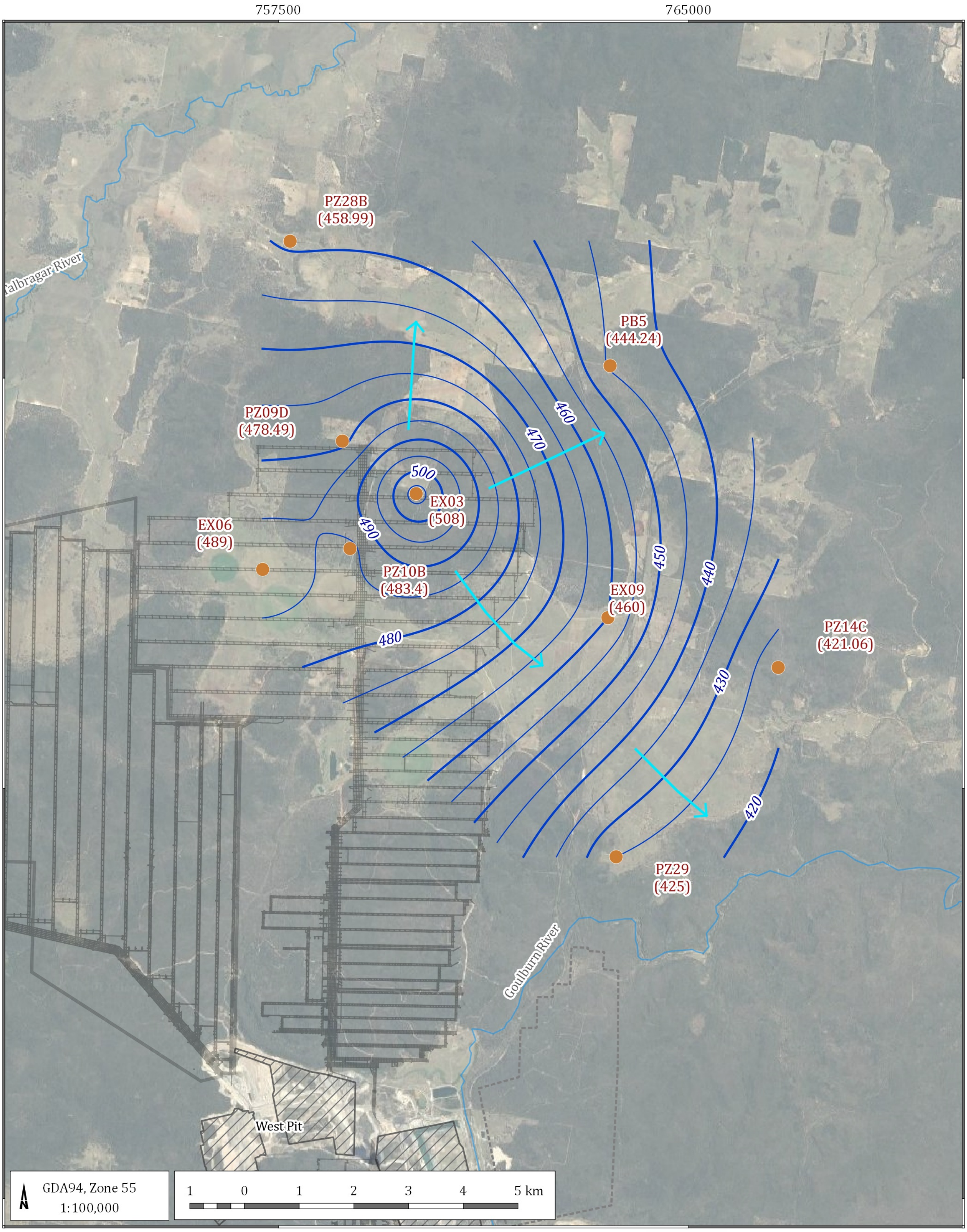
PZ07A and PZ07B are situated within the mine footprint. Observed drawdown at PZ07A exceeds the predicted drawdown whilst drawdown at PZ07B is less than predicted. Groundwater levels at PZ11A were stable (+/- 0.1 m), and similar to the results of 2018 monitoring.

The contours shown on Figure 7.3 indicate that groundwater is flowing towards the underground mine and drawdown is occurring within the Ulan Seam towards the active mine area, as predicted within the EA.

**Table 7.3 Permian coal measures groundwater levels**

| Site | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| PZ06A | 74.1 | 74.7 | 75.1 | 75.4 |
| PZ06B | 86.4 | 86.9 | 87.2 | 87.6 |
| PZ07A | 248.7 | 249.4 | 249.6 | no record |
| PZ07B | 248.3 | 249.4 | 249.7 | 248.8 |
| PZ08B | dry | dry | 168.0 | dry |
| PZ09A | 187.4 | 188.5 | 188.9 | 189.3 |
| PZ09B | 195.5 | 195.9 | 196.4 | 196.7 |
| PZ11A | 166.8 | 166.9 | 166.9 | 166.9 |
| PZ12A | dry | dry | dry | dry |
| PZ12B | 167.1 | 167.4 | 167.6 | 167.6 |
| PZ13A | no access | no access | no access | no access |
| PZ14A | no access | no access | 33.1 | 33.2 |
| PZ24A | 99.0 | 99.6 | 100.6 | 100.6 |
| PZ25A | no access | no access | no access | no access |
| PZ25B | no access | no access | no access | no access |
| PZ26A | no access | no access | no access | no access |
| PZ26B | no access | no access | no access | no access |

***Note:*** *ground water level in metres below reference point [GWL mBRP]*




LEGEND

- Major drainage
- Ulan underground
- Ulan open cut
- Moolarben mine area
- Monitoring bore (groundwater level, mAHD)
- Flow direction

**Interpolated groundwater contour (mAHD)**

- Major contour (10 m interval)
- Minor (10 m interval)

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**Interpolated groundwater contours - Jurassic**

AGE

DATE 16/03/2020

FIGURE No: **7.1**


Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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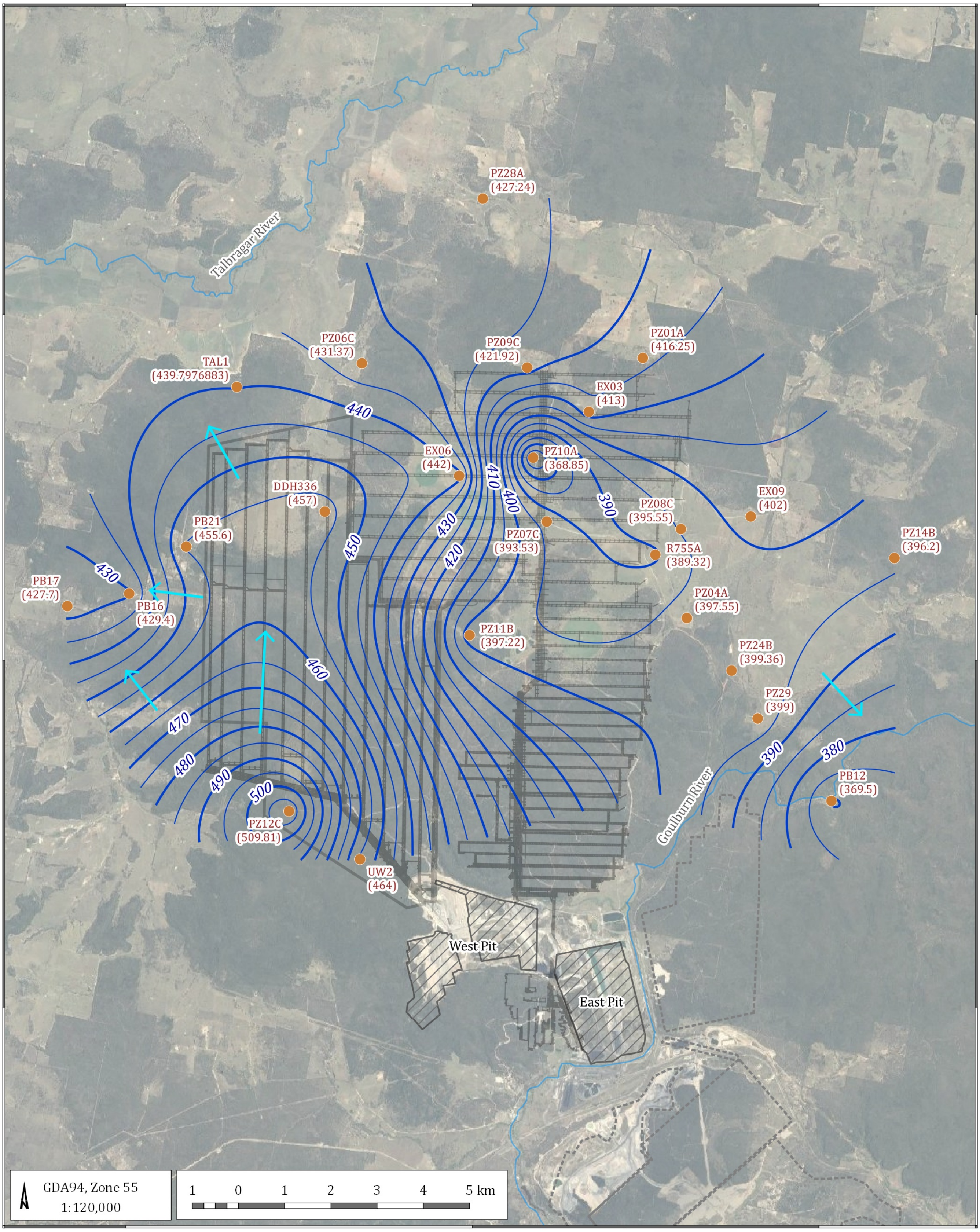


LEGEND

- Major drainage
- Ulan underground
- Ulan open cut
- Moolarben mine area
- Monitoring bore (groundwater level, mAHD)
- Flow direction

**Interpolated groundwater contour (mAHD)**

- Major contour (10 m interval)
- Minor (10 m interval)

Ulan Annual GW Review 2019 (G1985D)

## Interpolated groundwater contours - Triassic

AGE

DATE 17/03/2020

FIGURE No: **7.2**



Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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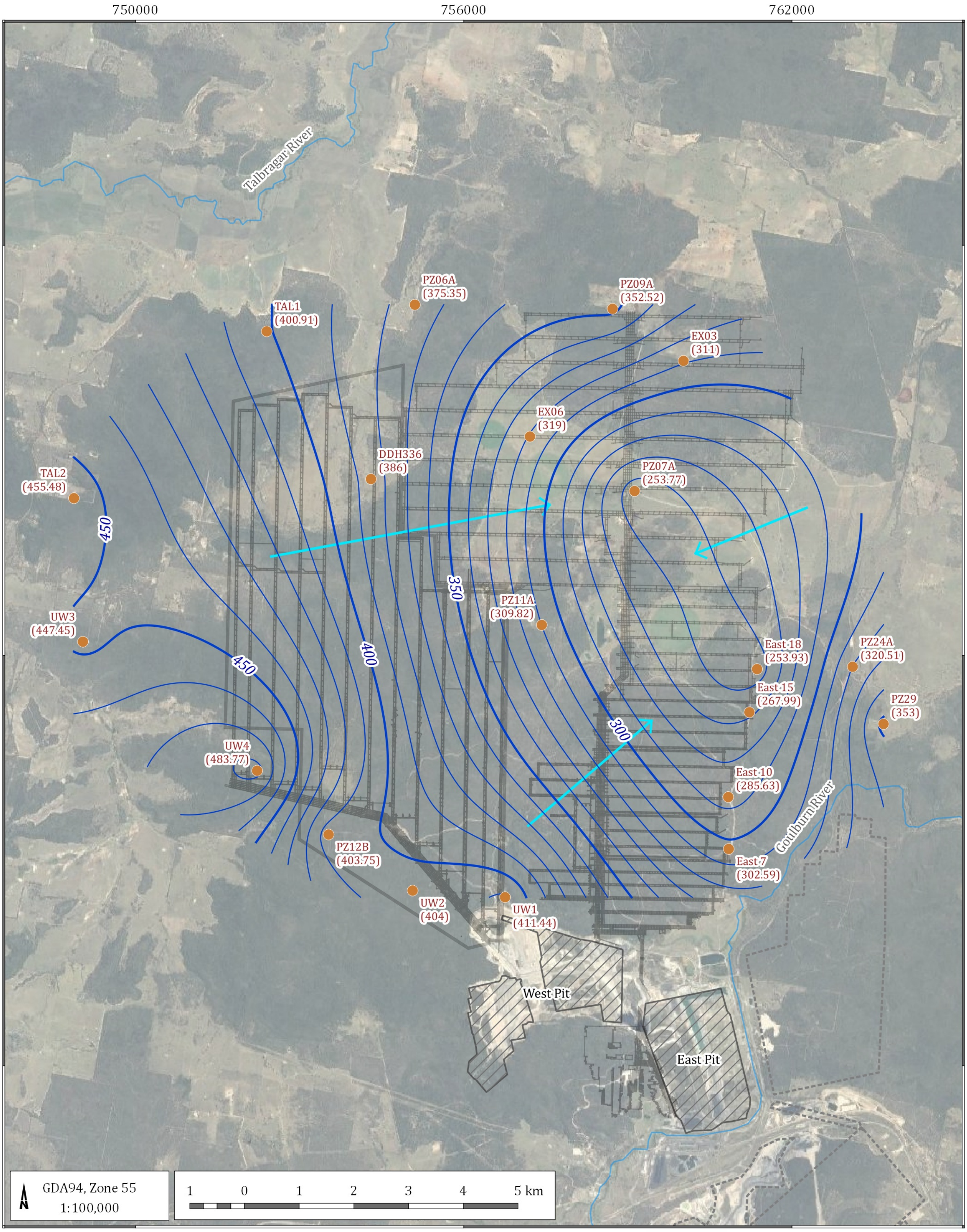


LEGEND

- Major drainage
- Ulan underground
- Ulan open cut
- Moolarben mine area
- Bobadeen Irrigation System (P1 - P5)
- Monitoring bore (groundwater level, mAHD)
- Flow direction

**Interpolated groundwater contour (mAHD)**

- Major contour (50 m interval)
- Minor contour (10 m interval)

Ulan Annual GW Review 2019 (G1985D)

## Interpolated groundwater contours - Permian sediments

AGE

DATE 17/03/2020

FIGURE No: **7.3**


Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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#### *7.1.1.1 Porewater pressure (VWPs)*

Porewater pressure is monitored in a number of VWP sensor arrays installed in the vicinity of Ulan Mine. The VWP sensor arrays are installed in a single borehole to measure changes in groundwater pressure over time at a specific depth. Details of the sensor depths are provided in GWMP. Where necessary, a comparison between observed pressures has been made with model predictions in the comments below. Hydrographs for 2018 and 2019 observed and predicted porewater pressure are presented in Appendix B. Comments regarding 2019 VWP data are as follows:

- DDH226 is located in the north west of the mine footprint and has three VWPs installed. Porewater pressures were not recorded in 2019 due to a malfunction (refer Section 6.2.2). For completeness, 2018 hydrographs are provided in Appendix B.
- DDH336 is located within the mine footprint approximately 1.6 km south east of DDH266. There are 8 sensors installed. The top sensor in the Triassic sediments has generally been stable, although with slight fluctuations since installation in 2009 which have continued in 2019. Sensors in the Triassic sediments below 62 m experienced a pressure decrease in early 2019. Groundwater pressure in the 62 m Triassic sediments sensor generally recovered to 2018 pressures after this initial decrease. Whilst groundwater pressures in the 82 m and 102 m Triassic sediments sensors also recovered and trended upward, they did not recover to 2018 pressures. The pressure decreases in the Triassic sediments are lower than those predicted in the groundwater model reflecting the conservatism applied in the model. Porewater pressures in the upper (122 m) and lowermost (183 m) Permian sensors continued to decline in 2019 until quarter 3 when they stabilised. After an initial decline, the groundwater pressure in the 146 m sensor recovered and stabilised through the remainder of 2019. Groundwater pressure in the 167 m sensor continued to decline throughout 2019. Whilst the porewater pressure declines in Permian stratigraphy are greater than that predicted in the model, it is noted that they are situated within the mine footprint and the declines likely reflect changes to operational timing from those modelled.

- EX03 is located in the north east of the mine footprint. There are 7 sensors installed. All sensors have been stable and show no apparent trends since installation in mid-2018. Whilst the 2018 annual review noted the bottom sensor in the Permian sequence at 297 m, exhibited a slight increasing pressure trend, pressures have now stabilised in this sensor. It is noted that whilst the 297 m sensor has stabilised, pressures at the 242 m sensor increased between April and October 2019, and then stabilised in late 2019. The reason of the increase is unclear and further evaluation of data through 2020 is recommended.

- EX06 is located within the mine footprint. There are 8 sensors installed in 3 holes which are within 10 m of each other. With the exception of the sensor located in the Permian coal measures (185 m), all sensors were stable in 2019 and show no apparent trends since their installation in late 2016. In mid-2019, porewater pressures declined at the 185 m sensor, however pressures subsequently stabilised. Whilst the pressure decline at the 185 m sensor is greater than predicted, similar to DDH336, EX06 is situated within the mine footprint and the declines in Permian coal measures likely reflect changes to operational timing from those modelled.

- EX09 has 7 sensors installed and is located approximately 2 km east of Ulan Mine. Pressures at the five uppermost and the lowermost sensors (Jurassic and Triassic sediments), have been stable and show no apparent trends since installation in 2017. The sensor located in the Triassic sediments (261 m) however, exhibited a pressure decline that, despite data gaps, is in line with an historic decreasing trend. No data was collected from the lowermost sensors (261 m and 301 m) from early 2019 and it is recommended that if possible, the sensors are reinstated.

- PZ29 (The Drip) is located outside of the mine footprint, approximately 1.3 km north of the Drip. Throughout 2019, all sensors were stable except for the bottom sensor which is in the Ulan Seam at 243 m. This sensor exhibits a slight decline over time which is expected given the depressurisation occurring in the Ulan Seam from Ulan Mine and Moolarben Mine. Review of observed porewater pressures against the model predictions indicates that observed pressures in the Jurassic sediments (18 m), upper Triassic sediments (50 m, 72 m and 90 m) and lowermost Permian units (183 m and 243 m) are higher than predicted. Whilst pressure in the lowermost Triassic sediments (122 m) is within the range predicted and the Permian Goulburn Seam pressures (143 m) are lower than predicted.

- TAL-1 has five sensors installed and is located 1 km north of the mine footprint. A very minor decreasing pressure trend (approximately 1 m) at Permian (61 m), first noted in 2018, has continued during 2019. This slight decline in pressure was also observed in overlying Triassic sensors (28 m and 45 m) and the lower Ulan Seam sensor (140 m). An increasing pressure trend continued to be recorded in Permian (97m). Except for the Permian (97m) increase, all changes are within the predicted range.
- TAL-2 is located 2.7 km west of the mine footprint and has four sensors installed, three in Permian stratigraphy and one in the Ulan Seam. Whilst historically there were disruptions to data collection, since repairs in 2018, data collection has been uninterrupted. All sensors identify stable porewater pressures throughout 2019.
- UW1 is located at the southern end of the mine footprint and has four sensors installed. The upper three sensors are within the Permian overburden sediments and the lowest is within the Ulan Seam. Whilst there is a gap in data collection between February and July 2019, groundwater pressures at all sensors are stable and do not show any decline. Whilst stable, the groundwater pressure in the uppermost Permian (22 m) is greater than that predicted in the groundwater model and those for the Ulan Seam less than predicted. The pressure trends for the Permian 35 m and 51 m are in line with the groundwater model predictions.
- UW2, with three sensors installed, is located 500 m from the south western boundary of the mine footprint. For most of 2019, porewater pressure in the Triassic sediments sensor (60 m) sediments was stable, however a slight decrease (approximately 1 m) was observed in late 2019. Similarly, the Permian sensor (90 m) was stable for much of 2019 and also decreased in late 2019. Pressures in both sensors have subsequently stabilised. Pressures in the Ulan Seam sensor (120 m) increased in early 2019, after being stable through 2018. Whilst pressures observed in 2019 are higher than predicted for all sensors, the overall trends are in line with the groundwater model predictions.
- UW3 is located 2.5 km west of the mine footprint and has four sensors, three installed in Permian sediments and one in the Ulan Seam. Pressures at the upper most Permian sensors (40 m and 60 m) and the Ulan Seam (98 m) were relatively stable throughout 2019. Pressures at the sensor within the Permian sediments (75 m) increased during early 2019, which is a reversal of a declining trend observed in 2018. The observed pressures are greater than those predicted in the model. Notably the recovery in pressure at the 75 m sensor marks a return to pressures which align closest with predictions.
- UW4 is located in the south-western corner of the mine footprint. Similar to UW3, three sensors are installed in Permian sediments and one in the Ulan Seam. During 2019, despite a gap in data, pressures at all sensors were stable during 2019. The observed pressures are within the range of those predicted in the model.

### 7.1.2 *Groundwater quality*

Field water quality parameters are measured on a six –monthly basis and a laboratory analysis suite is sampled annually. Hydrographs presenting time series of sites sampled in 2019, for EC, pH, TDS, nutrients and dissolved metals, where concentrations above the limit of reporting were recorded, are presented in Appendix A[2]. Except for molybdenum, collected samples were tested for all analytes, outlined within the GWMP.

#### *7.1.2.1 Physical parameters – EC and pH*

Table 7.4 presents the field water quality results for EC and pH recorded for the NMN monitoring bores during the 2019 monitoring period.

**Table 7.4 NMN field parameters (pH and EC)**

| Station | pH | | EC (uS/cm) | |
|---|---|---|---|---|
| | Quarter 1 | Quarter 3 | Quarter 1 | Quarter 3 |
| **Jurassic sediment** | | | | |
| PZ09D | 7.6 | 8.4 | 1,480 | 1,396 |
| PZ10B | 7.4 | 6 | 3,964 | 4,043 |
| PZ14C | no access | 6.6 | no access | 1,048 |
| PZ28B | 7.3 | 9.1 | 2,680 | 2,710 |
| **Triassic sediments** | | | | |
| PZ01A | 7.1 | 6.2 | 432 | 445 |
| PZ04A | 5.6 | dry | 215 | dry |
| PZ06C | 7.5 | 8.5 | 412 | 355 |
| PZ07C | 5 | 6.5 | 679 | 666 |
| PZ08C | 6.5 | 6.6 | 1,180 | 1,169 |
| PZ09C | 8 | 8.1 | 753 | 396 |
| PZ10A | 9.1 | no sample | 292 | no sample |
| PZ11B | 6.9 | 6.1 | 242 | 161 |
| PZ12C | 4.8 | 4.5 | 182 | 188 |
| PZ14B | no access | 8.9 | no access | 907 |
| PZ24B | 6.2 | 8.8 | 376 | 246 |
| PZ28A | dry | 9.4 | dry | 484 |
| R752 | dry | dry | dry | dry |
| **Permian coal measures** | | | | |
| PZ06A | 8.1 | 8.5 | 1,595 | 1,633 |
| PZ06B | 7.2 | 7.5 | 1,195 | 1,206 |
| PZ07A | 11.7 | no sample | 1,470 | no sample |
| PZ07B | 6.3 | no sample | 1,974 | no sample |
| PZ08B | dry | dry | dry | dry |
| PZ09A | 9.4 | 9.4 | 1,013 | 970 |
| PZ09B | 7.5 | 7.5 | 1,239 | 1,239 |
| PZ09C | 8 | 8.1 | 753 | 396 |

[2] Major ion concentrations are visually represented via Piper plots and hydro-chemical classification in Section 7.1.2.2.

| Station | pH | | EC (uS/cm) | |
|---|---|---|---|---|
| | Quarter 1 | Quarter 3 | Quarter 1 | Quarter 3 |
| PZ11A | 6.5 | 7 | 830 | 807 |
| PZ12A | dry | dry | dry | dry |
| PZ12B | 6.1 | 6.1 | 476 | 547 |
| PZ14A | no access | 6.7 | no access | 1 190 |
| PZ24A | 7.1 | 7.8 | 845 | 790 |

A summary of the average 2019 EC and pH and standard deviation for the stratigraphic units represented in the NMN is presented in Table 7.5. Table 7.5 also presents the historic average derived from the GWMP and collected data and the standard deviation value. The 2019 averages represent minimal change in EC and pH compared to historical averages and within the natural range, as defined by the standard deviation.

**Table 7.5 NMN field water quality data statistics - 2019**

| | | Jurassic sediments | Triassic sediments | Permian coal measures |
|---|---|---|---|---|
| EC (µS/cm) | Historic average (standard deviation) | 2,267 (729) | 635 (492) | 1,062 (399) |
| | 2019 average (standard deviation) | 2,318 (1 117) | 560 (336) | 1,195 |
| pH (pH unit) | 2019 average (standard deviation) | 7.5 (1.1) | 7.1 (1.8) | 8.4 (1.4) |
| | Historic average (10% deviation range) | 7.8 (1.2) | 7.5 (1.6) | 7.6 (1.1) |

### *7.1.2.2 Major ions and alkalinity*

The proportions of the major anions and cations were used to determine the hydro-chemical facies of the groundwaters sampled over the 2019 monitoring period. The anion-cation balance for the 2019 samples are shown on the Piper diagram in Figure 7.4, In summary, the hydro-chemical facies are relatively unchanged from 2018, with the 2019 results indicating the:

- Triassic sediments continue to exhibit Na-Cl, Na-Mg-HCO3-Cl and Na-Mg-Cl-$HCO_3$ type water;
- Jurassic sediments exhibit Na-Mg-Cl and Na-Mg-Cl-$HCO_3$ type water; and
- Permian coal measures, including the Ulan Seam, exhibit Na-$HCO_3$, Na-Cl-$CO_3$, Ca-Na-Mg-$SO_4$ and Na-$HCO_3$-Cl type water.

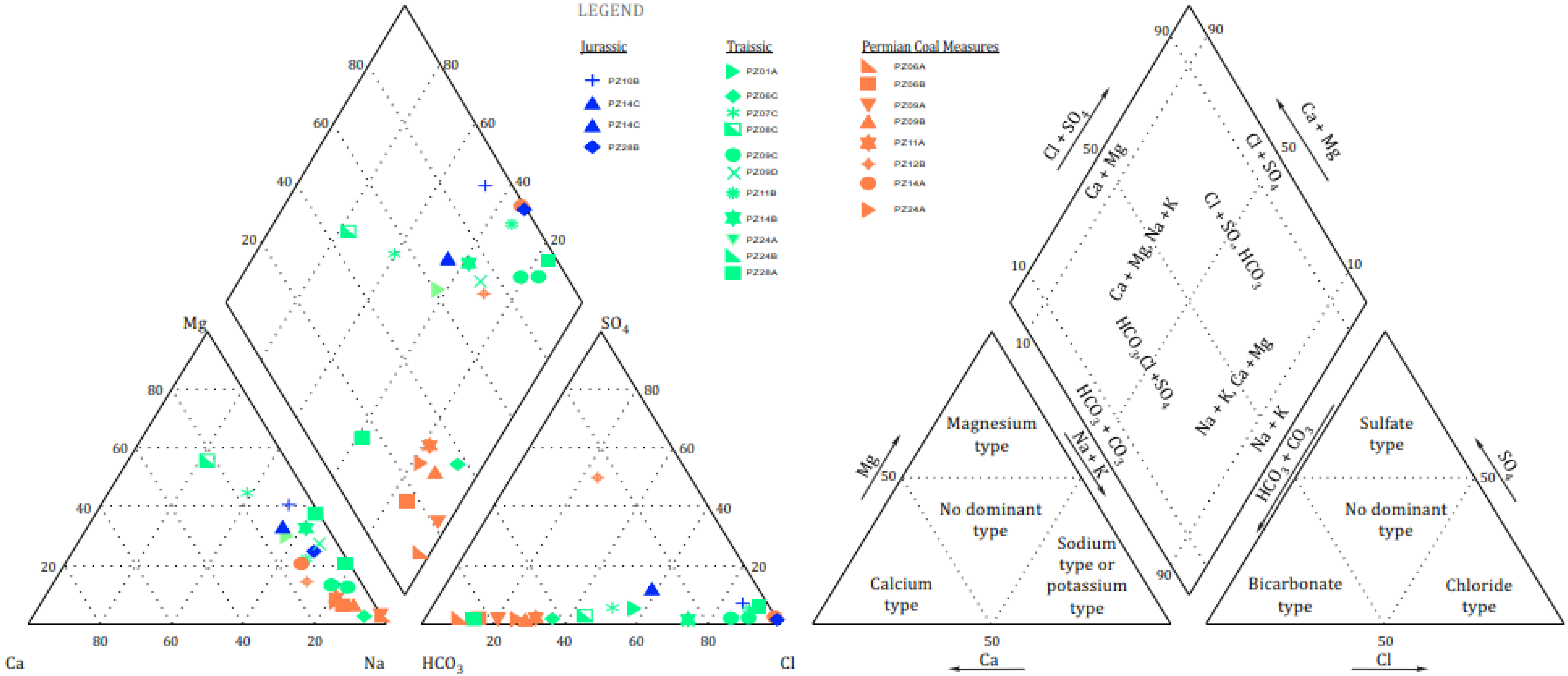



**Figure 7.4 NMN Piper plot**

### 7.1.2.3 Metals

A total of 22 NMN bores were sampled and analysed for dissolved metals (Al, As, B, Ba, Cd, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Sb, Se, Sr and Zn) in 2019. Except for molybdenum, this analytical suite is in accordance with the GWMP. The 2019 results were compared to the historical 80th percentile plus a 10% deviation for NMN monitoring bores. The results of this comparison, and general observations are:

- all bores recorded concentrations below the limit of reporting for the dissolved metals antimony, cadmium, lead, mercury, selenium and silver;
- concentrations of dissolved barium, lithium and strontium were reported at all bores. Some exceedances of SWGWRP triggers were noted, however these were minor. Rising strontium was noted at PZ06C, PZ09A, PZ09C and PZ10B;
- concentrations of dissolved manganese were reported at all bores. Results were mostly below the SWGWRP trigger with eight bores (PZ01A, PZ06C, PZ09B, PZ09C, PZ11B, PZ12B, PZ12C and PZ28B) being above their respective triggers but with concentrations below 1 mg/L. However, PZ10B (1.16 mg/L) and PZ14A (1.28 mg/L) were 1 mg/L above and also exceeding the SWGWRP trigger;
- twenty bores (90%) recorded concentrations below the limit of reporting for dissolved metals aluminium, arsenic, chromium and copper. Of those bores returning values, only PZ01A had concentrations (chromium and copper) above the SWGWRP trigger value. All other bores returned values below SWGWRP triggers;
- concentrations of dissolved iron were reported at 13 bores (59%). Results for five bores (PZ01A, PZ06A, PZ10B, PZ12B and PZ14A) exceed their respective SWGWRP trigger value. These exceedances were minor, however that for PZ14A (44.5 mg/L) was not and appears anomalous when compared to historic results for this bore. This could possibly be related to a decrease in pH observed during 2019 and it is recommended that an additional monitoring round be undertaken at this bore;
- concentrations of dissolved zinc were reported at 13 bores (59%). The results for five bores (PZ08C, PZ12B, PZ14A and PZ14C) slightly exceeded their respective SWGWRP trigger value. Whilst also minor, the result for PZ11B (0.09 mg/L) was 0.04 mg/L greater than its SWGWRP trigger;
- eight bores (36%) reported concentrations of dissolved nickel above the limit of reporting. Of those bores returning values, PZ01A, PZ11B and PZ14C had concentrations above their respective SWGWRP trigger value. All other bores returned values below SWGWRP triggers; and
- two bores (PZ10B and PZ12B), recorded ammonia concentrations slightly above their SWGWRP triggers.

## 7.2 Bobadeen Monitoring Network

The BMN is located in the Bobadeen Irrigation Scheme to monitor shallow groundwater response to irrigation. During the 2019 monitoring period, BMN monitoring bores were monitored on a quarterly basis. No groundwater level measurements or quality samples were able to be collected from any BMN monitoring bore during 2019 as all bores were dry. This is likely due to the dry conditions during 2019 (compared to historical rainfall, refer Table 5.1) during 2019. The BMN monitoring bores are shallow, with depths ranging between 1 mBGL (IMW08) to 11.4 mBGL (IMW05) total depth. It is noted that porewater pressures at NMN VWP EX06, situated within the BMN area (at greater depth), were stable throughout 2019.

Whilst there are no results to report, for completeness of reporting, the following sections document the results of quarterly monitoring at the BMN in 2019.

### 7.2.1 *Groundwater levels*

Quarterly groundwater level readings (in mBGL) for each of the BMN bores are presented in Table 7.6. Groundwater levels were not recorded at any BMN monitoring bore.

**Table 7.6 BMN water level data (mBGL)**

| Station | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| IMW01 | dry | dry | dry | dry |
| IMW02 | dry | dry | dry | dry |
| IMW03 | dry | dry | dry | dry |
| IMW04 | dry | dry | dry | dry |
| IMW05 | dry | dry | dry | dry |
| IMW06 | dry | dry | dry | dry |
| IMW07 | dry | dry | dry | dry |
| IMW08 | dry | dry | dry | dry |
| IMW09 | dry | dry | dry | dry |

### 7.2.2 *Groundwater quality*

No groundwater quality samples were able to be collected from BMN monitoring bores during the year as all were recorded as dry, as presented in Table 7.7.

**Table 7.7 Bobadeen water quality samples (pH, EC)**

| Station | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| IMW01 | dry | dry | dry | dry |
| IMW02 | dry | dry | dry | dry |
| IMW03 | dry | dry | dry | dry |
| IMW04 | dry | dry | dry | dry |
| IMW05 | dry | dry | dry | dry |
| IMW06 | dry | dry | dry | dry |

| Station | Quarter 1 | Quarter 2 | Quarter 3 | Quarter 4 |
|---|---|---|---|---|
| IMW07 | dry | dry | dry | dry |
| IMW08 | dry | dry | dry | dry |
| IMW09 | dry | dry | dry | dry |

## 7.3 Pleuger Monitoring Network

### 7.3.1 *Groundwater levels*

Monthly water level readings at six decommissioned dewatering bores within the PMN (East 7, East 9, East 10, East 15, East 18 and MG21) are presented in Table 7.8, except for March, Jun and October, as no measurements were recorded. The groundwater hydrograph presented in Figure 7.5 shows most groundwater levels were stable throughout 2019 although East 7, East 9 and MG21 slightly declined from minor groundwater level increases in 2018.

**Table 7.8 2019 PMN Groundwater Elevations (mAHD)**

| Station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EAST 10 | 285.7 | 285.7 | ND | 285.7 | 285.7 | ND | 285.8 | 285.7 | 285.9 | ND | 285.7 | 285.6 |
| EAST 15 | 268.0 | 268.0 | ND | 267.9 | 268.0 | ND | 268.0 | 268.0 | 268.0 | ND | 268.0 | 268.0 |
| EAST 18 | 253.9 | 253.9 | ND | 253.9 | 253.9 | ND | 253.9 | 253.9 | 253.9 | ND | 253.9 | 253.9 |
| EAST 7 | 303.3 | 303.9 | ND | 304.0 | 304.9 | ND | 304.8 | 304.3 | 303.9 | ND | 303.1 | 302.6 |
| EAST 9 | 303.2 | 303.7 | ND | 303.3 | 304.8 | ND | 304.7 | 304.1 | 303.8 | ND | 303.0 | 302.5 |
| MG 21 | 244.0 | 243.9 | ND | 243.9 | 244.0 | ND | 243.8 | 240.6 | 241.6 | ND | 240.7 | 240.6 |

***Note:*** *ND = No data*

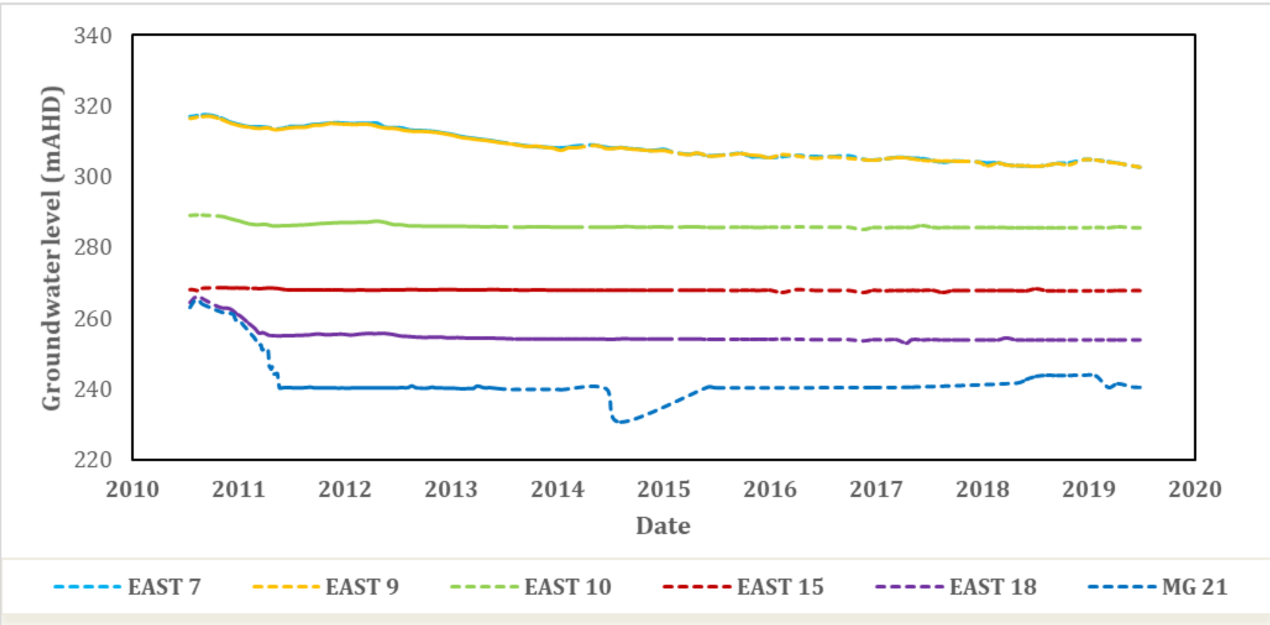



**Figure 7.5 PMN groundwater hydrograph**

### 7.3.2 *Groundwater quality*

The PMN in 2019 comprised eight active dewatering bores (East 20, MG23, MG26, MG27, MG28, MG29, LW A+B, UW TG1). Groundwater quality is sampled fortnightly from six of these bores and 2019 results are summarised in Table 7.9. 2019 hydrographs (MG23, MG26, MG28, MG29 and UW TG1) for the analytes in Table 7.9 are presented in Appendix C.

**Table 7.9 2019 Water quality (average)**

| Parameter | East 20 | MG 23 | MG 26 | MG 27 | MG 28 | MG 29 | UWTG1 |
|---|---|---|---|---|---|---|---|
| pH | 6.5 | 6.9 | 6.9 | 7.1 | 7.1 | 7.3 | 7.1 |
| Electrical Conductivity (µS/cm) | 1580.0 | 1158.8 | 945.0 | 926.0 | 921.9 | 875.0 | 1063.3 |
| Iron – Dissolved (mg/L) | 21.0 | 2.5 | 1.9 | 1.8 | 1.6 | 0.2 | 0.8 |
| Iron – Total (mg/L) | 21.8 | 3.1 | 2.2 | 2.4 | 1.9 | 1.3 | 2.3 |
| Manganese – Dissolved (mg/L) | 6.0 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 |
| Manganese – Total (mg/L) | 21.0 | 2.5 | 1.9 | 1.8 | 1.6 | 0.2 | 0.8 |
| Sulphate (mg/L) | 551.0 | 144.4 | 62.1 | 44.0 | 43.7 | 16.6 | 136.4 |
| Suspended Solids (mg/L) | 4.0 | 5.4 | 4.1 | 5.0 | 4.0 | 5.3 | 19.6 |
| Total Alkalinity as CaCO3 (mg/L) | 137.0 | 326.5 | 301.6 | 289.0 | 305.9 | 323.0 | 276.7 |

As groundwater abstracted for dewatering is subjected to treatment prior to site use, irrigation or discharge, development of triggers values is unwarranted. However, for the dissolved metals analysed, most bores recorded concentrations within limits under the ANZECC (2000) short term irrigation guidelines. However, East 20 consistently recorded iron (total and dissolved) concentrations above the ANZECC (2000) short term irrigation guideline level. This is a similar concentration to previous years with the general dissolved iron and manganese trend declining since 2016.

## 7.4 Private bores

During 2019, no complaints were received from private landholders regarding their bores.

### 7.4.1 *Groundwater levels*

Monitoring of the private bores is conducted annually, dependent on granting of access by the private landholder. During the 2019 monitoring period, 25 private bores were measured for field quality parameters. Of the 25 bores visited groundwater levels at 15 were not measured due to them being equipped with a pump and/or headworks.

During 2019, no complaints were received from private landholders regarding their bores. A number of private bores (PB05, PB08, PB09, PB10, PB11, PB14, PB17, PB21, PB26, PB30, PB31, PB32 and PB33) are predicted to experience groundwater level drawdowns in excess of 2 m. Of these bores, those that were monitored in 2019 were PB08, PB09, PB10, PB11, PB14, PB21, PB30, PB32 and PB33. Where obtained, recorded groundwater levels in these bores (PB08 and PB30) were in line with available historic levels for each bore and SWGWRP triggers were not exceeded. The remaining private bores, not predicted to be impacted, also recorded groundwater levels in line with historical levels.

The groundwater level hydrograph for each private bore measured in 2019 is presented in Appendix D.

### 7.4.2 *Groundwater quality*

During 2019 monitoring period, 25 private bores identified in the GWMP were sampled for field water quality (pH and EC). The groundwater quality was fresh to saline with EC ranging from 184 µS/cm (PB6) to 4,130 µS/cm (PB4). SWGWRP triggers were exceeded at:PB3 (957µS/cm), PB8 (1,768 µS/cm), PB9 (1,020 µS/cm), PB15 (1,830 µS/cm), PB24 (1,960µS/cm), PB28 (3,060 µS/cm) and PB30 (3,950 µS/cm). Whilst triggers are exceeded, the measured EC at these locations is in line with 2018 results and possibly attributable to low rainfall limiting groundwater recharge.

Measured pH was acidic to slightly alkaline ranging from 4.5 (PB17) to 7.9 (PB6). Some results were slightly above the trigger level deviation from baseline data, PB1 (pH 5.6), PB3 (pH 7.3) and PB6 (pH 7.9). PB1 is a bore with historically low pH.

The groundwater pH and EC hydrograph for each private bore monitored in 2019 are presented in Appendix D.

## 7.5 The Drip assessment

The Drip is located within a Triassic sandstone gorge along the Goulburn River and is recognised for its cultural significance and potential to sustain groundwater dependent ecosystems. The Drip is located to the east of Ulan, on the northern banks of the Goulburn River. Due to the incised nature of the gorge, it acts as a discharge area for the Triassic sandstone.

### 7.5.1 *Groundwater and surface water quality assessment*

The Triassic sandstone has been documented as having confined groundwater conditions within the region. Previous studies have conceptualised that the weathered sequences near the cliff face and at surface act as shallow perched groundwater systems. Groundwater monitoring and management commitments require that Ulan Mine collect field data in order to assess this assumption and subsequently model predictions. This includes water quality testing of water expressed at The Drip and installation of VWP sensor arrays (PZ29). The purpose of this data collection is to establish if The Drip is a perched system fed by rainfall, or a groundwater fed spring. This distinction is important for predicting potential impacts on The Drip.

Similar to 2018, samples returned an EC between 526 µS/cm and 638 µS/cm (East Drip) and 511 µS/cm and 657 µS/cm (West Drip). The laboratory results also indicate slightly alkaline pH, of between 8.3 and 8.6 at both East and West Drip sites.

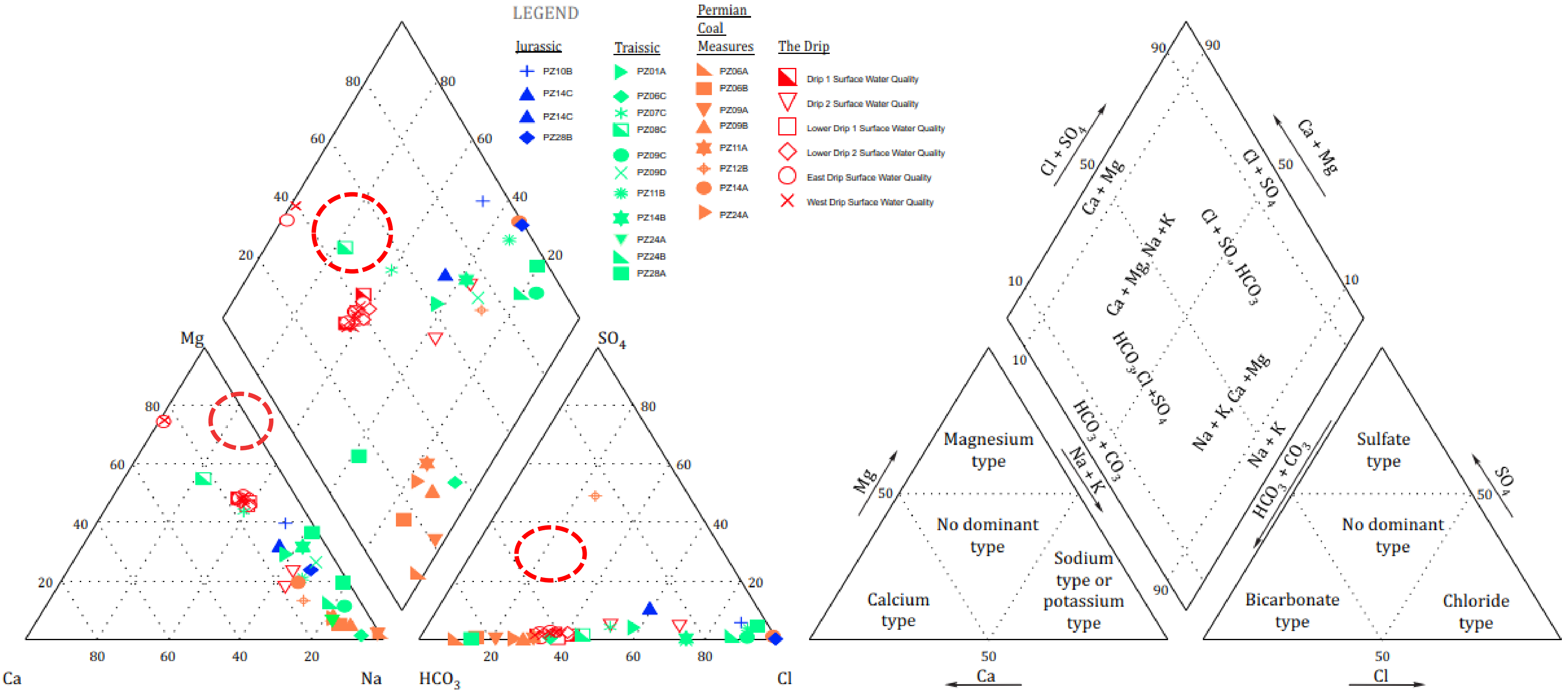
The anion-cation balance of The Drip (circled) from 2019 groundwater quality data is shown on the Piper diagram in Figure 7.6, compared to NMN Triassic water quality.

As shown on Figure 7.6, over 2019 The Drip consistently recorded a Mg-Ca-$HCO_3$-Cl water type. This indicates that anion composition tends to have a bicarbonate dominance with subordinate chloride. The cation composition for Drip samples has a higher proportion of manganese. This is in contrast to the cations for groundwater in Jurassic and Triassic sediments, which are generally dominated by sodium with a Na-Mg-Cl, Na-Cl or Na-Ca-$HCO_3$-Cl water types, as discussed in Section 7.1.2.

The Drip samples were also tested for metals, with the results summarised below:

- dissolved aluminium, arsenic, boron, iron and selenium (total) concentrations were below the limit of reporting;
- dissolved barium, total lithium, total manganese and total zinc concentrations of below 0.05 mg/L; and
- total strontium concentrations of below 0.2 mg/L.

Overall, The Drip water quality continues to exhibit proportions of major ions that are different to those collected from other Triassic sediments in the rest of the monitoring program. This difference in major ion composition suggests the influence of a different recharge source for The Drip.




*Note:* *The Drip sites are circled in red*

**Figure 7.6 Piper Plot - The Drip**

### 7.5.2 *Baseflow assessment*

Discharge in surface water systems such as the Goulburn River is generally assumed to be comprised of two components; quickflow that is sourced from direct rainfall, catchment runoff and interflow through the soil profile and baseflow which is sourced primarily from groundwater discharge.

The GWMP requires an assessment that potential impacts on groundwater baseflow volumes to surface water features are consistent with the predictions made in the EA. The GWMP states that this task will be undertaken via two processes:

- comparison of predicted and measure strata depressurisation across the respective catchments, which will be completed as per previous annual reviews; and
- review of flow gauging data.

The following sections details the assessment of 2019 monitoring data with regards to baseflow.

#### *7.5.2.1 Groundwater depressurisation*

A VWP (PZ29) was installed 1.3 km north of The Drip for the purpose of assessing groundwater gradients and trends around The Drip. The time-series data from the VWP is presented in Figure 7.7. The porewater pressure trends have been stable for 3 years, indicating that there is no drawdown in the Triassic sediments. Consistent with groundwater model predictions, there is minor drawdown in the Ulan seam (PCM 243) due the active mining and dewatering of that seam.

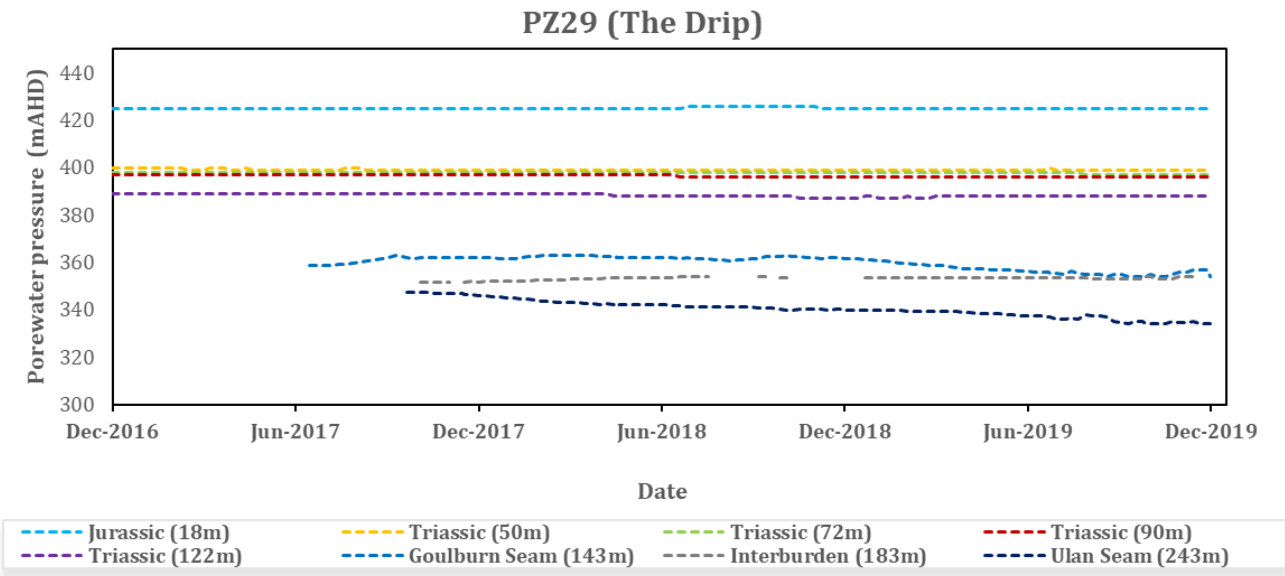



**Figure 7.7 PZ29 porewater pressure**

Monitoring site PZ24 is located around 2 km north of the Goulburn River and 1 km north of PZ29. The site has two monitoring bores, PZ24A and PZ24B, installed in the Permian coal measures and the Triassic sandstone, respectively. Figure 7.8 shows the groundwater hydrograph and, similarly to PZ29 there is no groundwater level drawdown (reduced strata pressure) in the Triassic Sandstone (PZ24B). PZ24A has a gradual drawdown, which is expected due the active mining and dewatering of the working seam.

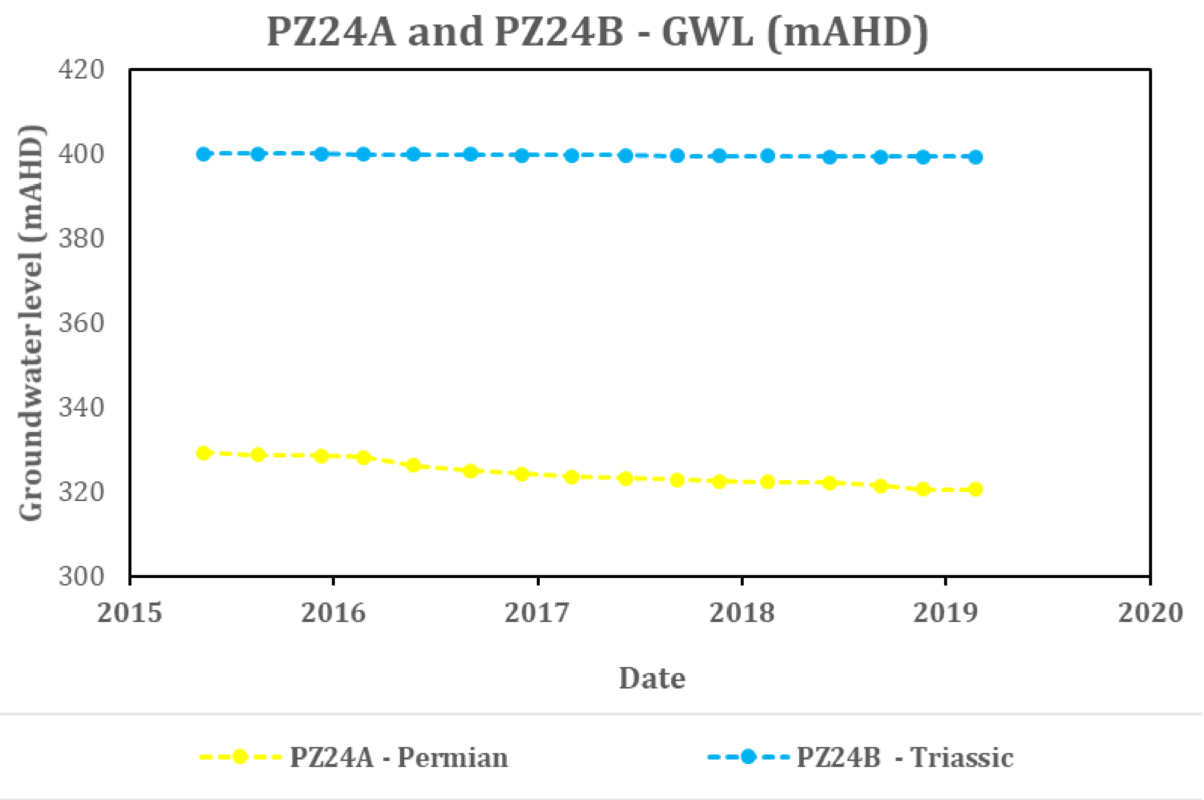



**Figure 7.8 PZ24 groundwater levels**

The 2019 observations from PZ29 and PZ24, show that strata depressurisation is observed only in the Permian strata, which is expected due the active mining and dewatering of the working seam. There is no or very limited observed depressurisation in the Triassic groundwater system at either site. These observations are in line with the predictions generated by the groundwater model.

Due to the limited strata depressurisation observed in the Triassic Sandstone, which the Goulburn River flows through, it is reasonable to conclude that baseflow loses would also be very limited if occurring at all. The predicted 0.037 ML/year Goulburn River baseflow loss is supported by the observations at PZ24 and PZ29.

Ulan Mine also monitors water levels within the Triassic and Permian strata in the Talbragar River catchment at two VWP arrays (TAL-1 and TAL-2). Review of 2019 water levels identified that at TAL-1, a very minor decreasing pressure trend (approximately 1 m) is being exhibited in the Permian (61 m). This decline was first noted in 2018 and has continued during 2019. Slight declines in pressure are also observed in overlying Triassic sensors (28 m and 45 m) and the lower Ulan Seam sensor (140 m). However, all changes are within the predicted range. All sensors at TAL-2 identify stable porewater pressures throughout 2019.

Therefore, there is no apparent change with regard to the predicted 0.22 ML/year baseflow loss to the Talbragar River as the result of mining operations.

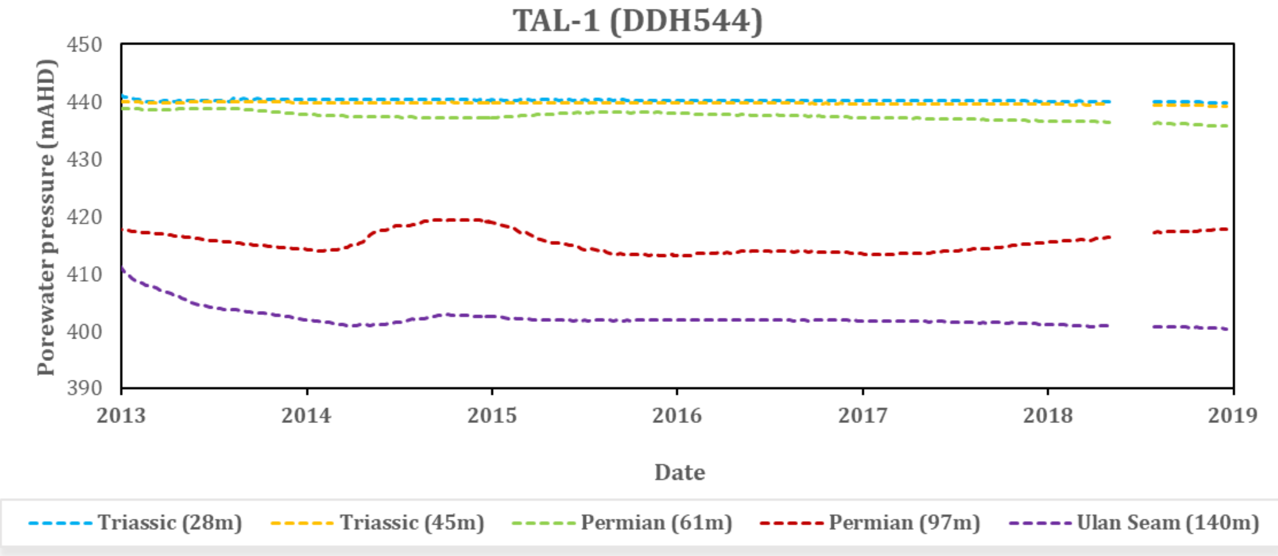



**Figure 7.9 TAL -1 groundwater levels**

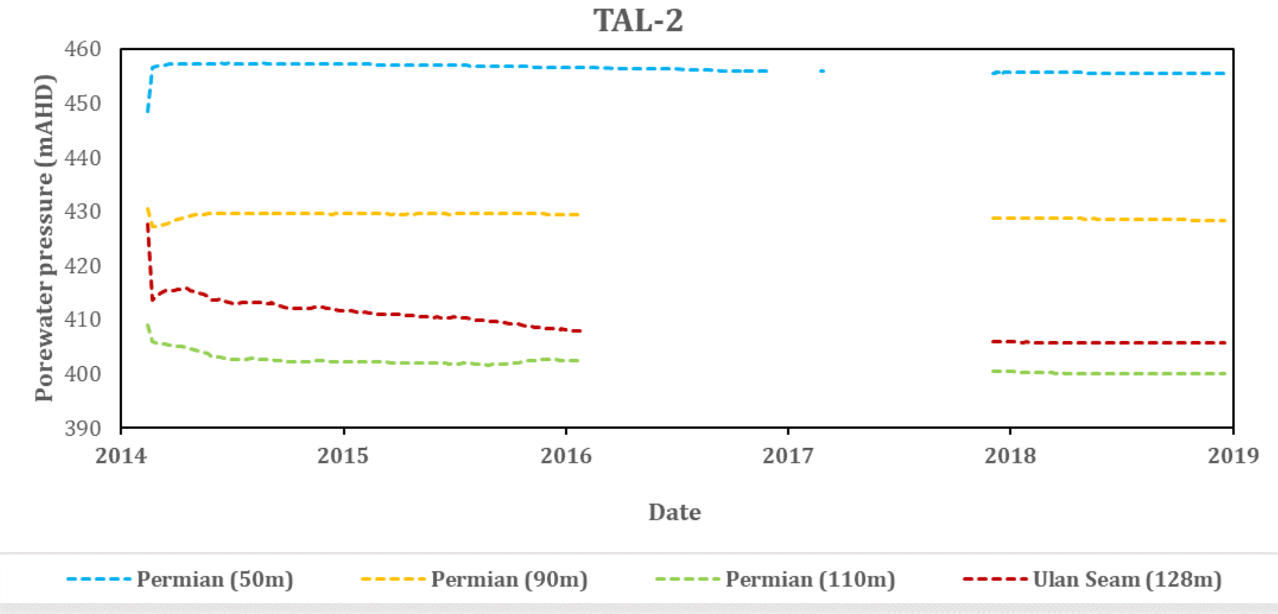



**Figure 7.10 TAL -2 groundwater levels**

#### *7.5.2.2 Baseflow separation*

AGE (2018) applied baseflow separation techniques to Goulburn River flow data collected at the Coggan stream gauge (#210006) to assess potential baseflow losses to the river. Coggan gauge is located approximately 30 km downstream of Ulan Mine and has been in operation since 1913. Analysis of Coggan data identifies that prior to Ulan Mine water discharge commencing in 2006, the baseflow contribution to discharge at Coggan gauge was 19,872 ML/year. In comparison, the period between 2006 and 2016, when Ulan Mine discharge was occurring the average the baseflow contribution to discharge was 29,539 ML/year. The increase in flow at Coggan gauge between 2006 and 2016 is considered unlikely to be solely attributed to rainfall runoff, due to the measured rainfall during this period being less than 95% of the amount that fell during the baseline period (1913 – 2006).

In 2019 Ulan Mine discharged 3,675 ML into Ulan Creek at an average rate of 10.1 ML/day, whilst the average daily Goulburn River flow at the Coggan stream gauge was 32.8 ML/day. Subsequently, Ulan Mine discharge sustains a level of flow in the Goulburn River that would otherwise not occur, especially in dry and drought conditions.

Therefore, as noted in Section 7.5.2.1, the actual baseflow loss in the Goulburn River resulting from operations at Ulan Mine is considered to be consistent with the predicted 0.037ML/day baseflow loss. The volume of mine water discharged by Ulan Mine in 2019 more than compensates for the predicted 0.037 ML/day baseflow losses from mine dewatering. Due to the absence of Talbragar River gauge data, baseflow separation was not conducted for this watercourse.

# 8 Site water management

Ulan Mine distributes abstracted water via a series of pipes and pumps to various locations around the site. Groundwater inflow to the underground workings is managed by pumping from dewatering bores for Ulan West and Ulan No. 3. Daily discharge volumes are measured daily from the dewatering system which comprises the Ulan No. 3 system (East 20, MG22, MG23, MG26, MG29, Ritz and LW A & B) and Ulan West (UW Tailgate and UW Boxcut).

Abstraction from Ulan West and Ulan No. 3 mine water systems are pumped to the NWSD and Bobadeen dam. Water is treated and used to supply water for site use. Excess water is released into Ulan Creek (LDP6 and LDP19) or used for the Bobadeen Irrigation scheme. Ulan Creek discharges into the Goulburn River and ultimately past EPL monitoring point SW02. Groundwater inflow volumes are discussed in Section 8.1, Bobadeen irrigation volumes are discussed in Section 8.2 and Goulburn River stream flow discussed in Section 8.3.

## 8.1 Groundwater Inflows

Monthly 2019 abstraction for Ulan West and Ulan No.3 is shown on Figure 8.1. Abstracted volumes from each operation comprised, Ulan West (14%) and Ulan No. 3 (86%) during 2019. Daily extracted water ranged between 8.6 ML/day and 15.6 ML/day, with a combined average of 15.1 ML/day. The total volume extracted was during 2019 was 5.52 GL. The mine inflows are within approval limits.

The most recent calibrated model for approved operations at Ulan Mine was developed in 2018 as part of the Modification 4 groundwater impact assessment by AGE (2018). The model was developed to predict future groundwater inflows to Ulan No. 3 and the Ulan West Mine. Figure 8.1 shows the modelled inflow combined for the two mine areas and indicates that actual inflows are less than the modelled inflows throughout the year.

The likely reason for this is the difference between how the model simulates groundwater inflow volumes and how the actual mine dewatering system operates. The model has been developed to estimate the volume of groundwater required to be abstracted and the potential impacts that dewatering and mining may cause. It has not been developed as a mine water management tool. The model does not simulate advance dewatering by bore abstraction, rather it simulates the de- saturation of the longwall panels as they are mined. As discussed in Section 7.3, Ulan Mine facilitates mining via advance dewatering, using PMN bores.

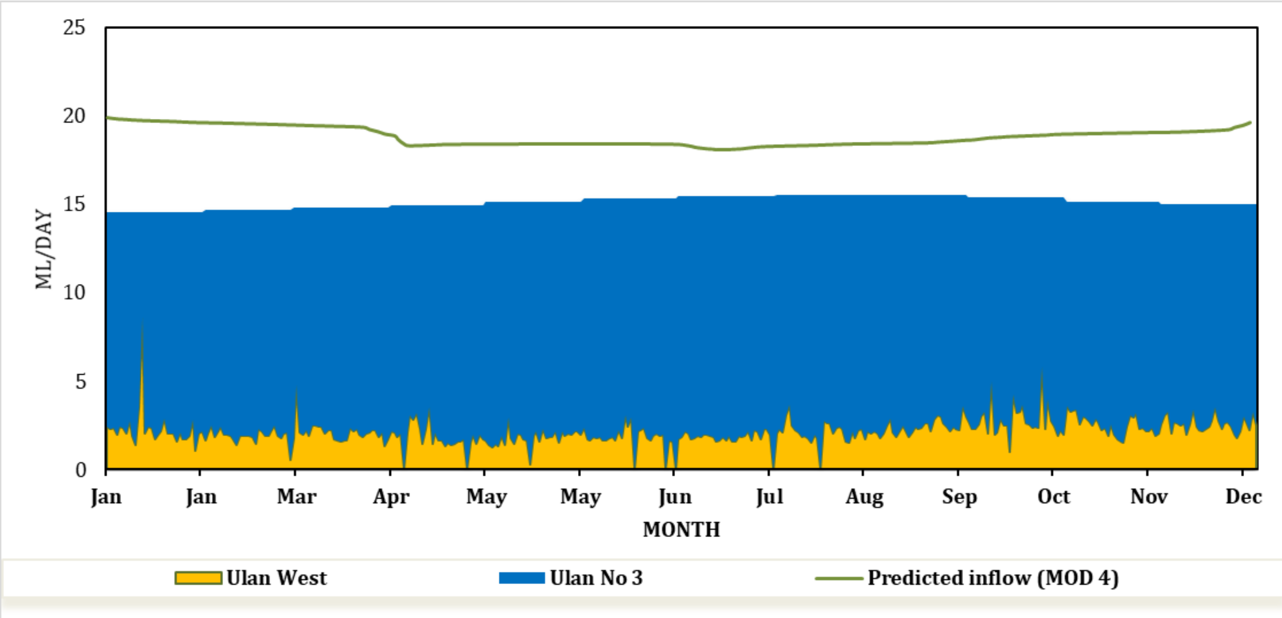



**Figure 8.1 2019 Ulan Mine dewatering proportion of abstraction**

## 8.2 Bobadeen Irrigation Scheme

Land above Ulan No. 3 is irrigated with treated mine water as part of the Bobadeen Irrigation Scheme (BIS). The BIS has been in place since 2003 and includes five central pivots (P1 to P5). The rate of water pumped to the pivots is monitored and recorded at station Farm 1 (pivot P5) and Farm 2 (pivots P1 to P4). Figure 8.2 depicts the monthly irrigation volumes during 2019. The generally consistent monthly irrigation volumes shown on Figure 8.2 reflect the low rainfall experienced through the region during 2019. As discussed in Section 7.2, even with the irrigation occurring, the groundwater levels remained low and all BMN monitoring bores were dry in 2019. This suggests high evaporation rates and soil moisture deficits.

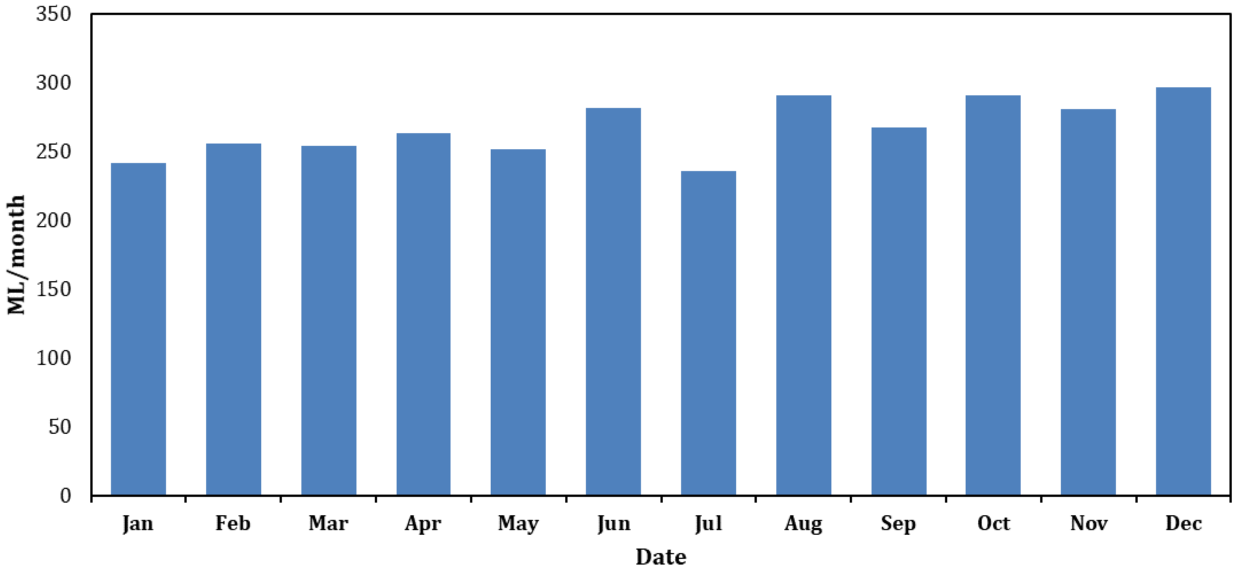



**Figure 8.2 Bobadeen irrigation volumes**

## 8.3 Ulan creek discharge (LDP6 and LDP19)

The Ulan Mine Complex is located at the headwaters of both the Goulburn River system and the Talbragar River system. The Talbragar River flows in a south-westerly direction across the northern extent of Ulan Mine. Mona Creek and Cockabutta Creek are ephemeral tributaries of the Talbragar River system. Ulan Creek, a tributary of the Goulburn River, currently experiences a perennial flow regime due to controlled discharge of treated water from Bobadeen Dam (LDP6) and the NWSD (LDP19). During the 2019 monitoring period, Ulan Mine discharged 3,675 ML from both LDP6 and LDP9. Total daily discharge ranged between 0 ML/day and 22.7 ML/day, with an average of 10.1 ML/day. Discharge from the discharge points is presented on Figure 8.3.

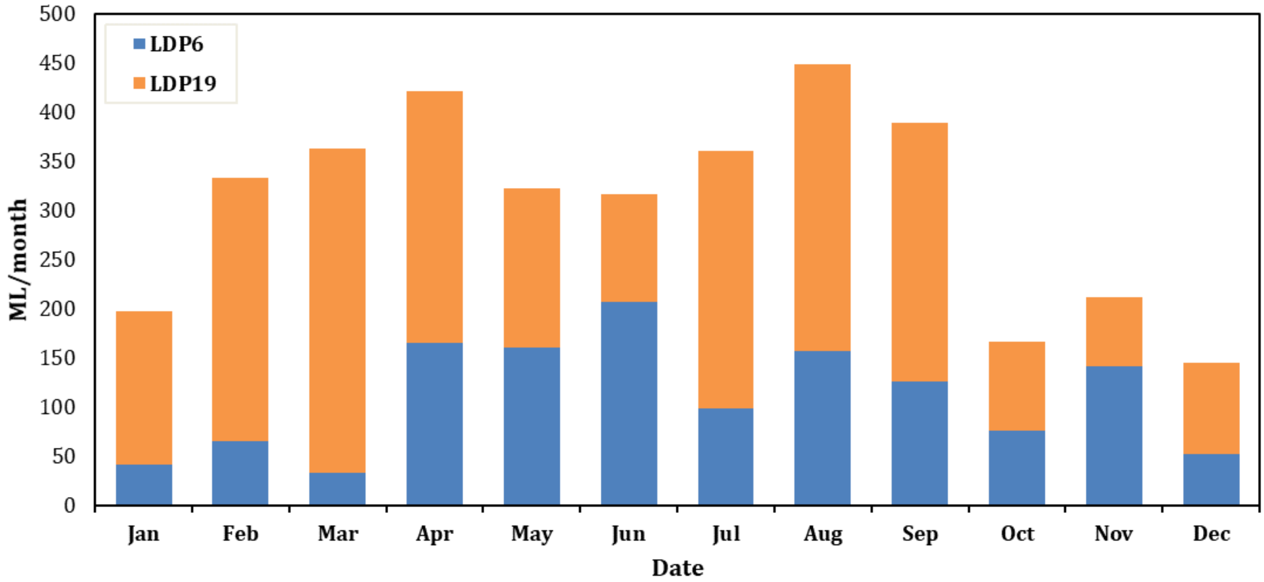
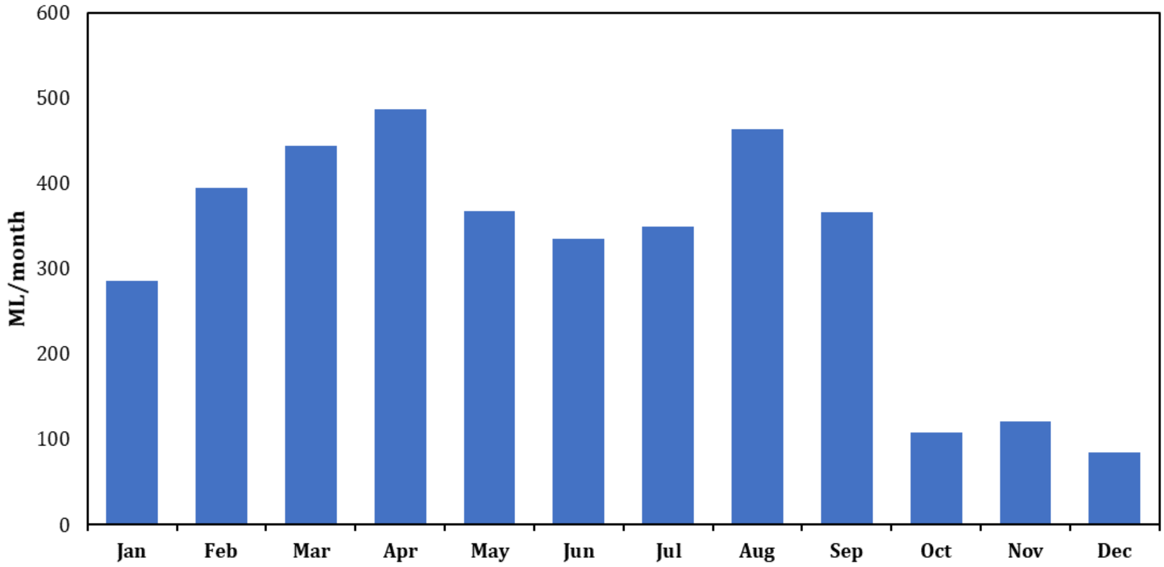



**Figure 8.3 LDP6 and LDP19 discharge volumes (2018)**

## 8.4 Goulburn River stream flow (SW02)

Ulan Mine measures stream flow in the Goulburn River. During the 2019 monitoring period, stream flow measured at monitoring point SW02 which is located downstream of Ulan Mine in and downstream of the Ulan Creek confluence. Both catchment runoff and Ulan Mine discharge contribute to stream flow measured at SW02. Measured flow ranged between 0.3 ML/day and 37.5 ML/day with an average flow of 12.7 ML/day. Goulburn River stream EC and pH is also measured SW02. During the year, EC within the Goulburn River ranged between 624 µS/cm and 914 µS/cm, and pH ranged between 6.4 and 8.5. Graphs and time series of Goulburn River discharge (ML/day), EC and pH measured at SW02 are shown on Figure 8.4.



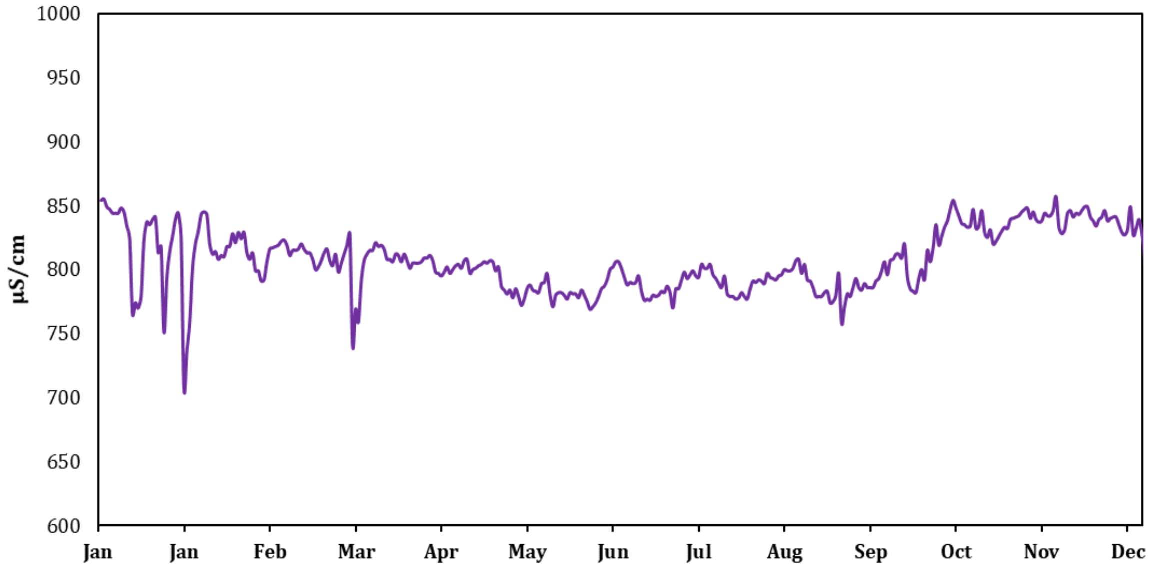




**Figure 8.4 Goulburn River discharge, EC and pH**

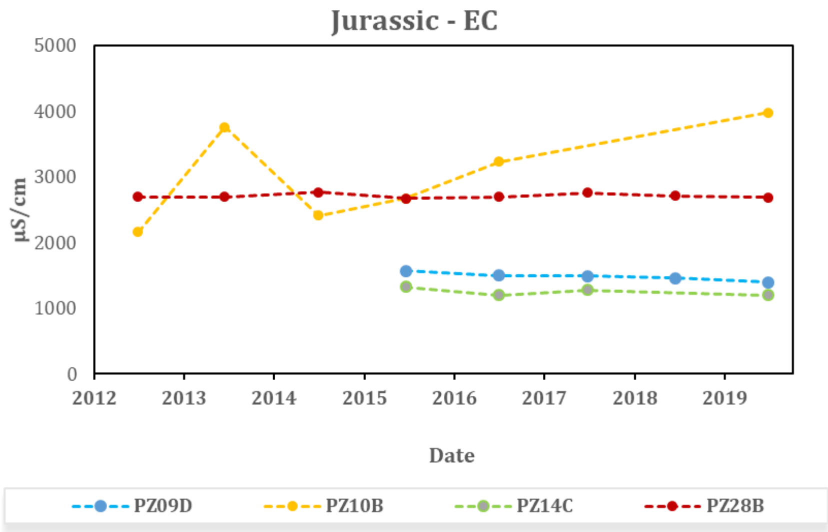
# 9 Summary

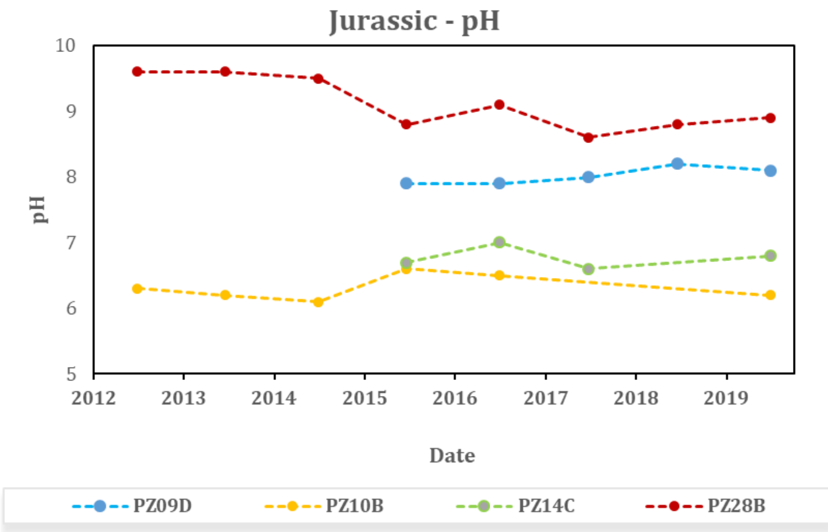
Groundwater level monitoring was conducted in accordance with the GWMP during 2019. Monitoring bores, intersecting Jurassic sediments, recorded relatively stable groundwater levels, indicating no mine related impacts. Monitoring bores and VWPs intersecting Triassic units over 2 km from the mine recorded relatively stable groundwater levels. Monitoring bores intersecting the Triassic units within 1 km of the mine area recorded less than a 1 m decline in groundwater levels. These observed changes align with model predictions. Groundwater within the Permian coal measures generally declined over the monitoring period, in line with model predictions. Groundwater levels observed in monitored private bores have remained stable with no marked decline during 2019 monitoring period.

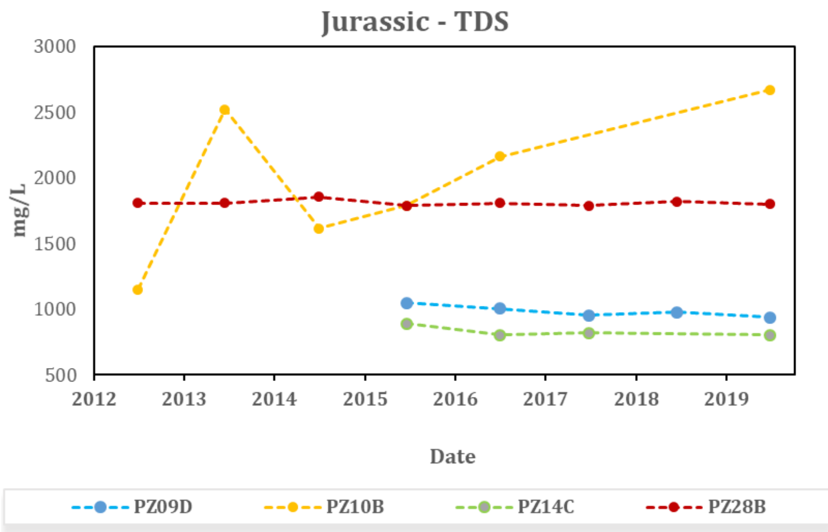
This review notes that whilst some SWGWRP triggers have been exceeded for the dissolved metals analysed (and with exception of iron), all bores recorded concentrations within acceptable limits under the ANZECC (2000) short term irrigation and stock water guidelines.

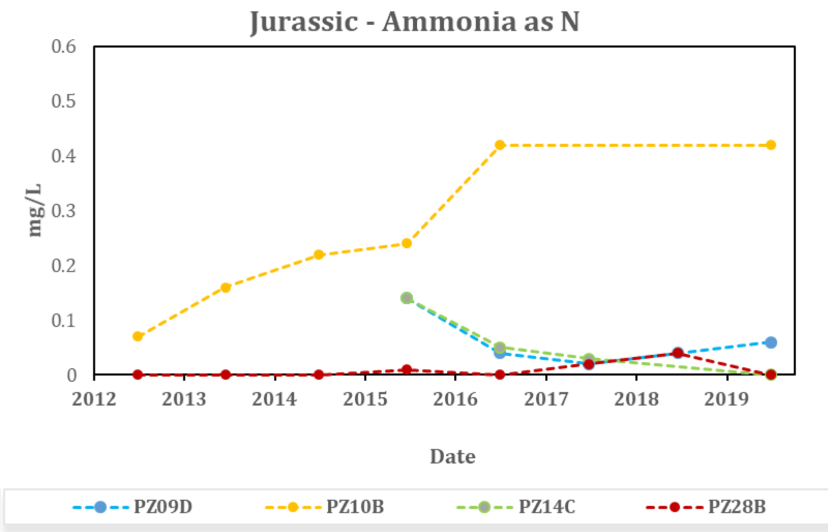
Water levels in Triassic and Permian units is monitored at key locations (PZ24, PZ29, TAL-1 and TAL-2) to inform ongoing assessment of baseflow loss to the Talbragar and Goulburn Rivers. In 2019, water levels at these locations were either stable or slightly declined line. These declines were in line with the predictions made in the groundwater model. This indicates that any reduction in baseflow remains within approved limits. In addition, water quality at The Drip continues to exhibit proportions of major ions that are different to those collected from other Triassic sediments in the rest of the monitoring network, suggesting influence from a different recharge source for The Drip.

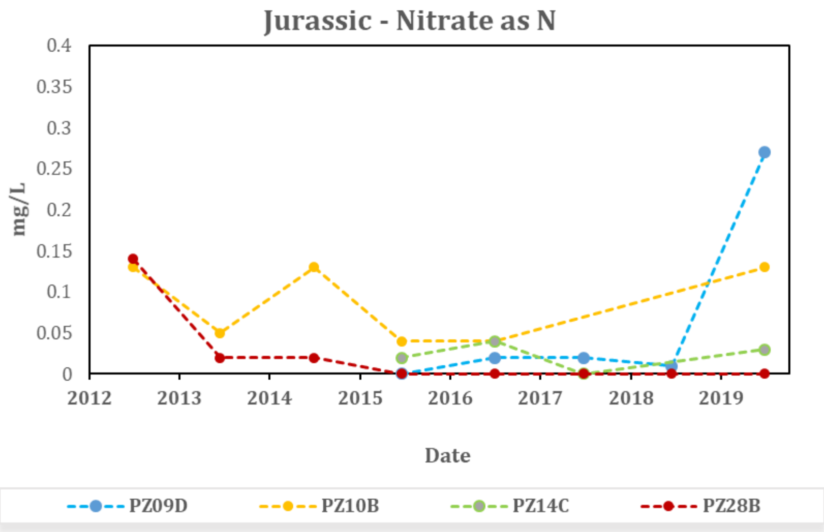
# *Appendix A* North Monitoring Network hydrographs (GWL and WQ)

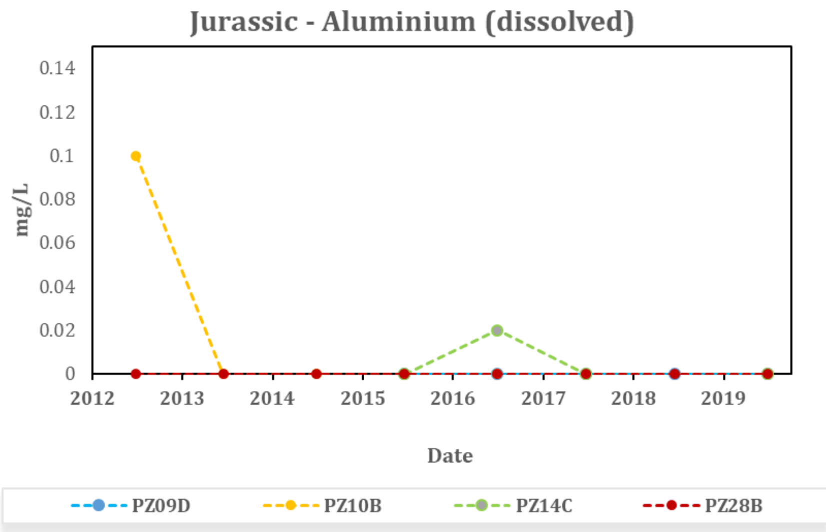

Jurassic - EC
µS/cm
Date
PZ09D
PZ10B
PZ14C
PZ28B

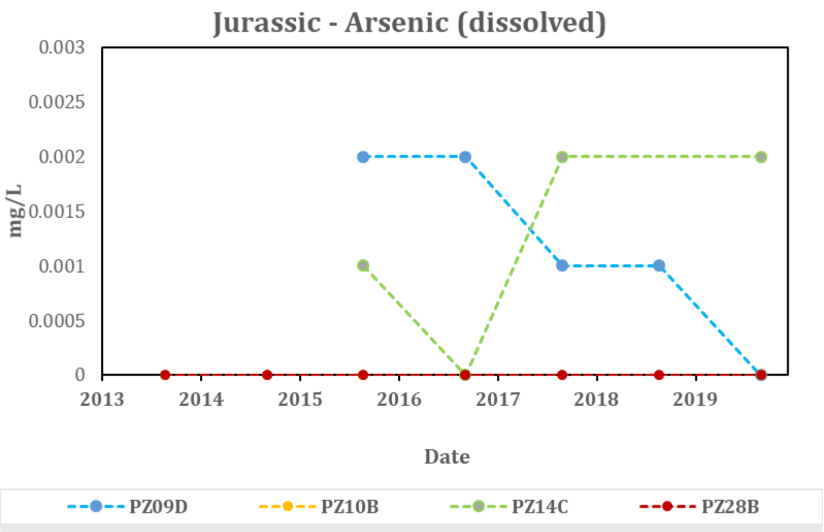

Jurassic - pH
pH
Date
PZ09D
PZ10B
PZ14C
PZ28B

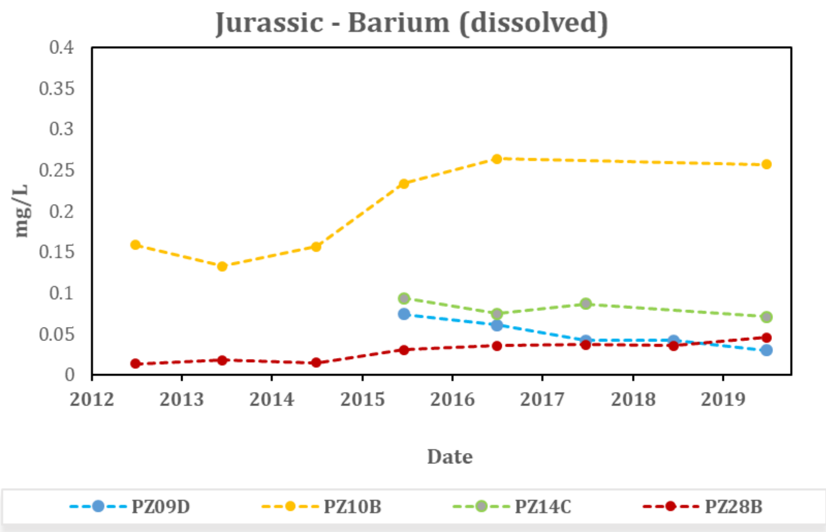

Jurassic - TDS
mg/L
Date
PZ09D
PZ10B
PZ14C
PZ28B

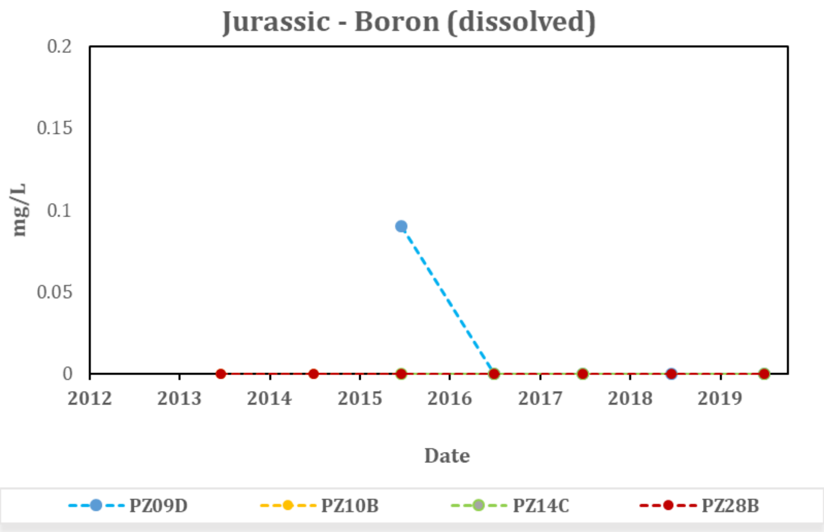

Jurassic - Ammonia as N
mg/L
Date
PZ09D
PZ10B
PZ14C
PZ28B

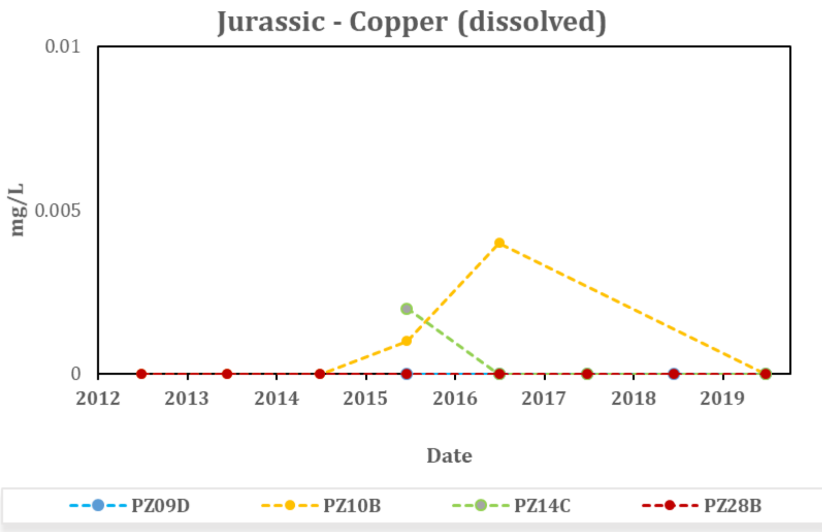

Jurassic - Nitrate as N
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

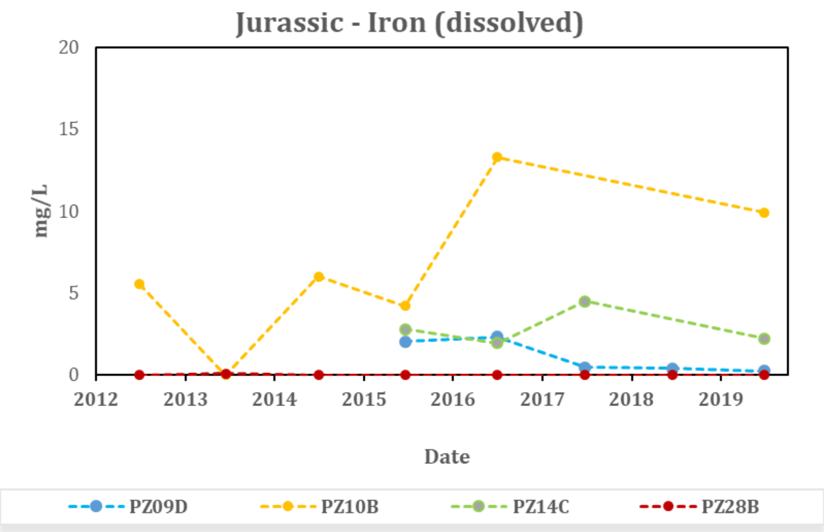

Jurassic - Aluminium (dissolved)
mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

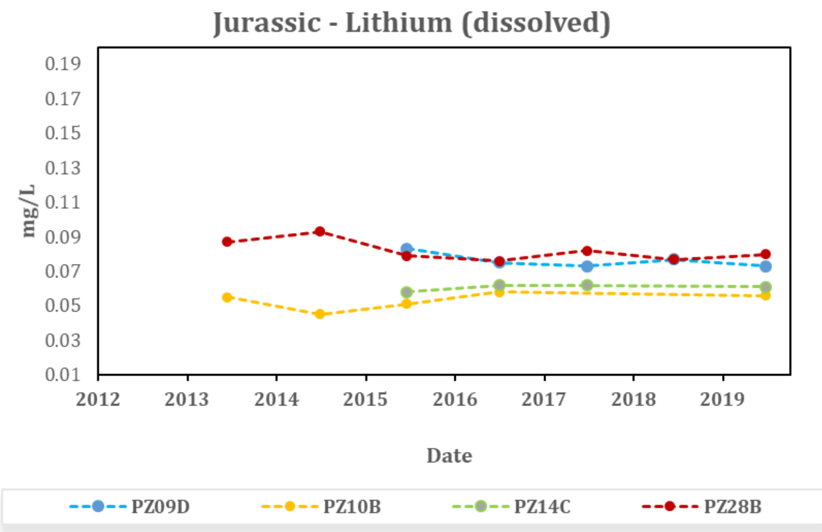

Jurassic - Arsenic (dissolved)
mg/L
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

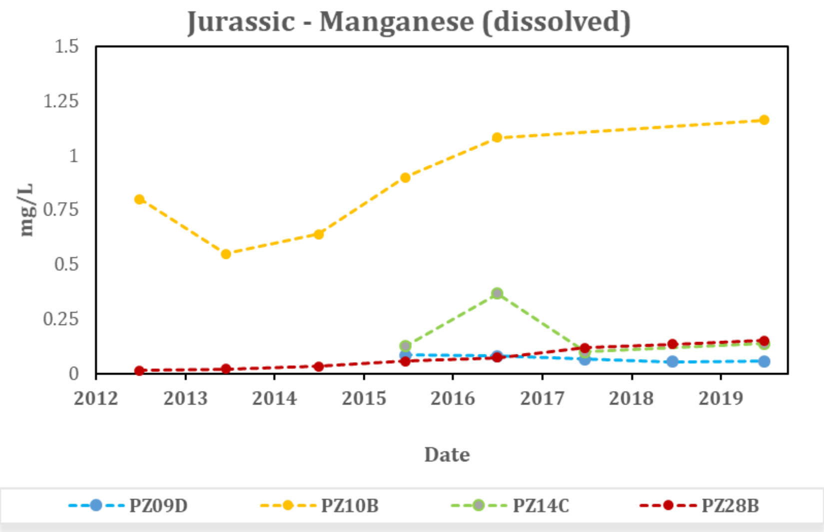

Jurassic - Barium (dissolved)
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

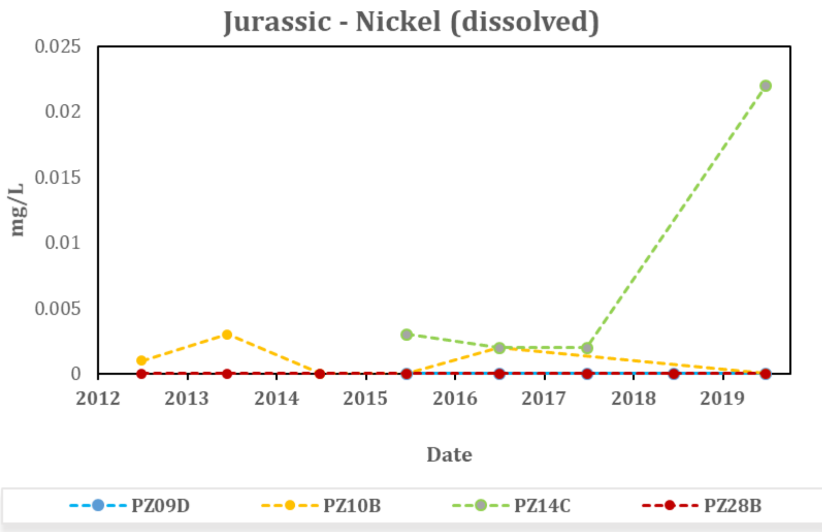

Jurassic - Boron (dissolved)
0.2
0.15
0.1
0.05
0
mg/L
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

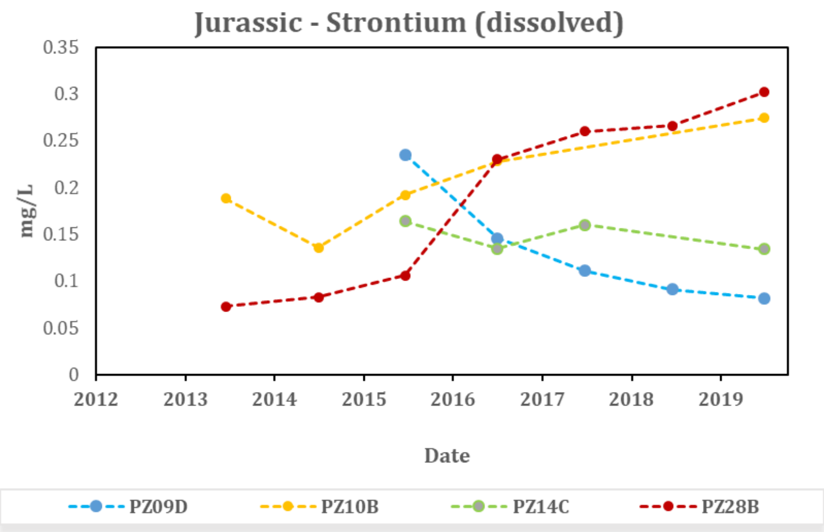

Jurassic - Copper (dissolved)
0.01
0.005
0
mg/L
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

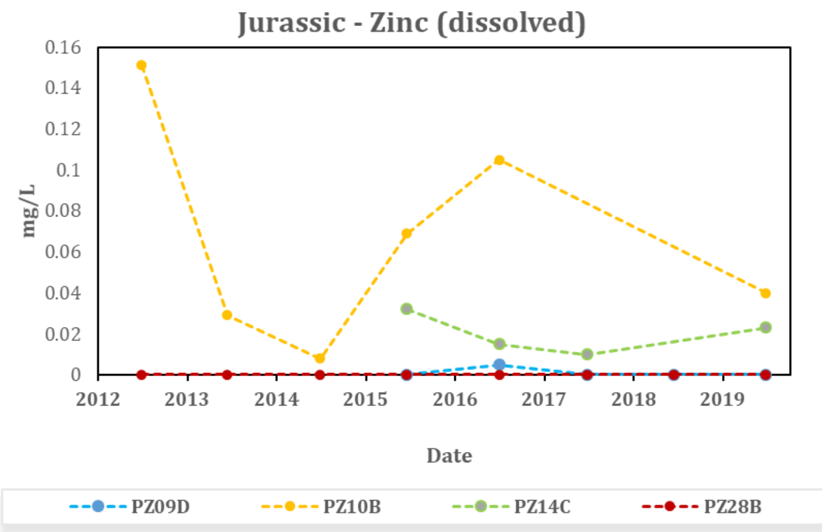

Jurassic - Iron (dissolved)
20
15
10
5
0
mg/L
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

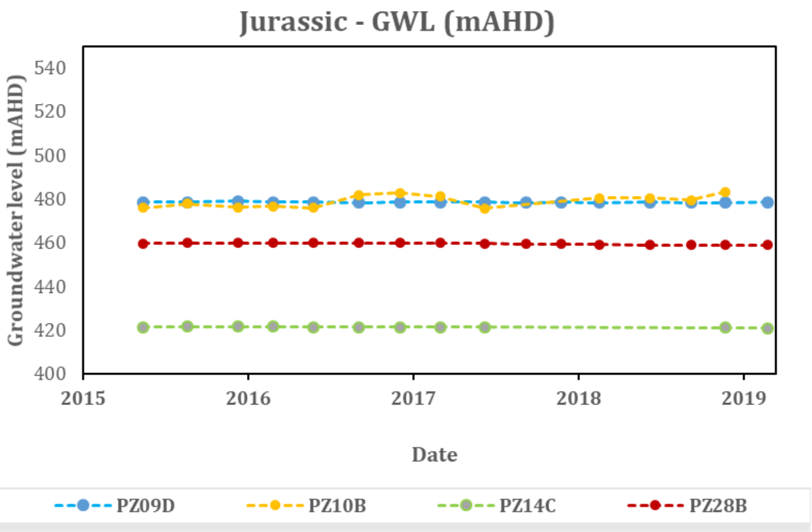

Jurassic - Lithium (dissolved)
0.19
0.17
0.15
0.13
0.11
0.09
0.07
0.05
0.03
0.01
mg/L
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

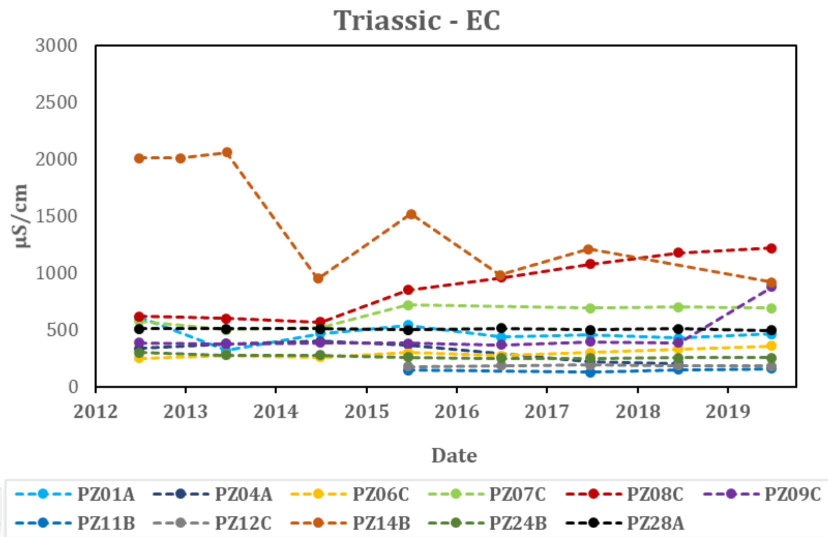

Jurassic - Manganese (dissolved)
mg/L
1.5
1.25
1
0.75
0.5
0.25
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

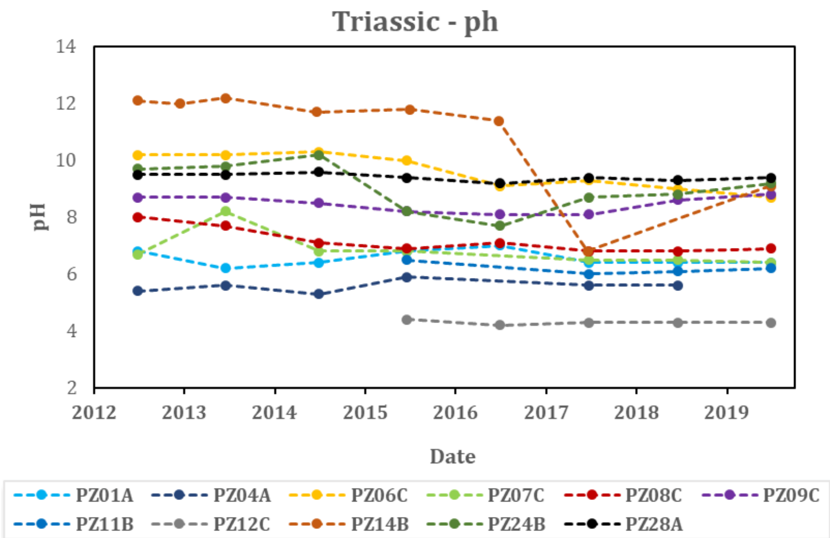

Jurassic - Nickel (dissolved)
mg/L
0.025
0.02
0.015
0.01
0.005
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

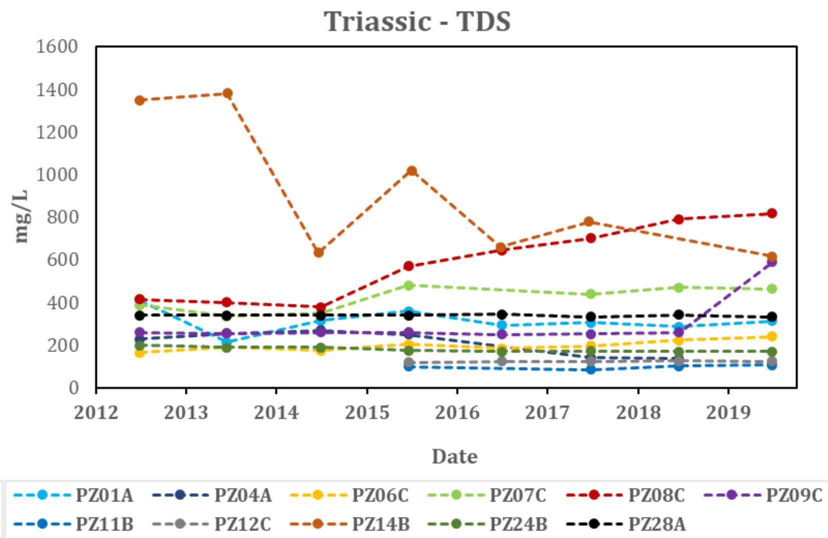

Jurassic - Strontium (dissolved)
mg/L
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

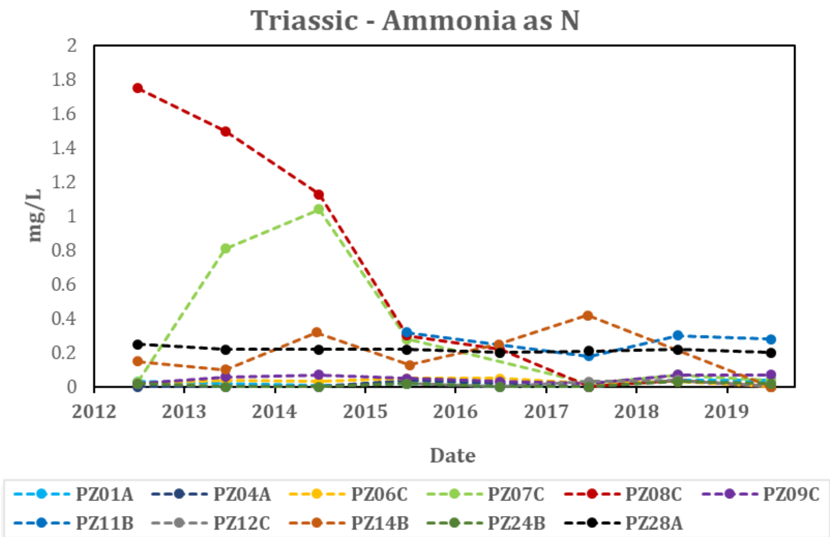

Jurassic - Zinc (dissolved)
mg/L
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B


Jurassic - GWL (mAHD)
Groundwater level (mAHD)
540
520
500
480
460
440
420
400
2015
2016
2017
2018
2019
Date
PZ09D
PZ10B
PZ14C
PZ28B

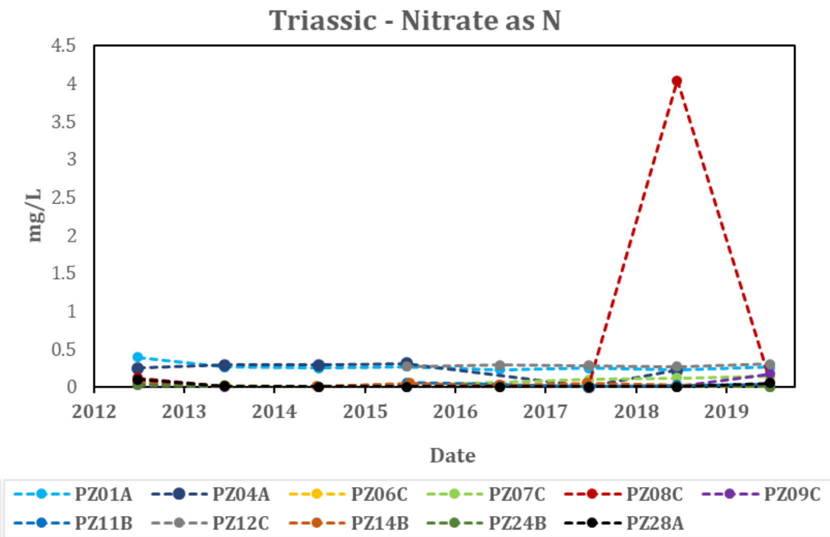

Triassic - EC
µS/cm
3000
2500
2000
1500
1000
500
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A


Triassic - ph
pH
14
12
10
8
6
4
2
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A

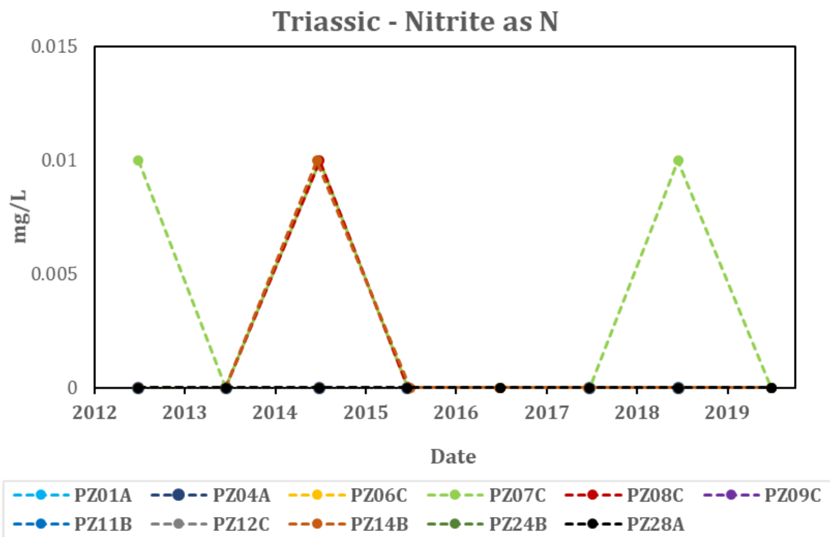

Triassic - TDS
mg/L
1600
1400
1200
1000
800
600
400
200
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A



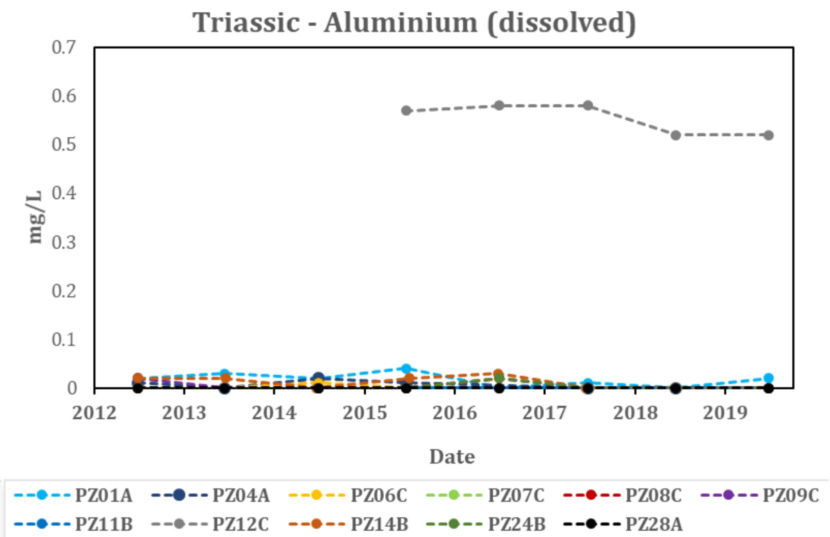
Triassic - Ammonia as N
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

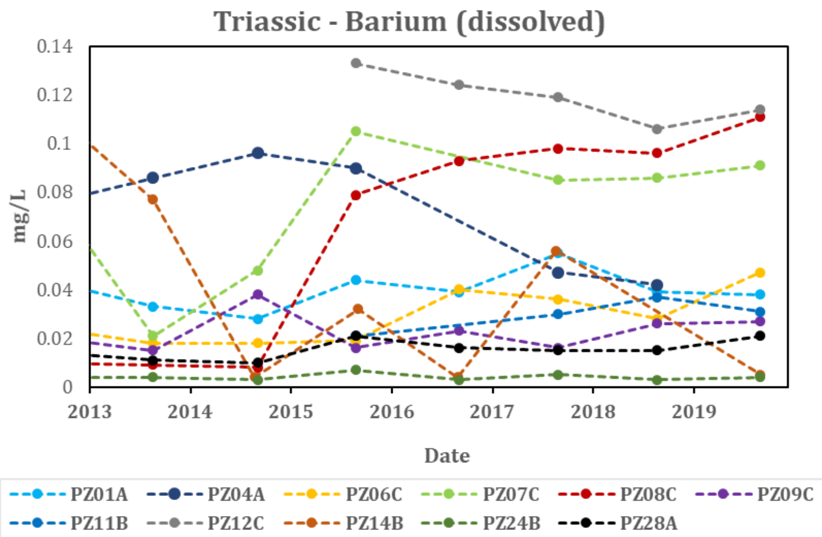
Triassic - Nitrate as N
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

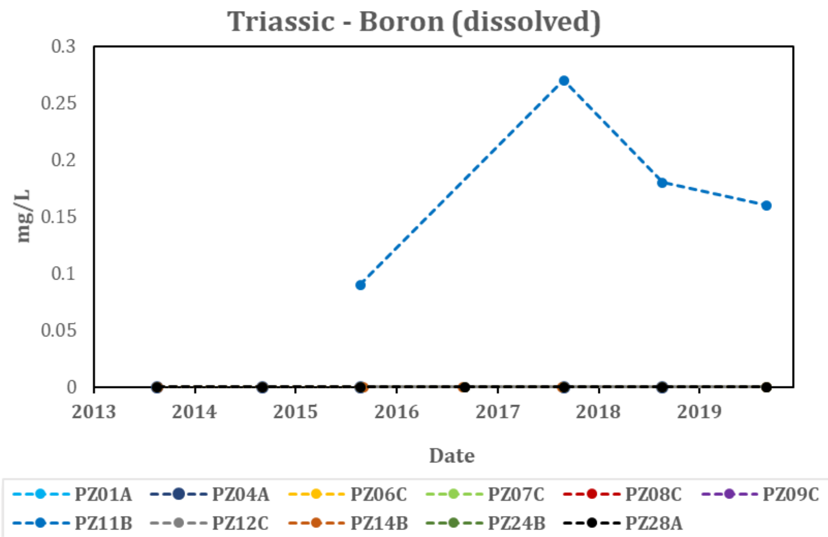



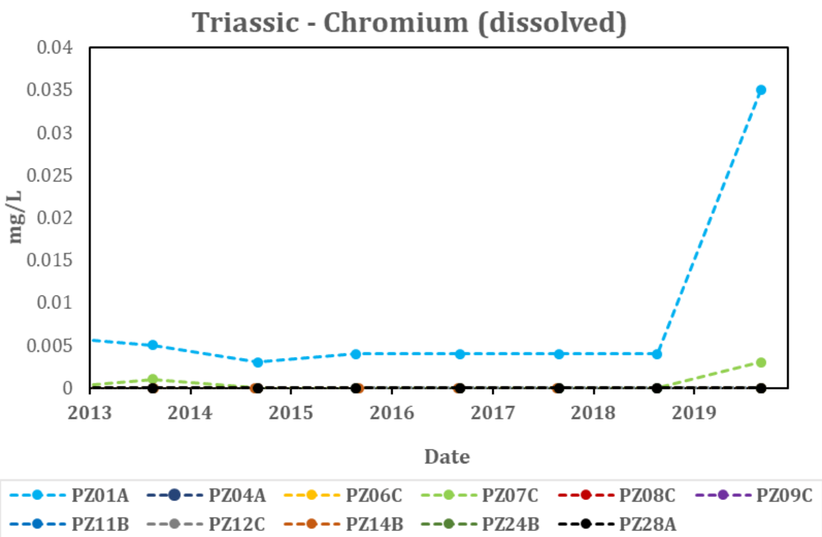
Triassic - Nitrite as N
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

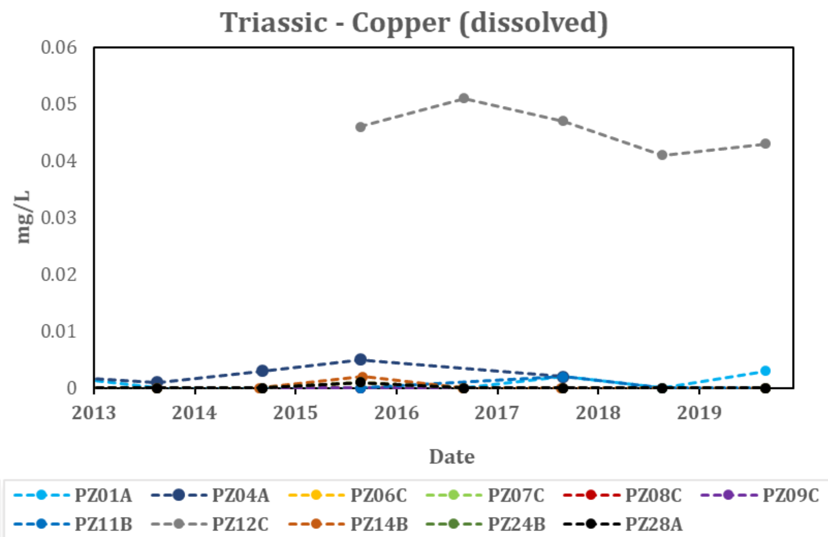



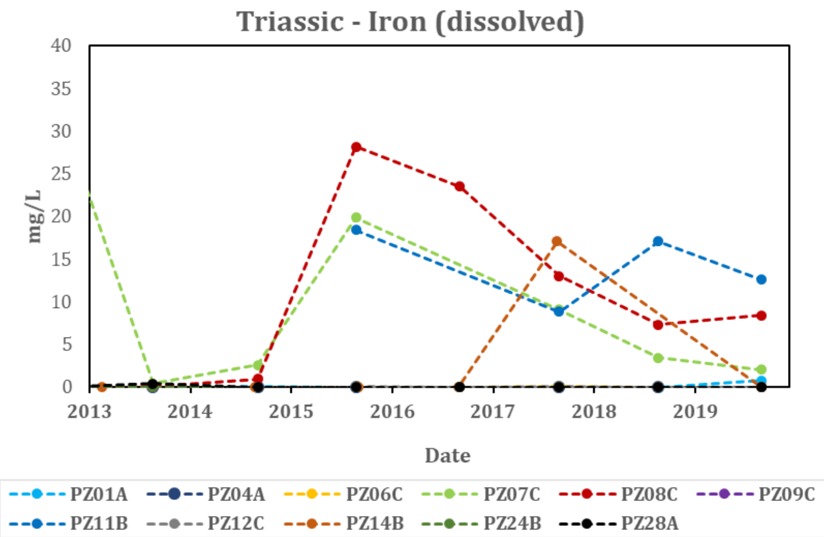
Triassic - Aluminium (dissolved)
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

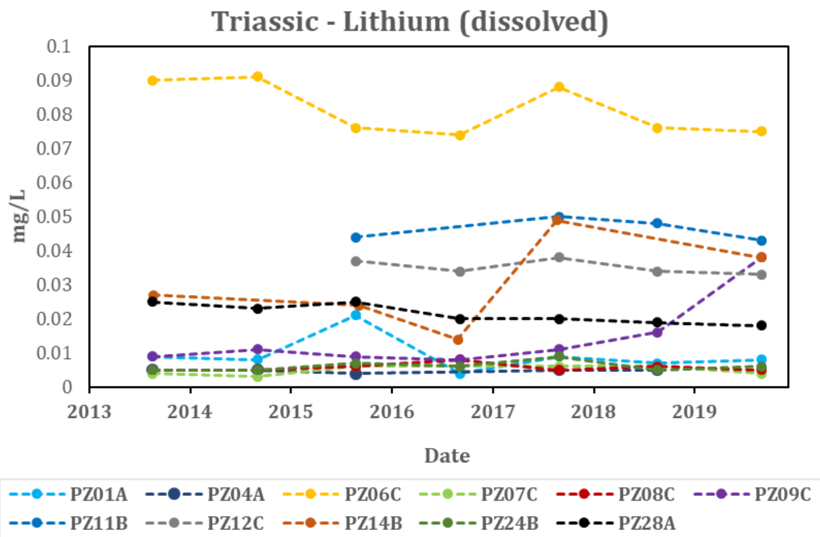

Triassic - Barium (dissolved)
mg/L
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

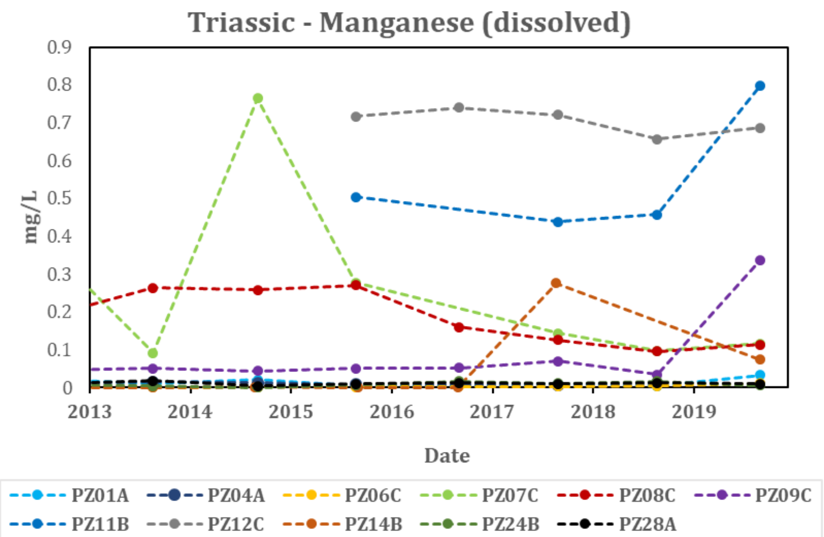

Triassic - Boron (dissolved)
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

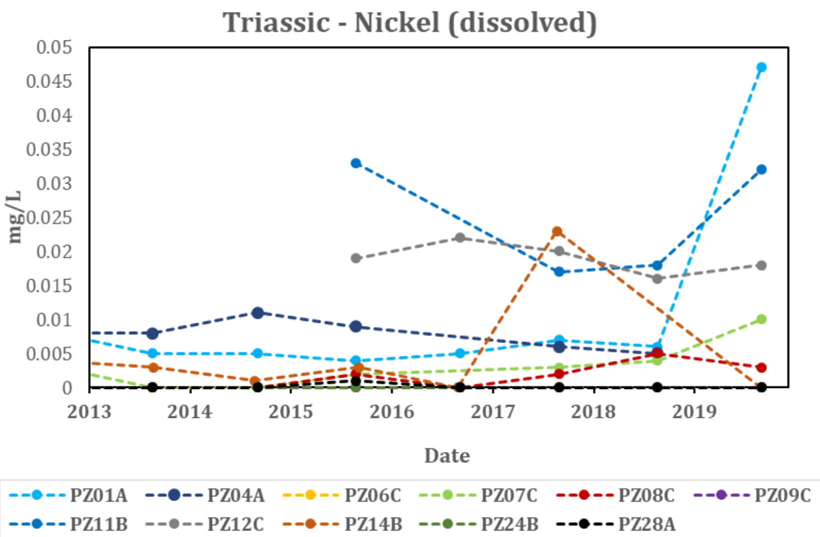

Triassic - Chromium (dissolved)
mg/L
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

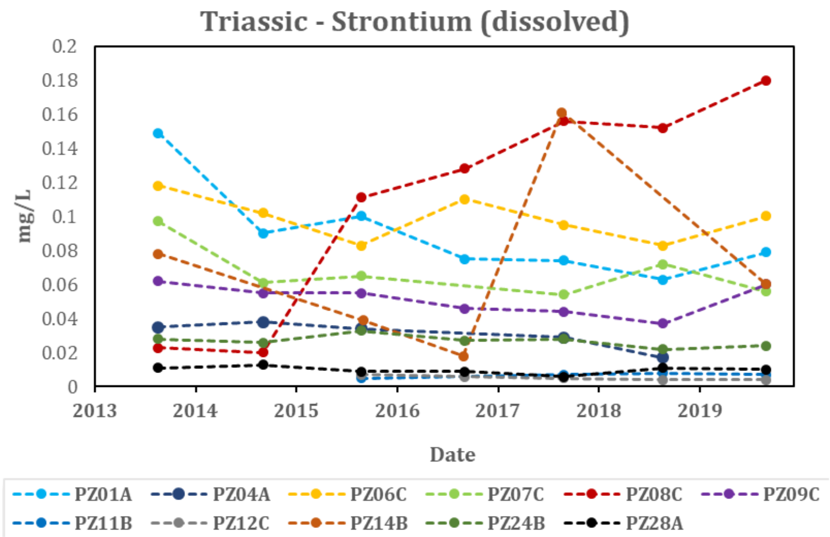

Triassic - Copper (dissolved)
mg/L
0.06
0.05
0.04
0.03
0.02
0.01
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

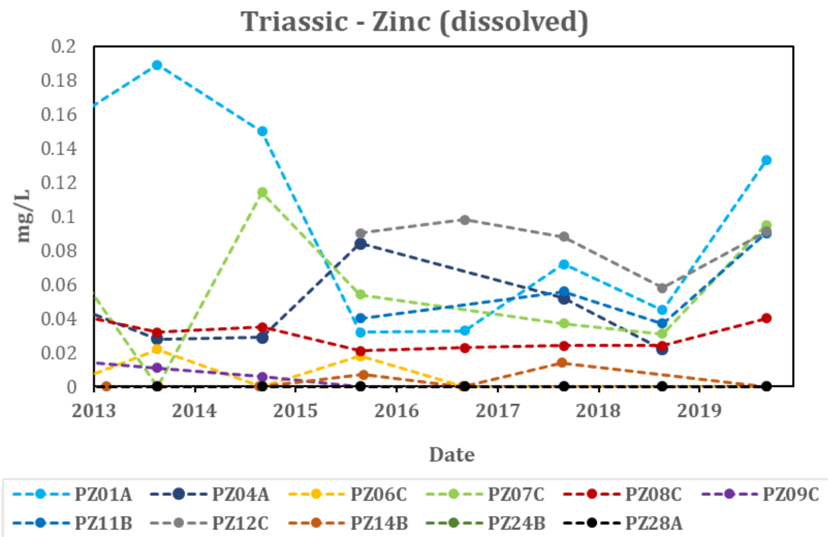

Triassic - Iron (dissolved)
mg/L
40
35
30
25
20
15
10
5
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A

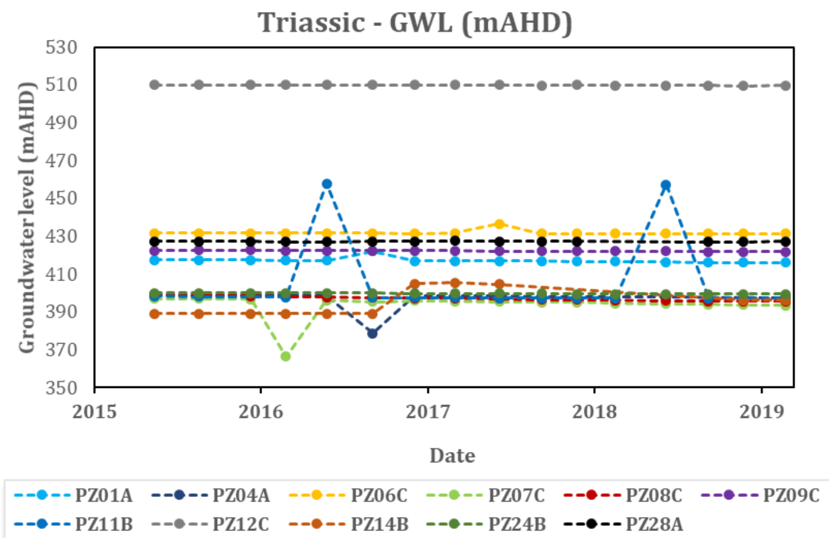

Triassic - Lithium (dissolved)
mg/L
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A

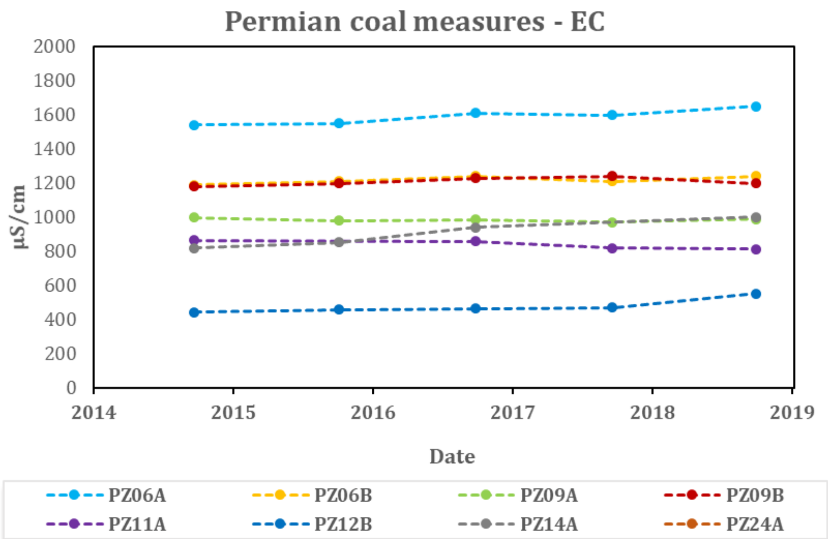

Triassic - Manganese (dissolved)
mg/L
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A

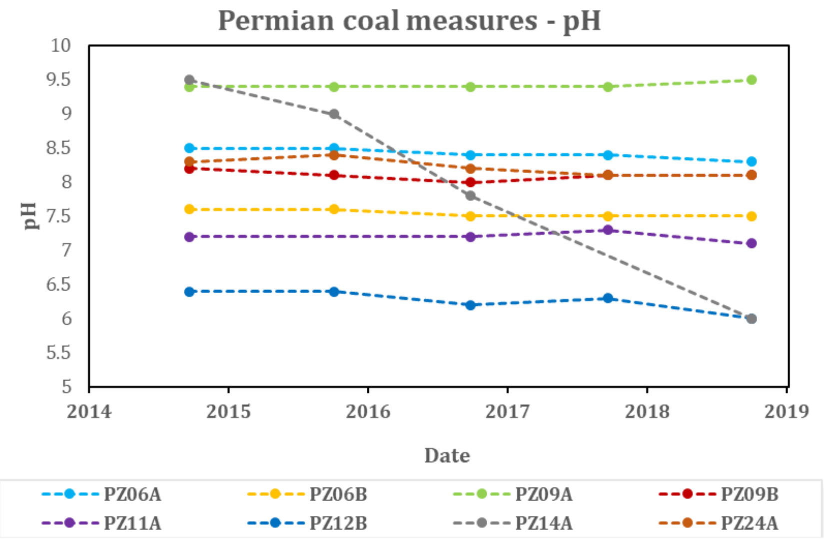

Triassic - Nickel (dissolved)
mg/L
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ01A
PZ04A
PZ06C
PZ07C
PZ08C
PZ09C
PZ11B
PZ12C
PZ14B
PZ24B
PZ28A

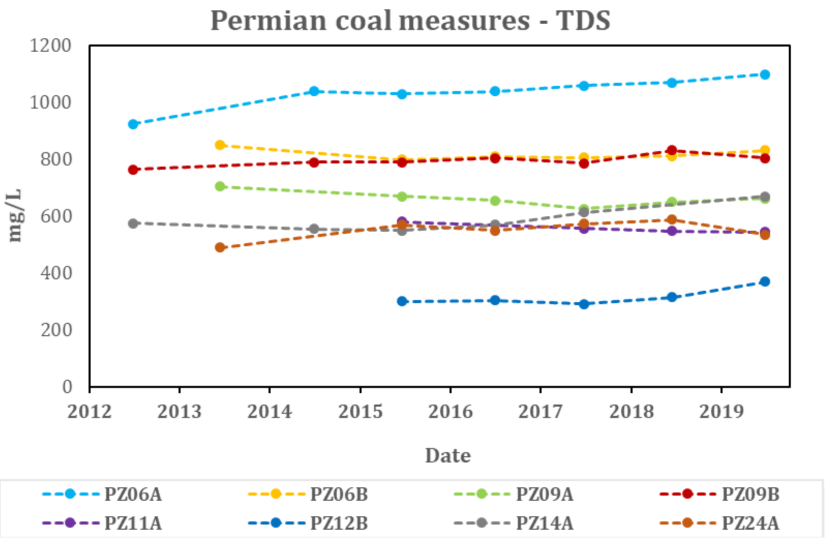

Triassic - Strontium (dissolved)
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

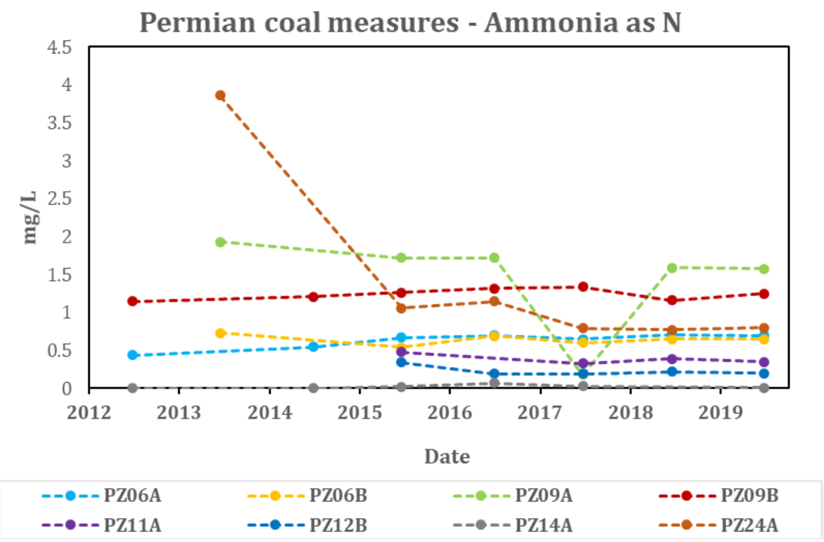

Triassic - Zinc (dissolved)
mg/L
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

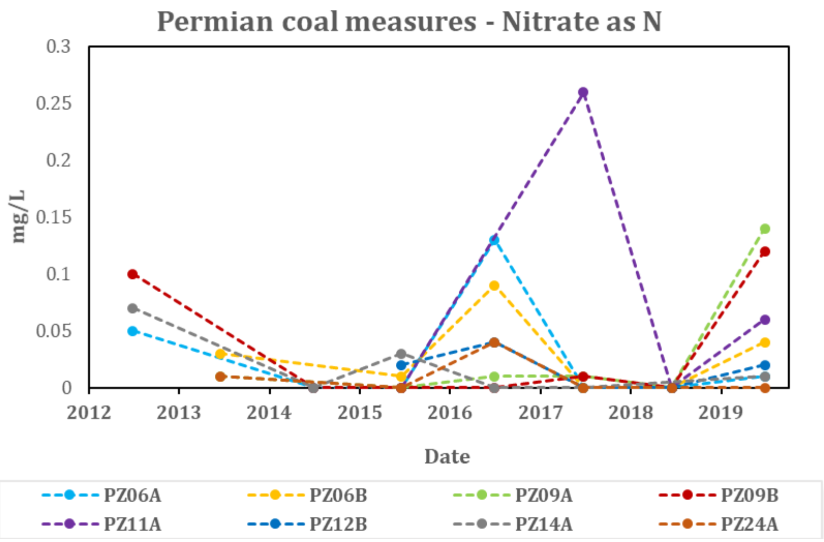

Triassic - GWL (mAHD)
Groundwater level (mAHD)
Date
PZ01A PZ04A PZ06C PZ07C PZ08C PZ09C
PZ11B PZ12C PZ14B PZ24B PZ28A

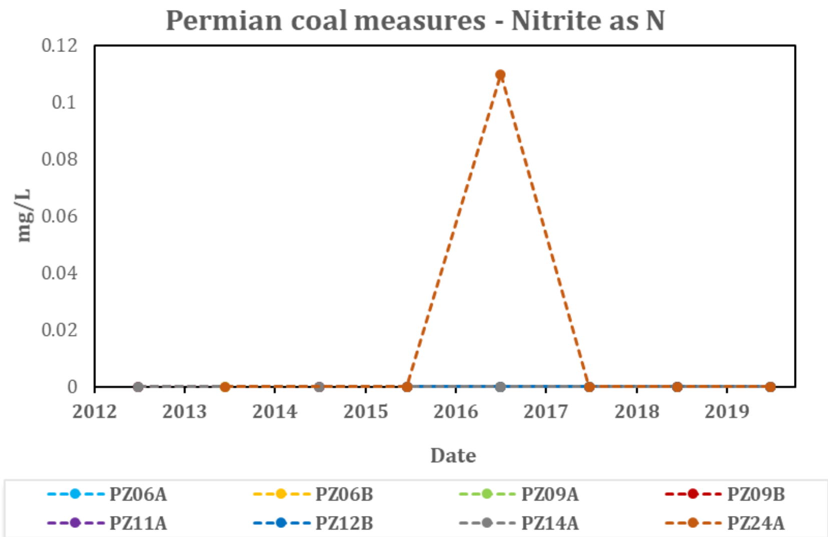

Permian coal measures - EC
µS/cm
Date
PZ06A PZ06B PZ09A PZ09B
PZ11A PZ12B PZ14A PZ24A

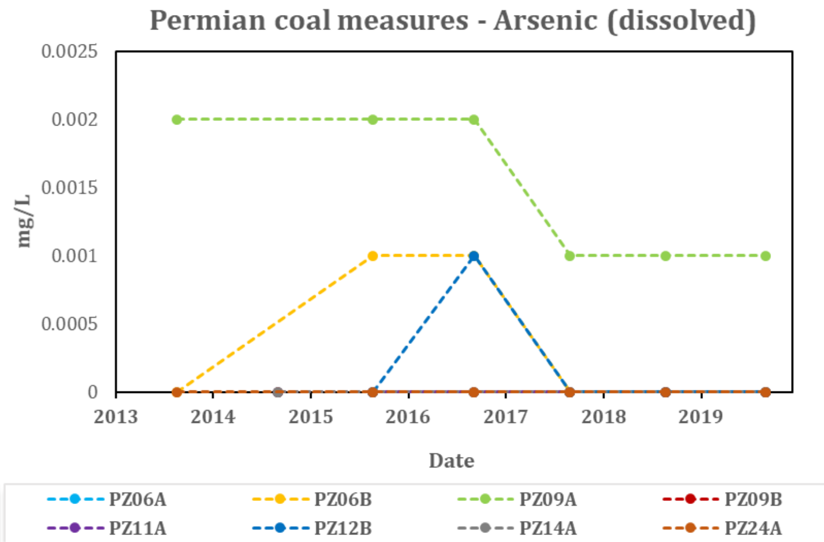

Permian coal measures - pH
pH
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

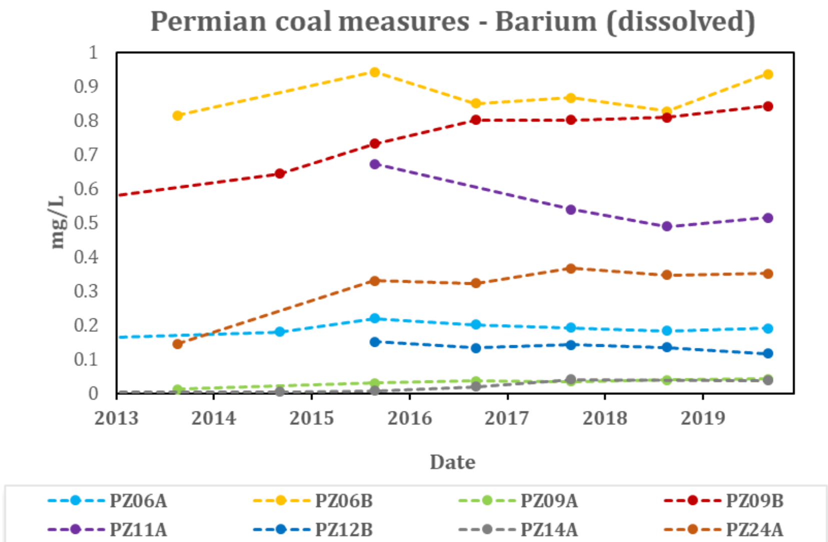

Permian coal measures - TDS
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

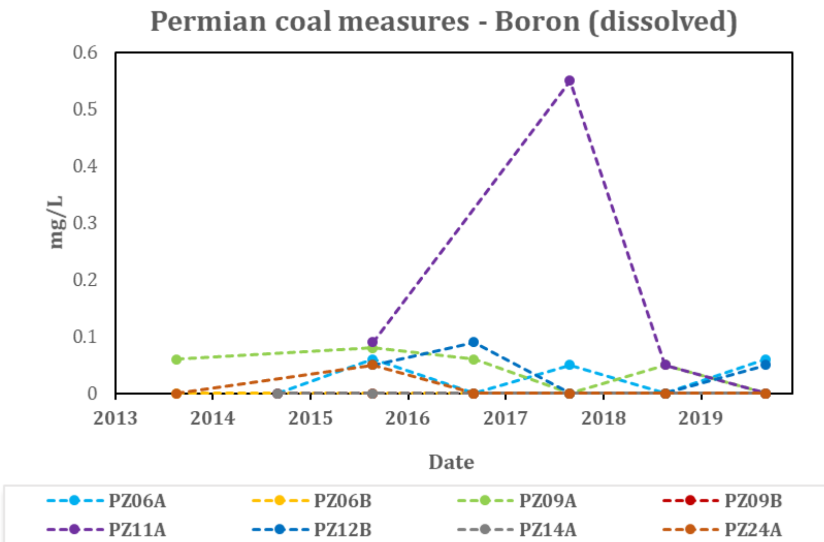

Permian coal measures - Ammonia as N
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

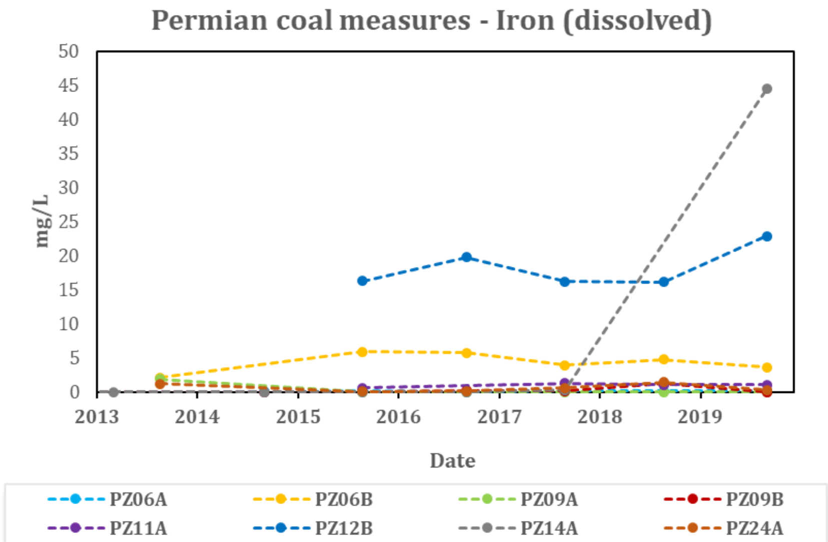

Permian coal measures - Nitrate as N
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

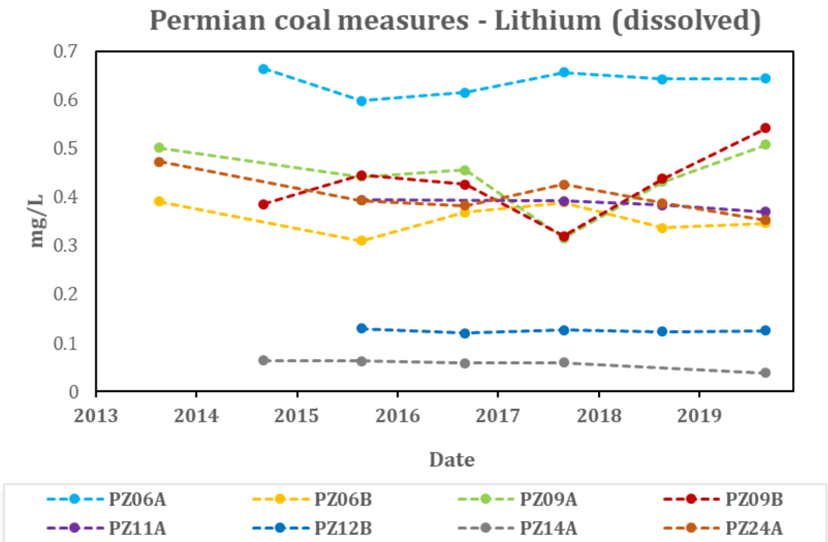

Permian coal measures - Nitrite as N
mg/L
0.12
0.1
0.08
0.06
0.04
0.02
0
2012
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

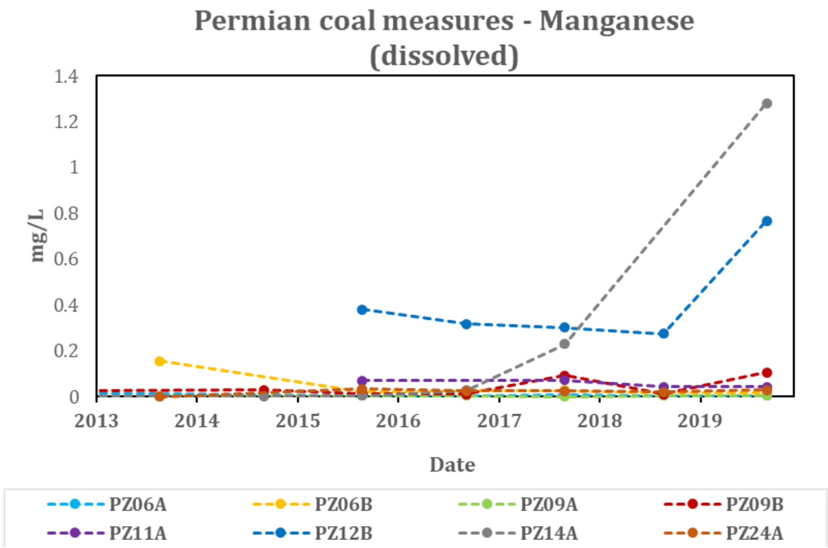

Permian coal measures - Arsenic (dissolved)
mg/L
0.0025
0.002
0.0015
0.001
0.0005
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

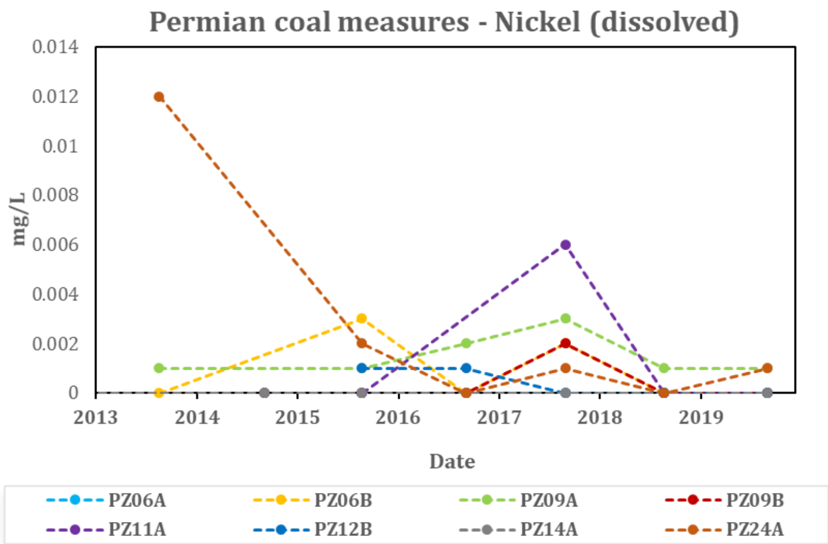

Permian coal measures - Barium (dissolved)
mg/L
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

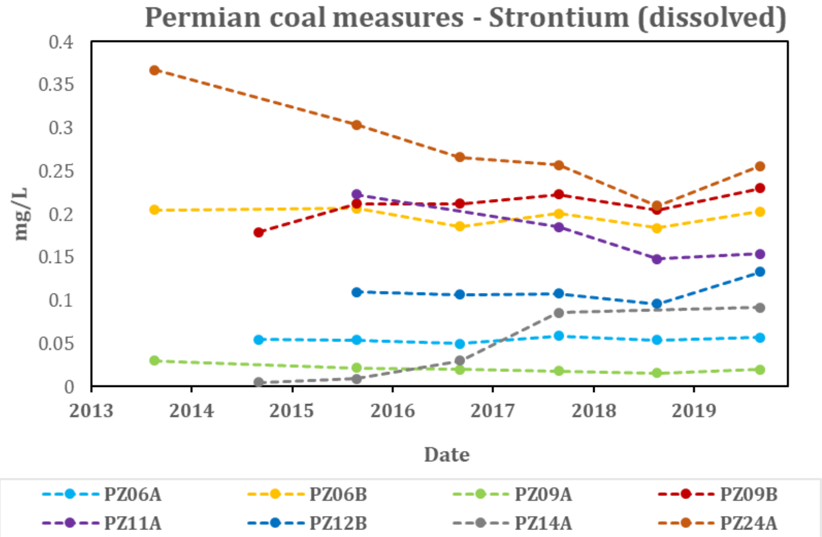

Permian coal measures - Boron (dissolved)
mg/L
0.6
0.5
0.4
0.3
0.2
0.1
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

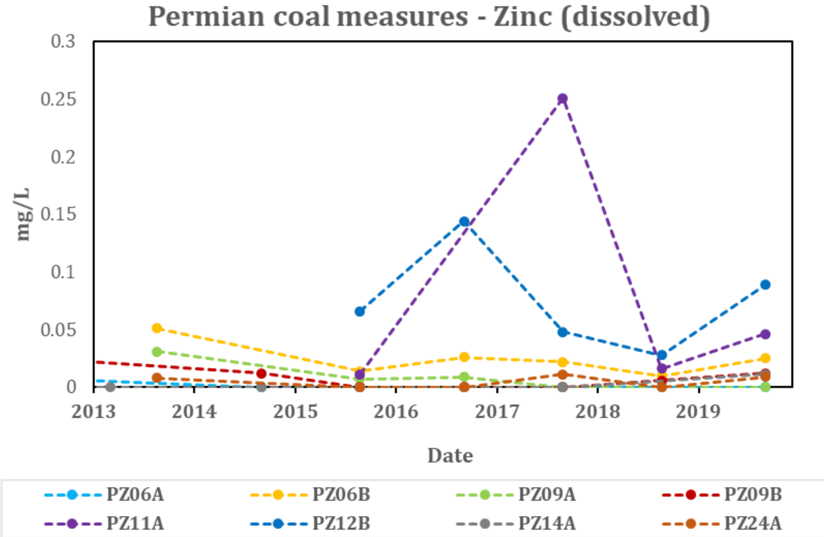

Permian coal measures - Iron (dissolved)
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

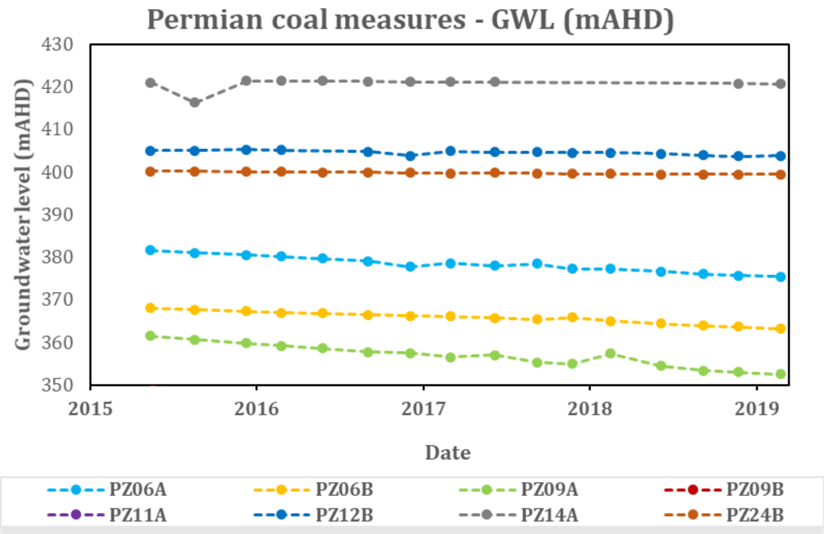

Permian coal measures - Lithium (dissolved)
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A


Permian coal measures - Manganese (dissolved)
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

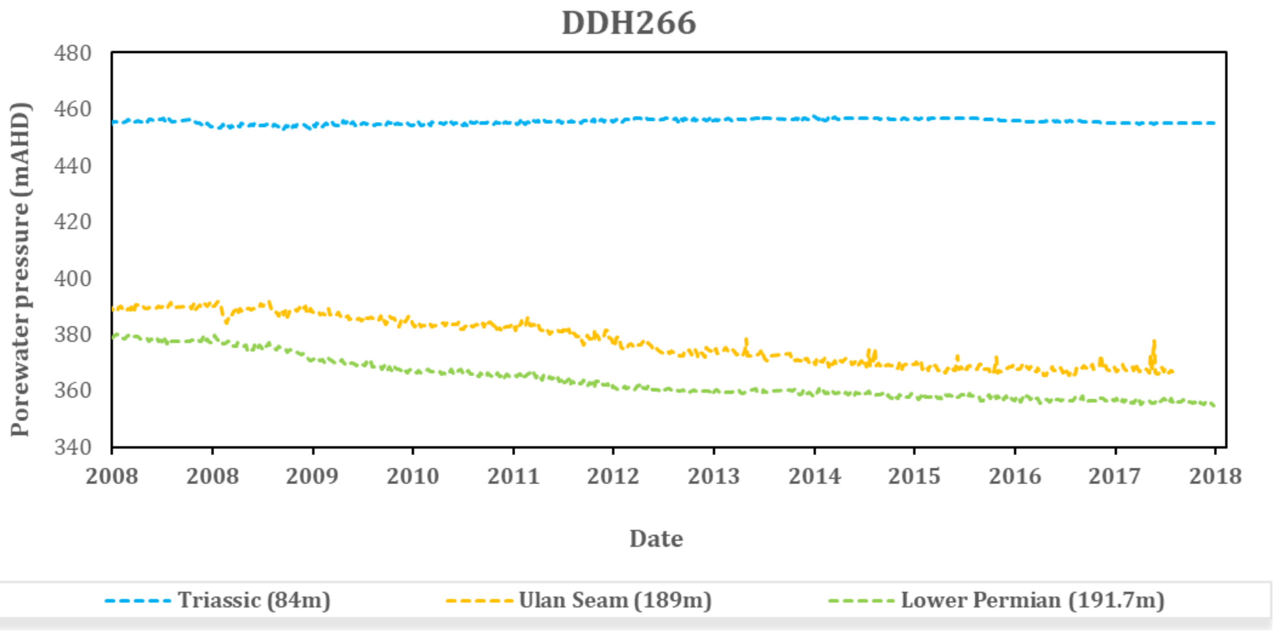

Permian coal measures - Nickel (dissolved)
mg/L
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

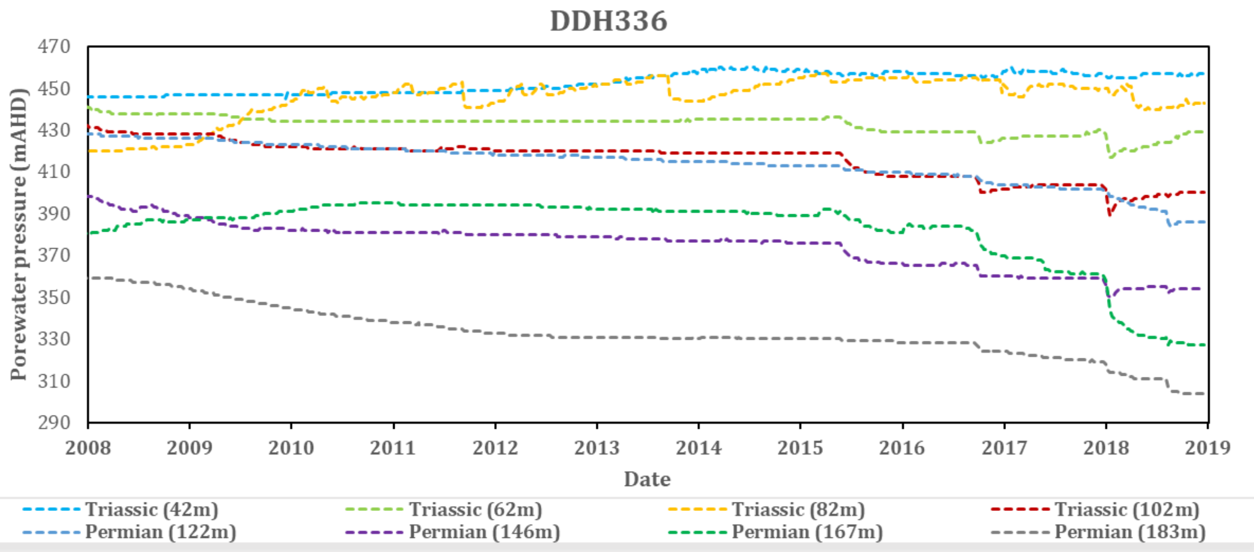

Permian coal measures - Strontium (dissolved)
mg/L
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

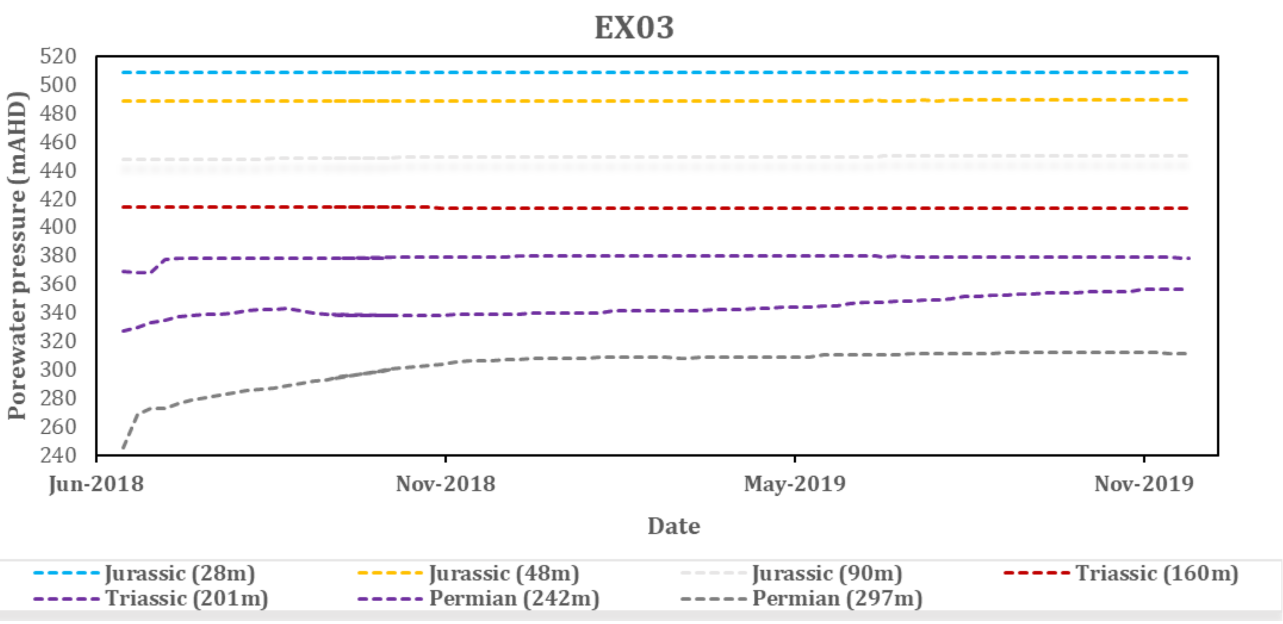

Permian coal measures - Zinc (dissolved)
mg/L
0.3
0.25
0.2
0.15
0.1
0.05
0
2013
2014
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24A

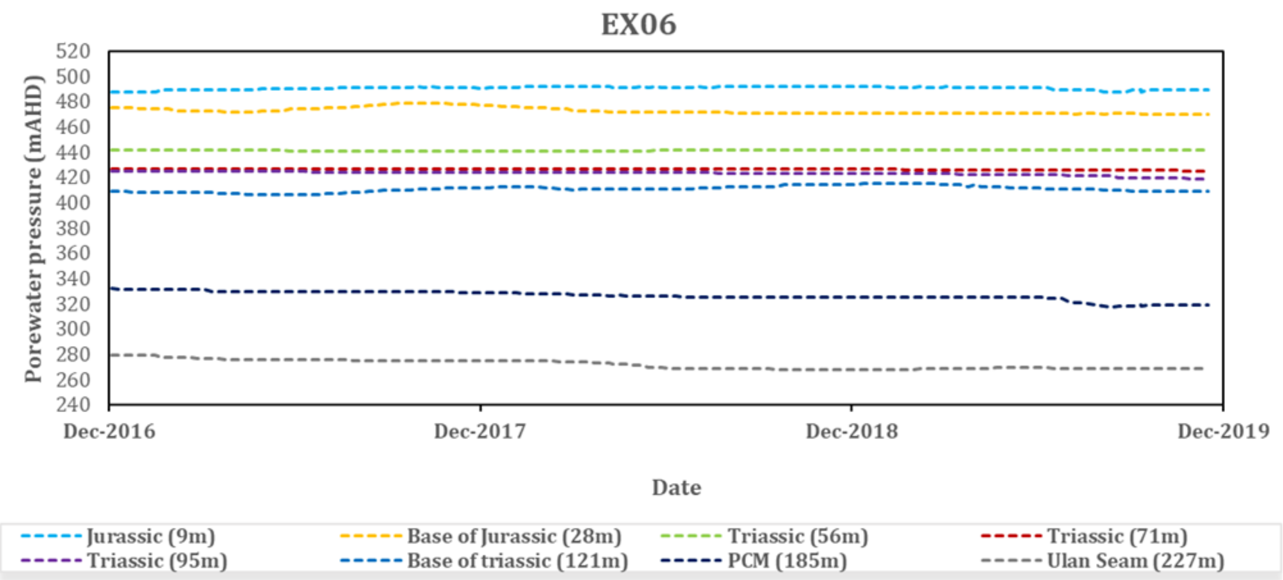

Permian coal measures - GWL (mAHD)
Groundwater level (mAHD)
430
420
410
400
390
380
370
360
350
2015
2016
2017
2018
2019
Date
PZ06A
PZ06B
PZ09A
PZ09B
PZ11A
PZ12B
PZ14A
PZ24B

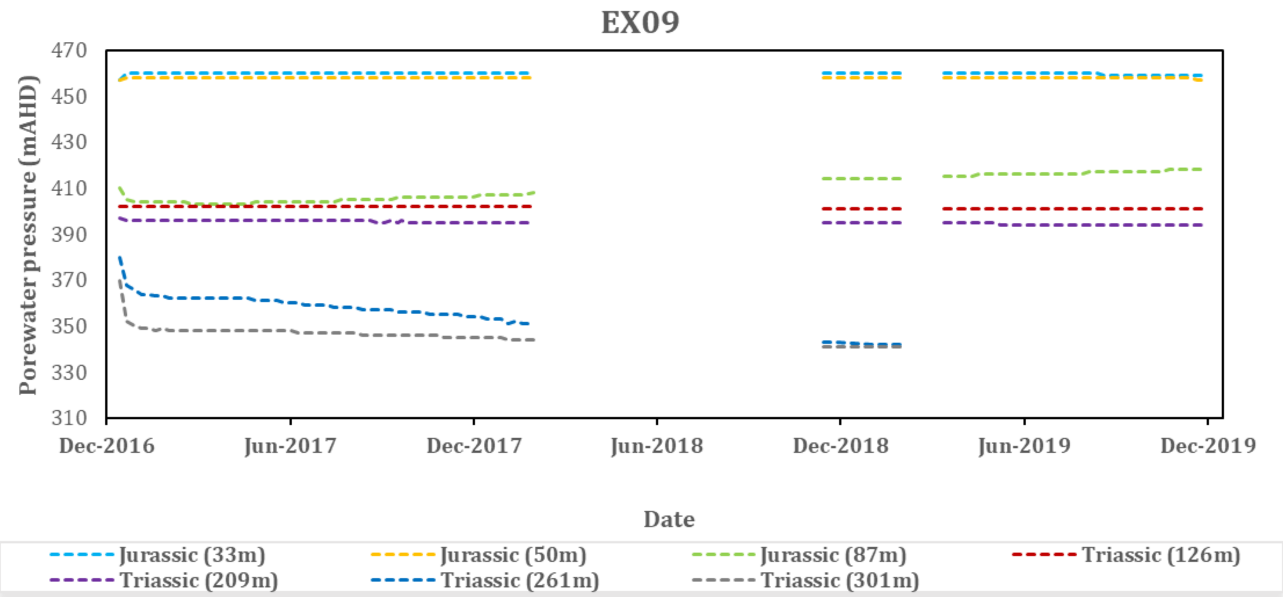
# *Appendix B* North Monitoring Network VWP hydrographs

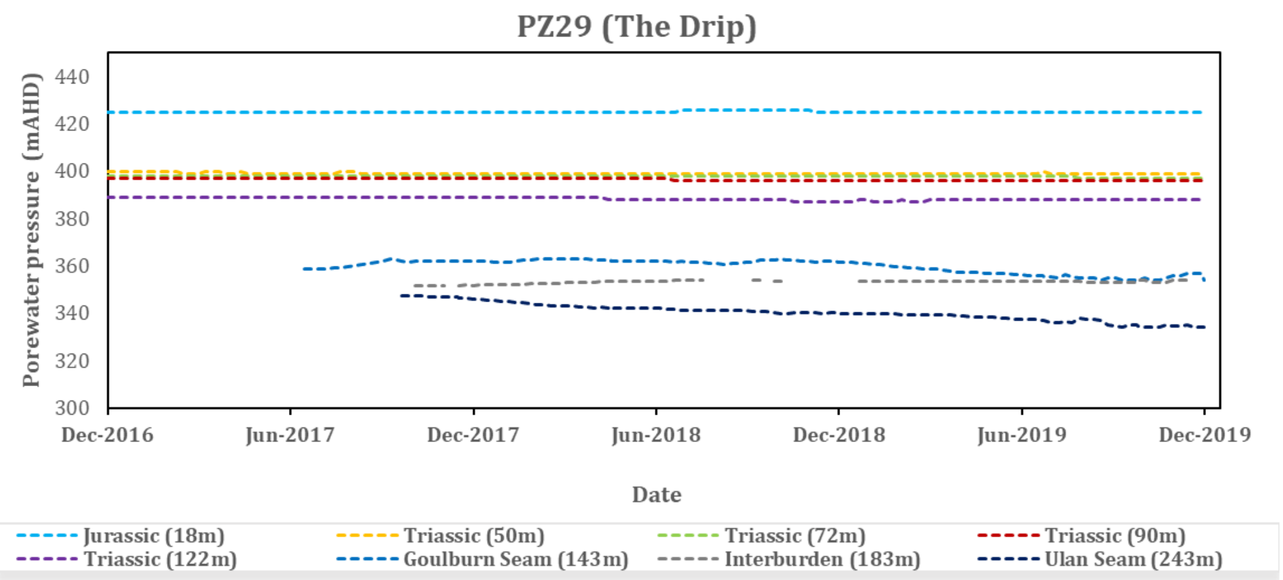

DDH266
Porewater pressure (mAHD)
480
460
440
420
400
380
360
340
2008
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
Date
Triassic (84m)
Ulan Seam (189m)
Lower Permian (191.7m)

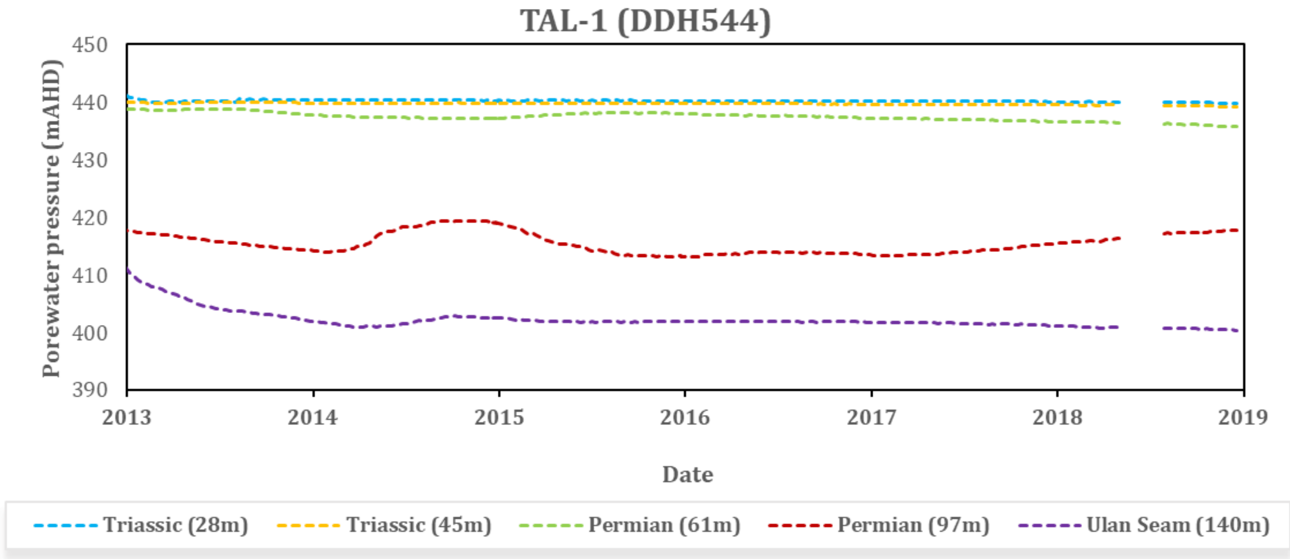

DDH336
Porewater pressure (mAHD)
470
450
430
410
390
370
350
330
310
290
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
Date
Triassic (42m)
Triassic (62m)
Triassic (82m)
Triassic (102m)
Permian (122m)
Permian (146m)
Permian (167m)
Permian (183m)


EX03
Porewater pressure (mAHD)
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
Jun-2018
Nov-2018
May-2019
Nov-2019
Date
Jurassic (28m)
Jurassic (48m)
Jurassic (90m)
Triassic (160m)
Triassic (201m)
Permian (242m)
Permian (297m)

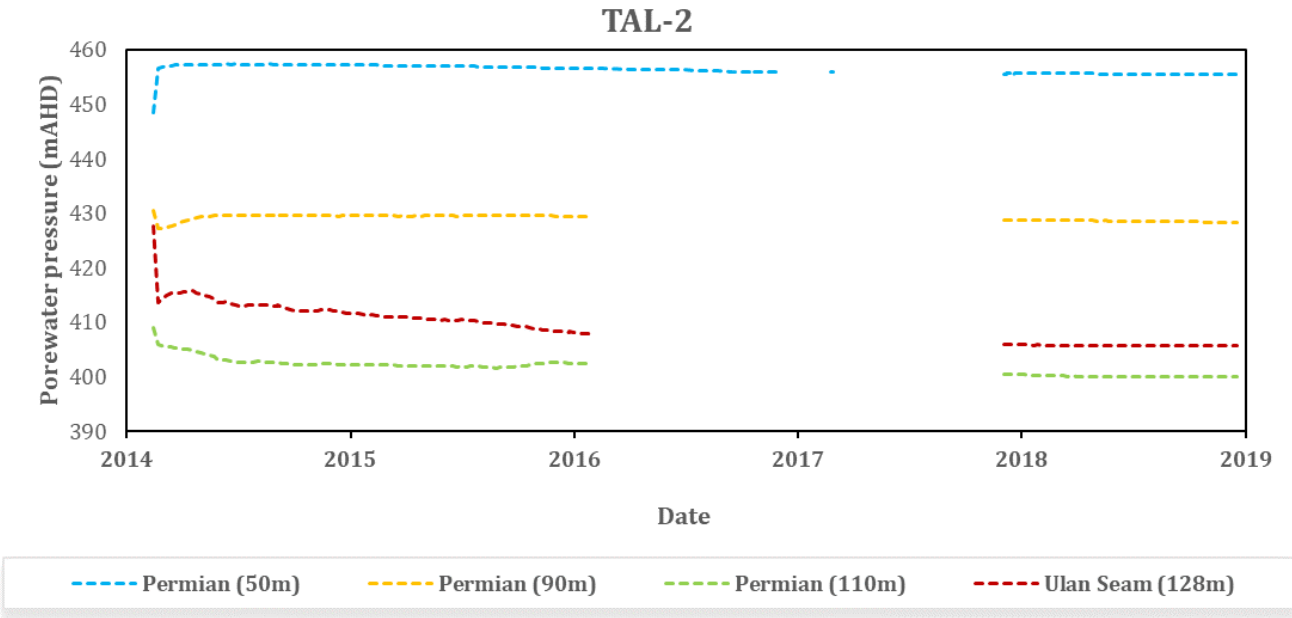

EX06
Porewater pressure (mAHD)
520
500
480
460
440
420
400
380
360
340
320
300
280
260
240
Dec-2016
Dec-2017
Dec-2018
Dec-2019
Date
Jurassic (9m)
Base of Jurassic (28m)
Triassic (56m)
Triassic (71m)
Triassic (95m)
Base of triassic (121m)
PCM (185m)
Ulan Seam (227m)


EX09
Porewater pressure (mAHD)
470
450
430
410
390
370
350
330
310
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Jun-2019
Dec-2019
Date
Jurassic (33m)
Jurassic (50m)
Jurassic (87m)
Triassic (126m)
Triassic (209m)
Triassic (261m)
Triassic (301m)

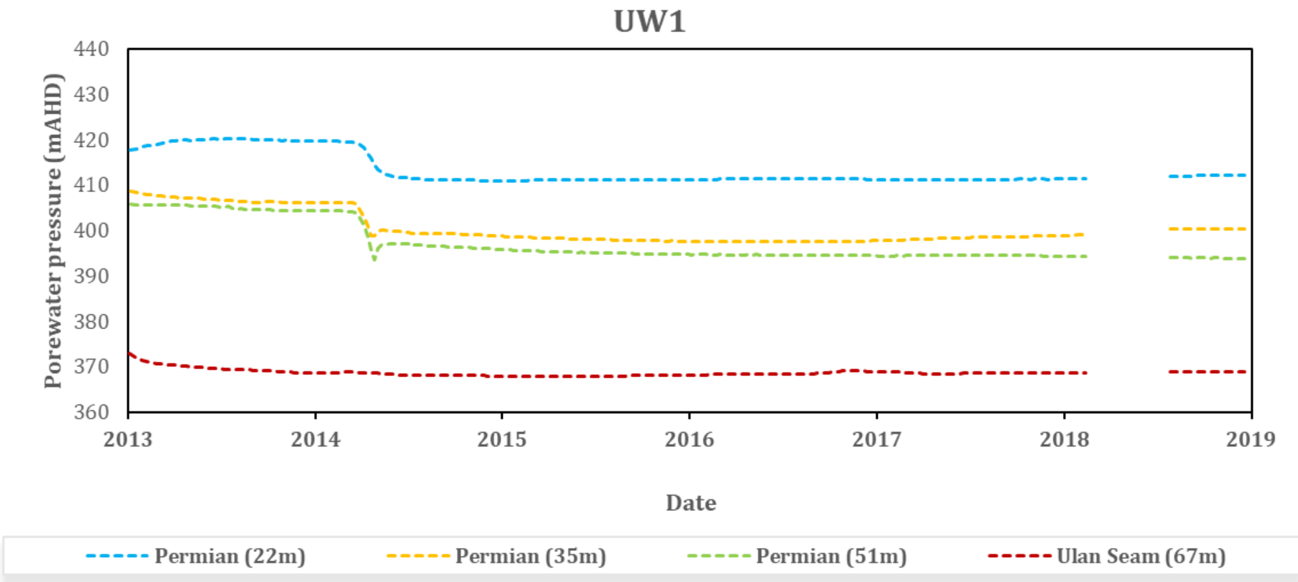

PZ29 (The Drip)
Porewater pressure (mAHD)
440
420
400
380
360
340
320
300
Dec-2016
Jun-2017
Dec-2017
Jun-2018
Dec-2018
Jun-2019
Dec-2019
Date
Jurassic (18m)
Triassic (50m)
Triassic (72m)
Triassic (90m)
Triassic (122m)
Goulburn Seam (143m)
Interburden (183m)
Ulan Seam (243m)



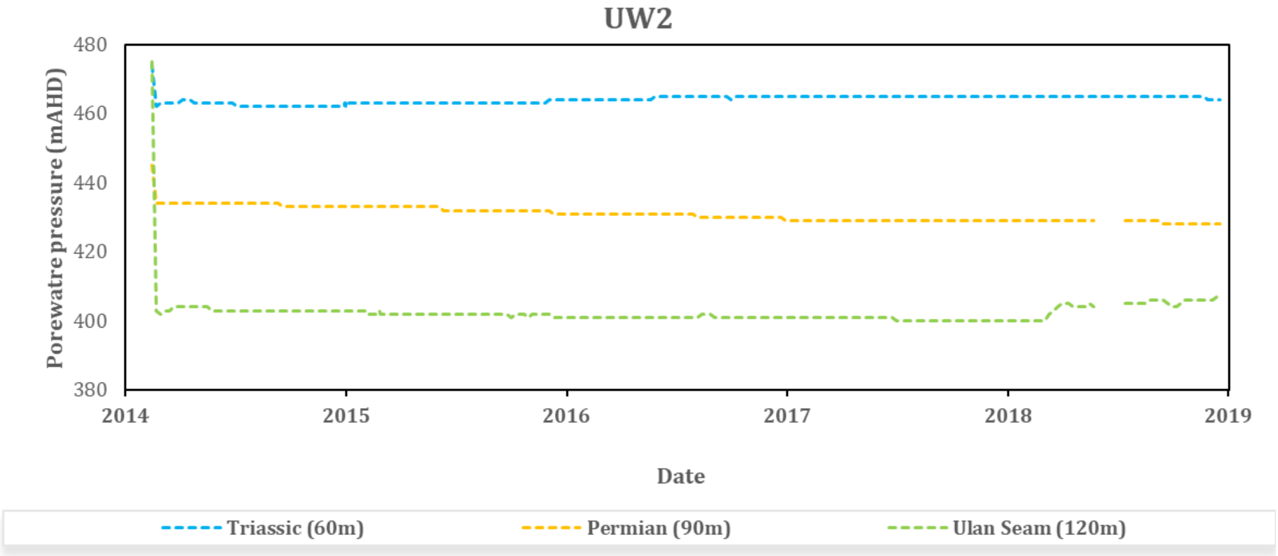
TAL-1 (DDH544)
450
440
430
420
410
400
390
Porewater pressure (mAHD)
2013
2014
2015
2016
2017
2018
2019
Date
Triassic (28m)
Triassic (45m)
Permian (61m)
Permian (97m)
Ulan Seam (140m)

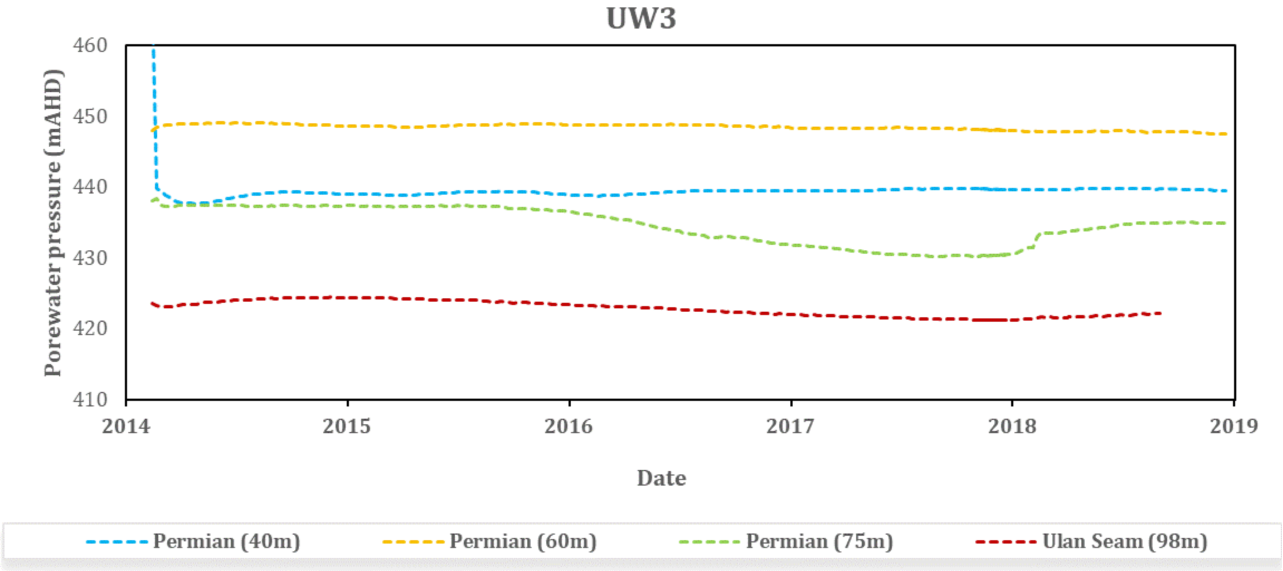



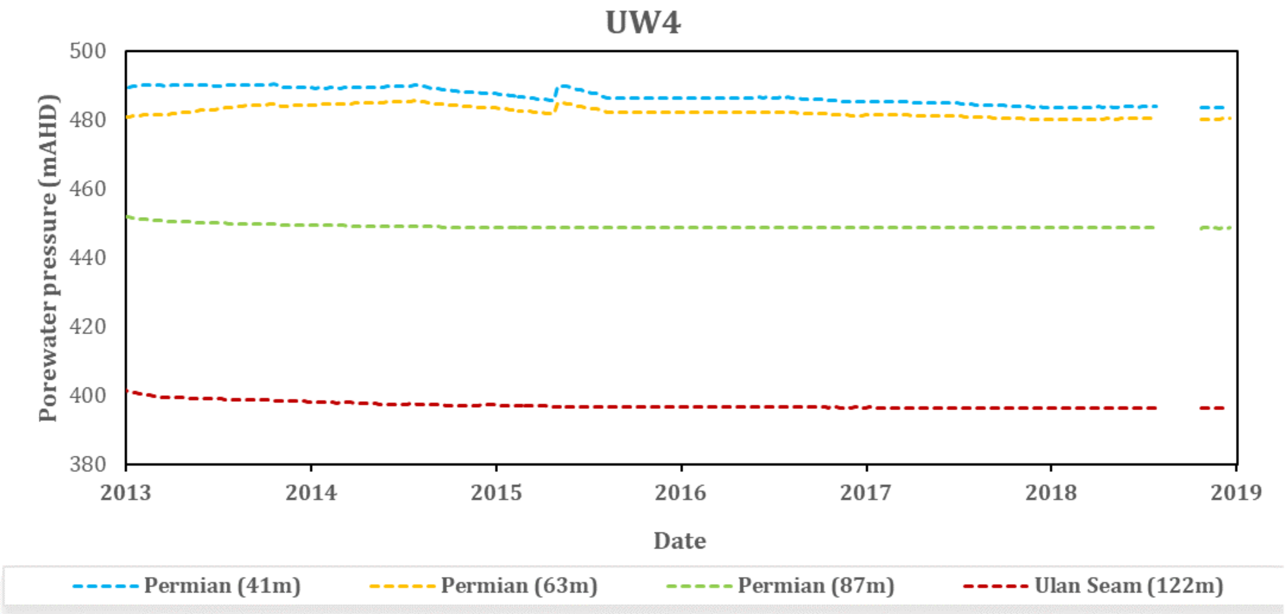
TAL-2
460
450
440
430
420
410
400
390
Porewater pressure (mAHD)
2014
2015
2016
2017
2018
2019
Date
Permian (50m)
Permian (90m)
Permian (110m)
Ulan Seam (128m)

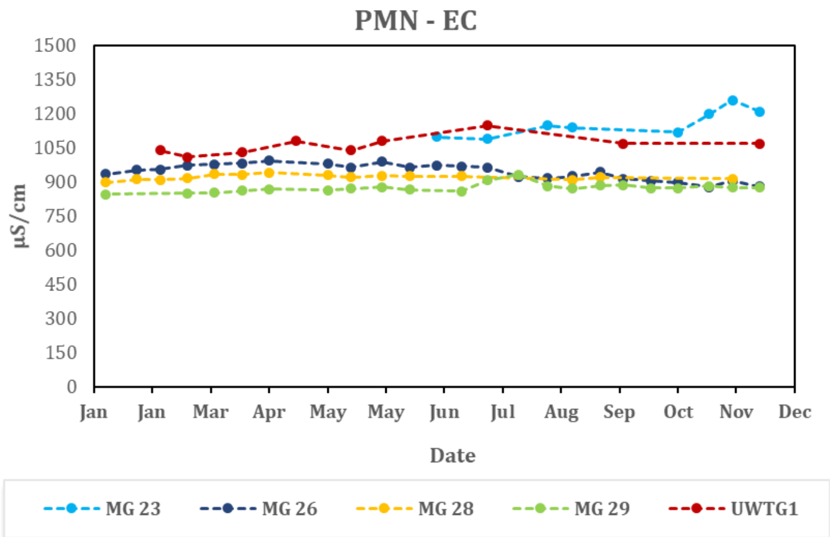
UW1
440
430
420
410
400
390
380
370
360
Porewater pressure (mAHD)
2013
2014
2015
2016
2017
2018
2019
Date
Permian (22m)
Permian (35m)
Permian (51m)
Ulan Seam (67m)

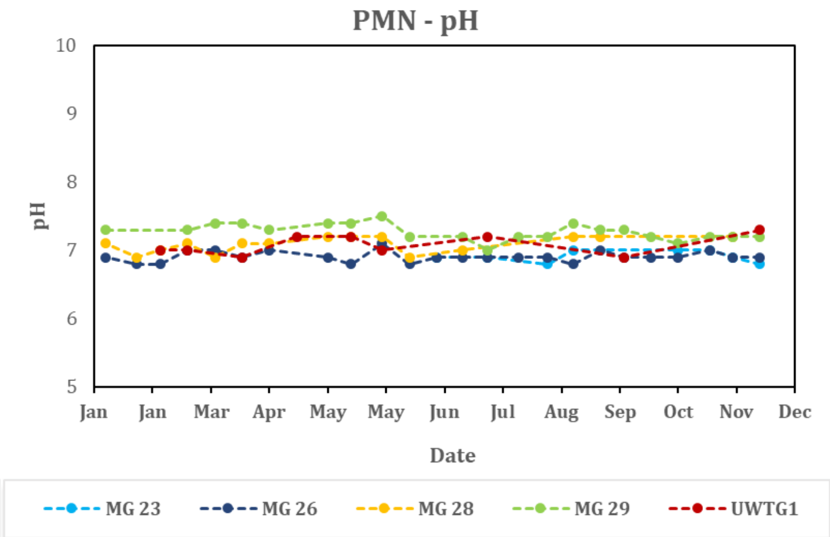

UW2
Porewatre pressure (mAHD)
480
460
440
420
400
380
2014
2015
2016
2017
2018
2019
Date
Triassic (60m)
Permian (90m)
Ulan Seam (120m)

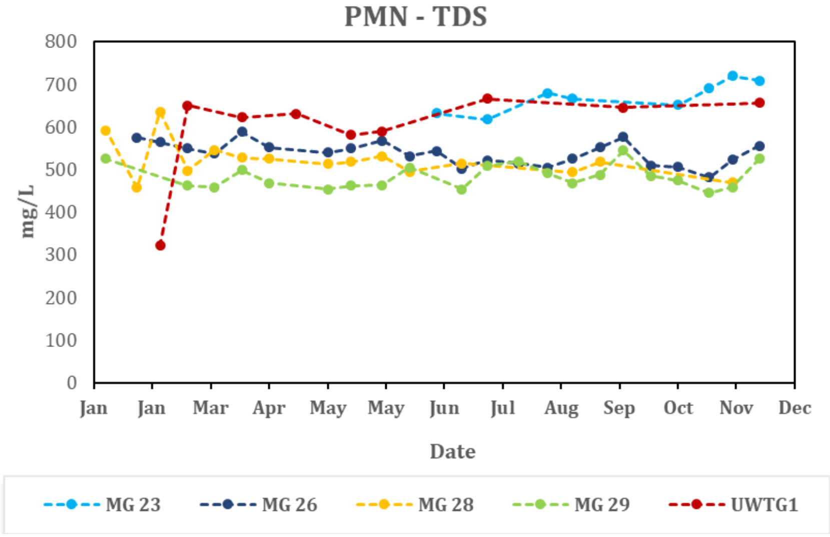

UW3
Porewater pressure (mAHD)
460
450
440
430
420
410
2014
2015
2016
2017
2018
2019
Date
Permian (40m)
Permian (60m)
Permian (75m)
Ulan Seam (98m)

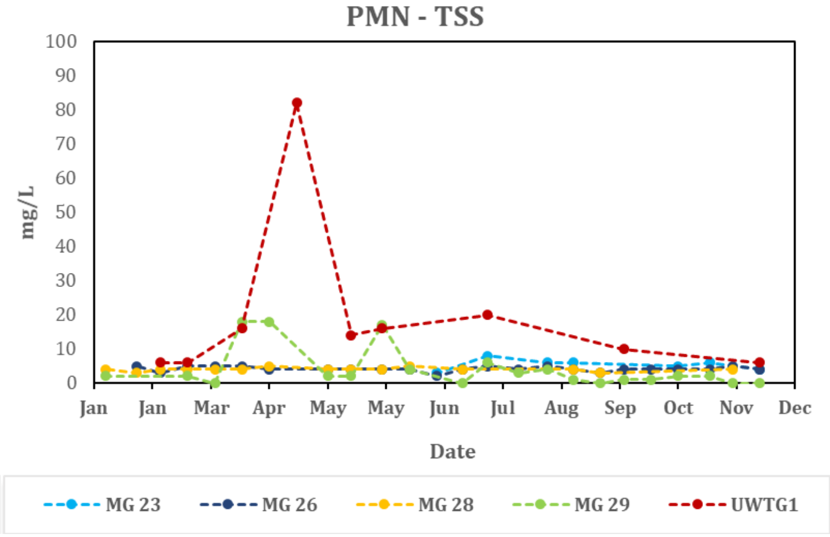

UW4
Porewater pressure (mAHD)
500
480
460
440
420
400
380
2013
2014
2015
2016
2017
2018
2019
Date
Permian (41m)
Permian (63m)
Permian (87m)
Ulan Seam (122m)

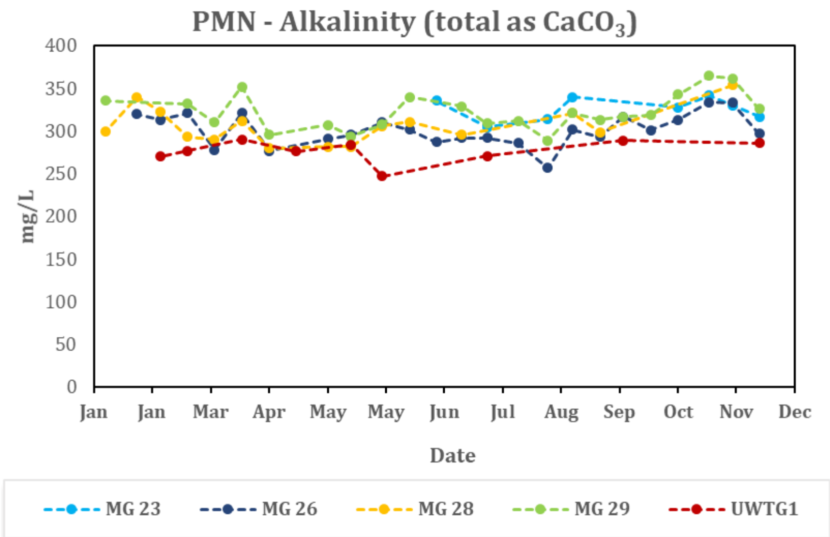
# *Appendix C* Pleuger Monitoring Network Hydrographs


PMN - EC
1500
1350
1200
1050
900
750
600
450
300
150
0
µS/cm
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

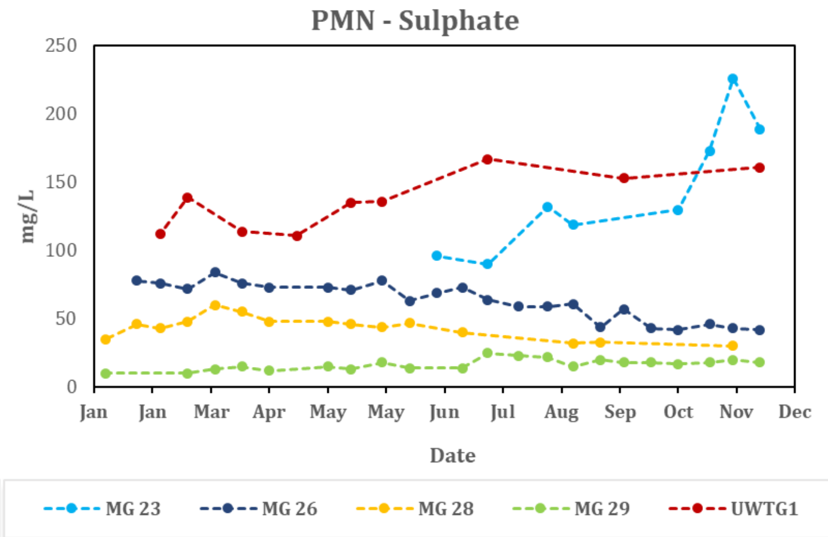

PMN - pH
10
9
8
7
6
5
pH
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1


PMN - TDS
800
700
600
500
400
300
200
100
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

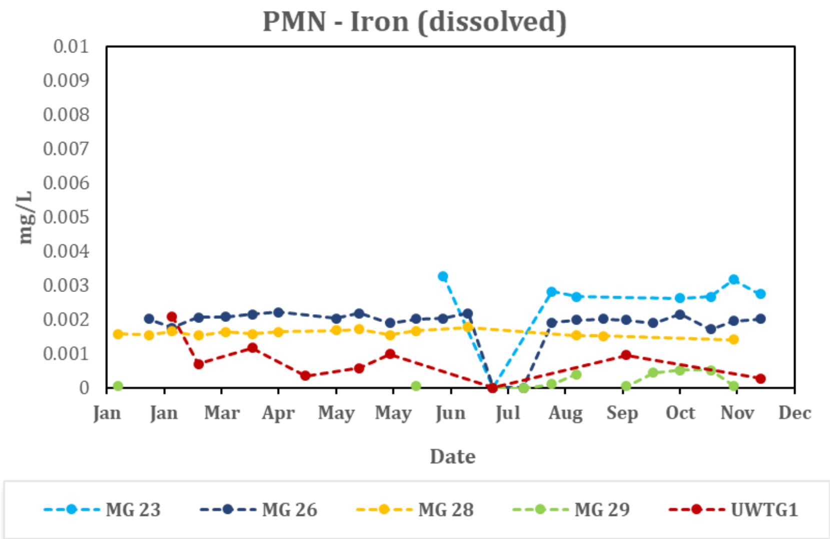

PMN - TSS
100
90
80
70
60
50
40
30
20
10
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1



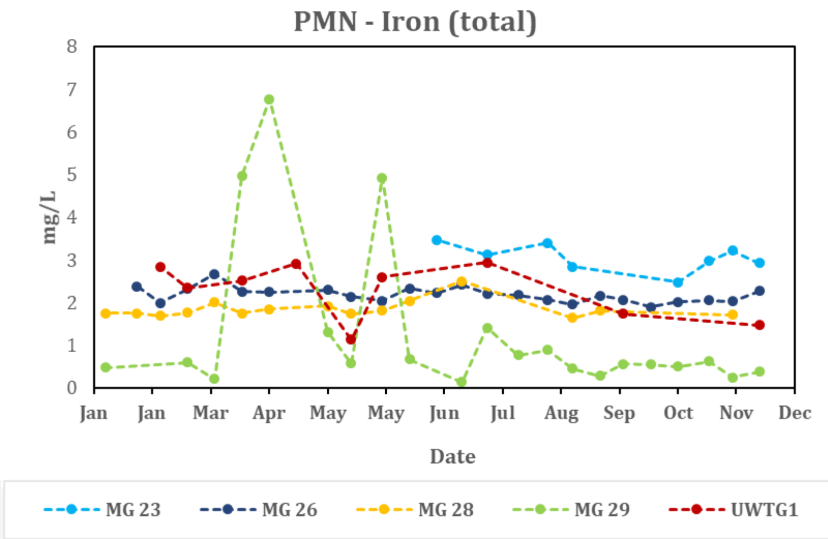
PMN - Alkalinity (total as $CaCO_3$)
400
350
300
250
200
150
100
50
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

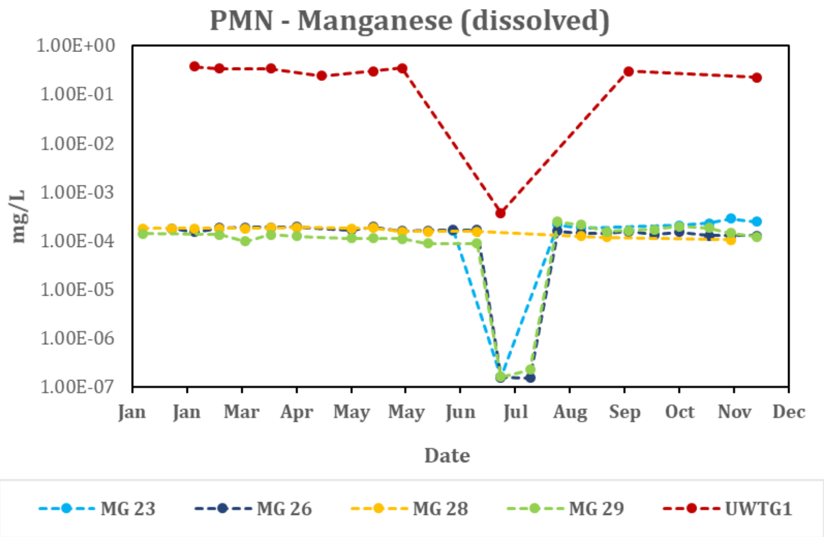
PMN - Sulphate
250
200
150
100
50
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

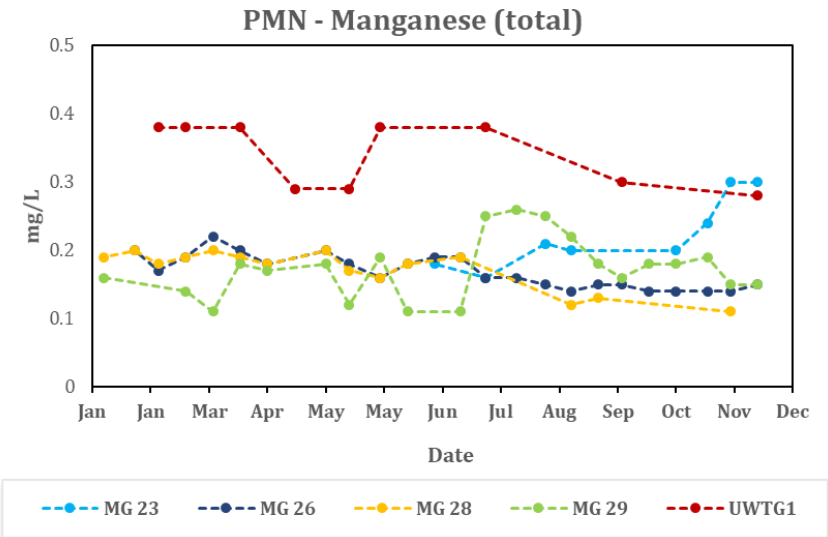



PMN - Iron (dissolved)
0.01
0.009
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

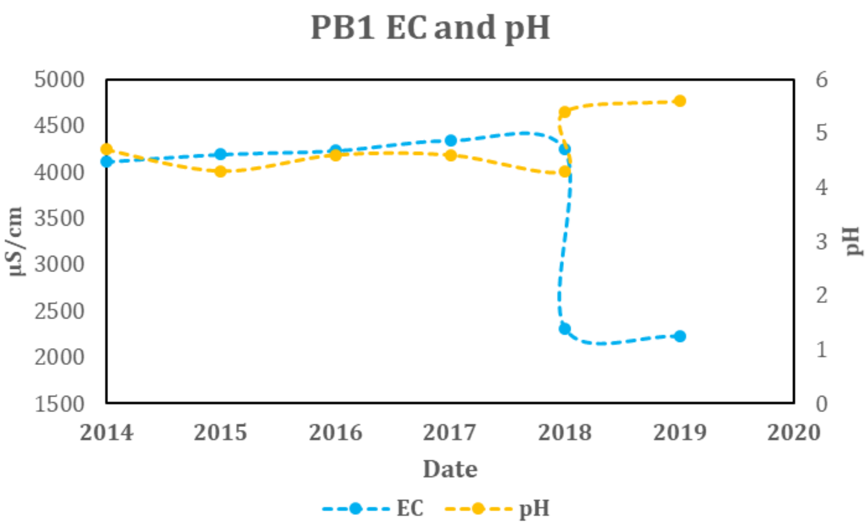



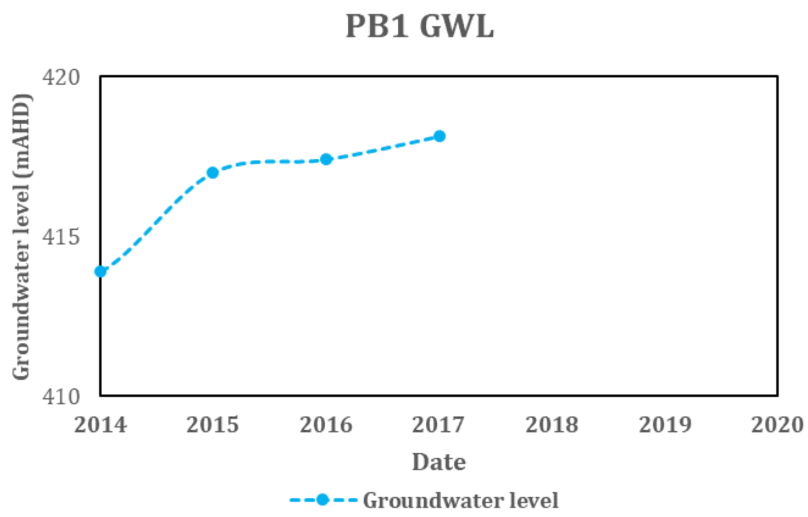
PMN - Iron (total)
8
7
6
5
4
3
2
1
0
mg/L
Jan
Jan
Mar
Apr
May
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

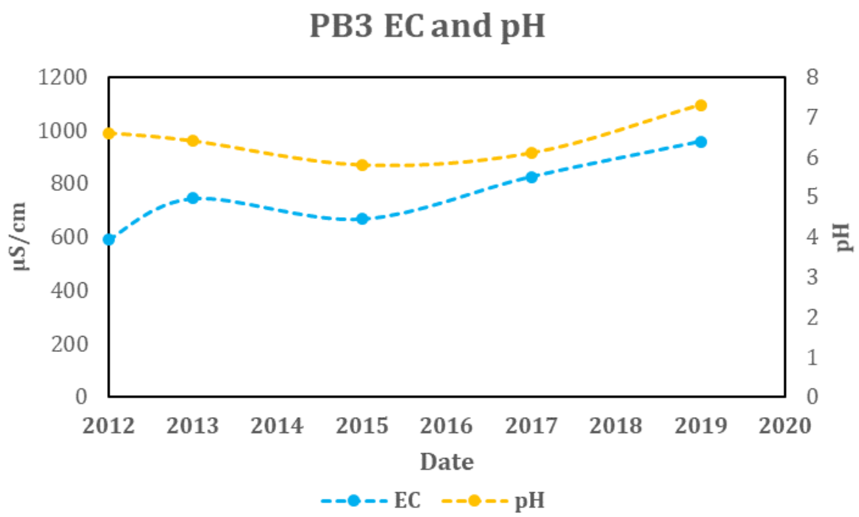

PMN - Manganese (dissolved)
mg/L
1.00E+00
1.00E-01
1.00E-02
1.00E-03
1.00E-04
1.00E-05
1.00E-06
1.00E-07
Jan Jan Mar Apr May May Jun Jul Aug Sep Oct Nov Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

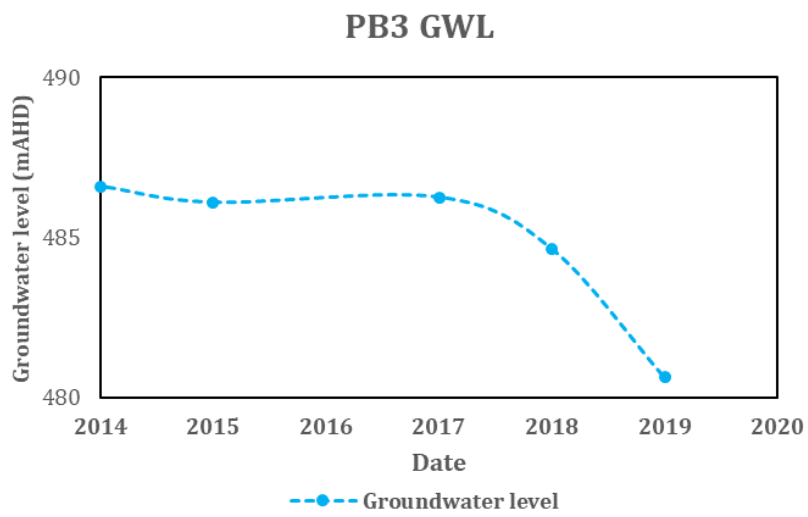

PMN - Manganese (total)
mg/L
0.5
0.4
0.3
0.2
0.1
0
Jan Jan Mar Apr May May Jun Jul Aug Sep Oct Nov Dec
Date
MG 23
MG 26
MG 28
MG 29
UWTG1

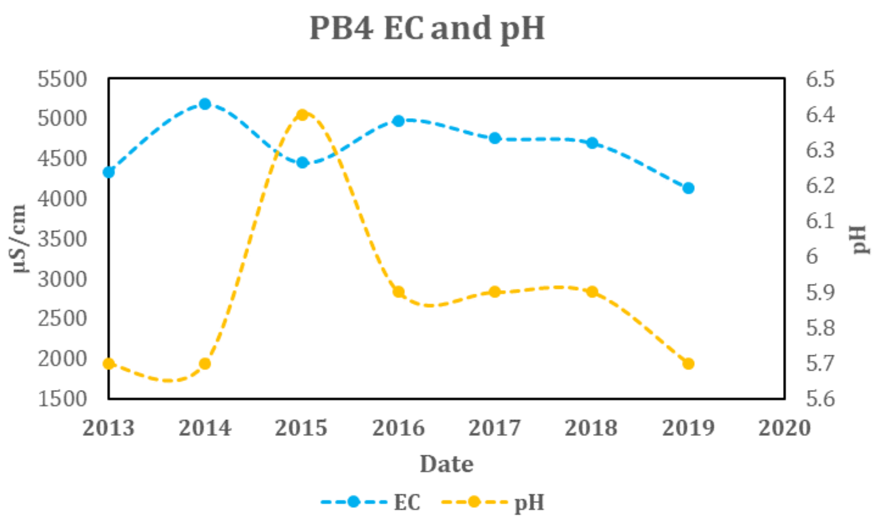
# *Appendix D* Private monitoring bores

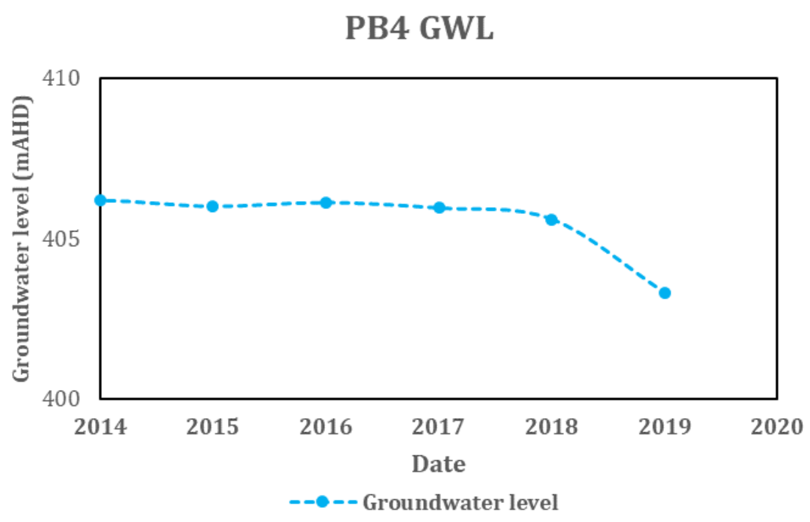

PB1 EC and pH
5000
4500
4000
3500
3000
2500
2000
1500
µS/cm
6
5
4
3
2
1
0
pH
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

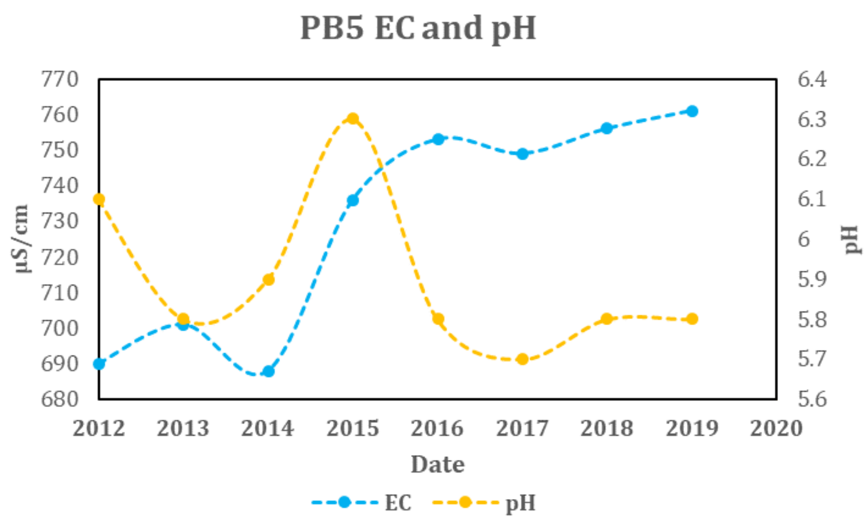

PB1 GWL
420
415
410
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

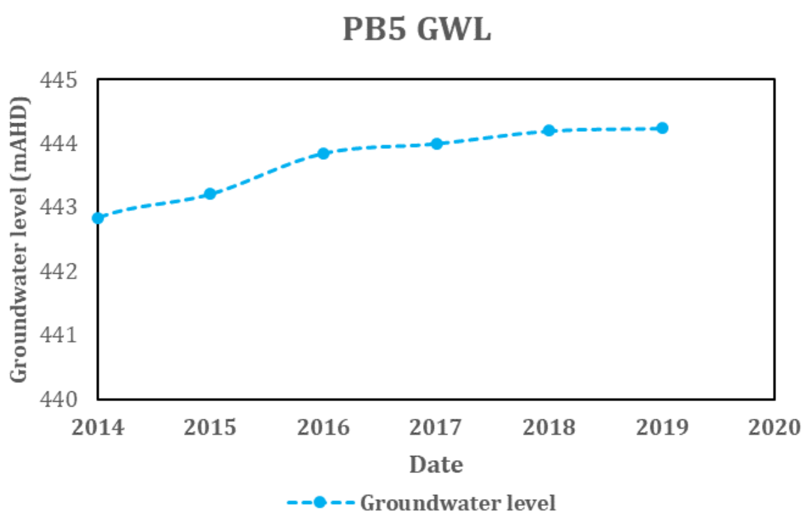

PB3 EC and pH
1200
1000
800
600
400
200
0
µS/cm
8
7
6
5
4
3
2
1
0
pH
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

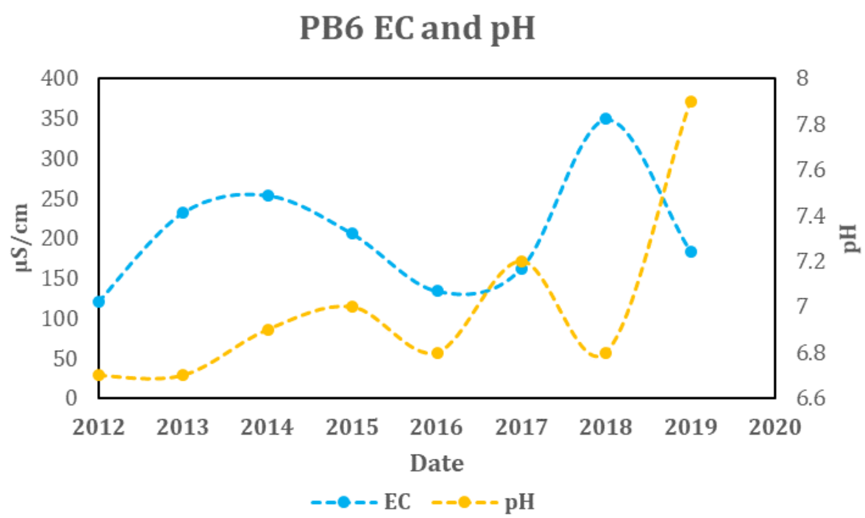

PB3 GWL
490
485
480
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

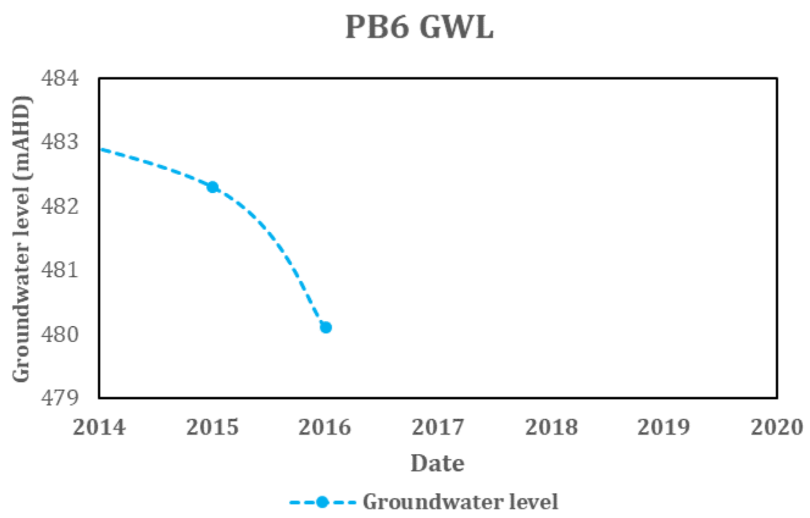

PB4 EC and pH
5500
5000
4500
4000
3500
3000
2500
2000
1500
µS/cm
6.5
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
pH
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

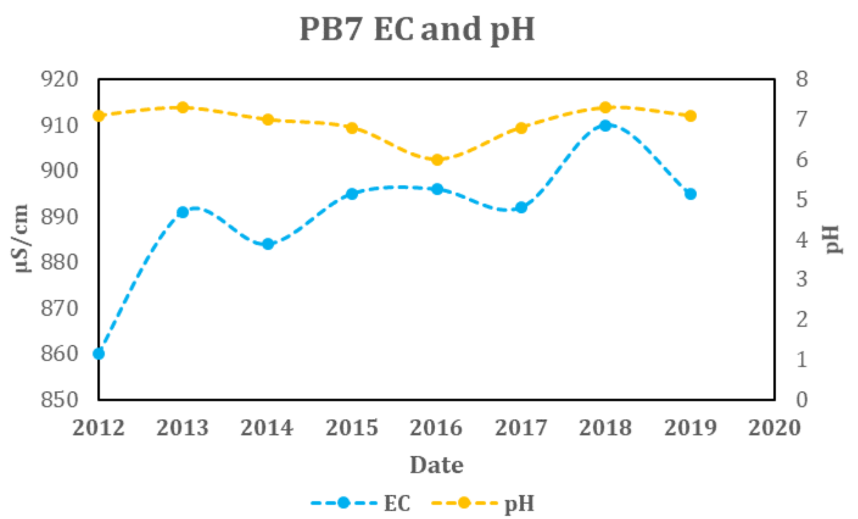

PB4 GWL
410
405
400
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

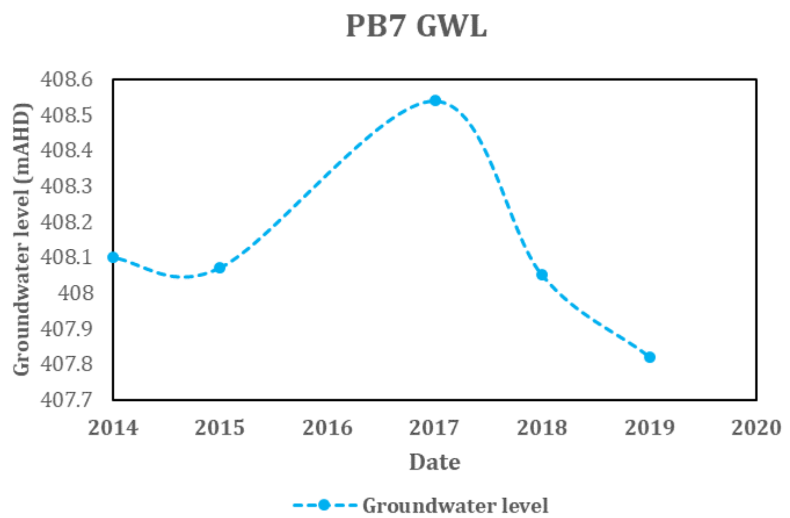

PB5 EC and pH
770
760
750
740
730
720
710
700
690
680
µS/cm
6.4
6.3
6.2
6.1
6
5.9
5.8
5.7
5.6
pH
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

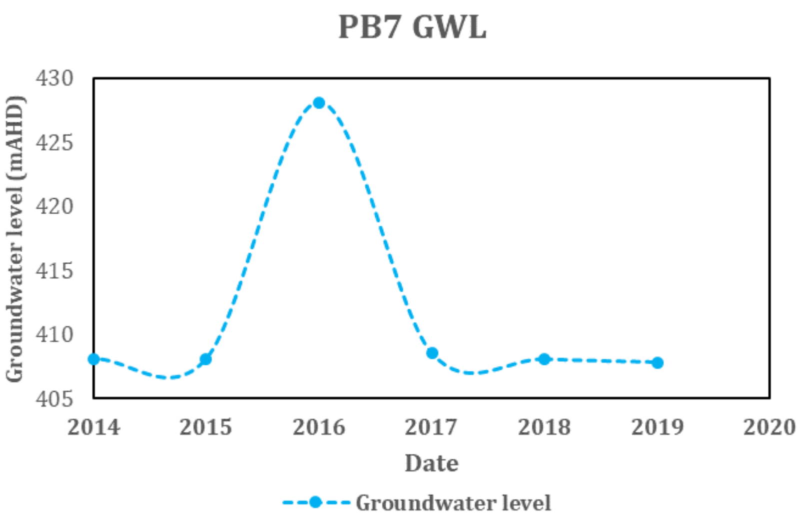

PB5 GWL
445
444
443
442
441
440
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

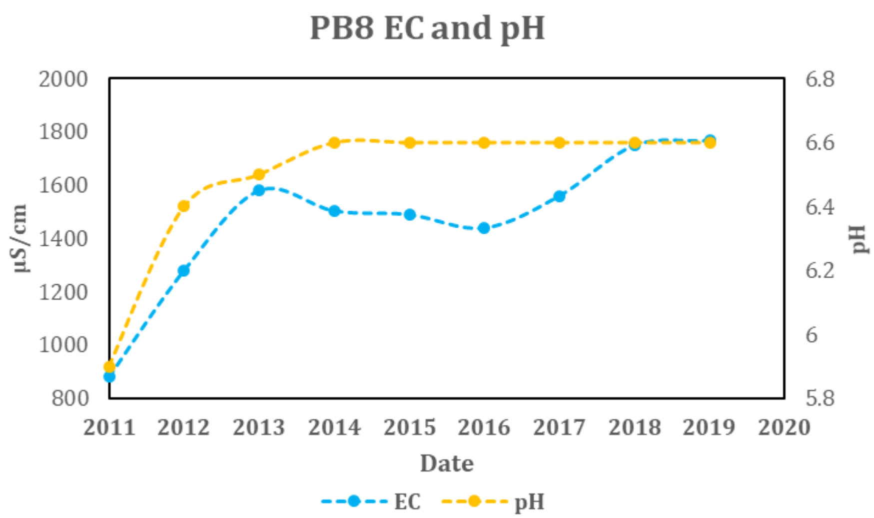

PB6 EC and pH
400
350
300
250
200
150
100
50
0
µS/cm
8
7.8
7.6
7.4
7.2
7
6.8
6.6
pH
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

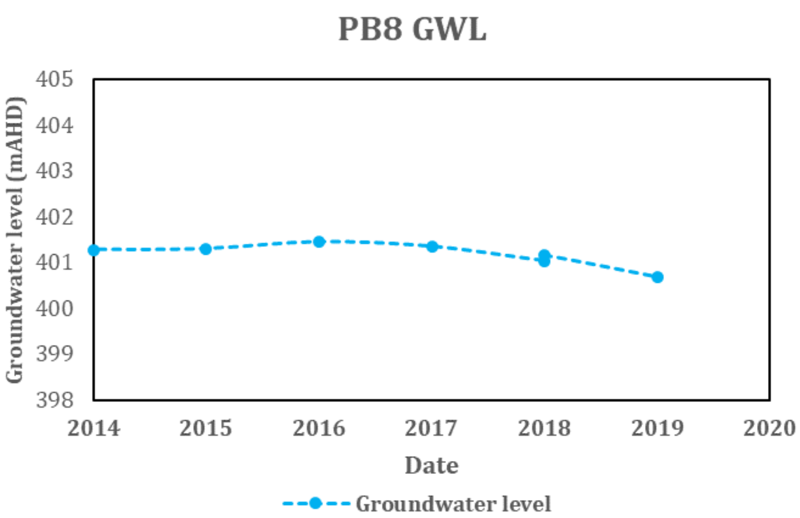

PB6 GWL
484
483
482
481
480
479
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

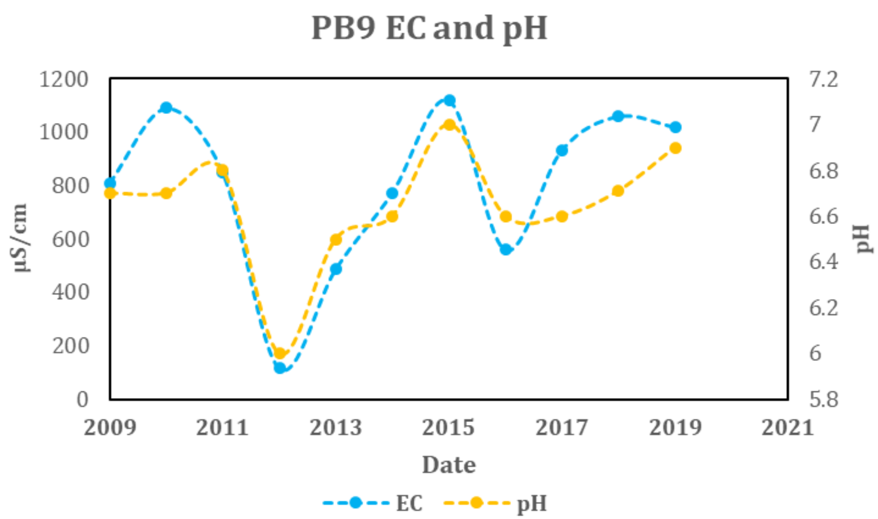

PB7 EC and pH
920
910
900
890
880
870
860
850
µS/cm
8
7
6
5
4
3
2
1
0
pH
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

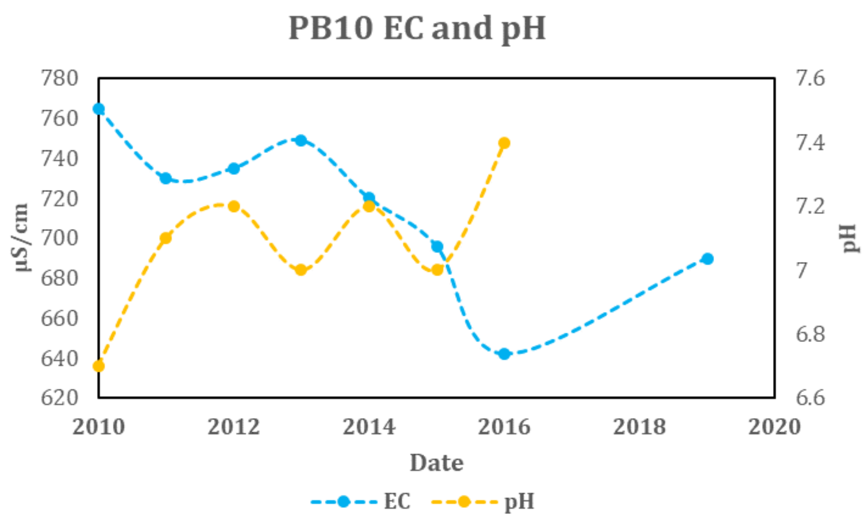

PB7 GWL
408.6
408.5
408.4
408.3
408.2
408.1
408
407.9
407.8
407.7
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

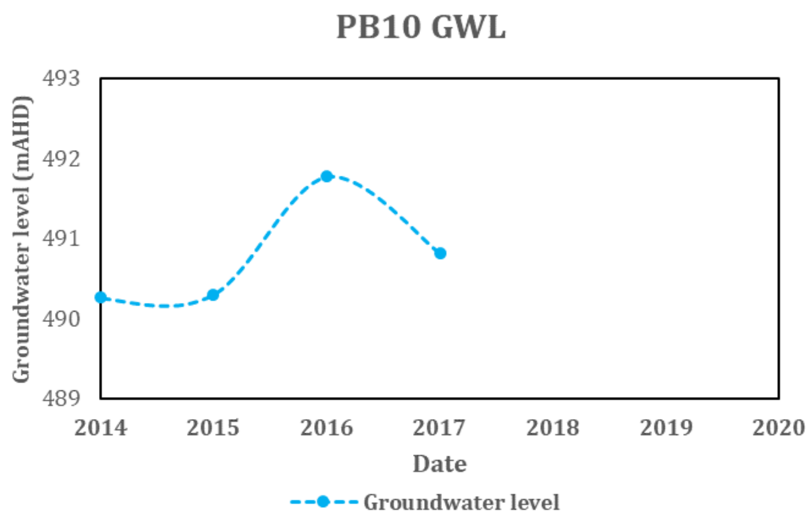

PB7 GWL
Groundwater level (mAHD)
430
425
420
415
410
405
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

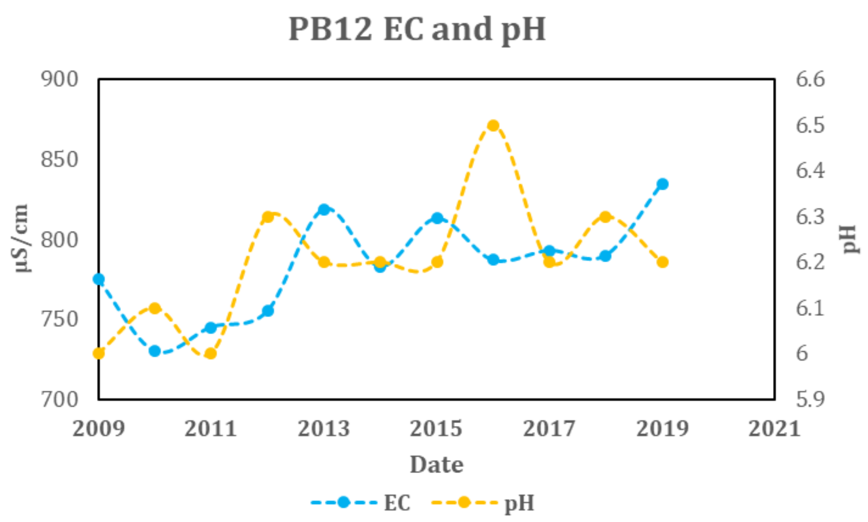

PB8 EC and pH
µS/cm
2000
1800
1600
1400
1200
1000
800
6.8
6.6
6.4
6.2
6
5.8
pH
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

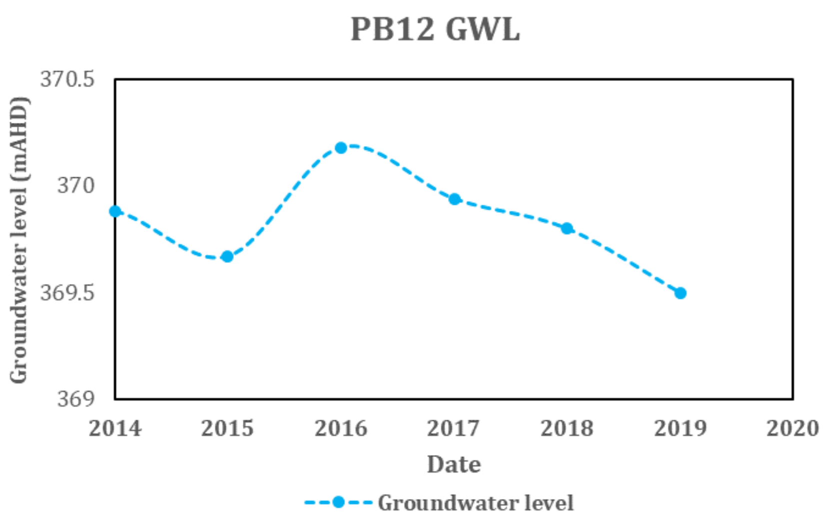

PB8 GWL
Groundwater level (mAHD)
405
404
403
402
401
400
399
398
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

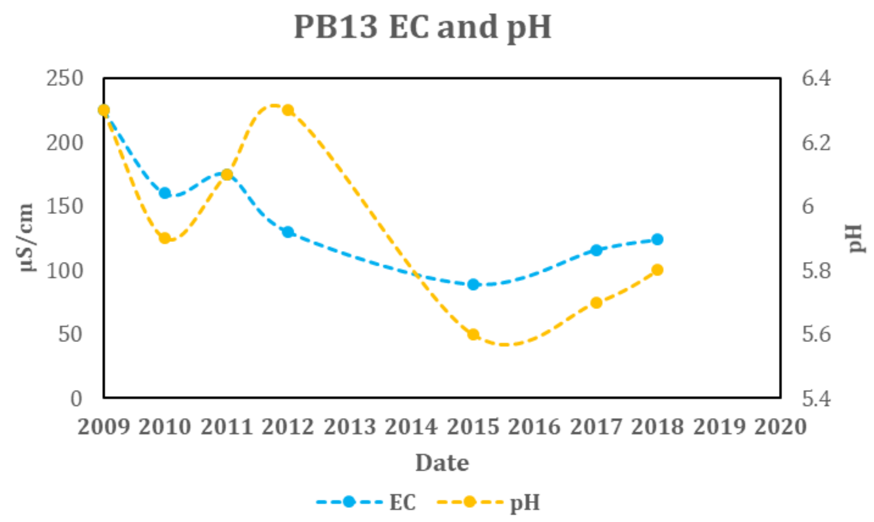

PB9 EC and pH
µS/cm
1200
1000
800
600
400
200
0
7.2
7
6.8
6.6
6.4
6.2
6
5.8
pH
2009
2011
2013
2015
2017
2019
2021
Date
EC
pH

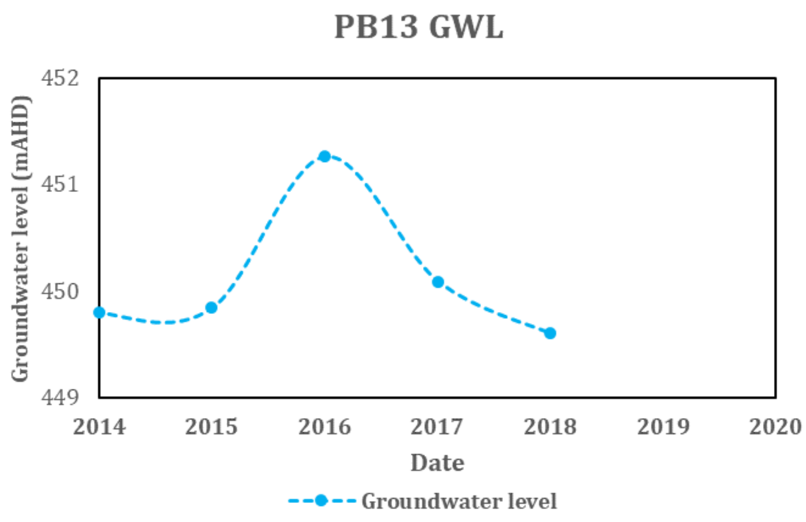

PB10 EC and pH
780
760
740
720
700
680
660
640
620
µS/cm
7.6
7.4
7.2
7
6.8
6.6
pH
2010
2012
2014
2016
2018
2020
Date
EC
pH

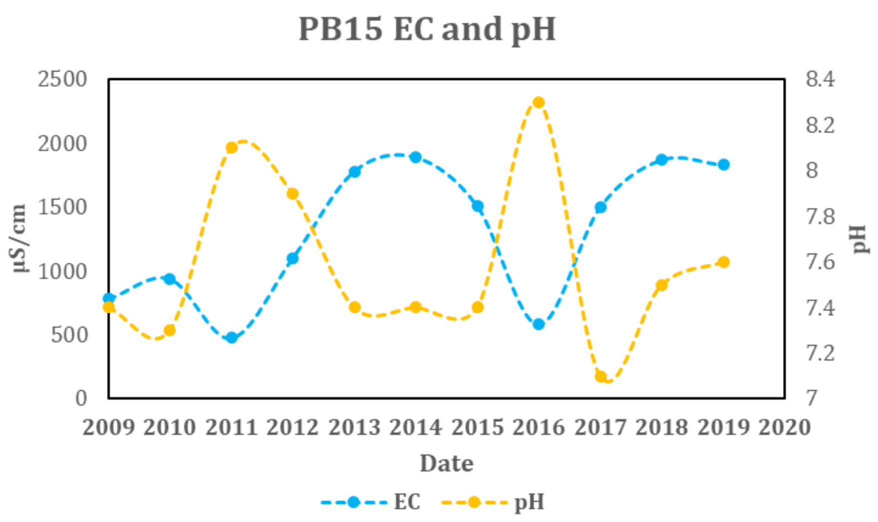

PB10 GWL
493
492
491
490
489
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

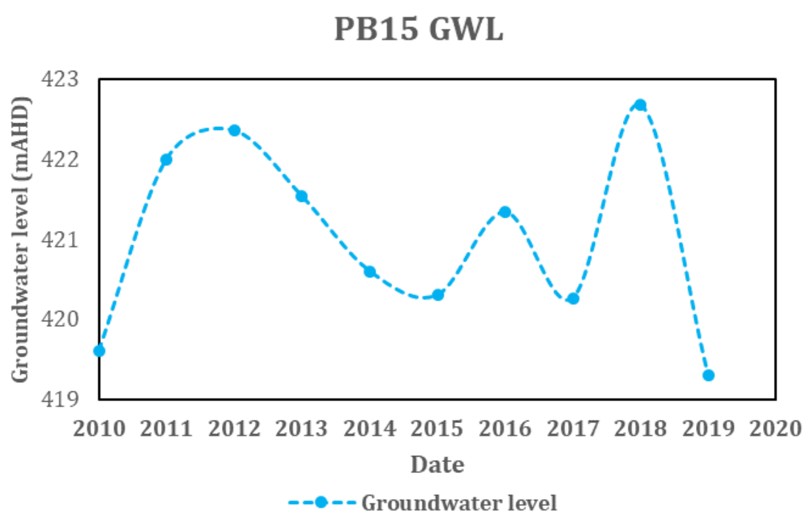

PB12 EC and pH
900
850
800
750
700
µS/cm
6.6
6.5
6.4
6.3
6.2
6.1
6
5.9
pH
2009
2011
2013
2015
2017
2019
2021
Date
EC
pH

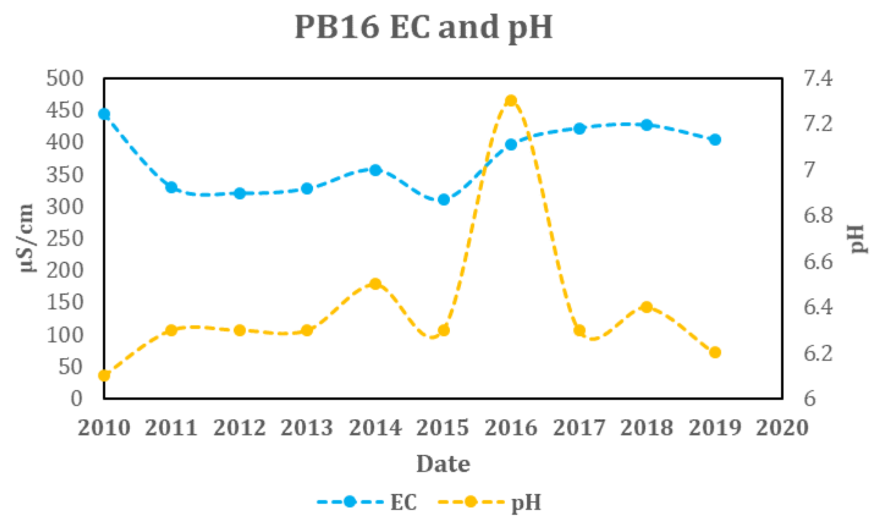

PB12 GWL
370.5
370
369.5
369
Groundwater level (mAHD)
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

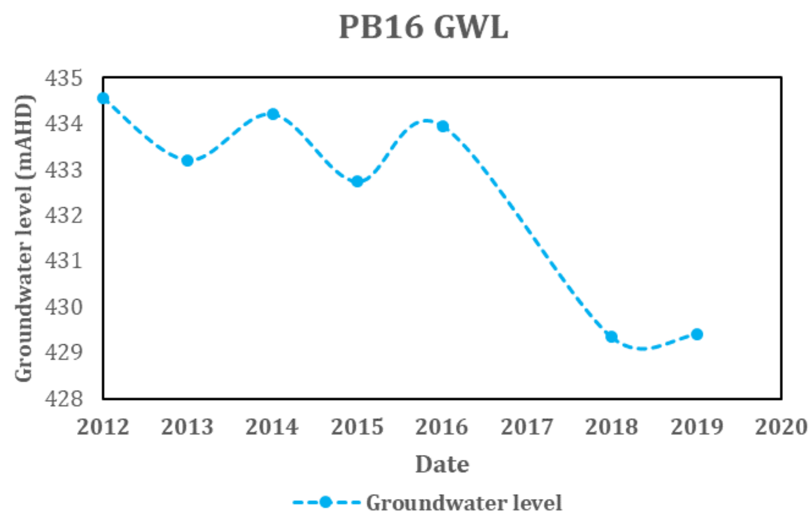

PB13 EC and pH
250
200
150
100
50
0
6.4
6.2
6
5.8
5.6
5.4
µS/cm
pH
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

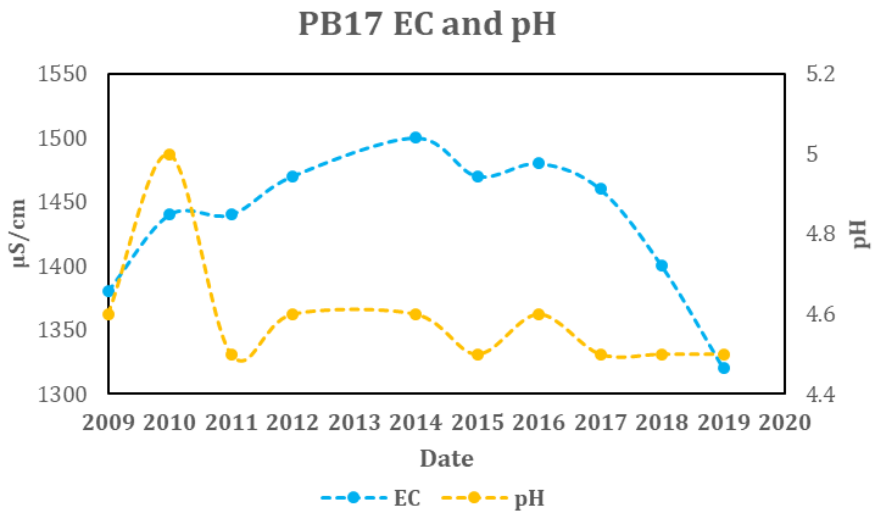

PB13 GWL
452
451
450
449
Groundwater level (mAHD)
2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

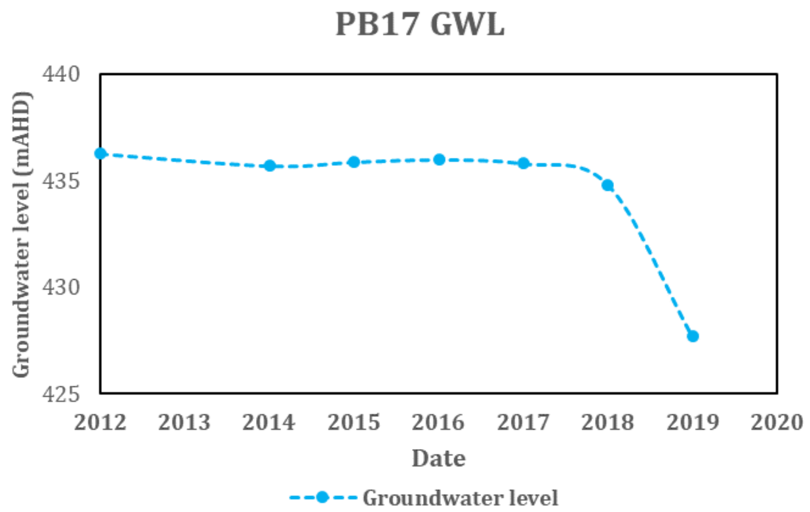

PB15 EC and pH
2500
2000
1500
1000
500
0
8.4
8.2
8
7.8
7.6
7.4
7.2
7
µS/cm
pH
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

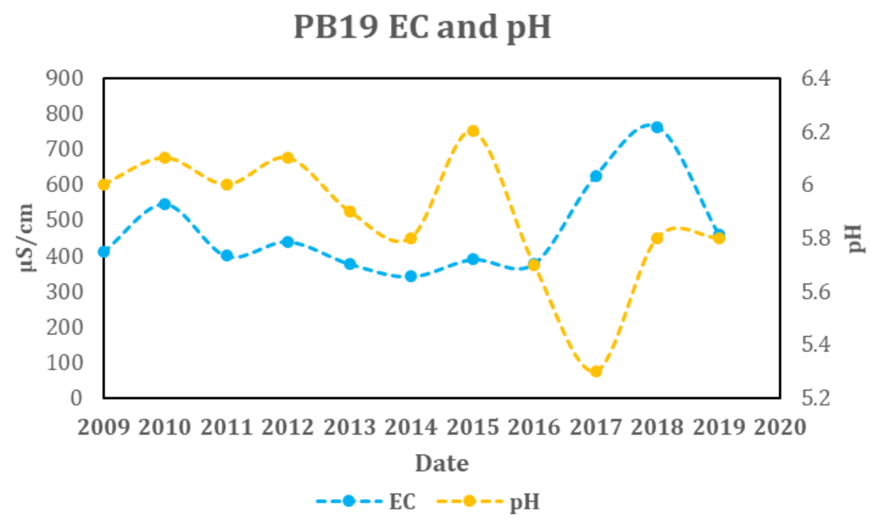

PB15 GWL
423
422
421
420
419
Groundwater level (mAHD)
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

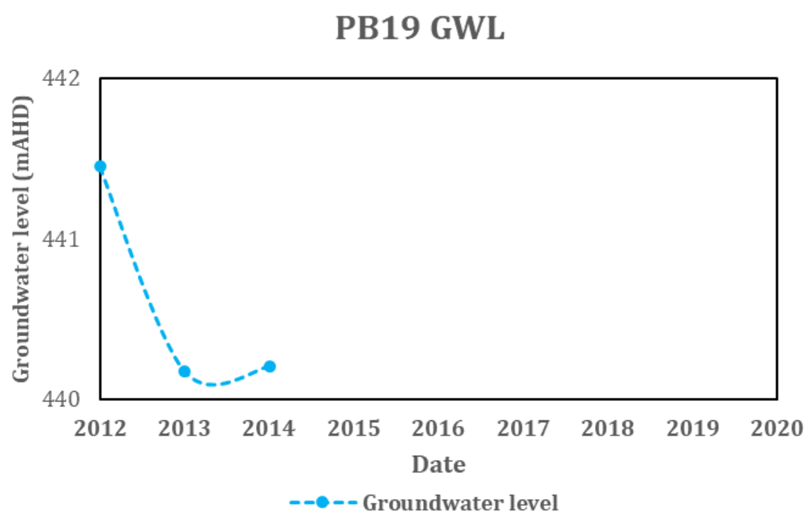

PB16 EC and pH
µS/cm
pH
Date
EC
pH

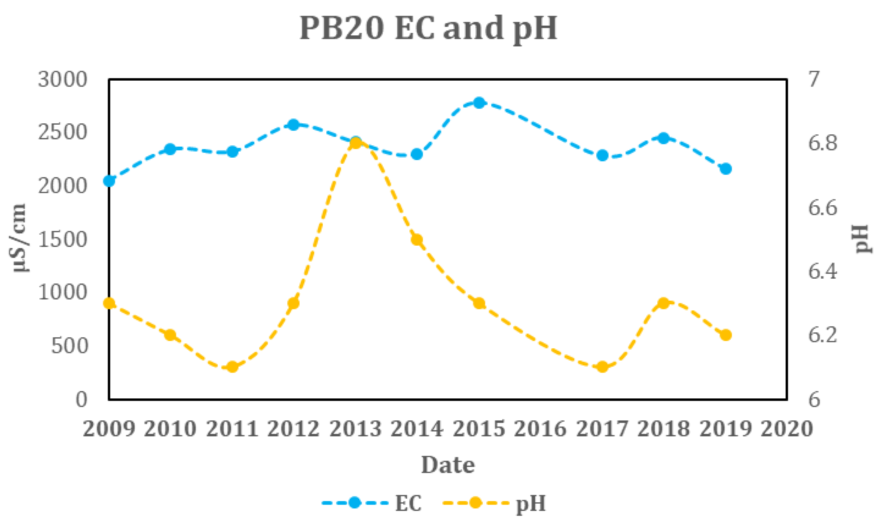

PB16 GWL
Groundwater level (mAHD)
Date
Groundwater level

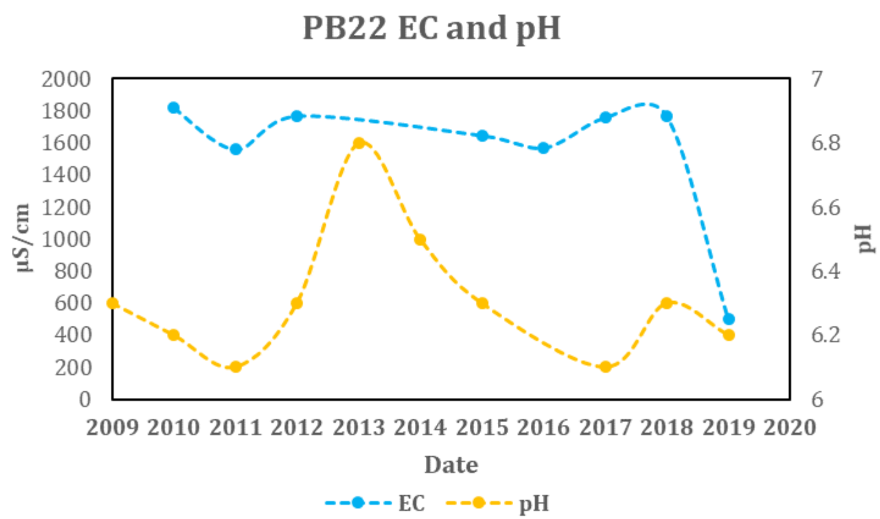

PB17 EC and pH
µS/cm
pH
Date
EC
pH

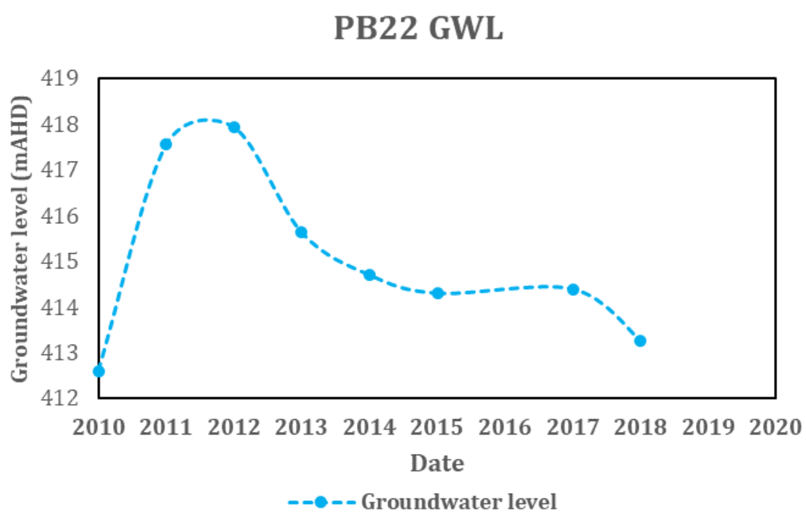

PB17 GWL
Groundwater level (mAHD)
Date
Groundwater level


PB19 EC and pH
900
800
700
600
500
400
300
200
100
0
µS/cm
6.4
6.2
6
5.8
5.6
5.4
5.2
pH
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

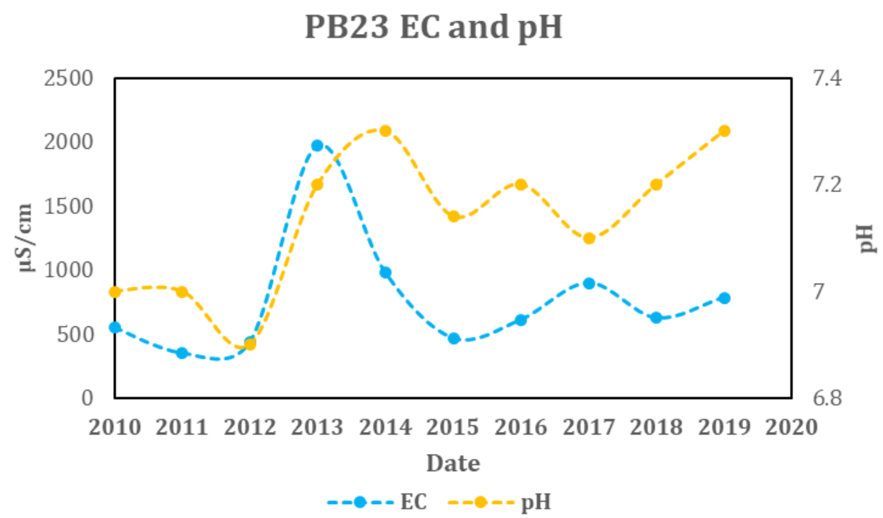

PB19 GWL
442
441
440
Groundwater level (mAHD)
2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level


PB20 EC and pH
3000
2500
2000
1500
1000
500
0
µS/cm
7
6.8
6.6
6.4
6.2
6
pH
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

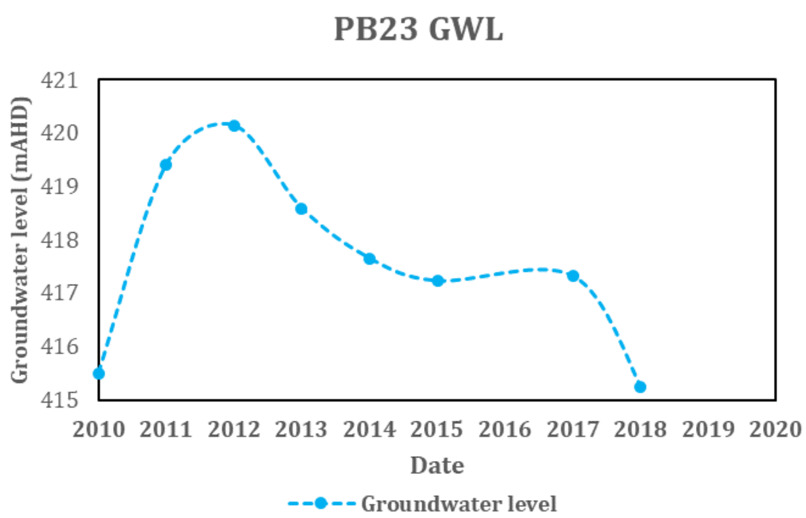

PB22 EC and pH
2000
1800
1600
1400
1200
1000
800
600
400
200
0
µS/cm
7
6.8
6.6
6.4
6.2
6
pH
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH



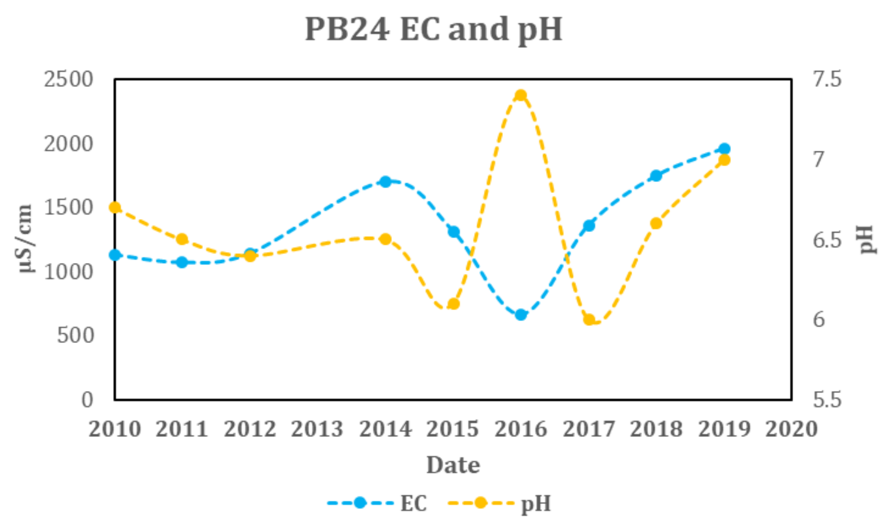
PB22 GWL
Groundwater level (mAHD)
419
418
417
416
415
414
413
412
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

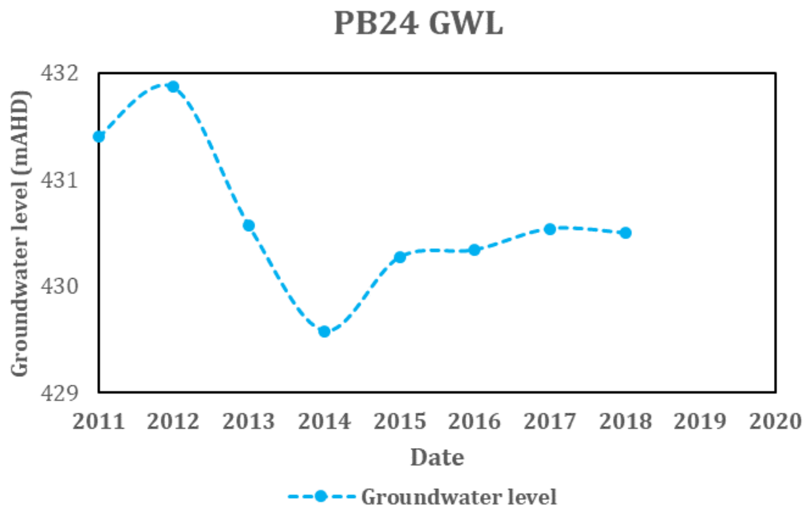
PB23 EC and pH
µS/cm
2500
2000
1500
1000
500
0
pH
7.4
7.2
7
6.8
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

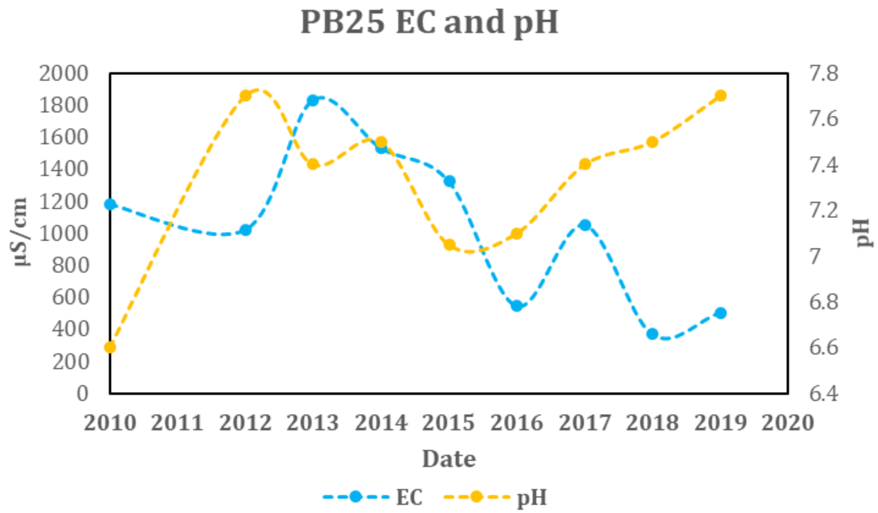



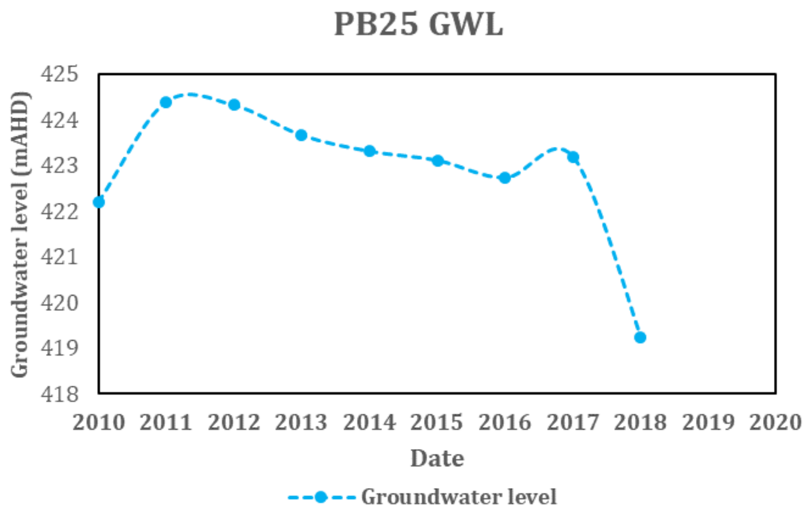
PB23 GWL
Groundwater level (mAHD)
421
420
419
418
417
416
415
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

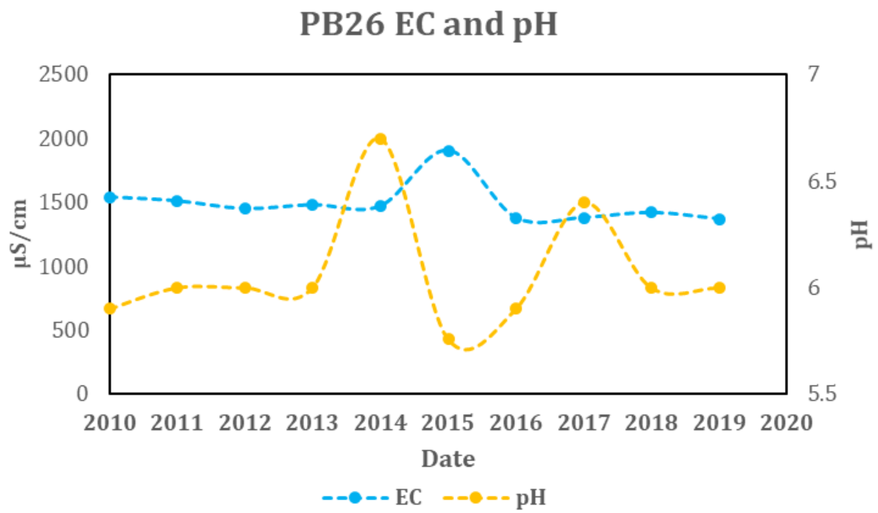



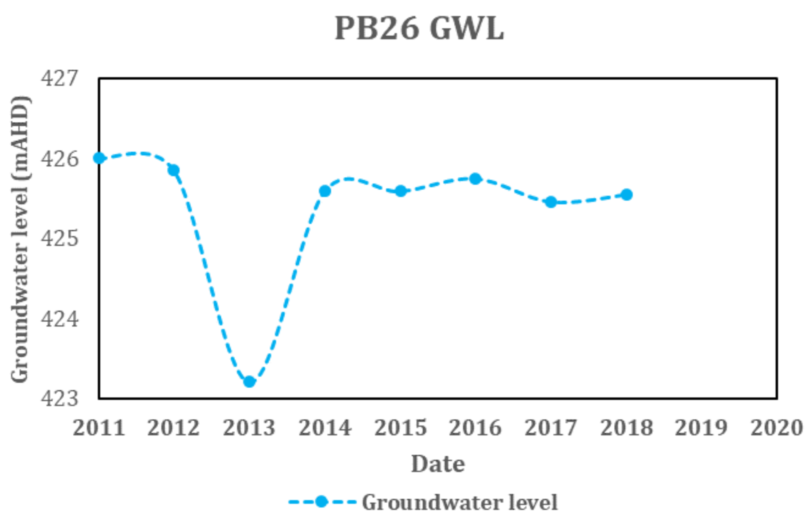
PB24 EC and pH
µS/cm
2500
2000
1500
1000
500
0
pH
7.5
7
6.5
6
5.5
2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

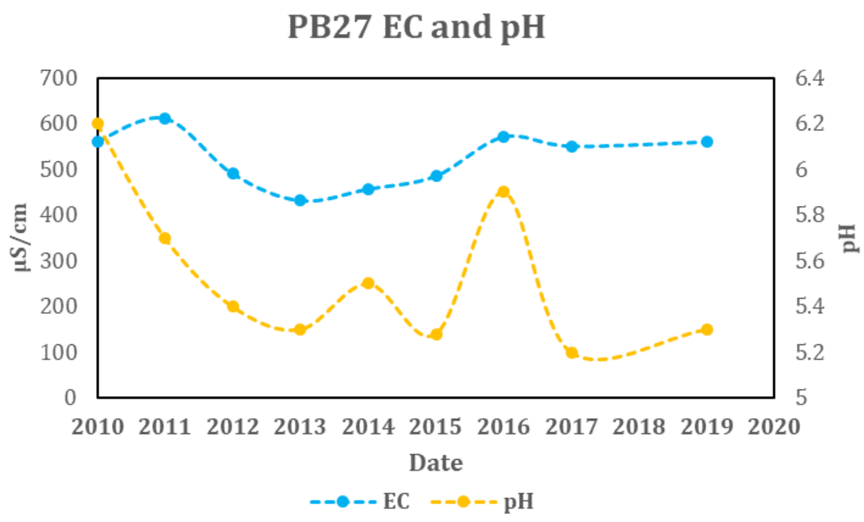

PB24 GWL
432
431
430
429
Groundwater level (mAHD)
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

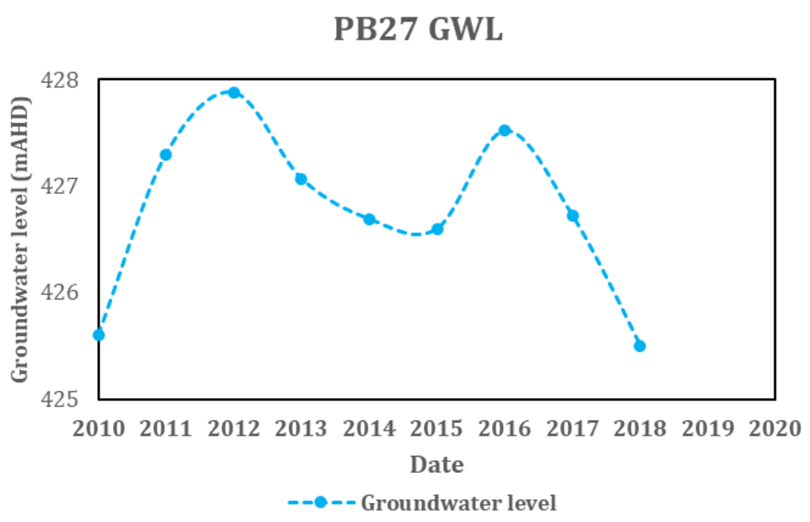

PB25 EC and pH
2000
1800
1600
1400
1200
1000
800
600
400
200
0
µS/cm
7.8
7.6
7.4
7.2
7
6.8
6.6
6.4
pH
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH

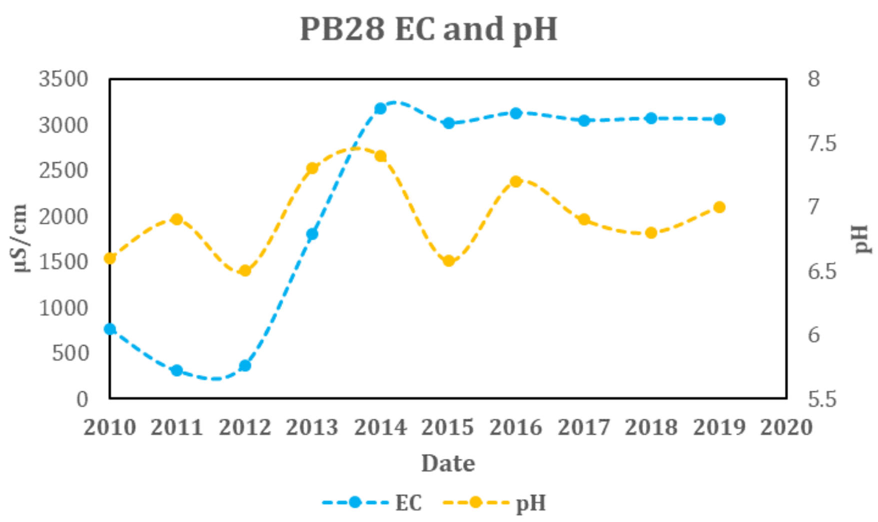

PB25 GWL
425
424
423
422
421
420
419
418
Groundwater level (mAHD)
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

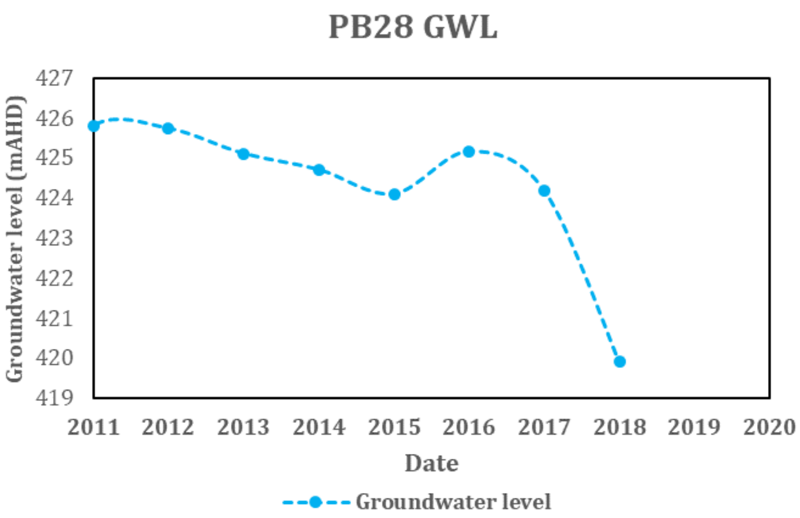

PB26 EC and pH
2500
2000
1500
1000
500
0
µS/cm
7
6.5
6
5.5
pH
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH


PB26 GWL
Groundwater level (mAHD)
427
426
425
424
423
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

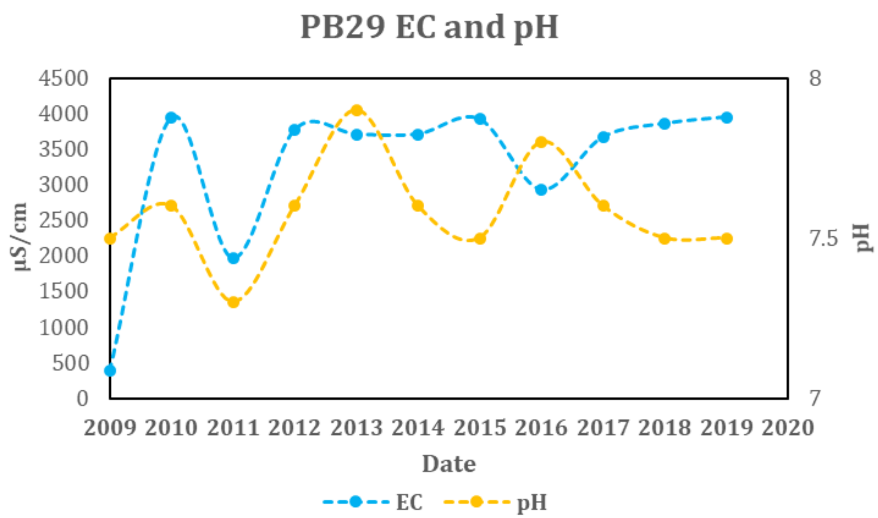

PB27 EC and pH
µS/cm
pH
700
600
500
400
300
200
100
0
6.4
6.2
6
5.8
5.6
5.4
5.2
5
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH


PB27 GWL
Groundwater level (mAHD)
428
427
426
425
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
Groundwater level

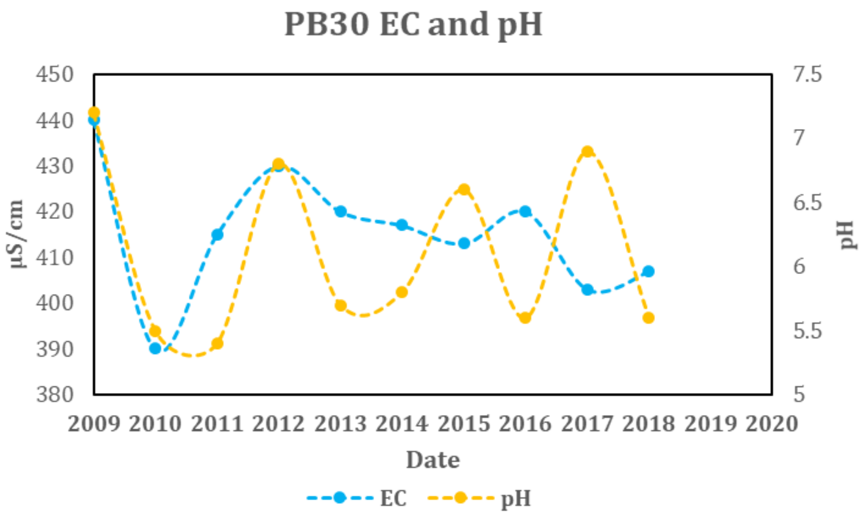

PB28 EC and pH
µS/cm
pH
3500
3000
2500
2000
1500
1000
500
0
8
7.5
7
6.5
6
5.5
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Date
EC
pH



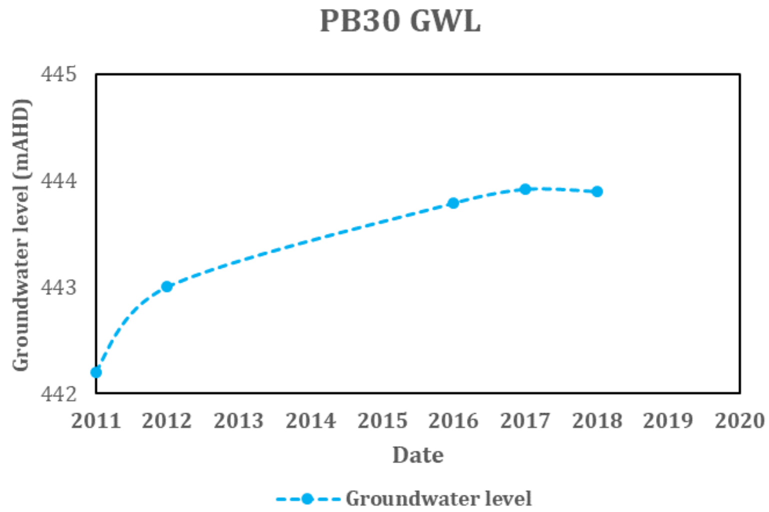
PB28 GWL
Groundwater level (mAHD)
427
426
425
424
423
422
421
420
419
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

PB29 EC and pH
µS/cm
4500
4000
3500
3000
2500
2000
1500
1000
500
0
pH
8
7.5
7
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

PB30 EC and pH
µS/cm
450
440
430
420
410
400
390
380
pH
7.5
7
6.5
6
5.5
5
2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
EC
pH

PB30 GWL
Groundwater level (mAHD)
445
444
443
442
2011 2012 2013 2014 2015 2016 2017 2018 2019 2020
Date
Groundwater level

# *Appendix E* Groundwater model (MOD4) level predictions v observed

| North monitoring network: Monitoring bores | 2019 Drawdown | |
|---|---|---|
| | Observed (m) | Modelled (m) |
| PZ01A | -0.2 | -0.11 |
| PZ04A | -0.3 | -0.11 |
| PZ06A | -1.3 | -3.22 |
| PZ06B | -1.2 | -3.21 |
| PZ06C | -0.1 | -0.04 |
| PZ07A | -0.9 | -0.66 |
| PZ07B | -0.5 | -0.69 |
| PZ07C | -0.8 | -1.43 |
| PZ08B | ND | -0.28 |
| PZ08C | -0.5 | -0.48 |
| PZ09A | -1.9 | -1.75 |
| PZ09B | -1.2 | -1.75 |
| PZ09C | -0.2 | -0.03 |
| PZ09D | 0.0 | -0.03 |
| PZ10A | -5.6 | -0.46 |
| PZ10B | 2.9 | -0.27 |
| PZ11A | -0.1 | -0.29 |
| PZ11B | -0.1 | -0.11 |
| PZ12A | ND | -0.01 |
| PZ12B | -0.5 | -0.01 |
| PZ12C | 0.0 | 0.00 |
| PZ13A | ND | -0.93 |
| PZ14A | -0.1 | ND |
| PZ14B | -0.1 | -0.06 |
| PZ14C | 0.0 | -0.05 |
| PZ24A | -1.6 | -0.67 |
| PZ24B | -0.1 | -0.03 |
| PZ25A | ND | -2.21 |
| PZ25B | ND | -2.17 |
| PZ26A | ND | -0.94 |
| PZ26B | ND | -0.94 |

| North monitoring network: Monitoring bores | 2019 Drawdown | |
|---|---|---|
| | Observed (m) | Modelled (m) |
| PZ28A | 0.1 | -0.13 |
| PZ28B | 0.0 | -0.10 |
| R752 | ND | -0.28 |
| R755A | -0.2 | -0.85 |

| North monitoring network: Vibrating wire piezometers | | 2019 Drawdown | |
|---|---|---|---|
| | | Observed (m) | Modelled (m) |
| DDH336 | Triassic (42m) | 2.0 | -0.1 |
| | Triassic (62m) | 7.0 | -0.1 |
| | Triassic (82m) | -7.0 | -0.1 |
| | Triassic (102m) | 6.0 | -4.8 |
| | Permian (122m) | -14.0 | -0.4 |
| | Permian (146m) | 4.0 | -1.6 |
| | Permian (167m) | -25.0 | -4.2 |
| | Permian (183m) | -11.0 | -6.4 |
| EX03 | Jurassic (28m) | 0.0 | ND |
| | Jurassic (48m) | 1.0 | ND |
| | Jurassic (90m) | 1.0 | ND |
| | Triassic (160m) | 0.0 | ND |
| | Triassic (201m) | -2.0 | ND |
| | Permian (242m) | 17.0 | ND |
| | Permian (297m) | 4.0 | ND |
| EX06 | Jurassic (9m) | -3.0 | -0.1 |
| | Base of Jurassic (28m) | -1.0 | -0.1 |
| | Triassic (56m) | 0.0 | -0.1 |
| | Triassic (71m) | -2.0 | -0.1 |
| | Triassic (95m) | -4.0 | -0.1 |
| | Base of triassic (121m) | -5.0 | -0.2 |
| | PCM (185m) | -6.0 | -2.9 |
| | Ulan Seam (227m) | 1.0 | -2.9 |
| EX09 | Jurassic (33m) | -1.0 | ND |
| | Jurassic (50m) | -1.0 | ND |
| | Jurassic (87m) | 4.0 | ND |
| | Triassic (126m) | 0.0 | ND |
| | Triassic (209m) | -1.0 | ND |
| | Triassic (261m) | ND | ND |
| | Triassic (301m) | ND | ND |
| PZ29 | Jurassic (18m) | 0.0 | 0.0 |

| North monitoring network: Vibrating wire piezometers | | 2019 Drawdown | |
|---|---|---|---|
| | | Observed (m) | Modelled (m) |
| | Triassic (50m) | 0.0 | 0.0 |
| | Triassic (72m) | -1.0 | ND |
| | Triassic (90m) | 0.0 | ND |
| | Triassic (122m) | 1.0 | 0.0 |
| | Goulburn Seam (143m) | -3.0 | -0.3 |
| | Interburden (183m) | 0.0 | -0.6 |
| | Ulan Seam (243m) | -2.0 | -0.7 |
| TAL-1 | Triassic (28m) | -0.3 | 0.0 |
| | Triassic (45m) | -0.3 | 0.0 |
| | Permian (61m) | -0.8 | -2.3 |
| | Permian (97m) | 2.4 | -2.3 |
| | Ulan Seam (140m) | -0.8 | -2.3 |
| TAL-2 | Permian (50m) | -0.2 | -0.9 |
| | Permian (90m) | -0.4 | -0.6 |
| | Permian (110m) | -0.3 | -0.6 |
| | Ulan Seam (128m) | -0.2 | -0.9 |
| UW1 | Permian (22m) | 0.7 | -0.1 |
| | Permian (35m) | 1.3 | -0.5 |
| | Permian (51m) | -0.6 | -0.5 |
| | Ulan Seam (67m) | 0.3 | 0.0 |
| UW2 | Triassic (60m) | -1.0 | -0.3 |
| | Permian (90m) | -1.0 | -0.3 |
| | Ulan Seam (120m) | 7.0 | 0.0 |
| UW3 | Permian (40m) | -0.1 | -0.8 |
| | Permian (60m) | -0.5 | -0.8 |
| | Permian (75m) | 4.1 | -0.3 |
| | Ulan Seam (98m) | 0.6 | -0.8 |
| UW4 | Permian (41m) | -0.1 | -0.9 |
| | Permian (63m) | 0.0 | -0.9 |
| | Permian (87m) | 0.1 | -0.9 |
| | Ulan Seam (122m) | 0.0 | -0.9 |

| Private bore monitoring network | 2019 Drawdown | |
|---|---|---|
| | Observed (m) | Modelled (m) |
| PB1 | ND | -0.02 |
| PB3 | -4.01 | -0.14 |
| PB4 | -2.30 | -0.02 |
| PB31 | ND | -0.12 |
| PB5 | 0.04 | -0.12 |
| PB7 | -0.23 | 0.00 |
| PB6 | ND | -0.04 |
| PB8 | -0.36 | -0.28 |
| PB9 | ND | -0.14 |
| PB10 | ND | -0.11 |
| PB11 | ND | -0.06 |
| PB12 | -0.30 | 0.00 |
| PB13 | ND | 0.00 |
| PB14 | -2.00 | -0.13 |
| PB15 | -3.38 | -0.03 |
| PB16 | 0.05 | -0.23 |
| PB17 | -7.12 | -0.13 |
| PB18 | -0.40 | -0.37 |
| PB19 | ND | -0.06 |
| PB20 | ND | -0.01 |
| PB21 | -2.05 | -0.02 |
| PB22 | ND | -0.02 |
| PB23 | ND | -0.03 |
| PB24 | ND | -0.05 |
| PB25 | ND | 0.00 |
| PB26 | ND | -0.07 |
| PB27 | ND | -0.06 |
| PB28 | ND | 0.00 |
| PB29 | ND | 0.00 |

| Private bore monitoring network | 2019 Drawdown | |
|---|---|---|
| | Observed (m) | Modelled (m) |
| PB30 | ND | -0.15 |
| PB32 | ND | -0.16 |
| PB33 | 0 | ND |
| PB34 | ND | ND |
| PB35 | ND | ND |
| PB36 | ND | ND |
| PB37 | ND | ND |
| PB38 | ND | ND |
| PB39 | ND | ND |
| PB40 | -5.17 | ND |

| Bobadeen monitoring network | 2019 Drawdown | |
|---|---|---|
| | Observed | Modelled |
| IMW01 | Dry | -0.04 |
| IMW02 | Dry | -0.05 |
| IMW03 | Dry | -0.03 |
| IMW04 | Dry | -0.04 |
| IMW05 | Dry | -0.95 |
| IMW06 | Dry | -4.50 |
| IMW07 | Dry | -7.74 |
| IMW08 | Dry | -1.23 |
| IMW09 | Dry | -0.37 |

# APPENDIX 3

# UCML Aquatic Monitoring Report 2019

## Ulan Coal Mines Limited

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## DOCUMENT TRACKING

| | |
|---|---|
| **Project Name** | UCML Aquatic Monitoring Report 2019 |
| **Project Number** | MUD19-12985 |
| **Project Manager** | Tom Kelly |
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| **Approved by** | Dr Andrew Butler |
| **Status** | **Final** |
| **Version Number** | **v5** |
| **Last saved on** | **30 March 2020** |

This report should be cited as 'Eco Logical Australia 2020. *UCML Aquatic Monitoring Report 2019*. Prepared for Ulan Coal Mines Limited.'

### ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Ulan Coal Mines Limited.

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# Abbreviations

| Abbreviation | Description |
|---|---|
| ANZECC | Australian and New Zealand Environment and Conservation Council |
| ARMCANZ | Agriculture and Resource Management Council of Australia and New Zealand |
| AUSRIVAS | Australian River Assessment System |
| BMP | Biodiversity Management Plan |
| DoEE | Department of Environment and Energy |
| DO | Dissolved oxygen |
| DP&E | Department of Planning and Environment |
| EC | Electrical conductivity |
| ELA | Eco Logical Australia |
| GCAA | Glencore Coal Assets Australia |
| LDP | Licensed Discharge Point |
| LGA | Local Government Area |
| MWRC | Mid Western Regional Council |
| PA | Project Approval |
| RCE | Riparian, Channel and Environment |
| SIGNAL | Stream Invertebrate Grade Number Average Level |
| UCC | Ulan Coal Complex |
| UCML | Ulan Coal Mines Limited |

# Executive Summary

This Aquatic Monitoring Report was prepared by Eco Logical Australia (ELA) on behalf of Ulan Coal Mines Limited (UCML). The Ulan Coal Complex (UCC) is situated in the central west of New South Wales near the village of Ulan, approximately 38 kilometres north-northeast of Mudgee. UCML operates the mine managed by Glencore Coal Assets Australia (GCAA).

In 2010, the NSW Department of Planning and Environment (DP&E) issued Project Approval (PA 08_0184) for continued operations of Ulan Coal Mine. As a requirement of this approval, UCML developed a Biodiversity Management Plan (BMP) which outlines the management, monitoring and reporting activities needed to satisfy approval specifications.

This report outlines results from surveys conducted in spring 2019 and makes comparisons to data from previous reports complied by the Biodiversity Monitoring Services (2012; 2013a; 2013b; 2014 and 2015) and ELA (2017; 2018; 2019).

The 2019 monitoring event occurred during prolonged drought conditions. Therefore, only nine of fourteen sites had enough water for the full suite of ecological samples to be collected. Due to the low rainfall in the lead up to sampling, flow at most sites was dominated by discharged mine water.

Aquatic macroinvertebrate taxonomic richness recorded in 2019 ranged from 12 to 17 taxa identified at sites upstream of UCC discharge locations and 14 to 20 taxa identified at downstream sites. SIGNAL2 scores ranged from 3.29 to 3.60 at upstream sites and 3.00 to 4.41 at downstream sites. These results indicate that aquatic macroinvertebrate communities apparently correlate to water flow and riparian condition, and both measures are reflective of disturbed systems, consistent with historical regional land-use practices. It is this historical disturbance, in conjunction with climatic conditions, which remain the key factors influencing macroinvertebrate communities. The presence of mine discharge water in the streams has allowed aquatic macroinvertebrate communities to persist in the landscape despite the drought.

The 2019 Riparian Channel and Environmental (RCE) Inventory scores were consistent with previous years for each site. Eleven (11) sites were classified as ‘Good’, whilst the three (3) remaining sites ranked as ‘Excellent’. Sites located in the Goulburn River Diversion have increased RCE scores since 2016 when remediation works commenced. Notable differences in RCE scores recorded in 2019, compared to previous years relate to variables affected by prolonged drought conditions, such as reduced water levels and macrophyte cover. Overall, the RCE results indicate that the riparian environment is not subject to any ongoing adverse effects resulting from mining operations and are rather, reflective of historical regional land use practices in the catchment.

Alkalinity and pH results were consistent with previous years. Turbidity was highest at sites upstream of UCC licenced discharge points (LDPs). Prolonged drought conditions led to isolated, stagnant pools at some sampling locations, which is considered to have influenced the turbidity results.. Consistent with previous years, electrical conductivity (EC) was elevated both upstream and downstream of UCCLDP19, indicative of naturally saline groundwater in the catchment. Dissolved oxygen (DO) concentration (% saturation) was lower than ANZECC and ARMCANZ (2000) guidelines at all sites excluding AQ2. Results from upstream and downstream sites and across multiple years indicate high

variability in DO concentrations. Installation of DO loggers upstream and downstream of the UCC operations would provide additional data to better understand how DO concentrations fluctuate in the local catchment.

# 1. Introduction

## 1.1 Ulan Coal Mine

The Ulan Coal Complex (UCC) is situated in the central west of New South Wales. It is located in the Mid-Western Regional Council (MWRC) Local Government Area (LGA) near the village of Ulan; approximately 38 kilometres north-northeast of Mudgee and 19 kilometres northeast of Gulgong. Ulan Coal Mines Limited (UCML) is managed by Glencore Coal Assets Australia (GCAA).

UCML owns or has long term leases over most of the land that is subject to mining activities and required for surface infrastructure. The area is primarily surrounded by rural landholdings, native vegetation and primary industries including agriculture, forestry, and mining (including other coal mining operations). The UCC straddles the Great Dividing Range and as such, is located in the upper catchments of both the Goulburn River and Talbragar River.

Project Approval (PA 08_0184) was issued by the NSW Department of Planning and Environment (DP&E), on 15 November 2010 for continued operations. PA 08_0184 authorises current and proposed mining of the Ulan Mine Complex for the next 14 years, and production of up to 20 Mtpa (million tonnes per annum) of product coal.

## 1.2 Biodiversity Management Plan

UCML developed a BMP to fulfil the requirements of Condition 44, Schedule 3 of PA 08_0184 and to satisfy the requirements of the Commonwealth Department of the Environment and Energy (DoEE) Approval (EPBC Ref: 2009/5252 and 2015/7511).

The purpose of the BMP is to describe the ecological management strategies, procedures, controls and monitoring programs and associated reporting that are to be implemented for the management of flora and fauna within the Project Area. The BMP represents the framework for the overall biodiversity management structure.

As part of the BMP, an aquatic ecology monitoring program was developed to assess the performance of biodiversity management measures and determine the ecological condition of creeks on-site. During spring 2019, aquatic ecology monitoring was undertaken at 14 sites along five creeks (Mona, Cockabutta, Bobadeen, Sportsmans Hollow and Ulan Creeks) and two rivers (Talbragar and Goulburn Rivers) in the Project Area.

This report provides details of the aquatic taxa and riparian environment present in the Project Area and will be used to suggest improvements to management actions across the Project Area in relation to management of aquatic ecology.

# 2. Methodology

## 2.1 Field Survey

Aquatic monitoring surveys were undertaken by ELA ecologists Dr Peter Hancock, Tom Kelly and Rebecca Croake from 13 to 15 November 2019. Weather during the monitoring was mostly fine and sunny, with maximum daytime temperatures ranging from 8.2°C to 27.0°C. No rainfall occurred during the survey period. Spring 2019 surveys were undertaken during a period of prolonged drought conditions characterised by well-below average rainfall (**Figure 1**; BOM 2019).

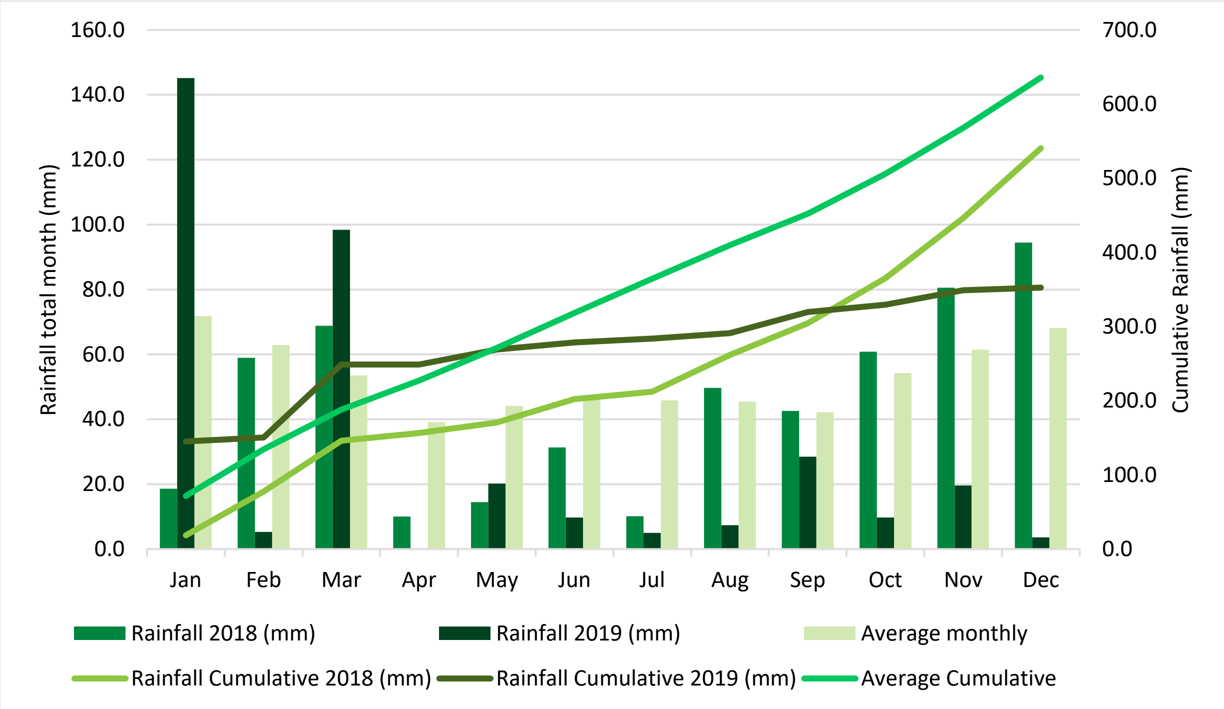


**Figure 1: Monthly and cumulative rainfall totals for 2018, 2019 and long-term average dating back to 1906 (UCML 2019; BOM 2019)**

### 2.1.1 Survey Sites

The UCC is situated in the upper reaches of the Goulburn River, which is part of the Hunter River catchment and drains eastward from the Great Dividing Range towards the coast. It is also part of the Talbragar River catchment, which drains west into the Murray-Darling Basin.

Fourteen (14) sites were sampled in spring 2019 (**Figure 2**). The aquatic habitat and riparian condition of all sites was assessed, whilst macroinvertebrate and water quality samples were collected at only nine of the sites with standing water. Three sites are located at the head of the Talbragar River catchment (AQ12, AQ15 and AQ22) and the remaining eleven sites on three creeks in the Goulburn River catchment and the Goulburn River itself.

A brief description of the sites monitored in 2019 is given in **Table 1** and their locations are shown in **Figure 2**.

**Table 1: Aquatic monitoring sites surveyed in spring 2019**

| Site | Easting | Northing | Watercourse | General Description | Year monitoring commenced |
|---|---|---|---|---|---|
| AQ2 | 761058 | 6428704 | Goulburn River | Beside Ulan Coal Mine in a channelised section of river. Site is adjacent to the mine operations. | 2003 |
| AQ5 | 760300 | 6429716 | Ulan Creek | Ulan Creek behind Rowan's Dam. Site is downstream of mine discharge point. | 2003 |
| AQ6 | 761185 | 6430521 | Goulburn River | Relatively undisturbed stretch of river. Site is downstream of mine operations and discharge point. | 2003 |
| AQ7 | 762068 | 6431195 | Goulburn River | Relatively undisturbed stretch of river. Site is downstream of mine operations and discharge point. | 2003 |
| AQ8 | 756754 | 6431647 | Ulan Creek | Ulan Creek at Old Ulan Hotel site. Site is approximately 6 km downstream of LDP6. | 2006 |
| AQ11 | 758309 | 6436142 | Ulan Creek | Ulan Creek at series of rock pools in advanced regeneration woodland. Site is upstream of LDP6. This site was dry in spring 2019. | 2006 |
| AQ12 | 751646 | 6436586 | Cockabutta Creek | Series of pools in remnant woodland on Wonga Roo Road. Site is downstream of mine operations. This site was dry in spring 2019. | 2011 |
| AQ13 | 761793 | 6436977 | Bobadeen Creek | Pools through grazed paddocks. Site is upstream of mine operations. This site was dry in spring 2019. | 2011 |
| AQ15 | 754595 | 6439685 | Mona Creek | Large pool through cleared paddock. Site is downstream of mine operations. This site was dry in spring 2019. | 2011 |
| AQ18 | 762769 | 6432121 | Goulburn River | River near The Drip parking area. Site is downstream of mine operations LDP19 and close to UCML SW02. | 2003 |
| AQ19 | 763811 | 6432556 | Goulburn River | River at The Drip. Site is downstream of mine operations and LDP19. | 2012 |
| AQ20 | 757703 | 6424647 | Sportsmans Hollow Creek (upstream of Goulburn River) | Sportsmans Hollow Creek access via gate opposite Flannery house. Site is upstream of mine operations and upstream to UCML SW01. | 2015 |
| AQ21 | 761271 | 6426461 | Goulburn River | Goulburn River Trial Remediation Area. Site is adjacent to the mine operations. | 2016 |
| AQ22 | 755515 | 6446975 | Talbragar River | Leo Nott Bridge adjacent to cleared, agricultural paddocks. Site is upstream of mine operations. This site was dry in spring 2019. | 2018 |

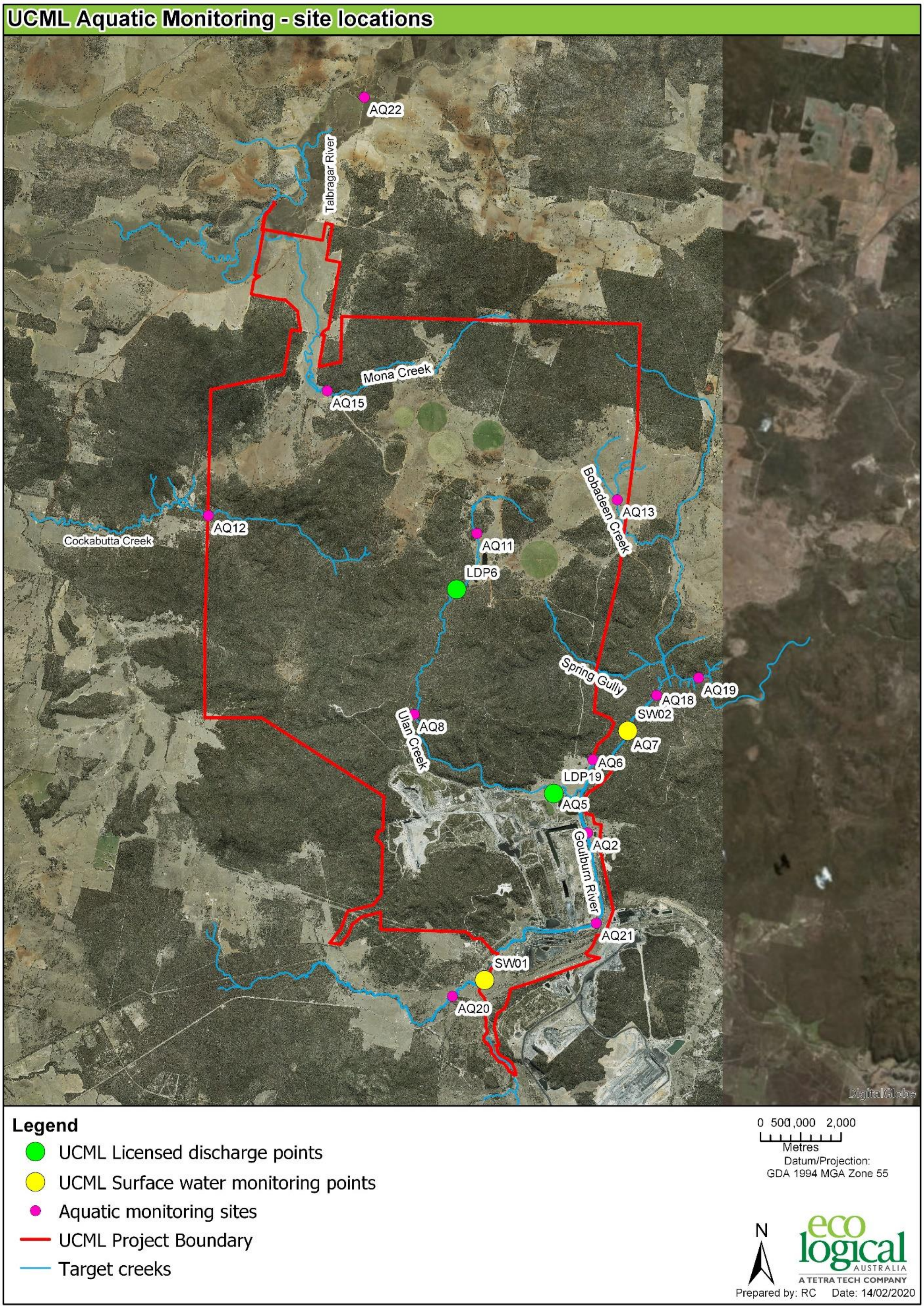


**Figure 2: Aquatic monitoring locations**

### 2.1.2 Aquatic Macroinvertebrates

A 100 m reach of river or creek was selected at each site for macroinvertebrate sampling. Within the reach, a 10 m composite of riffle and edge habitat was sampled for macroinvertebrates. Macroinvertebrate communities were sampled using the Australian River Assessment System (AUSRIVAS) protocol at all sites. This involved dislodging macroinvertebrates in riffles by kicking the substrate and allowing flow to carry disturbed macroinvertebrates into the collection net. In edge or pool habitats, the collection net was used to disturb the benthos and/or aquatic vegetation and then swept through the water column to collect dislodged macroinvertebrates. Suitable edge habitats for sampling included backwaters with abundant benthic leaf-litter, fine organic/silt deposits, macrophyte beds, overhanging banks and areas with trailing bank vegetation (Turak *et al*. 2004).

Macroinvertebrate samples were live-sorted in the field for a minimum of 40 minutes. If new taxa were collected in the period between the 30$^{th}$ and 40$^{th}$ minutes, sorting continued for an additional 10 minutes, for a maximum sorting time of 60 minutes. Sorting stopped if no additional taxa were found. Specific care was taken to ensure cryptic, fast moving taxa were represented. Picked specimens were preserved in jars with ethanol and transported to the laboratory for identification.

Macroinvertebrates were identified in the laboratory using a Leica M80 stereo microscope. Taxa were identified to family level, with the exception of Acarina, Hirudinae, Ostracoda, Oligochaete and Cladocera (to order), Platyhelminthes (to phylum) and Copepoda (to subclass).

To make an assessment of macroinvertebrate taxa richness, richness from the current sampling period for each site was compared to taxa from previous monitoring periods. SIGNAL2 scores (see **Section 2.2.1**) were also compared across monitoring periods.

### 2.1.3 Riparian Habitat Assessment

Aquatic habitat assessments were based on the *Policy and Guidelines for Fish Habitat Conservation and Management* (DPI Fisheries 2013), which outlines the features important for fish habitat in freshwater, estuarine, and marine areas. Habitat assessments allow the significance of river reaches to be determined and help inform the context of additional monitoring, such as macroinvertebrate sampling.

Aquatic habitat variables (environmental data) were noted for each site, with observations made from the bank on the following characteristics:

- General signs of disturbance
- Habitat type
- Channel topography
- Current water level
- Bank and bed slope
- Degree of river shading
- Amount of detritus
- Macrophyte type and extent
- Riparian zone width
- Snags and large woody debris coverage
- Stream width and depth
- Surrounding land use

- Description of the natural substrate
- Extent of bank overhang
- Amount of trailing bank vegetation.

Riparian habitat assessment was undertaken using a version of the Riparian, Channel and Environmental (RCE) inventory (Peterson 1992) that was modified for Australian conditions (Chessman *et al.* 1997). Data for the RCE index was collected from the same 100 m stretch of stream in which the macroinvertebrate samples were collected. Attributes measured include in-stream vegetation structure, bank and streambed structure and condition, riparian vegetation width and condition, and surrounding land use (see **Section 2.2.2**).

### 2.1.4 Water Quality

Water quality parameters including, dissolved oxygen (DO) (% saturation and mg/L), pH, electrical conductivity (EC), temperature and alkalinity were measured at nine sites using water quality and alkalinity probes (**Table 2**). Water quality was also measured at UCML licensed discharge point (LDP) LDP19.

Water samples were collected from below the water surface, where items entrained in the surface film would not contribute to the sample. The water sample was allowed to settle for approximately 2 minutes prior to taking readings for temperature, DO, pH and EC using a YSI-556 meter. Turbidity was measured with a Hach 2100Q Turbidimeter.

**Table 2: Water quality attributes measured and equipment used.**

| Parameter | Instrument | Unit of Measurement |
|---|---|---|
| Temperature | YSI-556 Multi-parameter Meter | °C |
| EC | YSI-556 Multi-parameter Meter | µS/cm |
| DO (%) | YSI-556 Multi-parameter Meter | % Saturation |
| DO (mg/L) | YSI-556 Multi-parameter Meter | mg/L |
| pH | YSI-556 Multi-parameter Meter | N/A |
| Turbidity | Hach 2100N Turbidimeter | NTU |
| Alkalinity | Hanna HI755 Alkalinity Colorimeter | ppm |

### 2.1.5 Opportunistic sightings of significant fauna

Opportunistic sightings of significant, threatened or migratory fauna were recorded during surveys. General searches for evidence of *Hydromys chrysogaster* (Water Rat) and *Ornithorhynchus anatinus* (Platypus) (e.g. sightings, burrows, scats, etc.) were also conducted at each site.

## 2.2 Monitoring Indices (Assessment Method)

### 2.2.1 Stream Invertebrate Grade Number Average Level; version 2 (SIGNAL2)

To make an assessment of the ecological health of each site, SIGNAL2 scores were calculated for the macroinvertebrate community occurring at each site. SIGNAL2 is a biotic index that allocates a value to each macroinvertebrate taxon based upon their sensitivity to disturbance. A SIGNAL2 score of 10 indicates high sensitivity and a SIGNAL2 score of 1 indicates low sensitivity to water pollution and other human impacts. The SIGNAL2 score for the entire site is determined by calculating the mean SIGNAL2 scores from all taxa present. SIGNAL2 scores are used to grade water quality into the following categories (Gooderham and Tsyrlin 2009):

- SIGNAL2 Score >6: Healthy habitat
- SIGNAL2 Score 5-6: Mild disturbance
- SIGNAL2 Score 4-5: Moderate disturbance
- SIGNAL2 Score <4: Severe disturbance.

### 2.2.2 Riparian, Channel and Environmental (RCE) Inventory

The modified RCE (Chessman *et al.* 1997) has 13 descriptors, each allocated a score from 1 (most modified) to 4 (least modified). Descriptors include width and condition of the riparian zone, surrounding land use, extent of bank erosion, stream width, water depth, occurrence of pools, riffles and runs, sub-stratum type, presence of snags and woody debris, in-stream and emergent macrophytes, algae and barriers to fish passage. The total score for each site is derived by summing the score for each descriptor and calculating the result as a percentage of the highest possible score.

Sites with a high RCE score (up to 52, or 100%) indicate that the riparian zone is unmodified by human activity, while those with a low score have undergone substantial modification. Based on the classification established by Peterson (1992), site condition was rated as follows:

- RCE Score of 0-24%: Poor
- RCE Score of 25-43%: Fair
- RCE Score of 44-62%: Good
- RCE Score of 63-81%: Very Good
- RCE Score of 82-100%: Excellent.

## 2.3 Water quality guidelines

The introduction of revised quality guidelines and the water quality framework in 2018 (https://www.waterquality.gov.au/anz-guidelines) has not provided new triggers for physico-chemical stressors for aquatic ecology. Hence, water quality parameters measured during surveys were compared with the ANZECC and ARMCANZ (2000) guidelines for protection of aquatic environments. The ANZECC and ARMCANZ (2000) guidelines provide different ranges for upland and lowland streams, with upland streams being those above 150 m altitude. All sites surveyed for this project are considered upland stream sites. ANZECC and ARMCANZ (2000) guidelines for DO (% saturation) is 90 – 110 %, whilst guidelines for Turbidity are 2 – 25 NTU.

# 3. Results and Discussion

## 3.1 Aquatic macroinvertebrates

Macroinvertebrate results are presented in **Table 3**. Macroinvertebrate taxonomic richness during 2019 was highest at site AQ7 (20 taxa) and AQ19 (19 taxa). At the time of sampling, these sites had a variety of available micro-habitat for macroinvertebrates; including macrophytes and riffles which contribute to the high taxa richness scores. In contrast, the site with the lowest taxonomic richness was AQ20 with twelve (12) taxa recorded. This site consisted of an isolated deep pool providing minimal habitat features and no water flow. The most widely distributed taxa were Coleoptera subfamily Dytiscidae (predaceous diving beetles) and Hygrophila subfamily Physidae (bladder snails), both of which were present at all sites except AQ20.

Average SIGNAL2 scores for each site ranged from 3.0 (severe disturbance – AQ5) to 4.41 (moderate disturbance – AQ6). Only three sites had average SIGNAL2 scores above 4 (moderate disturbance – AQ5 (4.41); AQ18 (4.25); AQ7 (4.06)) indicative of the disturbed riparian environment and broader catchment. All three of these sites are located downstream of UCC LDPs in relatively undisturbed sections of the Goulburn River with a variety of habitat features (e.g. riffles, macrophytes and logs) present. These three sites also contained a high diversity of Trichoptera (caddisfly) taxa (**Table 3**). Many caddisfly taxa are indicative of low pollution and disturbance (Chessman *et al.* 1997). These results indicate that water flow levels and habitat availability linked to historical land use practices, are key factors determining macroinvertebrate results. There is no clear correlation between water quality results and average SIGNAL2 scores.

### 3.1.1 Aquatic Macroinvertebrates comparison across monitoring years

Of the nine sites surveyed in 2019, there was an increase in average SIGNAL2 score at six sites compared to 2018, whilst one site (AQ5) remained stable (**Figure 6**). The two sites where SIGNAL2 scores fell (AQ19 and AQ20) had reduced water inundation and flow compared to 2018, which limits the available macroinvertebrate habitat present at the sites.

Of the nine sites surveyed in 2019, six sites had average SIGNAL 2 scores slightly below the overall average for each respective site and similarly the average SIGNAL2 score across all sites in 2019 was 3.7, slightly lower than the average across all sites and years of 3.8. Combined with the below average SIGNAL2 score of 3.3 in 2018, 2019 results may indicate the impact of prolonged drought conditions on macroinvertebrate communities, through reduced water inundation and flow, resulting in decreased habitat.

Assessing average SIGNAL2 scores across the full monitoring period (2011 to 2019) demonstrates that upstream sites have overall higher scores (mean = 4.1) than downstream sites (mean = 3.0). As discussed above, these results are indicative of the higher quality riparian and instream habitat present at these sites and also suggest the importance of stream flow, provided by mine discharge water, in sustaining macroinvertebrate communities at downstream sites.

**Table 3: Macroinvertebrate taxa collected at each site during spring 2019**

| Order | Family | Signal Score | AQ02 | AQ05 | AQ06 | AQ07 | AQ08 | AQ18 | AQ19 | AQ20 | AQ21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Acarina | | | | | | | 2 | | | | |
| Bivalvia | Sphaeriidae | 3 | | | | | | | | | 3 |
| Cladocera | | | 2 | | | | | | | | |
| Coleoptera | Dytiscidae | 2 | 2 | 2 | 2 | 2 | | 2 | 2 | 2 | 2 |
| Coleoptera | Hydrophilidae | 2 | 2 | | | | | | | | 2 |
| Coleoptera | Scirtidae | 6 | 6 | | | | | | | | 6 |
| Coleoptera | Gyrinidae | 4 | | | | | | | 4 | | |
| Coleoptera | Hydraenidae | 3 | | | | | | | | | 3 |
| Copepoda | | | | | | | | | | 10 | |
| Decapoda | Atyidae | | | | 4 | | | | | | |
| Diptera | Ceratopogonidae | 4 | 4 | 4 | | | 4 | | | 4 | |
| Diptera | Chironomidae | 3 | | | | | | 3 | | | |
| Diptera | Simuliidae | 5 | | | 5 | 5 | | 5 | 5 | | |
| Diptera | Tabanidae | 3 | 3 | | | | | | | | |
| Diptera | Chironomidae (orthocladiinae) | 3 | | 3 | 3 | 3 | 3 | 3 | 3 | 3 | |
| Diptera | Chironomidae (tanypodinae) | 3 | 3 | | | 3 | 3 | | 3 | 3 | 3 |
| Diptera | Chironomidae (chironominae) | 3 | | 3 | 3 | 3 | 3 | | 3 | 3 | 3 |
| Diptera | Culicidae | 1 | 1 | 1 | | | 1 | | 1 | | |
| Diptera | Dixidae | 7 | 7 | | | | | | | 7 | |
| Diptera | Ephydridae | 2 | | | | | | | | 2 | |
| Diptera | Dolichopodidae | 3 | | | | | 3 | | | | |
| Ephemeroptera | Baetidae | 5 | | | 5 | 5 | | 5 | | | |
| Ephemeroptera | Caenidae | 4 | | | 4 | 4 | 4 | 4 | 4 | | |

| Order | Family | Signal Score | AQ02 | AQ05 | AQ06 | AQ07 | AQ08 | AQ18 | AQ19 | AQ20 | AQ21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Ephemeroptera | Leptophlebidae | 8 | | | 8 | 8 | 8 | 8 | | | 8 |
| Hemiptera | Veliidae | 3 | 3 | 3 | | 3 | | | | | |
| Hemitptera | Micronectidae | 2 | 2 | | 2 | | | | 2 | 2 | |
| Hemitptera | Notonectidae | 1 | 1 | | | | 1 | | | | |
| Hirudinae | | | | | | | | | | | 2 |
| Hygrophila | Planorbidae | 2 | | | | 2 | | 2 | | | |
| Hygrophila | Physidae | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 1 |
| Hygrophila | Lymnaeidae | 1 | | 1 | | 1 | | | 1 | | |
| Megaloptera | Corydalidae | 7 | | | | | | | 7 | | |
| Odonata | Aeshnidae | 4 | 4 | 4 | | | | | | | |
| Odonata | Coenagrionidae | 2 | | | | | | | | 2 | |
| Odonata | Corduliidae | 5 | | 5 | | 5 | | 5 | 5 | 5 | 5 |
| Odonata | Gomphidae | 5 | | | 5 | 5 | | 5 | 5 | | |
| Odonata | Lestidae | 1 | | 1 | | | | | | | |
| Odonata | Libellulidae | 4 | | | | | | | 4 | | |
| Odonata | Synlestidae | 7 | 7 | | | | | | | | |
| Odonata | Platycnemididae | 4 | | | 4 | | | | | | |
| Odonata | Telephlebiidae | 9 | | 9 | | | | | | | |
| Oligochaete | | | 6 | | | 5 | 8 | | 1 | 1 | 4 |
| Ostracoda | | | 5 | | | | | 9 | | | |
| Ostracoda | Seed Shrimp | | | 5 | | 7 | | | | | |
| Platyhelminthes | | 2 | | 2 | 2 | | | 2 | | | |
| Podocopida | Seed Shrimp | | | | | | | | | | 4 |
| Trichoptera | Calamoceratidae | 7 | | | 7 | 7 | | 7 | 7 | | |

| Order | Family | Signal Score | AQ02 | AQ05 | AQ06 | AQ07 | AQ08 | AQ18 | AQ19 | AQ20 | AQ21 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trichoptera | Hydrobiosidae | 8 | | | 8 | | | | | | |
| Trichoptera | Hydropsychidae | 6 | | | 6 | 6 | | 6 | 6 | | |
| Trichoptera | Hydroptilidae | 4 | | | 4 | 4 | 4 | 4 | 4 | | |
| Trichoptera | Leptoceridae | 6 | | | 6 | 6 | 6 | 6 | | | |
| **Number of Taxa** | | | **17** | **14** | **18** | **20** | **14** | **17** | **19** | **12** | **13** |
| **Average Signal2 Score (Not abundance weighted)** | | | **3.29** | **3.00** | **4.41** | **4.06** | **3.42** | **4.25** | **3.72** | **3.30** | **3.60** |

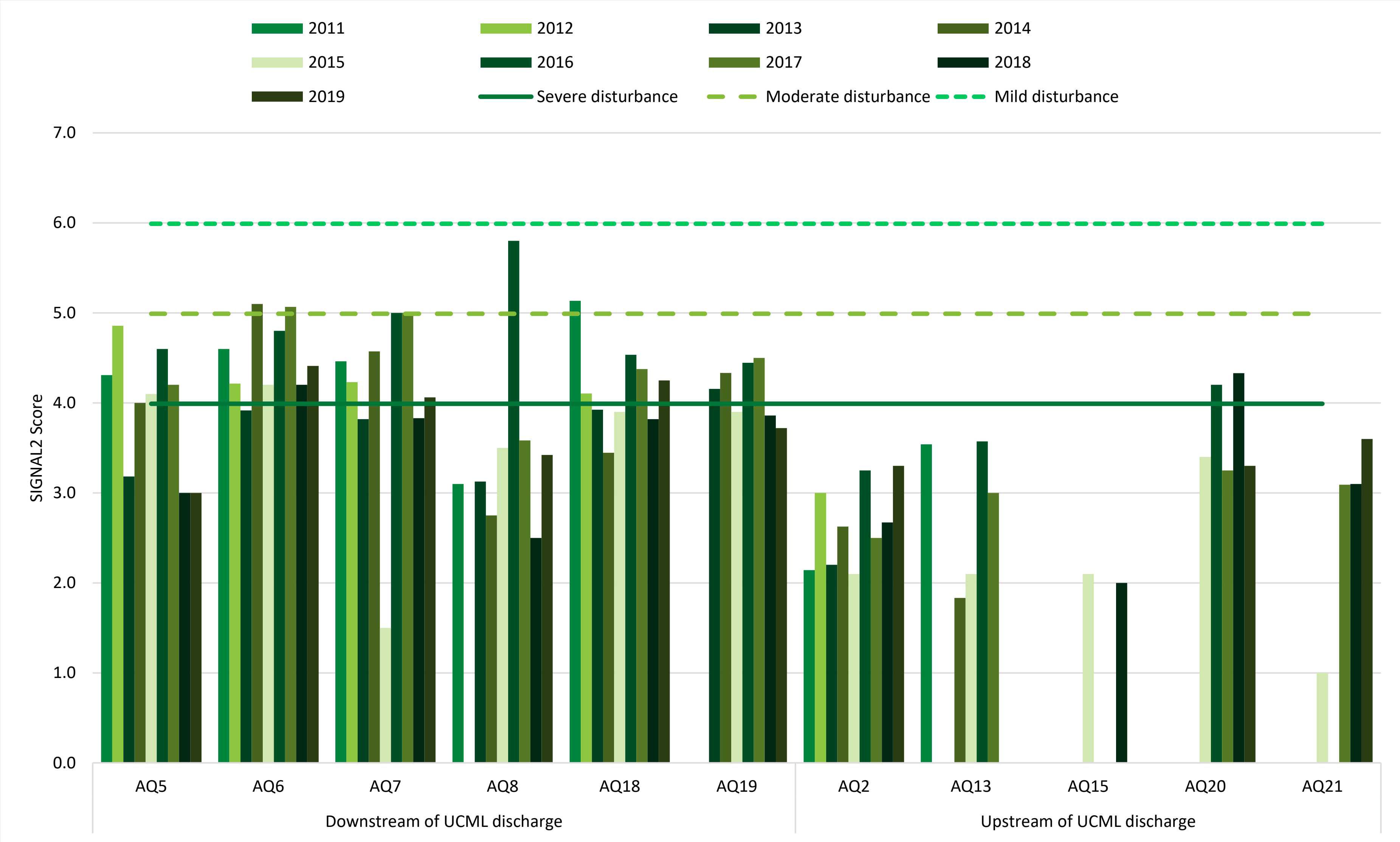


**Figure 3: Average SIGNAL2 scores for each site; 2011 to 2019**

## 3.2 Riparian Habitat Assessment

Riparian Habitat Assessment results were consistent across all sites, with the only notable differences being for variables relating to prolonged drought conditions that resulted in reduced water levels and macrophyte cover. This pattern was recorded at sites upstream of the UCML LDPs including AQ2, AQ15, AQ20 and AQ21.

The RCE Inventory scores for spring 2019 are shown in **Table 4.** Eleven (11) sites scored RCE Inventories of Good (44-62%) and the remaining three (3) sites scored RCE Inventories of Excellent (82-100%) (AQ11, AQ12 and AQ19). All RCE Inventory scores are consistent with 2018 monitoring (**Figure 4**).

AQ5, AQ12, AQ20 and AQ21 all scored low (1) for stream bed, and sites AQ2, AQ5, AQ15, AQ20 and AQ21 all scored low (1) for in-stream retention devices. These sites are all located in historically cleared paddocks or the Goulburn River Diversion and as such, there is minimal or no riparian vegetation to contribute to litter and historical modification has eliminated bedrock and in-stream sediment accumulation.

A comparison of RCE results from 2011 to 2019 (where available due to varied site establishment) reveals highly consistent results. Photographic comparisons of each site (**Appendix B**) further demonstrate the relative stability observed at each site across monitoring years. RCE results for individual sites reflect the nature of the riparian habitat present. Both Goulburn River Diversion sites AQ2 and AQ21 experienced an increase in their RCE scores since 2016, in line with remediation works undertaken during this period. Overall, the RCE results indicate that the riparian environment is not subject to any ongoing adverse effects resulting from mining operations and are reflective of historical regional land use practices in the catchment.

**Table 4: RCE scores for sites surveyed in spring 2019**

| | AQ02 | AQ05 | AQ06 | AQ07 | AQ08 | AQ11 | AQ12 | AQ13 | AQ15 | AQ18 | AQ19 | AQ20 | AQ21 | AQ22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Land use beyond riparian zone | 3 | 3 | 3 | 4 | 3 | 4 | 4 | 2 | 2 | 4 | 4 | 3 | 3 | 2 |
| 2. Width of riparian strip | 3 | 2 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 4 | 2 | 3 | 3 |
| 3. Completeness of riparian strip | 3 | 3 | 4 | 3 | 3 | 4 | 4 | 2 | 1 | 4 | 4 | 3 | 3 | 2 |
| 4. Vegetation within 10 m of channel | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 | 2 | 4 | 4 | 2 | 4 | 2 |
| 5. Bank structure | 4 | 4 | 4 | 3 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| 6. Bank undercutting | 4 | 3 | 3 | 3 | 2 | 3 | 4 | 4 | 2 | 4 | 4 | 3 | 3 | 2 |
| 7. Channel form | 1 | 3 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 4 | 3 | 1 | 2 |
| 8. Riffle/pool sequence | 1 | 3 | 4 | 3 | 3 | 3 | 3 | 2 | 2 | 3 | 4 | 3 | 2 | 2 |
| 9. In-stream retention devices | 1 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 2 | 4 | 1 | 1 | 2 |
| 10. Channel sediment accumulation | 2 | 2 | 2 | 3 | 2 | 4 | 2 | 4 | 4 | 3 | 2 | 4 | 2 | 4 |
| 11. Stream bottom | 2 | 1 | 3 | 3 | 2 | 3 | 1 | 2 | 2 | 3 | 4 | 1 | 1 | 2 |
| 12. Stream detritus | 1 | 1 | 3 | 3 | 3 | 4 | 4 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| 13. Aquatic vegetation | 1 | 1 | 1 | 2 | 4 | 4 | 3 | 4 | 4 | 1 | 2 | 3 | 1 | 4 |
| **Total** | **30** | **31** | **42** | **41** | **39** | **47** | **43** | **34** | **29** | **40** | **47** | **33** | **29** | **32** |
| **RCE (%)** | **57.7** | **59.6** | **80.8** | **78.8** | **75.0** | **90.4** | **82.7** | **65.4** | **55.8** | **76.9** | **90.4** | **63.5** | **55.8** | **61.5** |

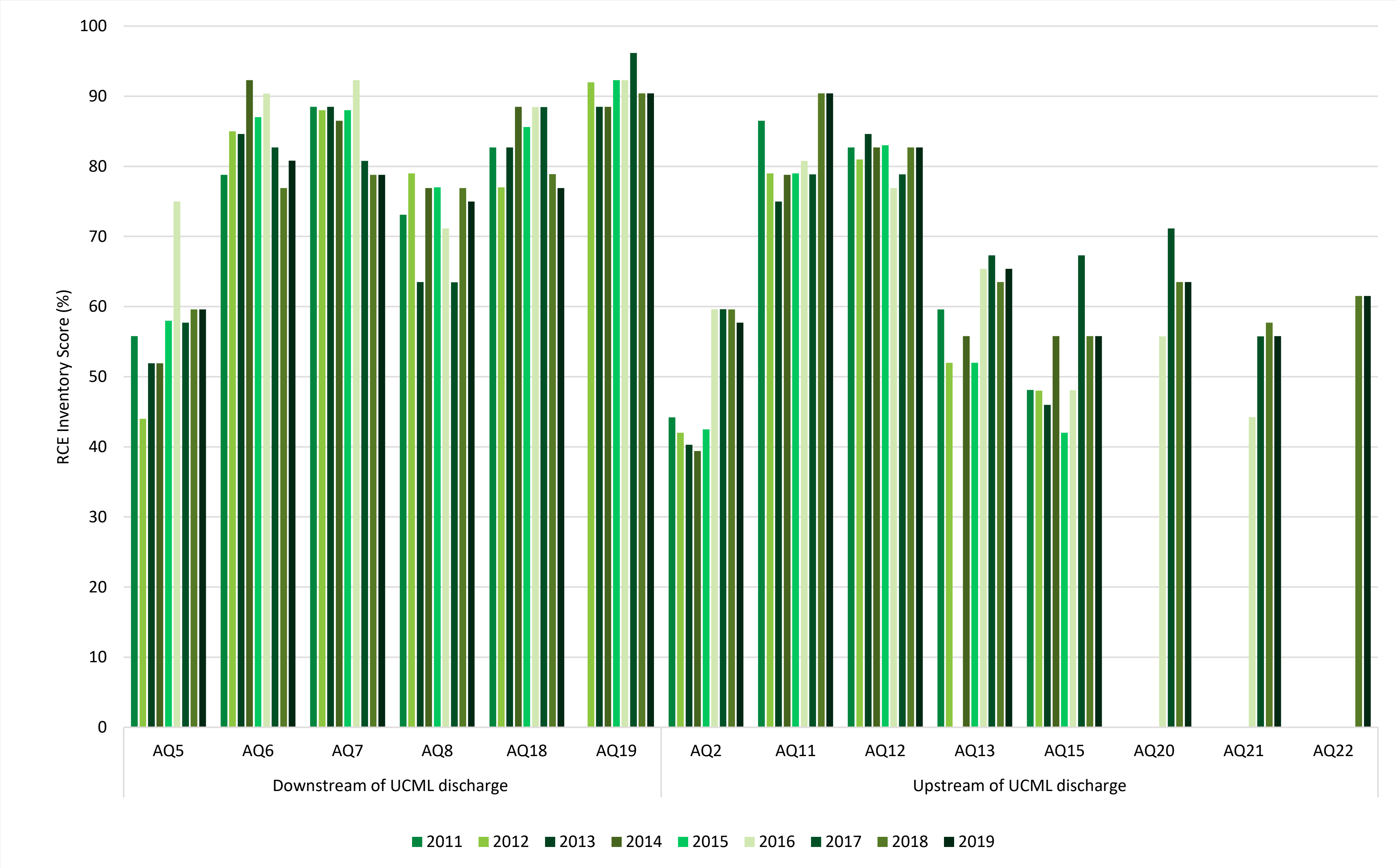


**Figure 4: Comparison of RCE Inventory percentage scores across sites between 2011 and 2019**

## 3.3 Water Quality

Water quality results from nine monitoring sites and LDP19 surveyed during 2019 are displayed below in **Table 3**. Alkalinity and pH results were consistent with previous years. Turbidity was highest and above ANZECC and ARMCANZ (2000) guidelines at sites upstream from UCML LDPs, within the Goulburn River Diversion (AQ2 and AQ21) and further upstream (AQ20). These sites had high macrophyte density and low water flow due to prolonged drought conditions (see **Figure 1** and **Table 4**). EC was high overall, indicative of naturally saline groundwater in the region (BIO-ANALYSIS 2015 and UCML 2019), at two of three sites upstream (AQ2 and AQ21) and two of six sites downstream (AQ6 and AQ7) of UCML LDP19.

DO (% saturation) was below ANZECC and ARMCANZ (2000) guidelines at all sites excluding AQ2, which recorded the highest DO (108.8% saturation). Results were similar both upstream and downstream of UCML LDP19. The sites with the lowest DO concentrations were AQ20 (48.9% saturation) and AQ21 (36.5% saturation) which are located upstream of UCML discharge points. During 2019, water flow at these sites was restricted to isolated pools due to prolonged drought conditions, with abundant macrophyte growth, filamentous algae and periphyton also present.

Low DO can be caused by a range of factors including plant respiration, high water temperature, de-oxygenating chemicals, increases in organic matter and bacterial activity, and low circulation rates in water. A combination of these factors is likely at play for these sites given the low natural water flow and absence of high flow ‘flushing’ events, as well as the presence of macrophytes, algae and periphyton. Under drought conditions, the dominance of upwelling groundwater, which is low in dissolved oxygen, can cause concentrations to fall.

Sites with higher DO saturation levels, excluding AQ2, were those directly downstream from UCML discharge points along Ulan Creek (AQ5 and AQ8) and the Goulburn River (AQ6, AQ7, AQ18 and AQ19). At these sites, water was flowing so oxygen was continuously being absorbed, keeping DO saturation levels high.

**Table 5: Water quality results 2019**

| US/DS of UCML LDPs | Site | Date | Temperature (°C) | Conductivity (uS/cm) | DO (% saturation) | DO (mg/L) | pH | Turbidity (NTU) | Alkalinity |
|---|---|---|---|---|---|---|---|---|---|
| Down-stream | AQ5 | 13/11/2019 | 17.29 | 815 | 67 | 6.4 | 7.1 | 3.62 | 49 |
| | AQ6 | 13/11/2019 | 17.15 | 1037 | 87.2 | 8.36 | 7.75 | 1.64 | 124 |
| | AQ7 | 13/11/2019 | 25.15 | 857 | 75.3 | 6.2 | 7.92 | 2.89 | 137 |
| | AQ8 | 14/11/2019 | 19.12 | 814 | 80.5 | 7.07 | 8.22 | 10.1 | 227 |
| | AQ18 | 14/11/2019 | 13.78 | 845 | 65.9 | 6.81 | 7.75 | 4.39 | 146 |
| | AQ19 | 14/11/2019 | 17.24 | 830 | 75.8 | 6.97 | 7.8 | 1.25 | 144 |
| Up-stream | AQ2 | 13/11/2019 | 26.83 | 965 | 108.8 | 8.28 | 6.6 | 89.8 | 60 |
| | AQ20 | 13/11/2019 | 26.27 | 323 | 48.9 | 3.9 | 7.15 | 37.7 | 61 |
| | AQ21 | 15/11/2019 | 14.82 | 1208 | 36.5 | 36.6 | 7.29 | 28.8 | 144 |
| N/A | LDP19 | 13/11/2019 | 19.1 | 824 | 69.3 | 6.43 | 7.21 | - | - |

Two (2) LDPs; LDP6 and LDP19 are currently in use at the UCC. Both LDPs discharge water into Ulan Creek, which flows into the Goulburn River (see **Figure 2**). Surface water monitoring data, including flow data was provided by UCML for surface water monitoring sites SW01 and SW02 (AQ7). Water quality data and flow data daily averages for November 2019 for LDP6, LDP19, SW01 and SW02 are shown in **Table 6.** Given the prolonged drought conditions under which 2019 monitoring was undertaken, discharged mine water comprised the majority of flow within sites downstream of discharge points. The low flow rate (0.406 ML) recorded at upstream site SW01 further demonstrates this.

Comparison of water quality results from the 2019 aquatic monitoring program (**Table 5**) with UCML water quality results from November 2019 (**Table 6**) for equivalent sites (LDP6 – AQ8; LDP19 – AQ5; SW01 – AQ20; SW02 – AQ7) indicate that EC, pH and turbidity results were generally consistent, except for slightly higher pH results at AQ8 (pH 8.22), compared to LDP6 (pH 7.6). This shows that the macroinvertebrate sampling was undertaken when water quality conditions were representative for the sampling period.

**Table 6: Water quality and flow data daily averages for November 2019 (UCML 2019)**

| Parameter | LDP6 | LDP19 | SW01 | SW02 |
|---|---|---|---|---|
| EC (µS/cm) | 800 | 755 | 591 | 837 |
| pH | 7.6 | 7.0 | 7.4 | 7.9 |
| Turbidity (NTU) | 3.97 | 0 | 17.0 | 2.00 |
| Discharge (ML) | 4.741 | 2.337 | 0.406 | 4.057 |

### 3.3.1 Water Quality comparison across monitoring years

Overall, low DO concentrations recorded in 2019 were largely consistent with 2016 and 2018 results, however, they were notably lower than 2017 results. There is no clear explanation as to why DO results have been observed to fluctuate across monitoring years, with no clear climatic pattern observable (BOM 2019). Fluctuations have been observed upstream and downstream of UCC discharge points and operational boundaries. Additionally, variable DO concentrations have been recorded within the same year at adjacent sites of similar condition which indicates that DO concentrations are naturally variable within the local catchment.

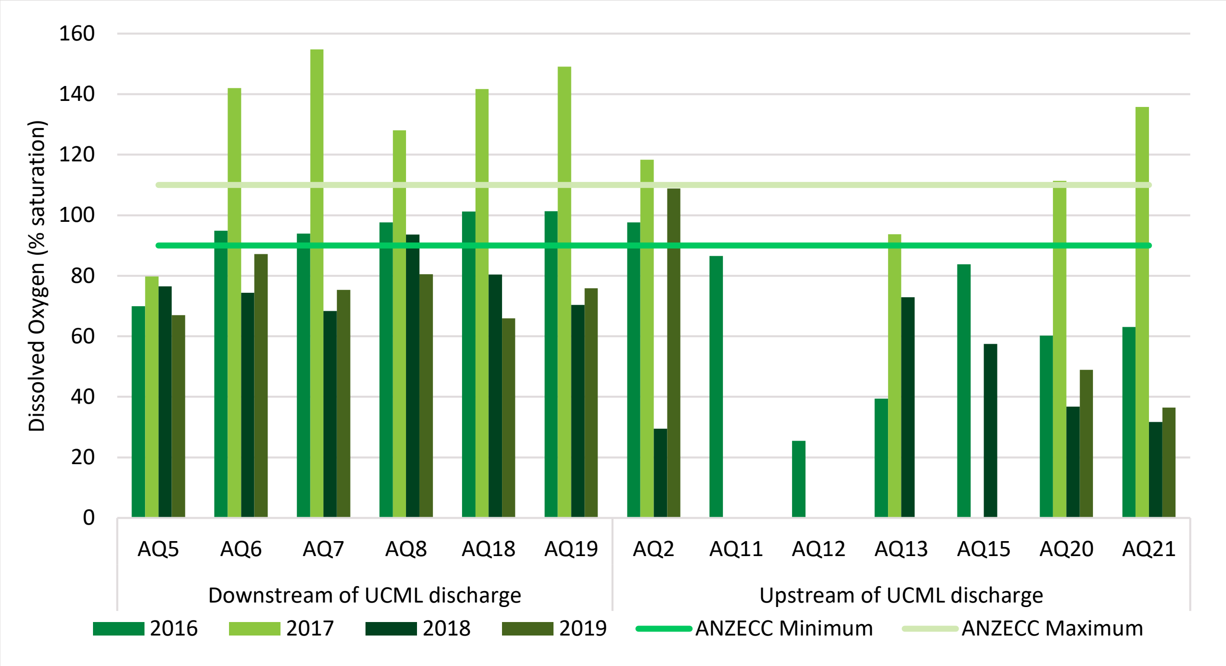


**Figure 5: Percentage (%) saturation of dissolved oxygen (DO) at each site with the minimum and maximum ANZECC and ARMCANZ (2000) guideline range.**

## 3.4 Assessment of macroinvertebrate scores relative to riparian habitat and water quality

Comparison of macroinvertebrate results indicate a correlation between macroinvertebrate results and riparian habitat results, with the highest average SIGNAL2 cores being recorded at the same sites with the highest average RCE scores (AQ6, AQ7, AQ18 and AQ19). Each of these sites occur in relatively undisturbed riparian woodland reaches of the Goulburn River downstream of the UCC and also contain a range of habitat features.

There is no clear temporal correlation between macroinvertebrate results with DO (% saturation) results, however, there is some correlation at the site level. All five sites with the highest average SIGNAL2 scores also have the highest average DO (% saturation) results, with all of these sites (AQ6, AQ7, AQ8, AQ18 and AQ19) located downstream of UCML discharge points, indicating the influence of water flow in keeping DO saturation levels high.

# 4. Conclusion and Recommendations

Aquatic monitoring was undertaken at a total of fourteen (14) permanent sites in the target creeks and rivers within and surrounding the UCC, in accordance with PA 08_0184 and the methodology set out in the BMP (UCML 2018). Given the prolonged drought conditions under which 2019 monitoring was undertaken, discharged mine water comprised the majority of flow within the Goulburn River catchment, with all sites upstream of UCC discharge points, either dry or comprised of isolated pools. As such, only nine (9) sites were sampled using the full aquatic monitoring methodology, inclusive of water quality and macroinvertebrate sampling.

Macroinvertebrate results continue to be linked to stream flow levels, riparian and in-stream habitat condition and the nature and history of surrounding land usage. SIGNAL2 scores showed an overall increase in 2019, compared to 2018, and were reflective of moderate to severely disturbed systems. The historical disturbance present at monitoring sites, as well as prevailing climatic conditions (including stream flow provided by mine water discharge sustaining macroinvertebrate communities), remain the key factors influencing macroinvertebrate results.

Riparian Habitat Assessment results were consistent across all sites surveyed in 2019, with the only notable differences relating to variables affected by prolonged drought conditions, such as reduced water levels and macrophyte cover, predominantly at sites upstream of UCML LDPs. A comparison of RCE results from 2011 to 2019, along with photographic comparisons, reveal highly consistent results. RCE results for individuals sites reflect the nature of the riparian habitat present at each site. Overall, the RCE results indicate that the riparian environment is not subject to any ongoing adverse effects resulting from mining operations and are rather, reflective of historical regional land use practices in the catchment.

Alkalinity and pH results were consistent with previous years. Turbidity was highest and above ANZECC and ARMCANZ (2000) guidelines at sites upstream from LDPs, with prolonged drought conditions likely responsible for these results through reduced water flow leading to isolated, stagnant pools. Consistent with previous years, EC was high both upstream and downstream of LDPs, indicating the contribution of naturally saline groundwater in the catchment.

DO (% saturation) was lower than ANZECC and ARMCANZ (2000) guidelines at all sites except AQ2. Results from both upstream and downstream sites and across multiple years show high variability, with additional baseline data required to better understand how DO is functioning in the local catchment. The installation of DO loggers would provide this additional data.

Installation of DO loggers upstream and downstream of the UCC is recommended.

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# Appendix A UCML Aquatic Monitoring site photos

**Site AQ2 macroinvertebrate sampling habitat demonstrating isolated stagnant pools with abundant macrophyte growth within the Goulburn River Diversion**

**Site AQ5 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ6 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ7 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ8 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ11 upstream and downstream**

**Site AQ12 upstream and downstream**

**Site AQ13 upstream and downstream**

**Site AQ15 upstream and downstream**

**Site AQ18 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ19 macroinvertebrate sampling habitat upstream and downstream**

**Site AQ20 macroinvertebrate sampling habitat upstream and downstream demonstrating isolated stagnant pools**


**Site AQ21 macroinvertebrate sampling habitat demonstrating isolated stagnant pools with abundant macrophyte growth within the Goulburn River Diversion**


**Site AQ22 upstream and downstream**

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# UCML Annual Floristic Monitoring Report 2019

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## DOCUMENT TRACKING

| | |
|---|---|
| **Project Name** | UCML Annual floristic monitoring report 2019 |
| **Project Number** | **MUD19-12774** |
| **Project Manager** | **David Allworth** |
| **Prepared by** | **Rebecca Croake, David Allworth** |
| **Reviewed by** | **Tom Kelly, Andrew Butler** |
| **Approved by** | **Andrew Butler** |
| **Status** | **Final** |
| **Version Number** | **V1a** |
| **Last saved on** | **25 March 2020** |

This report should be cited as 'Eco Logical Australia 2020. *UCML Annual floristic monitoring report 2019*. Prepared for Ulan Coal Mines Limited.'


## ACKNOWLEDGEMENTS

This document has been prepared by Eco Logical Australia Pty Ltd with support from Ulan Coal Mines Limited.

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# Abbreviations

| Abbreviation | Description |
|---|---|
| BMP | Biodiversity Management Plan (UCML 2018) |
| BVT | Biometric Vegetation Type |
| ELA | Eco Logical Australia |
| FBS | Floristic based subsidence |
| GCAA | Glencore Coal Assets Australia |
| ha | hectares |
| HBT | Hollow bearing tree |
| LGA | Local Government Area |
| IBRA | Interim Biogeographic Regionalisation for Australia |
| LW | Longwall |
| LWD | large woody debris |
| LWW | Longwall west |
| MOP | Mining Operations Plan |
| MWRC | Mid-Western Regional Council |
| MZ | Management Zone |
| NSW | New South Wales |
| OEH | Office of Environment and Heritage |
| PA | Project Approval |
| PFC | Projected foliage cover |
| QLD | Queensland |
| SOA | Salinity Offset Area |
| UCML | Ulan Coal Mines Limited |
| UG | Ulan Underground No 3 |
| UW | Ulan West |

## Key Points

**Natural regeneration**: Increase in tree cover through the process of natural regeneration is a major contributor to biodiversity in the Ulan Project Area. Examination of historical aerial photography shows that some 1,100 ha of previously cleared agricultural land within the Ulan Project Area has successfully naturally regenerated to the point of forming woodland/open forest tree cover. This gives confidence that natural tree regeneration is a viable option for achieving improvements in tree cover in forthcoming years.

Within the Ulan Project Area there are measurable areas of very young regeneration (<1 m high) fringing remnant woodland/open forest areas or isolated mature trees. This indicates that natural tree regeneration is an on-going process. Mapping of the extent of this natural regeneration front has commenced this year and provides a baseline against which future changes can be measured. It is recommended that this baseline mapping be undertaken across all relevant areas of the Ulan complex. This will help to understand where natural regeneration is likely to readily occur, where management intervention may be necessary and how natural regeneration might be assisted. This will help meet the goal of the Biodiversity Management Plan (BMP) for natural regeneration to be occurring within the Ulan complex management zones, in particular Management Zone (MZ) 2 and MZ4a.

**Revegetation**: Approximately 220 ha in MZ3 (revegetation MZ) has been successfully planted or directed seeded with the aim of creating either the target gum-box grassy woodland or ironbark woodland/open forest vegetation communities. This represents 90% of the area to be planted and the tree planting/direct seeding program is close to fulfilling the tree planting commitment of the BMP. However, the native plant communities are still developing and species richness of MZ3 is still below benchmark, and exotic covers are regularly not within benchmark limits.

**Native Plant Species Trends**: Nine (9) years of floristic data shows there is a strong positive correlation of native plant species richness to rainfall (Figure 1). It is difficult to determining whether changes in native plant species richness are affected by other factors (such as biodiversity management measures) by just examining simple temporal trends. Recommendations are made in the report for a way forward to allow assessment of whether native plant species richness is trending upward or is stable.

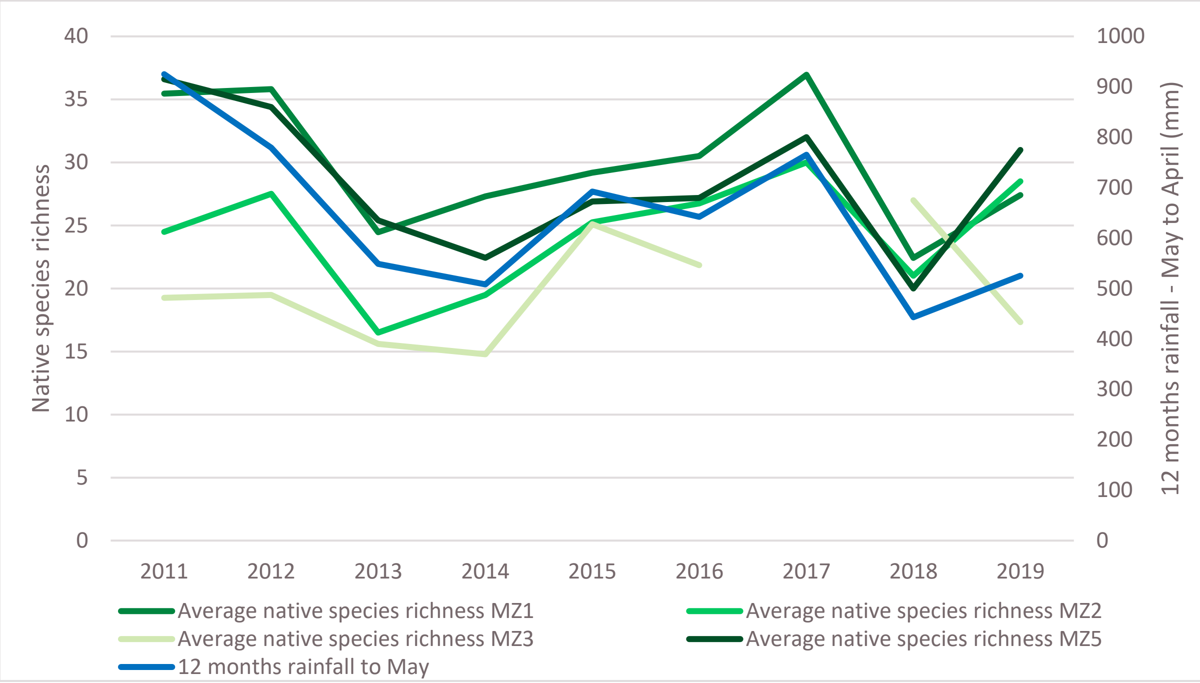


**Figure 1: Native species richness plotted against annual rainfall; 2011-2019**

**Rehabilitation Establishment**: Monitoring plots in MZ5 (open cut rehabilitation MZ) indicate that a significant proportion of the area already has a woodland/open forest cover or cover is being established as required by the BMP.

Flora monitoring plots are dominated by local native plant species as required by the BMP. Local is interpreted as belonging to the locally occurring Kerrabee Interim Biogeographic Regionalisation for Australia (IBRA) sub-region. Although no native plant species richness targets are set for MZ5 revegetation, on average (all sites across all years), native species richness is currently meeting the benchmark for HU574 (Narrow-leaved Ironbark – Grey Gum shrubby woodland) and are below the benchmark for HU551 (Grey Box – Narrow leaved Ironbark shrubby woodland. These two vegetation communities are target communities for future rehabilitation programs. However, the cover and abundance of native plant species varies significantly from remnant areas.

Average exotic ground cover for monitoring plots across MZ5 across all years is less than 10%, with no evidence of weeds compromising rehabilitation.

A range of fauna has been identified within the rehabilitation areas of MZ5 indicating the presence of fauna habitat features, although flora monitoring plot records show low levels of LWD and HBTs. Direct fauna surveys provide a more appropriate measure of the provision of fauna habitat across MZ5 than surrogates such as LWD and HBTs contained within flora monitoring plots.

**Rare plant protection - *Acacia ausfeldii***: The Highett Road *Acacia ausfeldii* population has continued to decline with over 50% of individuals marked in 2011 now dead. This trend is consistent with the known short-lived ecology of the species. *A. ausfeldii* has been successfully established in the open cut rehabilitation area.

**Subsidence**: Results indicate that subsidence is having a negligible impact on ecological communities and therefore that relevant performance measures (UCML 2019) are being met.

**Weeds**: St John's Wort remains the most widespread listed weed. Control of this species is challenging while working to maintain biodiversity. Other listed weed species, such as *Opuntia stricta* (Prickly Pear) occur as isolated populations and spot spraying is a viable strategy for control.

# 1. Introduction

Eco Logical Australia (ELA) was engaged by Ulan Coal Mines Limited (UCML) to undertake floristic monitoring during autumn and spring 2019. Monitoring was undertaken in accordance with the requirements of the UCML Biodiversity Management Plan (UCML 2018).

## 1.1 Background

UCML is part of Glencore Coal Assets Australia Pty Limited (GCAA).

GCAA's UCML complex is located within the Mid-Western Regional Council (MWRC) Local Government Area (LGA), approximately 1.5 kilometres from the village of Ulan and 38 kilometres north east of Mudgee. UCML landholdings straddle the Great Dividing Range and are located at the headwaters of the Goulburn and Talbragar River catchments.

The UCML complex comprises an approximate area of 13,700 hectares (ha), made up of:

- Open Cut Mining – approximately 239 ha of open cut operations.
- Previous Mining and Surface Infrastructure Areas – approximately 1,004 ha of previous open cut mining areas that have a combination of rehabilitation areas and final voids that remain to support future mining activities (water storage, tailings disposal, underground access etc.), the rehabilitation makes up 475 ha of this area.
- Residual Project Area – the remainder of the Project Area (approximately 10,711 ha) that is not subject to the current project. This includes large areas that have been previously undermined, agricultural grazing land, irrigation pivots and large areas of remnant native vegetation.
- Biodiversity Offset and Cliff-line Management Areas, including:
    - Bobadeen Vegetation Offset Area – 992 ha
    - Bobadeen East Vegetation Offset Area – 124 ha
    - Brokenback Conservation Area – 58 ha
    - Spring Gully Cliff-line Management Area – 273 ha
    - Bobadeen Vegetation Offset Corridor – 243 ha
    - Highett Road *Acacia ausfeldii* Management Area – 21 ha.
- Salinity Offset Area – 4465 ha which overlaps parts of the Biodiversity Offset Areas and Residual Project Area.

UCML developed a Biodiversity Management Plan (BMP) to guide management of the UCML complex subject to the requirements of Condition 44, Schedule 3 of the Project Approval (PA 08_0184) and the requirements of the Commonwealth Approval (EPBC Ref: 2009/5252).

## 1.2 UCML Management Zones

The BMP divides the UCML complex into six Management Zones (MZs) (Figure 2) based on the vegetation condition and the management strategies to be undertaken within these areas. The Management Zones are:

- MZ1 (Benchmark Vegetation) – remnant woodland areas which are of benchmark condition and exhibit high native species richness and vegetation structure. Large areas of MZ1 have undergone some form of historical disturbance, mostly in the form of logging. MZ1 includes the Brokenback Conservation Area, Spring Gully Cliff-Line Management Area and Highett Road *Acacia ausfeldii* Management Area, and areas of the wider UCML complex;

- MZ2 (Natural Regeneration) – previously cleared areas containing components of benchmark vegetation and often directly adjacent to remnant woodland (i.e. sources of natural recruitment). These areas are managed to avoid adverse disturbances and to maximise natural regeneration success;
- MZ3 (Assisted Revegetation) – disturbed areas within BOAs which require intervention to revegetate the structure and dominant species composition of disturbed vegetation to a condition similar to that of the corresponding benchmark community;
- MZ4a (Salinity Offset Area Regeneration/Revegetation) – disturbed areas within the Salinity Offset Areas (SOAs) which are managed to encourage natural regeneration of cleared areas in combination with continued grazing.
- MZ4b (Salinity Offset Area Benchmark Vegetation) – remnant woodland areas of benchmark condition within SOAs which are managed to maintain or increase biodiversity values (as per MZ1);
- MZ5 (Operational Area) – includes areas of existing and previous mining operations including the former open cut rehabilitation areas and the Goulburn River diversion remediation area. These areas are subject to progressive rehabilitation with the primary objective of creating a stable landform comprising native vegetation communities characteristic of pre-mining compositions. Management actions for this MZ are provided in the Mining Operations Plan (MOP; UCML, 2017);
- MZ6 (Agricultural Leasehold and Private Property) – areas of agricultural leasehold and private property within the UCML complex which are utilised for cattle grazing. These lands are managed consistent with the relevant requirements of the Project Approval and the UCML Environmental Management Strategy. MZ6 does not overlap with any UCML Biodiversity or Cliffline Management Offset areas.

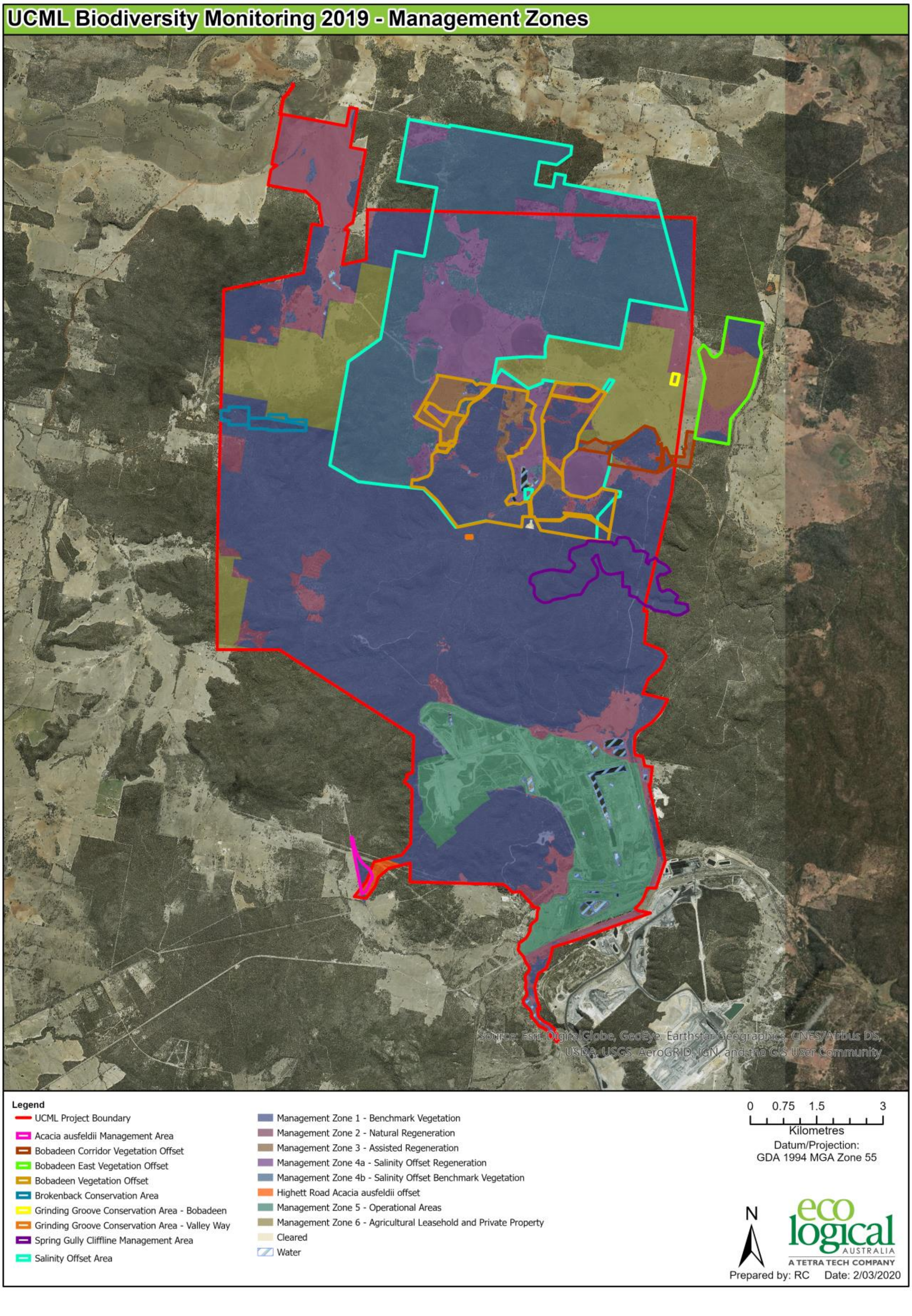


**Figure 2: Management zones within the UCML Complex**

## 1.3 2019 Monitoring Overview

A total of 103 sites were monitored during 2019 (autumn and spring) across the UCML complex consisting of:

- 19 full floristic sites (biometric plots) and 10 rapid assessment sites surveyed in autumn 2019.
- 12 full floristic sites and 2 rapid assessment sites surveyed in spring 2019.
- 60 floristic based subsidence sites monitored in autumn and spring 2019.

A full list of sites, methodology and weather conditions for the duration of survey are provided in **Appendix A**.

The 2019 monitoring program only covers a proportion of existing sites, particularly in relation to full floristic monitoring. The sites surveyed in 2019 have been added to previous years' data to update analysis of long-term trends that are occurring within Management Zones, as well as the associated BioMetric Vegetation Types (BVTs).

BVT benchmarks used in the following analysis are those set out in the UCML BMP, which were specifically developed for the Ulan complex's revegetation and regeneration areas and derived from MZ1 data. However, the benchmarks in the UCML BMP do not include habitat features such as hollow-bearing trees (HBTs) and fallen logs. At this time, Hunter-Central Rivers BVT Benchmarks (OEH, 2008) are used in any analysis completed for these habitat features.

## 2. Influence of Rainfall on Flora Monitoring Attributes

The Ulan area was listed as drought affected throughout the duration of 2019, with below average rainfall and above average mean temperatures consistent with ongoing persistent drought conditions experienced throughout 2019 (DPI, 2019; BoM, 2020a). Only 352.2 mm of rainfall was recorded at UCML for January to December 2019 compared to an average rainfall of 636.3 mm (UCML 2019; BoM, 2020). Average root zone soil moisture levels across the study area ranged from 7 to 12% during autumn monitoring and 2 to 7% during spring monitoring (BoM, 2020b) indicating that throughout the year, moisture available for plant growth and function was minimal. Field observation in 2019 was that native plant species richness counts and exotic groundcover were predictably lower due to the low rainfall.

Nine (9) years of data has allowed the statistical analysis of the relationship between antecedent rain and native plant species richness and exotic groundcover.

Rainfall data was summed on a 12-month basis (June to May) and compared to native species richness and exotic groundcover averaged across all sites per year per MZ. The June to May period was chosen on the basis of field experience that rain in the season prior was a driver of native plant species richness. A Pearson's correlation coefficient was calculated for data from each MZ to determine how closely rainfall and native species richness and exotic ground cover patterns were related.

Results from this analysis indicate that rainfall and native species richness across all MZs tends to follow the pattern of annual rainfall with increases in plant species richness occurring when there is an increase in annual rainfall and vice versa (**Figure 3**). The correlation coefficient between rainfall and native species richness at MZ1 sites (r=0.9006) indicates that the relationship is statistically significant and explains more than 80% of the variation in the data.

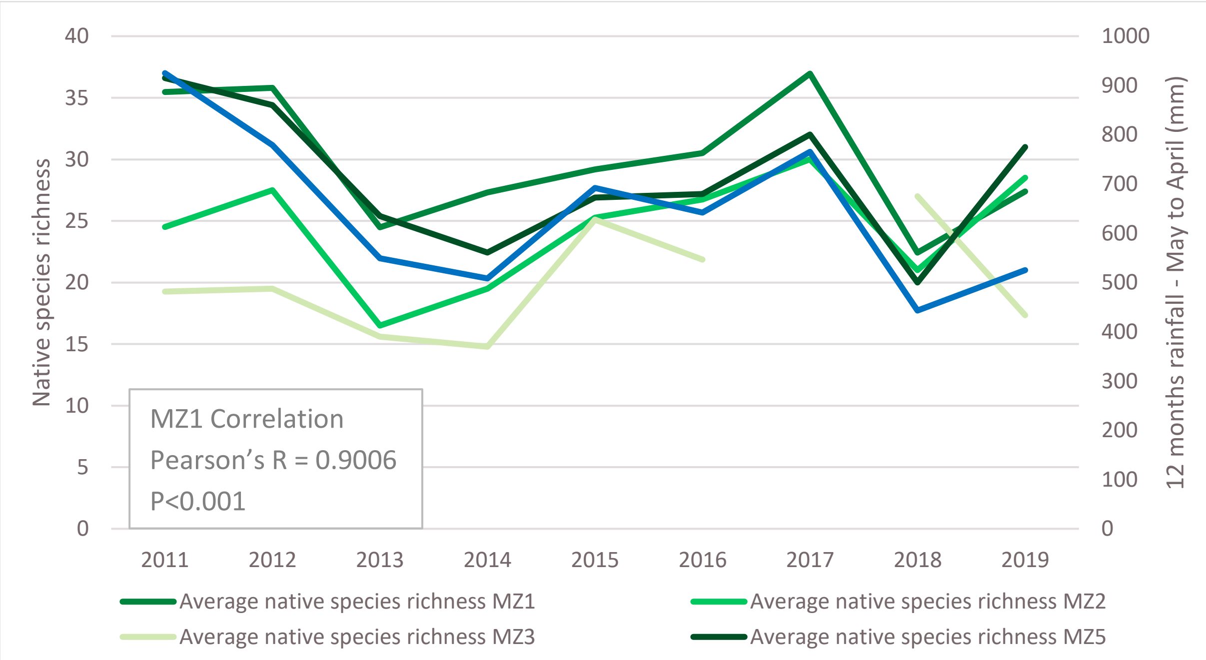


**Figure 3: Native species richness compared to annual rainfall for each MZ across years. (Note: no monitoring of MZ3 sites undertaken in 2017)**

A similar relationship was observed between annual rainfall and exotic species ground cover, as shown in **Figure 4**. The relationship was not as clear for all MZs, with MZ1 and MZ2 sites showing a similar pattern of increasing or decreasing trend in exotic species ground cover with increasing or decreasing rainfall. The correlation coefficient between rainfall and exotic species ground cover at MZ1 sites (r=0.8646) indicates that the relationship is statistically significant and explains more than 70% of the variation in the data.

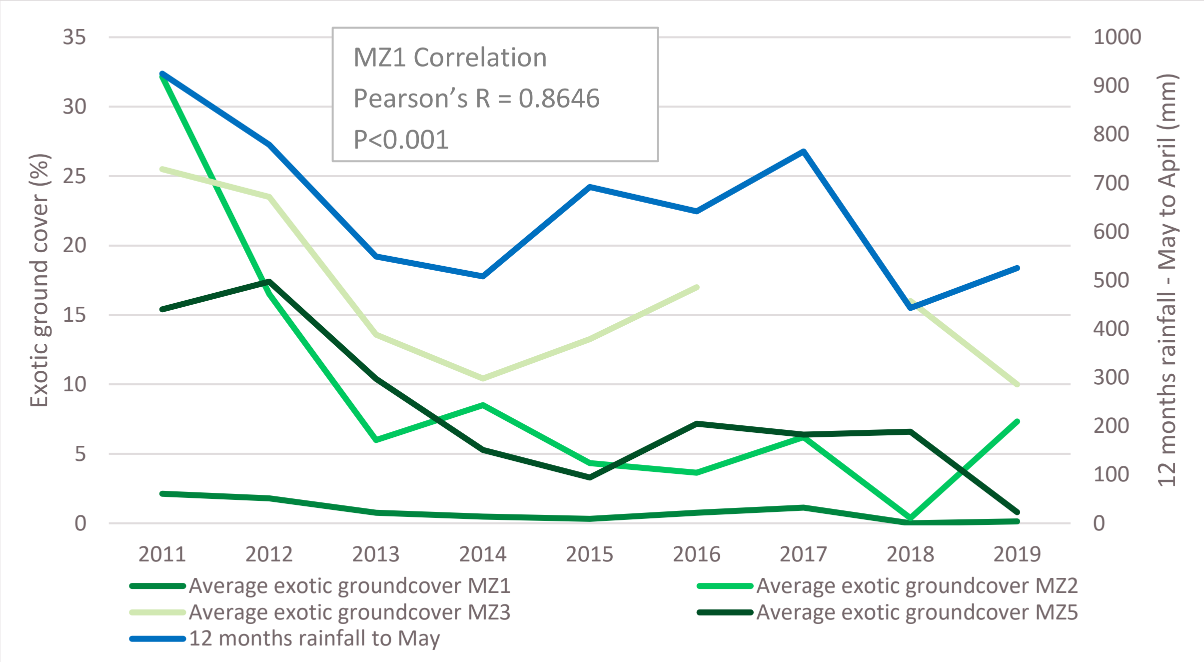


**Figure 4: Exotic species richness compared to annual rainfall for each MZ across years (Note: No monitoring of MZ3 sites undertaken in 2017)**

The analysis of the influence of rainfall patterns on vegetation community attributes has shown that caution is needed in the interpretation of changes in vegetation attribute values between years and in making inferences about the success or otherwise of management actions when there is an apparent decline in vegetation condition.

## 2.1 Implications for the use of benchmark value for performance assessment

Benchmarks describe the reference state to which sites are compared to assess and score their site-scale biodiversity values (Eyre, Kelly and Neldner, 2017). The Biometric Vegetation Type (BVT) benchmarks used in this report, as provided in the BMP, are fixed values that do not cater for fluctuations due to seasonal climatic events such as persistent drought conditions. Generally, monitoring undertaken from 2017 to 2019 at UCML indicates that native ground cover is the stratum most affected by drought conditions even in remnant (MZ1) vegetation communities. The drought has caused a lowering of cover, abundance and species richness values.

The management intent in the BMP and MOP is that that there is "an upward trend in species diversity and density towards analogue sites within the targeted community" and that annual monitoring is able to demonstrate that this is occurring. However, given that changes in native plant species richness closely parallels variation in rainfall, trying to determine the intrinsic change in native plant species diversity due to drivers other than rainfall is challenging and may require a change in the way data is analysed.

The monitoring of the Voluntary Conservation Agreements starting in autumn 2020 will help to increase data from remnant vegetation communities and provide an improved understanding of the natural variation that occurs in these relatively undisturbed areas. This may allow a change in the way annual data and trend analysis is assessed in the future. As has been demonstrated, attribute values do not follow a neat uniform trend with time as there will be seasonal/temporal variation in environmental conditions that may affect year on year performance. However, if there is some similarity in the way regenerating and analogue/benchmark communities respond to these environmental drivers (such as has been demonstrated for native species richness or exotic cover at Ulan), with sufficient replication, it may be possible to account for these seasonal effects and thus reveal underlying trends. For example, rather than examining the trend of the attribute value from the regenerating site to assess performance (as is done currently), examining the trend in the difference in an attribute value between a MZ1 site and a regenerating site (such as MZ2 or MZ3 sites) can be used to assess trajectories (i.e., by examining the difference between the data values over time, the seasonal effect is minimised). A similar approach can be taken if trend towards a fixed BVT benchmark is the required performance measure. Examining the trend in the difference in proximity of an analogue site value and a regenerating site value to the benchmark value is more informative than examining the trend in the attribute value from the regenerating site alone. The change in approach to data analysis and the improvement in trend analysis that this allows is illustrated in **Figure 5** (not field data).

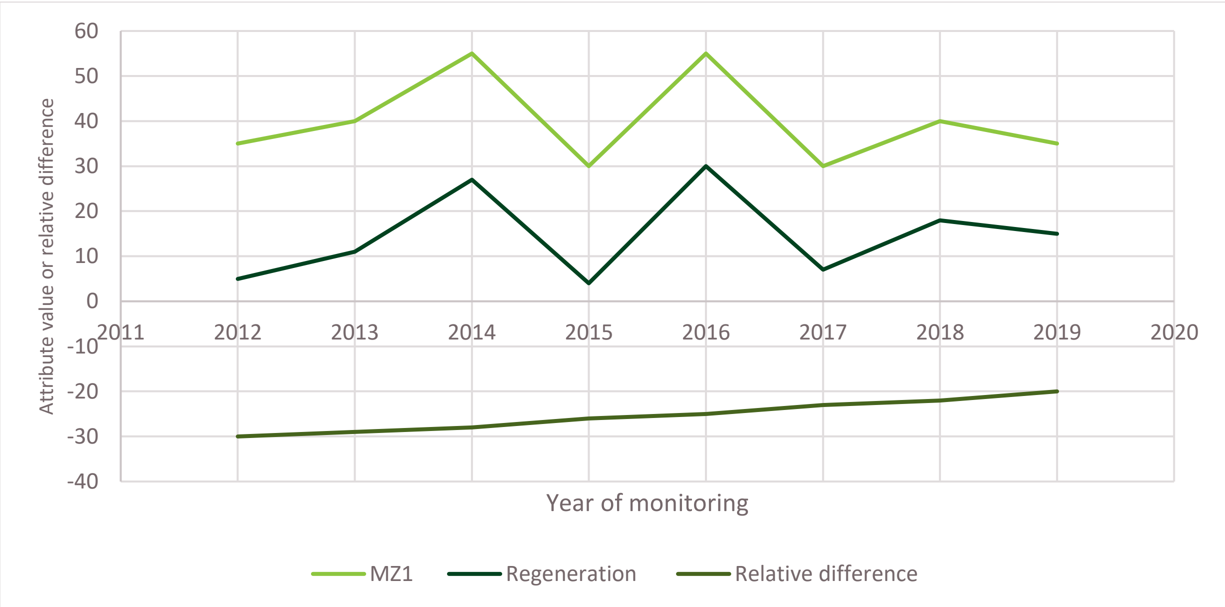


**Figure 5: Hypothetical example of comparing the relative change between benchmark vegetation community in MZ1 and regeneration areas (typically MZ2 and MZ3) for a particular measured attribute.**

# 3. Results and Discussion

Data collected within the floristic sites during 2019 adds to the existing database of over 450 plot surveys undertaken between 2011 and 2019. A full floristic database covering years 2011 – 2019 has been provided electronically. This database is inclusive of both ongoing and discontinued monitoring sites.

## 3.1 Management Zone 1 (Benchmark Vegetation)

MZ1 is comprised of forest or woodland vegetation communities that are relatively intact, in good condition and have high species richness (UCML 2015). MZ1 provides benchmarks for revegetation, regeneration and rehabilitation of all remaining MZs at UCML. BVT benchmarks are not applied as performance criteria for MZ1 sites. However, given the clear effects of rainfall on vegetation condition and on BVT benchmark attribute values, it is illustrative to compare MZ1 site data to BVT benchmarks as this provides context for the outcomes of comparisons made at other MZs and apparent variations in performance over the years. The comparisons against BVT benchmarks also provide an indication of whether the management aims are being achieved.

Objectives for MZ1 are:

- Protection from ongoing impacts
- The protection/improvement of existing flora habitat
- The protection/improvement of existing fauna habitat values
- Control noxious weeds and management to minimize exotic ground cover.

MZ1 does not require revegetation management actions.

### 3.1.1 Monitoring Results and Discussion

Twenty-two (22) monitoring sites located within MZ1 were surveyed in 2019. This is comprised of nine (9) full floristic plots and 13 rapid assessment plots (**Appendix A**). Biometric data for all full floristic sites in MZ1 is presented in **Appendix D,** with rapid assessment data presented in **Appendix B**. Data obtained during 2019 monitoring relating to all attributes (native species diversity, exotic species cover and habitat features) has been averaged across sites within the same vegetation community to show changes in attribute values over the years. Given the fluctuations observed the median of annual results was calculated. This shows whether over the years benchmarks have been met on more than 50% of occasions (i.e., when median exceeds the BVT benchmark this indicates that values more often than not exceed the BVT). The results are discussed with reference to the overarching management aims for MZ1.

In terms of provision of flora habitat:

- Each BVT in MZ1 has more often than not achieved its respective benchmark for native species richness (Table 1)**.** Annual values below BVT benchmarks (particularly across 2013, 2014, 2018 and 2019) correspond to low rainfall years as described in **Section 2.**

In terms of provision of fauna habitat:

- **Table 2** shows that within MZ1, median large woody debris (LWD) within six (6) of the eight (8) BVTs was below the BVT benchmark. Fire history across sites within BVTs HU552 and HU608 may explain why LWD is below benchmark in these communities. These sites show evidence of fire approximately 15 to 20 years ago, with charring still present on adult trees.
- **Table 2** shows two (2) out of eight (8) BVTs met the benchmark for HBTs. At some sites, values below the benchmark likely reflect the fact that much of MZ1 had been subject to logging and clearing prior to the 1960s; and, many areas throughout MZ1 represent old regrowth which has not had enough time to develop the required density of hollows. HBTs can often take more than 100 years to form (Koch et al 2008). However, there are areas within MZ1 with high concentrations of tree hollows (ELA 2015b). This shows the limitations of relying solely on plot data, without reference to broadscale mapping.

In terms of weed/exotic groundcover:

- The exotic ground cover across all monitoring years for each BVT is shown in **Table 3.** Exotic groundcover has shown a noticeable decrease since 2016 which may be attributed to below average rainfall and subsequent dry conditions experienced during the monitoring periods. All BVTs have met the Year 9 Completion Criteria of <15% cover of weeds in each year to date indicating the management aim has been achieved for this attribute.

**Table 1: Average native species richness by year per BVT-MZ1**

| BVT | No. of sites | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median value | BVT Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakely's Red Gum – Yellow Box Grassy open forest | 9 | 35 | 29 | 23 | 23 | 26 | 35 | 47 | 32 | 40 | 32.2 | 32 | 25 |
| HU551: Grey Box – Narrow-leaved Ironbark shrubby woodland | 3 | 36 | 44 | 33 | 36 | 35 | 32 | 36.5 | 21.7 | 23 | 33 | 35 | 35 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 15 | 29 | 27 | 20 | 21 | 23 | 27 | 33 | 16 | NA | 24.5 | 25 | 23 |
| HU574: Narrow-leaved Ironbark – Grey Gum shrubby woodland | 2 | 31 | 30 | 21 | 31 | 35 | 39 | 40 | N/A | NA | 32.4 | 31 | 26 |
| HU575: Narrow-leaved Ironbark shrubby open forest | 3 | 32 | 40 | 21 | 29 | 32 | 33 | 34.5 | N/A | NA | 31.6 | 32 | 29 |
| HU605: Rough-barked Apple grassy open forest | 8 | 41 | 34 | 25 | 24 | 23 | 29 | 32.7 | N/A | 33 | 30.2 | 31 | 29 |
| HU608: Scribbly Gum – Brown Bloodwood woodland | 5 | 48 | 42 | 29 | 30 | 31 | 17 | N/A | N/A | 20 | 31 | 30 | 25 |
| HU654: White Box – Yellow Box grassy woodland | 7 | 31.7 | 40.5 | 23.8 | 24.5 | 28.5 | 32 | 35 | 20 | 21 | 28.6 | 28.5 | 23 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value. 'NA'= not monitored in that year. Only HU552, HU574 or HU575 sites were monitored by full floristic methodology in 2019'

**Table 2:Habitat features per BVT for all years – MZ1**

| BVT | No. of sites | Median LWD) (m) | BVT LWD Benchmark (m) | Median HBT | BVT HBT Benchmark |
|---|---|---|---|---|---|
| HU515: Blakely's Red Gum – Yellow Box Grassy open forest | 9 | 32.5 | 5 | 2 | 1 |
| HU551: Grey Box – Narrow-leaved Ironbark shrubby woodland | 3 | 17 | 5 | 0 | 3 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 15 | 30 | 66 | 2 | 0.8 |
| HU574: Narrow-leaved Ironbark – Grey Gum shrubby woodland | 2 | 18 | 70 | 2 | 3 |
| HU575: Narrow-leaved Ironbark shrubby open forest | 3 | 12.5 | 70 | 0 | 3 |
| HU605: Rough-barked Apple grassy open forest | 8 | 9 | 10 | 0 | 1.5 |
| HU608: Scribbly Gum – Brown Bloodwood woodland | 5 | 15 | 66 | 0 | 0.8 |
| HU654: White Box – Yellow Box grassy woodland | 7 | 22 | 50 | 0 | 2 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value

**Table 3: Averages of exotic species cover (%) by year per BVT – MZ1**

| BVT | No. of sites | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median | MZ Benchmark year 9 (2020) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakely's Red Gum – Yellow Box Grassy open forest | 9 | 3.00 | 3.00 | 0.60 | 0.23 | 0.17 | 1.30 | 0.04 | 0 | 0.04 | 0.93 | 0.23 | <15% |
| HU551: Grey Box – Narrow-leaved Ironbark shrubby woodland | 3 | 0 | 0.10 | 0 | 0.10 | 0 | 1.05 | 0 | 0 | 1 | 0.25 | 0 | <15% |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 15 | 0.36 | 0.25 | 0 | 0.01 | 0 | 0.01 | 0 | 0 | NA | 0.07 | 0 | <15% |
| HU574: Narrow-leaved Ironbark – Grey Gum shrubby woodland | 2 | 0 | 0 | 0 | 0.05 | 0.05 | 0 | 0 | NA | NA | 0.01 | 0 | <15% |
| HU575: Narrow-leaved Ironbark shrubby open forest | 3 | 1.00 | 1.00 | 1.00 | 0.10 | 0.10 | 0 | 0 | NA | NA | 0.36 | 0.1 | <15% |
| HU605: Rough-barked Apple grassy open forest | 8 | 4.40 | 3.00 | 1.00 | 0.50 | 0.04 | 1.20 | 7.00 | NA | 0 | 1.90 | 1 | <15% |
| HU608: Scribbly Gum – Brown Bloodwood woodland | 5 | 0.50 | 0.50 | 0.25 | 0 | 0 | 0 | NA | NA | 0 | 0.14 | 0 | <15% |
| HU654: White Box – Yellow Box grassy woodland | 7 | 7.75 | 6.50 | 3.20 | 2.87 | 2.20 | 2.55 | 2.02 | 0.05 | 0.05 | 3.02 | 2.55 | <15% |

Note: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year

## 3.2 Management Zone 2 (Natural Regeneration)

Sites within MZ2 are comprised of areas of previously cleared land that are expected to naturally regenerate towards vegetation communities that existed prior to the disturbance/clearing. Areas of MZ2 are generally located adjacent to remnant woodland, which acts as a seed source and provides regrowth in the form of juvenile suckers. Areas of natural regeneration already occur within MZ2.

The relevant BVT Biometric benchmark values for each vegetation community are used to assess performance against management aims within MZ2 as per Section 7.9 of the BMP.

Objectives for MZ2 are:

- Protection from ongoing impacts
- Protect and improve existing flora habitat
- Protect and improve existing fauna habitat values, including connectivity
- Control noxious weeds and ensure that exotic plants do not pose a risk to rehabilitation
- Determine the effectiveness of natural regeneration and identify areas of change where targeted plantings or seeding may be required.

### 3.2.1 Monitoring Results and Discussion

Five (5) full floristic sites were monitored in MZ2 during 2019 (Table A-1, **Appendix A**). Biometric data for all full floristic sites in MZ2 is presented in **Appendix D**, with rapid assessment data presented in **Appendix E**. The data from the 2018 monitoring is incorporated with previous years to give an update of long-term trends and current status. The results are discussed with reference to the overarching management aims for MZ2.

In terms of provision of flora habitat:

- Native plant species richness for each BVT monitored in MZ2 is shown in **Table 4** . Averaging native plant species richness over all years each BVT in MZ2 has exceeded benchmark.

In terms of provision of fauna habitat:

- Average and median habitat features for each BVT across year (2011 to 2019) is shown in **Table 5**. The median measures of LWD for all years are below their respective benchmark for all BVTs.

In terms of weed management:

- Exotic groundcover for each BVT monitored in MZ2 is shown in Table 6. Exotic groundcover in HU515 and HU552 has been uniformly low and has already met the 9-year completion criteria for exotic ground cover (<15%) in all years to date. Exotic groundcover has been higher in HU605 and HU654 compared to other MZ2 BVTs. The higher exotic ground cover is likely caused by higher soil fertility within these BVTs. However, over the years, these BVTs have been below the 9-year (2020) completion criteria for exotic ground cover (<15%) in more years than not.

**Table 4: Average native species richness in MZ2 per year per BVT**

| BVT | No. of sites | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median value | BVT Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 1 | NA | NA | NA | NA | 30 | 31 | 38 | NA | 37 | 33 | 33 | 25 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | NA | NA | NA | NA | 26 | 21 | 27 | 23 | NA | 24 | 24 | 23 |
| HU605: Rough-barked Apple grassy open forest | 9 | 24 | 28 | 20 | 20 | 23 | 31 | 27 | 22 | 30 | 25 | 24.5 | 24 |
| HU654: White Box – Yellow Box grassy woodland | 6 | 25 | 27 | 13 | 19 | 22 | 24 | 28 | 18 | 18.5 | 23 | 22.5 | 22 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value. 'NA'= not monitored in that year. (Note: BVT551 MZ2 was not monitored during 2019)

**Table 5: Habitat features overages for each BVT in MZ2 across years (2011 – 2019)**

| BVT | No. of sites | Median value | BVT LWD Benchmark (m) | Median value | BVT HBT Benchmark |
|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 1 | 2.25 | 5 | 0 | 1 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | 0 | 66 | 0 | 0.8 |
| HU605: Rough-barked Apple grassy open forest | 9 | 6 | 10 | 0 | 1.5 |
| HU654: White Box – Yellow Box grassy woodland | 6 | 10 | 50 | 0 | 2 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value.

**Table 6: Exotic species cover (%) for each BVT in MZ2 across years**

| BVT | No. of sites | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median value | MZ2 Benchmark year 9 (2020) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 1 | NA | NA | NA | NA | 1 | 1 | 0 | 0 | 0 | 0.4 | 0 | <15% |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | NA | NA | NA | NA | 1 | 1 | 0 | 0 | NA | 0.5 | 0.5 | <15% |
| HU605: Rough-barked Apple grassy open forest | 9 | 34.3 | 3 | 3 | 11.83 | 4.16 | 7.86 | 12 | 0 | 15.5 | 10.20 | 7.86 | <15% |
| HU654: White Box – Yellow Box grassy woodland | 6 | 30 | 30 | 9 | 5.2 | 11.17 | 4.75 | 12.8 | 1.5 | 6.5 | 12.34 | 9 | <15% |

Note: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year

### 3.2.2 Natural regeneration in MZ2

Field observations indicate that natural regeneration is occurring in the Ulan complex. This observation prompted a broad-scale natural regeneration assessment using historical aerial photographs. In 2017 air photographs from 1964 and 1990 were obtained of the northern parts of the Ulan complex.

By comparing these historical air photographs with 2012 imagery, changes in tree cover were delineated **Figure 6**. This showed that approximately 1,100 ha of previously cleared land now has substantial tree cover. The full extent of natural regeneration is likely to be greater, as analysis using remote sensing makes it difficult to determine the extent of very young trees such as those recorded in natural regeneration transects of the current flora monitoring program.

Since natural regeneration has occurred over previous decades, it is likely that this process is ongoing. Providing conditions that allow for passive natural regeneration is a desired management approach for improving biodiversity outcomes in MZ2.

There are 20 floristic monitoring sites located in six of the seven different BVTs that exhibited natural regeneration between 1964 and 2012. The one BVT that has natural regeneration but does not have a floristic site in that regeneration is HU551 (Grey Box woodland).

Data in **Table 7** shows how sites with advanced regeneration are performing with regards to benchmarks for their respective BVTs set out in the Ulan BMP. Generally advanced natural regeneration sites achieve benchmarks of remnant areas, except for presence of hollow bearing trees (HBT). An exception for achieving benchmark native plant species diversity is the scribbly gum community (HU608), but this a limited to a sample of one site.

In areas with long and intensive agricultural use and deep basalt soils, which comprise part of the area of BVT HU654 White Box – Yellow Box woodland on basalt (i.e. Bobadeen East), there are no mature natural regeneration sites to provide an indication of likely future performance of passive natural regeneration.

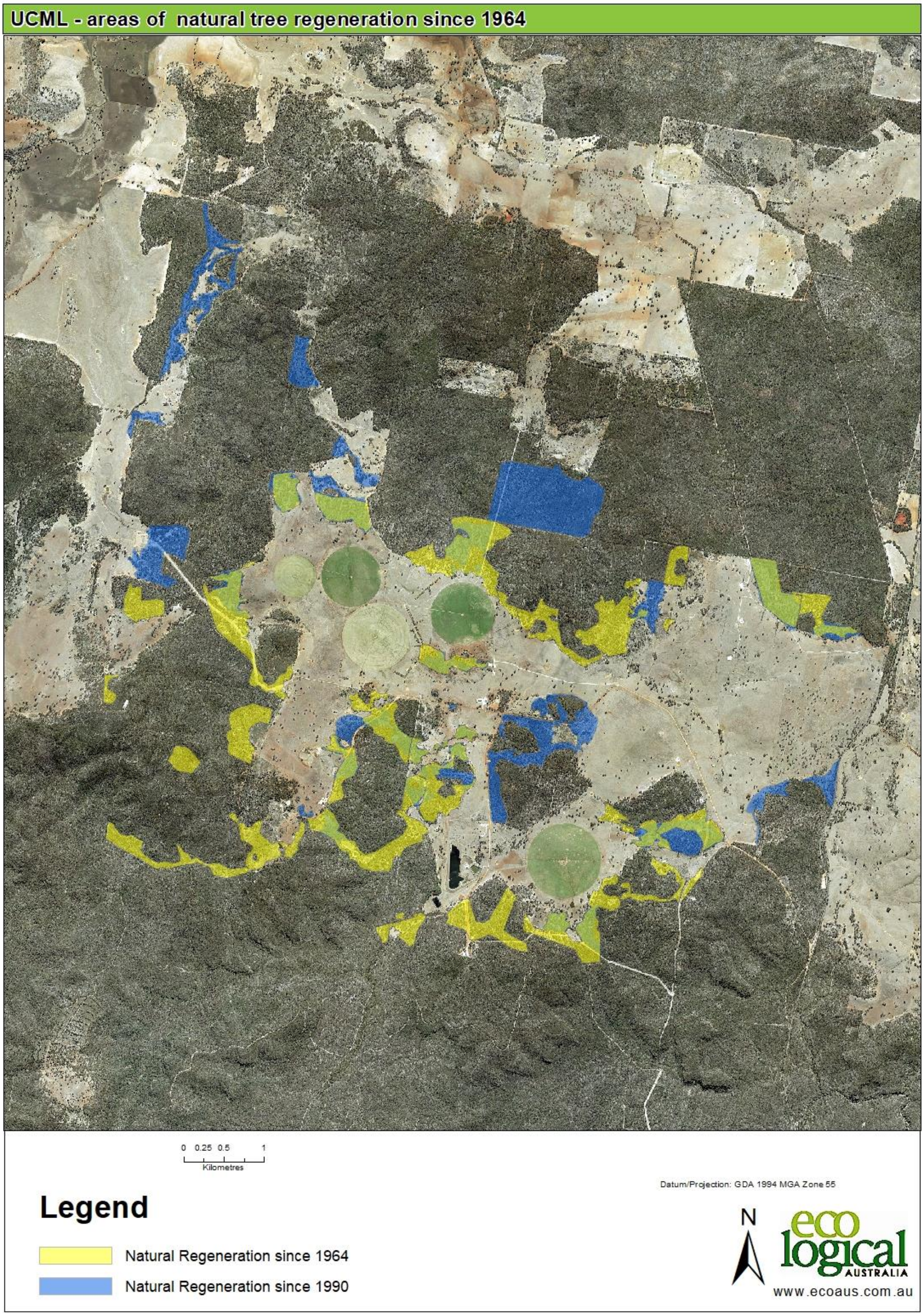


**Figure 6: Extent of areas which were cleared prior to 1990 showing natural regeneration**

**Table 7: Comparison of biometric results of advanced natural regeneration sites versus benchmarks**

| BVT No. | BVT description | No. of sites | Native species number | | | Exotic ground cover % | | Habitat Tree number | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Average for BVT | Benchmark for BVT (BMP) | Benchmark for BVT (OEH) | Average for BVT | Benchmark for year-9 | Average for BVT | Benchmark for BVT (OEH) |
| HU515 | Blakely's Red Gum – Yellow Box Grassy Woodland | 6 | 28 | 25 | 32 | 1.8 | <15 | 0.15 | 1 |
| HU552 | Ironbark Open Forest on sandstone | 2 | 24 | 23 | 25 | 0.3 | <15 | 0 | 0.8 |
| HU575 | Narrow-leaved Ironbark on colluvium | 1 | 32 | 29 | 35 | 0.5 | <15 | 0 | 3 |
| HU605 | Rough-barked Apple on colluvium/alluvium | 5 | 30 | 29 | 31 | 1.2 | <15 | 0.2 | 1.5 |
| HU654 | White Box – Yellow Box woodland on basalt | 5 | 29 | 23 | 23 | 4.3 | <15 | 0.2 | 2 |
| HU608 | Scribbly Gum woodland – heathland on sandstone | 1 | 17 | 25 | 25 | 0 | <15 | 0 | 0.8 |

## 3.3 Management Zone 3 (Assisted Regeneration)

MZ3 is located on land that has been previously cleared and requires management intervention, particularly planting of tubestock and/or direct seeding.

The objectives for MZ3 are:

- Protection from ongoing impacts
- Replanting of vegetation communities comparable to original type
- Protect and improve existing flora habitat
- Protect and improve existing fauna habitat values, including connectivity
- Control noxious weeds and ensure that exotic plants do not pose a risk to rehabilitation.

### 3.3.1 Monitoring Results and Discussion

Monitoring of the tree planting program in MZ3 shows that nearly 220ha has been successfully established with the tree mixes representative of target vegetation communities of either gum-box grassy woodland or ironbark woodland/open forest. This represents a 90% success rate for area planted. The tree planting/direct seeding program has brought very close to fulfilment the tree planting commitment of the BMP.

Three (3) full floristic sites were monitored in MZ3 during 2019 (Table A-1, **Appendix A**). Biometric data for all full floristic sites in MZ3 is presented in **Appendix D**, with rapid assessment data presented in **Appendix B**. The data from the 2019 monitoring is incorporated with previous years to give an update of long-term trends and current status. The results are discussed with reference to the overarching management aims for MZ3.

In terms of provision of flora habitat:

- Native species richness for each BVT in 2019 is shown in **Table 8**. Averaged over the years the majority of BVTs have not yet reached benchmark values for native plant species richness.

In terms of provision of fauna habitat:

- The average across all years for habitat features in each BVT in MZ3 is shown in **Table 9**. All BVTs continue to be below benchmark values for both LWD and HBTs. The LWD and HBTs is present within MZ3 in low densities outside of established monitoring plots. MZ3 is typified by isolated large paddock trees with hollows and may provide LWD in the form of dropped limbs at the base of paddock trees.

In terms of weed management:

- Exotic groundcover for each BVT across the years is shown in **Table 10**. Exotic groundcover has been variable but generally higher in HU515 and HU654 compared to other MZ3 BVTs. Although exotic cover was zero in BVT HU654 in 2019, in more years than not exotic cover in BVTs HU515, HU605 and HU654 have not achieved the 9-year completion criteria of exotic groundcover (<15%). This indicates the management aim has not yet been achieved for this attribute in these BVTs.

**Table 8: Native plant species richness for each BVT in MZ3 averaged across years.**

| BVT | No. of sites | Area (ha) | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median value | BVT Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 7 | 56.9 | 14.5 | 16.5 | 13.3 | 18.25 | 23.3 | 21 | NA | NA | 24 | 18.7 | 18.3 | 25 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | 32.5 | NA | NA | NA | NA | 38 | NA | NA | NA | 19 | 28.5 | 28.5 | 23 |
| HU605: Rough-barked Apple grassy open forest | 2 | 15.4 | 28 | 26 | 20 | 13 | 20 | NA | NA | NA | NA | 21.4 | 20.0 | 29 |
| HU654: White Box – Yellow Box grassy woodland | 9 | 184.2 | 15.3 | 16 | 13.5 | 13.1 | 19.1 | 22.7 | | 27 | 9 | 17.0 | 15.7 | 23 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value.

**Table 9: Habitat features averages for each BVT in MZ3.**

| BVT | No. of sites | Area (ha) | Average LWD (m) | Median value | BVT LWD Benchmark | Average HBT | Median value | BVT HBT Benchmark |
|---|---|---|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 7 | 56.9 | 0 | 0 | 5 | 0 | 0 | 1 |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | 32.5 | 0 | 0 | 66 | 0 | 0 | 0.8 |
| HU605: Rough-barked Apple grassy open forest | 2 | 15.4 | 0 | 0 | 10 | 0 | 0 | 1.5 |
| HU654: White Box – Yellow Box grassy woodland | 9 | 184.2 | 0 | 0 | 50 | 0 | 0 | 2 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value.

**Table 10: Exotic species cover (%) per BVT in MZ3 across years.**

| BVT | No. of sites | Area (ha) | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Median value | MZ3 Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU515: Blakley's Red Gum – Yellow Box Grassy open forest | 7 | 56.9 | 5.5 | 5.5 | 5.75 | 19.25 | 25 | 17 | NA | NA | 30 | 15.5 | 18 | <15% |
| HU552: Grey Gum – Narrow-leaved Stringybark – ironbark woodland | 1 | 32.5 | NA | NA | NA | NA | 5 | NA | NA | NA | 0 | 2.5 | 2.5 | <15% |
| HU605: Rough-barked Apple grassy open forest | 2 | 15.4 | 10 | 10 | 5 | 2 | 2 | NA | NA | NA | NA | 5.8 | 5 | <15% |
| HU654: White Box – Yellow Box grassy woodland | 9 | 184.2 | 61 | 55 | 30 | 10 | 21 | 17 | NA | 16 | 0 | 26.25 | 19 | <15% |

Note: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year.

## 3.4 Management Zone 4a (Salinity Offset Area Regeneration / Revegetation)

MZ4a is located within the Salinity Offset Area (SOA) and has been previously cleared. Part of this area is dedicated to pivot irrigation and grazing, with the rest of the area a grassland habitat with isolated trees.

The overall management aim of MZ4a outside of the pivot irrigation areas is to encourage natural regeneration within cleared areas in combination with continued rotational grazing.

Specific performance criteria related to MZ4a outside the pivot irrigation areas are:

- stable to increasing groundcover with a stable to increasing native plant diversity
- there are no significant noxious weed infestations and weeds do not comprise a significant proportion of the species in any stratum, nor a risk to revegetation
- no significant erosion present
- natural regeneration of the vegetation cover is occurring.

The BVT benchmarks applied to MZ2 and MZ3 do not apply to vegetation status MZ4a. However, the BMP benchmark for year 9 exotic ground cover (<15%) is utilised for assessment.

### 3.4.1 Monitoring Results

#### *3.4.1.1 Floristic Monitoring*

In MZ4a six (6) sites were subject to full floristic monitoring in 2019. Three sites (SOA4, SOA5 and SOA6) within MZ4a underwent both natural regeneration and rapid floristic assessment monitoring during autumn 2019.

Results from full floristic survey and rapid assessment undertaken in MZ4a Salinity Offset Area, averaged across all sites per year is shown in **Table 11.** The results from MZ4a rapid assessment monitoring are provided in **Appendix A** .

Exotic ground cover has achieved the benchmark in all monitoring years except one and has been very low in recent years. The management aim for this attribute is being achieved.

Groundcover will vary with season. It cannot always be increasing and when it has reached a certain level will always fluctuate. Poor performance would be indicated by a steady and progressive decline. Ground cover (including native groundcover, litter, rocks and cryptogam) has decreased over 2018 and 2019 across MZ4a sites. This is attributable with below average rainfall conditions experienced within these years. It is anticipated that ground cover will increase when average annual rainfall is received, and the recent results are not necessarily an indication of site degradation.

As all floristic monitoring sites in MZ4a have been part of the analysis of native plant species trends in MZ2 and MZ3 (refer **Section 2.2** and **2.3**) no separate analysis is undertaken here. The results of those broader assessments can be applied to MZ4a.

**Table 11: Average exotic cover and other cover in MZ4a from 2011-2019**

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Exotic ground cover (%) | 13.7 | 18 | 8.6 | 3.1 | 8.35 | 6.4 | 3.2 | 0.5 | 2.5 | 7.15 | <15% |
| Native groundcover, litter, rocks and cryptogam cover (%) | 79.8 | 74.8 | 88.5 | 90.7 | 74.4 | 76.2 | 73.4 | 68.4 | 55.0 | 75.7 | Stable or increasing |

Note exotic cover: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit.

#### *3.4.1.2 Natural Regeneration Transects*

The natural regeneration transects in MZ4a that were monitored in 2019 are positioned adjacent to remnant woodland in recognition of the observed pattern of natural regeneration across the UCML complex. Natural regeneration monitoring results are shown in **Table 12**, with mapping of regeneration presented in **Appendix C**.

Both natural regeneration transects SOA4 and SOA6 have shown an increase in stems per hectare and species richness since previous monitoring in 2017 with 2019 monitoring recording *Eucalyptus crebra, E. melliodora* and *E. blakelyi* for the first time at SOA4 and *E. fibrosa* for the first time at SOA6. Transect SOA5 recorded less regeneration than previous monitoring with 102 stems of <5 cm DBH per hectare recorded in 2017 and 70 stems of <5cm DBH per hectare recorded in 2019. This anomaly will be checked at the next monitoring event. However, species diversity of regenerating stems at SOA5 increased with *E. melliodora* regeneration recorded for the first time in 2019.

**Table 12: Stem count of endemic canopy species in natural regeneration plots 2016 to 2019**

| Transect | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | <5 cm | 5-15 cm | <5 cm | 5-15 cm | <5 cm | 5-15 cm | <5 cm | 5-15 cm |
| SOA1 | 92 | 4 | | | 162 | 2 | | |
| SOA2 | 60 | 0 | | | 40 | 16 | | |
| SOA3 | 60 | 0 | | | 64 | 2 | | |
| SOA4 | | | 104 | 4 | | | 108 | 15 |
| SOA5 | | | 102 | 0 | | | 70 | 0 |
| SOA6 | | | 16 | 4 | | | 63 | 0 |

The monitoring of natural regeneration transects give an insight to the natural regeneration process at a site, but it does not provide an indication of the spatial extent of natural regeneration occurring within a MZ.

An area in the SOA was examined for changes in area of tree cover over nearly three decades due to natural regeneration. When comparing the extent of cleared land in 1990 with that in 2019 that there has been an increase of 50 ha of treed area in an area of 150 ha of previously cleared land, as shown in **Figure 7**. The extent of tree cover was delineated as the limit of young trees that occur in fringe areas extending out from remnant woodland and isolated trees. Although the quality of the 1990 aerial photography may not have been sufficient to show all small trees, comparison with that flown in 2019 shows there has been a noticeable increase in tree cover both in terms of extent and cover density over this period. The current presence of very small trees in the form of seedlings and saplings indicates that natural regeneration is ongoing in the SOA.

Most importantly this mapping of the natural regeneration front in part of the SOA will provide a baseline against which future changes can be measured. For a more complete assessment of natural regeneration this baseline mapping should be undertaken across the SOA and other relevant areas in the Ulan complex.

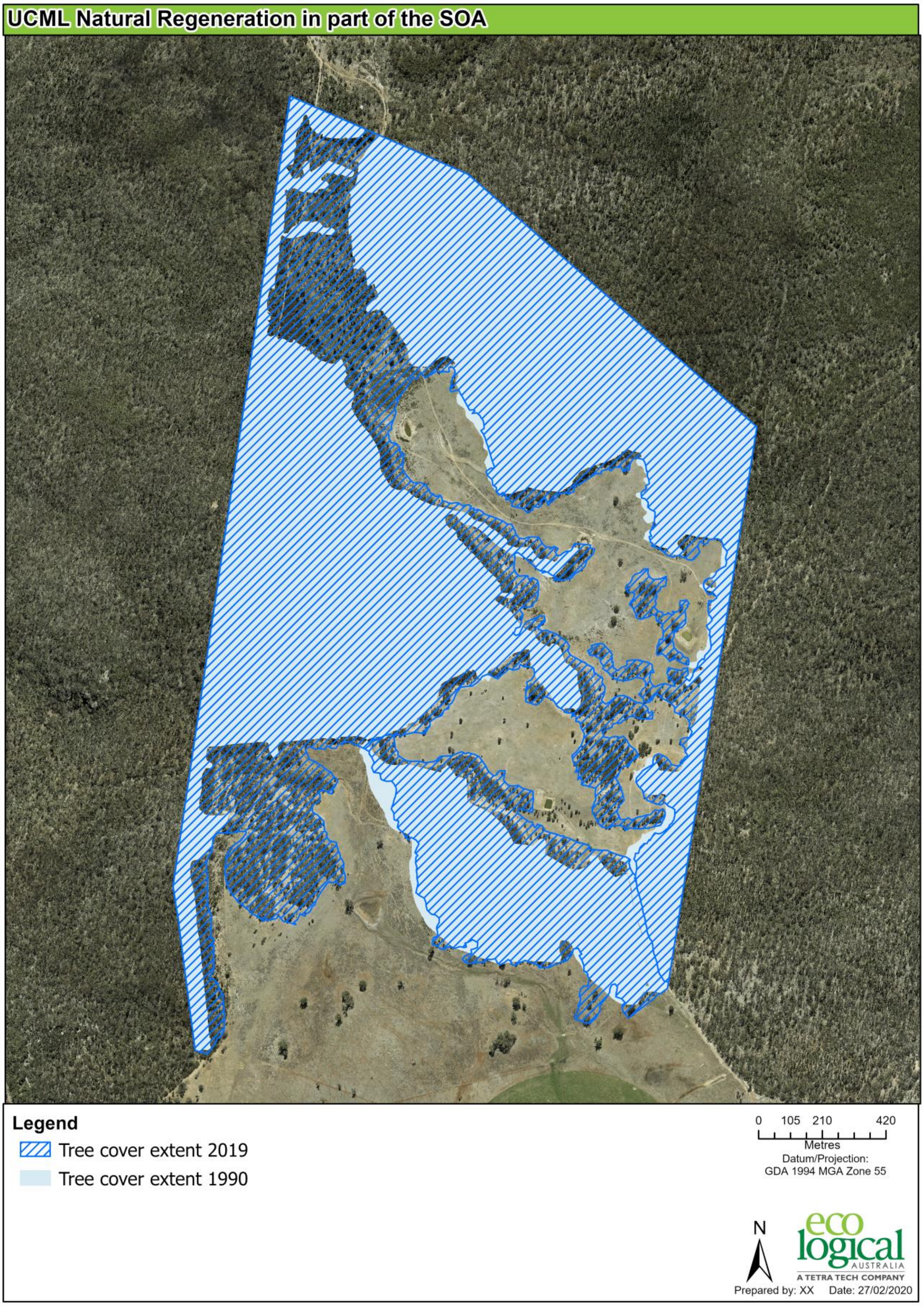


**Figure 7: Extent of tree cover in SOA in 1990 compared to 2019**

## 3.5 Management Zone 4b -SOA Benchmark Vegetation

Benchmark vegetation in the SOA is managed as part of MZ1. As such, this area has been addressed in **Section 3.1**.

## 3.6 Management Zone 5 – Operational Area – Open Cut rehabilitation area

Management actions for this MZ are provided in the Mining Operations Plan (MOP; UCML 2017). The primary objective for MZ5 is to create a stable landform with a landscape capable of self-sustaining native vegetation communities characteristic of the pre-mining compositions.

The MOP also provides Completion / Success Criteria for the Open Cut rehabilitation area (UCML MOP, Appendix B). Relevant criteria which apply to the floristic monitoring program are as follows:

- Erosion: monitoring verifies there are no gully or erosion features, or rills >20 mm deep that are active and that pose a risk to the final land use.
- Vegetation density: the density of shrubs and trees is comparable to that of analogue sites.
- Ecosystem structure: native rehabilitation areas provide a range of structural features (e.g. trees, shrubs, ground cover, developing leaf litter etc.).
- Ecosystem composition: revegetation areas contain a range of flora species consistent with the seed mix planted and flora assemblages characteristic of the surrounding ecosystems.
- Reproduction: rehabilitation monitoring verifies second generation tree seedlings area present or likely to be, based on comparable older rehabilitation sites.
- Weed presence: weed presence does not pose a risk to the establishment of the revegetation area. Records indicate that noxious weeds are controlled in accordance with legislation.
- Presence of native fauna and a range of fauna habitats: monitoring confirms a range of fauna species are recorded utilizing rehabilitation areas and a range of fauna habitat is available.
- Pest animal density: pest animal presence does not pose a risk to the establishment of the rehabilitation area.

### 3.6.1 Monitoring Results and Discussion

Eight (8) MZ5 sites underwent floristic monitoring, landform stability and habitat value assessments during 2019. These sites were:

- Four (4) previously established sites; OC4B, OC3a, OC5B, OC8a
- Four (4) sites established in 2019; OC7A, OC7B, OC2B and OC11A.

Additionally, site OC6B underwent rapid assessment monitoring in 2019.

Erosion assessments were undertaken with minor sheet erosion present at all sites. However, all sites remain stable except for OC11A in Domain 11 which recorded sheet erosion across the entire length of the transect. Site OC11A was established during autumn 2019 after the area underwent rehabilitation in December 2018. No topsoil was applied during the preparation of this area for rehabilitation. The site currently has very low vegetative or litter groundcover to provide protection against erosional forces.

Biometric data for all full floristic sites in MZ5 is presented in **Appendix D,** whilst rapid assessment data is presented in **Appendix B**. The data from the 2019 monitoring was collated with that from previous years to give an update of long-term trends and current status.

Many areas currently monitored (Secondary Domain B as defined by the MOP) achieve the completion criteria of a woodland. However, in other areas the density of stems means many of the rehabilitation areas would currently be classified as open forest. If a woodland structure is desired, stem thinning will be required.

In these woodland and open forest areas the mix of species is not reflective of any particular BVT. However, of the native plant species present, 95% are native to the Kerrabee IBRA sub-region in which the Ulan open cut mine is located.

Average native species richness for all sites each year is presented in **Table 13**. There is no benchmark requirement for woodland in MZ5, however the use of BVT benchmarks provide guidance for assessing rehabilitation progress with respect to ecosystems composition. Two locally common BVTs (HU574 and HU551) which have been chosen as target communities for future rehabilitation have been selected for use as the benchmarks. The average of all years (28.4 native species) exceeds the native species richness benchmark for HU574 Narrow-leaved Ironbark – Grey Gum shrubby woodland (26 native species) and is under the native species benchmark for HU551 Grey Box – Narrow-leaved Ironbark shrubby woodland of (35 native species). Average native species richness has fallen within this range in all years since 2015 with the exception of 2018.

**Table 13: Average native species richness for all sites in each year for MZ5**

| Vegetation type | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | No of sites |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Woodland Formation | 37 | 34 | 25 | 22 | 27 | 27 | 32 | 20 | 31 | 28 | 19 |

Appendix B of the MOP (UCML 2017) details the following completion criteria for vegetation density which is to be assessed from 5 years post rehabilitation establishment.

*The density of shrubs and trees is within the range gauged at analogue Woodland sites.*

Stem counts in the BioMetric plot are made within a 400 $m^2$ plot which is smaller than the tree count plot size now used as standard in NSW (OEH 2017) and Queensland (Kelly and Ayres 2006) of 1000 $m^2$ and 5000 $m^2$ respectively. As such the data for stem density of canopy and shrub species counts undertaken in BioMetric plot in MZ5 needs to be used with caution when comparing it to analogue-condition native woodland. A recently instituted open cut rehabilitation wide mapping exercise, which includes measurement of stem density, will provide a more detailed assessment of this attribute.

McIntrye (2002) suggests a stem density for woodland sites of 30 mature stems per ha. All except one site measured in 2019 are near or above this score. The exception is site OC11 which was only a year old at the time of survey. As demonstrated in **Table 14**, canopy stem density is variable across monitoring sites. These scores correlate with field observations which indicate that overall canopy species have established successfully, but in varying densities. A few areas contain low numbers of canopy trees, whilst others would be regarded as having very high stem density relative to local native woodland and open forest areas.

**Table 14: 2019 MZ5 monitoring sites canopy and shrub stems per hectare**

| Site | Canopy stems / ha | Shrub stems / ha |
|---|---|---|
| OC4B | 25 | 25 |
| OC3A | 50 | 100 |
| OC5B | 125 | 25 |
| OC8A | 25 | 200 |
| OC7A | 50 | 100 |
| OC7B | 100 | 75 |
| OC2B | 25 | 125 |
| OC11A | 0 | 75 |

Exotic ground cover results for sites across MZ5 since 2011 are shown in Table 15. There is no quantitative benchmark for exotic ground cover for MZ5; however, the benchmark value for MZ2 and MZ3 sites at Year 9 (<15%) has been used. The average cover of exotic species across sites during monitoring in 2019 was the lowest since monitoring began. This is likely a result of climatic conditions unfavourable to the germination and persistence of many commonly recorded exotic species previously present across MZ5. It is likely that, should climatic conditions become more favourable exotic species cover may increase due to the presence of exotic species in the seed bank. No listed weeds (Central Tablelands LLS, 2017) were recorded in 2019 and only isolated occurrences identified have been identified in previous years. Weed presence does not pose a risk to being able to implement rehabilitation measures in MZ5.

**Table 15: Exotic ground cover (%) for sites across MZ5**

| BVT | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | Benchmark Year 9 (2020) | No of sites |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Woodland Formation / Class VI | 15.4 | 17.4 | 10.4 | 5.29 | 3.29 | 7.18 | 6.38 | 6.6 | 0.8 | 8.1 | <15% | 19 |

Note exotic cover: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year.

Habitat features for MZ5 monitoring sites is shown in **Table 16**. LWD and HBTs remain below benchmark across MZ5; however, the average from 2011 to 2019 is the highest average recorded to date for LWD. This indicates that LWD is developing within MZ5 and is likely to continue to do so into the future as branch falls increase as trees mature and tall *Acacia* spp. senescence (particularly *Acacia doratoxylon* and *A. linearifolia*). The density of HBTs is low as hollows can often take more than 100 years to form (Koch *et al* 2008). Nest boxes have been installed within MZ5 to provide additional habitat for hollow utilising species.

**Table 16: Habitat features averages of all sites across years for MZ5**

| Vegetation community | Average LWD (m) | Median value | LWD Benchmark (m) | Average HBTs | Median value | HBT Benchmark | No. of sites |
|---|---|---|---|---|---|---|---|
| Woodland Formation / Class VI | 1.1 | 0 | 5 | 0 | 0 | 3 | 19 |

Note: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value. 'NA'= not monitored in that year.

Habitat assessments were undertaken throughout MZ5 monitoring sites, with the results presented in **Table 17**. OC2B was the best performing site, with four (4) out of nine (9) habitat assessment criteria met. Three (3) sites; OC4B, OC5B and OC8A met only one habitat assessment criteria (flowering shrubs and trees). The results are characterised by a distinct lack of HBTs in all sizes and surface water proximal to the monitoring site.

As the rehabilitation matures, it is expected that habitat features will increase.

A relatively good range of fauna types are using the rehabilitation areas in MZ5, even though flora monitoring plots score poorly for several habitat features. The expanded fauna monitoring program for MZ5 which will undertake detailed fauna counts and habitat assessments is the appropriate source of information for management actions going forward. Management intervention may involve further habitat augmentation to improve the amount of large woody debris, bush rock / outcropping rock and hollows.

**Table 17: Habitat assessment results 2018 and 2019**

| Site | Year | Large-woody debris (LWD) | Small HBTs (microbat /glider) | Medium HBTs (woodland birds) | Large HBTs (owls) | Koala feed trees | Diverse vegetation structure | Bush rock / outcropping rock | Flowering shrubs / trees | Surface water |
|---|---|---|---|---|---|---|---|---|---|---|
| OC2B | 2019 | Yes | Yes | No | No | No | Yes | No | Yes | No |
| OC3A | | Yes | No | No | No | No | No | No | No | No |
| OC4B | | No | No | No | No | No | No | No | Yes | No |
| OC5B | | No | No | No | No | No | No | Yes | Yes | No |
| OC6B | | No | No | No | No | No | No | No | Yes | No |
| OC7A | | No | No | No | No | No | No | No | No | No |
| OC7B | | No | No | No | No | No | No | No | No | No |
| OC8A | | No | No | No | No | No | No | Yes | No | No |
| OC11B | | No | No | No | No | No | No | No | No | No |
| OC3C | 2018 | No | No | No | No | No | No | No | No | No |
| OC4A | | No | No | No | No | Yes | No | Yes | Yes | Yes |
| OC4C | | No | No | No | No | Yes | No | No | Yes | No |
| OC5A | | No | No | No | No | Yes | Yes | No | No | No |
| OC6A | | No | No | No | No | Yes | Yes | No | Yes | No |
| **Total sites with features** | | **2** | **1** | **0** | **0** | **4** | **3** | **2** | **7** | **1** |

## 3.7 Management Zone 6 – Agricultural Leasehold Land

MZ6 are areas within the UCML complex which are used for cattle grazing. The key management goal within MZ6 is to control weeds and feral animals.

### 3.7.1 Monitoring results

No MZ6 sites were monitored during 2019 and no monitoring has been undertaken since 2016.

Exotic ground cover for MZ6 up to 2016, averaged across all sites is shown in **Table 18**. Results indicate an average exotic ground cover across all years of 8.25%, with year to year exotic ground cover fluctuating. There is no quantitative benchmark for exotic ground cover for MZ6; however, the benchmark value for MZ2 and MZ3 of <15% at Year-9 (2020) has been used, and MZ6 is within the limit.

**Table 18: Exotic ground cover for MZ6 BVT across all years**

| BVT | No. of sites | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Average | BVT Benchmark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HU654: White Box – Yellow Box grassy woodland | 2 | 5 | 3 | 4 | 14 | 3 | 20.3 | NA | NA | NA | 8.25 | <15% |

Note: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year

## 3.8 *Acacia ausfeldii* monitoring

*Acacia ausfeldii* is a threatened species listed as vulnerable under the NSW BC Act and is known to occur in the Mudgee – Gulgong region, including within the UCML complex. UCML is required to undertake a number of activities to ensure the survival of the species, including:

- Translocation of the species from areas disturbed by mining activities to the Open Cut rehabilitation areas
- Protection of the species in its natural occurrence at the Highett Road property
- The trialling of direct seeding the species within Open Cut rehabilitation areas.

Performance criteria for areas of translocation requires the establishment of 150 individual stems, or a minimum of 1 stem for every 5 $m^2$. This performance criterion was deemed to have been met following the completion of monitoring in 2016 and as such, monitoring of translocation sites AA1 and AA2 has been discontinued. *A. ausfeldii* has been established successfully by seed on the rehabilitation area (MZ5). This is monitored through annual walkovers, and the extent will be mapped in early 2020.

Two *A. ausfeldii* habitat monitoring sites located within the Highett Road property (ACQ1 and ACQ2) and part of MZ1 were surveyed during 2019. Methodology for this monitoring is found in **Appendix A6.**

### 3.8.1 Monitoring results

Two habitat condition monitoring plots ACQ1 and ACQ2 at Highett Road underwent full floristic and disturbance monitoring during spring 2019. Additionally, the condition rating of 100 tagged *A. ausfeldii* in the same general area was undertaken in conjunction with a search for recruitment of *A. ausfeldii.*

Average native species richness and exotic ground cover for both sites across all years is shown in **Table 19**. There were no signs of disturbance and the variation in native species richness is consistent with variation throughout MZ1 described in **Section 2**. There is no evidence of significant disturbance although, as acknowledged in the BMP, disturbance (e.g., fire) is needed to prevent the decline of the *A. ausfeldii* population at Highett Road.

**Table 19: *Acacia ausfeldii* monitoring plots average native species richness and exotic ground cover across all years**

| | No. of sites | 2011 | 2014 | 2016 | 2017 | 2019 | Average | Benchmark |
|---|---|---|---|---|---|---|---|---|
| Native species richness | 2 | 40.5 | 31.5 | 38 | 32 | 16.5 | 31.7 | 29 |
| Exotic ground cover | 2 | 0 | 0 | 0 | 0 | 0 | 0 | <15% |

Note native species: Red (low) = 0 = 30% of benchmark value, Orange (moderate) = 31 – 99% of benchmark value, Green (good) = ≥100% of benchmark value. 'NA'= not monitored in that year.

Note exotic cover measures: Red = >20% above benchmark limit. Orange = <20% above benchmark limit, Green = below benchmark limit. 'NA'= not monitored in that year

The condition rating across the duration of monitoring of the 100 tagged *A. ausfeldii* individuals within the Highett Road property is displayed below in Figure 8**.** The results indicate an ongoing senescence of *A. ausfeldii*, with half the tagged population having died between monitoring in 2011 and 2019. This is consistent with the pattern of natural senescence of *A. ausfeldii.* The assessment of tagged trees does not provide an indication of overall survival of this species within the Highett Road property. Populations will be expected to fluctuate. This species is likely to have a dormant soil seedbank which germinates in response to fire. The literature indicates that strong germination of *A. ausfeldii* seeds occurs at temperature treatments of 100ºC (Brown, Enright & Miller 2008, OEH 2013). As other conditions at the site remain favourable (threatening processes controlled), it is anticipated that long-term monitoring will yield results which demonstrate this response. Should a fire go through the monitoring area, germination would be expected increase dramatically. The BMP seeks that the seedbank of *A. ausfeldii* be maintained. A soil seedbank germination trial needs to be conducted to check status.

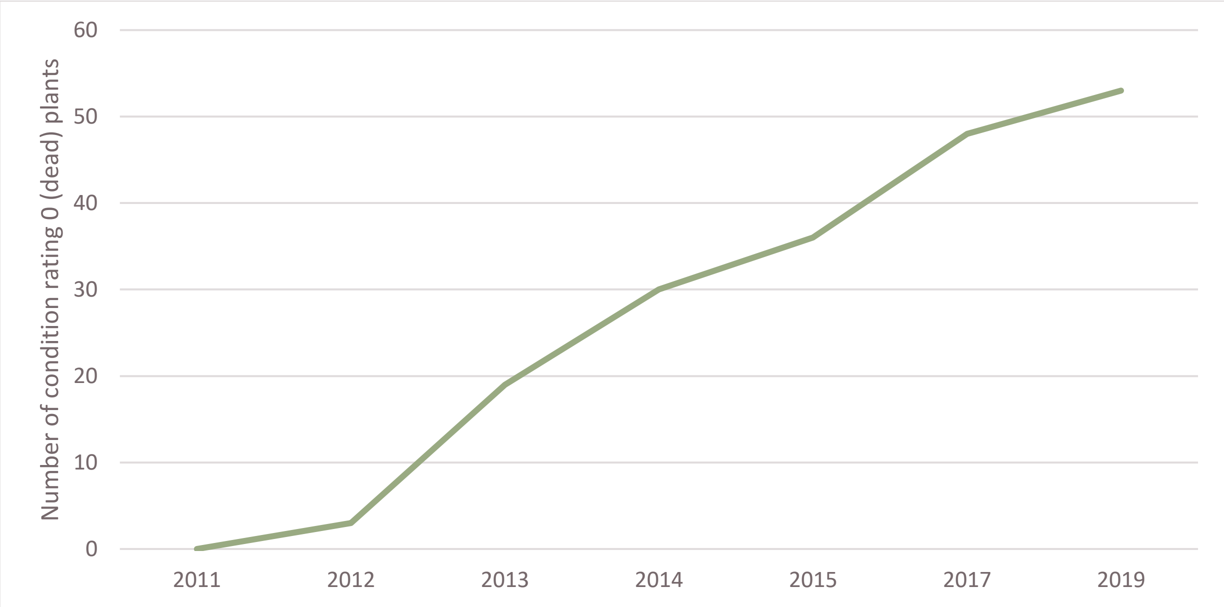


**Figure 8: Change in number of tagged *Acacia ausfeldii* with condition rating 0 (dead) within the Highett Road property, 2011 to 2019**

## 3.9 Floristic based subsidence monitoring

The biodiversity performance criterion for subsidence from underground mining requires that mining operations to have a negligible impact upon threatened species, populations, habitat or ecological communities. Condition 24 of the UCML Project Approval (08_0184) states that "*The proponent shall ensure that the project does not cause any exceedances of the performance measures*". The following performance criteria from the Extraction and Subsidence BMP (UCML 2019) are used for assessing potential subsidence impacts:

- >10% negative movement (ie. 15% to 5% PFC) in vegetation cover and abundance over two or more monitoring periods outside of normal seasonal fluctuation; or
- >10% negative change in vegetation between the White Box Woodland communities located above LW1 and LW2 and analogue vegetation sites.

A new floristic-based subsidence (FBS) monitoring method was introduced during autumn 2017 for all sites established after that date, replacing the previously utilised BioMetric methodology. This new methodology focuses on canopy health and visual assessments to provide a more targeted assessment of potential subsidence impacts. A further description of the methodology is detailed in **Appendix A**.

Consistent with previous years, sites established before autumn 2017 were monitored in 2019 using the Biometric methodology of data collection to enable direct comparisons to be made with previous assessments.

Twenty (20) new FBS sites located at longwall panels UW LW6 and UG LWW6 were established in autumn 2019. A total of 40 previously established sites along UW LW4, UG LWW4, UW LW5 and UG LWW5 also underwent monitoring in 2019. The sites are monitored twice yearly in both spring and autumn.

### 3.9.1 Canopy health FBS results

Sites UW LW6 L1-10 and UG LWW6 L1-10 were established and underwent baseline monitoring during spring 2019. Baseline monitoring results for UW LW6 and UG LWW6 are provided in **Appendix F.** Consistent results were recorded across UW LW6 sites L1-10. Similarly, UG LWW6 recorded consistent results across sites L1-10. These areas have not been undermined and the data will be used to provide baseline vegetation condition. Spring 2019 was the second year of monitoring for longwall UW LW5 L1-L10. The results for UW LW5 L1-10 to date are provided in **Appendix F**.

For sites with three or more years of data, trends between longwall and transition sites have been compared. Full monitoring results are provided in **Appendix F.** Average projected foliage cover (PFC) results for the duration of monitoring for UW LW4, UG LWW4 and UG LWW5 are shown in **Table 20**. The results indicate that percentage change in PFC across all monitoring locations is reasonably consistent between longwall and transition sites for the duration of monitoring. Both decreases and to a lesser extent increases in PFC have been recorded. The dominance of a decrease in PFC across both longwall and transition sites may be associated within ongoing drought conditions resulting in dieback in the canopy and, to some extent, observer variation between monitoring periods. Therefore, it cannot be determined that subsidence is impacting upon the vegetation on UW LW4, UG LWW4 and UG LWW5; however, no longwalls recorded a 10% or greater negative move in PFC for the duration of monitoring.

UW LW4 will undergo the final round of monitoring in spring 2020, with UG LWW4 and UG LWW5 completing the final round of monitoring in autumn 2021, as per the methodology outlined in the BMP (UCML 2019).

**Table 20: UW LW4, UG LWW4 and UG LWW5 average PFC for longwall compared to transition**

| Site | Season | Year | Longwall | | Transition | |
|---|---|---|---|---|---|---|
| | | | Average PFC% | absolute % change 2017 to 2019 | Average PFC% | absolute % change 2017 to 2019 |
| UW LW4 | Spring | 2017 | 16 | | 19 | |
| | | 2018 | 17 | | 17 | |
| | | 2019 | 14 | -2% | 17 | -2% |
| | Autumn | 2017 | 16 | | 19 | |
| | | 2018 | 14 | | 17 | |
| | | 2019 | 17 | 1% | 18 | -1% |
| UG LWW4 | Spring | 2017 | 17 | | 14 | |
| | | 2018 | 20 | | 15 | |
| | | 2019 | 20 | 3% | 17 | 3% |
| | Autumn | 2017 | - | | - | |
| | | 2018 | 20 | | 16 | |
| | | 2019 | 15 | -5% | 14 | -2% |
| UG LWW5 | Spring | 2017 | 24 | | 19 | |
| | | 2018 | 20 | | 17 | |
| | | 2019 | 23 | -1% | 20 | 1% |
| | Autumn | 2017 | - | | - | |
| | | 2018 | 24 | | 20 | |
| | | 2019 | 20 | -4% | 17 | -3% |

### 3.9.2 Biometric FBS results

Biometric FBS monitoring of native species richness results for all sites across all years is provided in **Table 21**. There is no consistent decline in native species richness that indicates an adverse effect of subsidence. Rainfall was likely the most dominant influence on the results of native plant species richness, as described in **Section 2.**

Crown dieback would indicate an adverse impact of subsidence which manifests as reduced canopy cover. The percentage canopy cover of native species is variable across years for all the sites, as shown in **Table 22**. There is no clear trend showing canopy decline over-time that would indicate an adverse impact of subsidence on tree health.

**Table 21: Native species richness results for Biometric FBS monitoring sites across all years**

| Site | Longwall | Year undermined | 2011 | | 2012 | 2013 | 2014 | | 2015 | 2016 | | 2017 | 2018 | | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Spr | Spr | Spr | Spr | **Spr** | Aut | Spr | Aut | Spr | Aut | Spr | Aut | Spr |
| BOB13B | UG LWW3 | 2017 | | | | 26 | 34 | 34 | 37 | 37 | 32 | 28 | 22 | 35 | 17 |
| FBS10 | UG LW30 | - | | | | | | 17 | | | | | | 18 | |
| FBS11 | UW LW4 | 2017 | | | | | | 25 | 25 | 30 | | | | | |
| FBS5 | UW LW1 | 2014 | | | 18 | 25 | 36 | 30 | 33 | 32 | 30 | | | | |
| FBS6 | UW LW6 | 2015 | | | | 20 | 33 | 29 | 31 | 25 | 29 | 20 | | | |
| FBS8 | UG LW29 | 2015 | | | | 27 | 28 | 32 | 25 | 32 | 35 | 27 | | | |
| FBS9 | UW LW3 | 2016 | | | | | 48 | 34 | 38 | 44 | 44 | 34 | 31 | 46 | |
| RPA12 | UG LW29 | 2013 | 39 | 37 | 23 | 25 | 26 | 26 | 21 | 29 | | | | | |
| Annual rainfall (May-April) (mm) | | | 925 | | 779 | 549 | 508 | | 692 | 642 | | 765 | 443 | | 525 |

Note: Spr = spring; Aut = autumn

**Table 22: Native canopy species cover results for Biometric FBS monitoring sites across all years**

| Site | Longwall | Year undermined | 2011 | | 2012 | 2013 | | 2014 | 2015 | 2016 | | 2017 | 2018 | | 2019 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Spr | Spr | Spr | Spr | Spr | Aut | Spr | Aut | Spr | Aut | Spr | Aut | Spr |
| BOB13B | UG LWW3 | 2017 | | | | 15 | 12 | 31 | 20 | 21.5 | 19 | 15.5 | 22 | 10 | |
| FBS10 | UG LW30 | - | | | 20 | 20 | 15 | 9.1 | 8 | 9 | 13 | | | 26 | |
| FBS11 | UW LW4 | 2017 | | | | | | 29 | 22 | 23.7 | | | | | |
| FBS5 | UW LW1 | 2014 | | | 20 | 20 | 15 | 9.1 | 8 | 9 | 13 | | | | |
| FBS6 | UW LW6 | 2015 | | | | 20 | 15 | 6.1 | 7 | 5 | 8.5 | 5 | | | |
| FBS8 | UG LW29 | 2015 | | | | 20 | 15 | 6 | 28 | 12.3 | 11 | 9.5 | | | |
| FBS9 | UW LW3 | 2016 | | | | | 25 | 12 | 14 | 8.5 | 12.5 | 12 | 15 | 17.5 | |
| RPA12 | UG LW29 | 2013 | 1 | 1 | 1 | 5 | 5 | 0.2 | 1 | 2.5 | | | | | |
| Annual rainfall (May-April) (mm) | | | 925 | | 779 | 549 | | 508 | 692 | 642 | | 765 | 443 | | 525 |

Note: Spr = spring; Aut = autumn

## 3.10 Weeds and other disturbances

A map displaying the location of all weeds and other disturbances recorded during monitoring in 2019 is provided in **Appendix G**.

One species, *Hypericum perforatum* (St. John's Wort), which is listed as a regional priority weed in the Central Tablelands (Central Tablelands Local Land Service 2017) was recorded during monitoring in 2019. Additionally, three species listed as weeds of community concern, *Heliotropium amplexicaule* (Blue Heliotrope), *Opuntia stricta* (Prickly Pear) and *Xanthium spinosum* (Bathurst Burr), were also recorded.

St John's Wort is the most common and widespread declared weed present within the UCML complex and was recorded within nine monitoring sites with very low cover compared to previous years. All other declared weed species were recorded in isolated occurrences and in relatively low abundance.

Literature indicates that St John's Wort can be outcompeted by both pasture and shade (Parsons and Cutherbertson, 2001). It would be worthwhile assessing whether tree planting/natural regeneration is helping reduce the occurrence/cover of St John's Wort. Similar observations should be made for other exotic species.

Numerous opportunistic sightings and signs of the declared pest *Sus scrofa* (Feral Pig) were recorded during 2019 flora monitoring (see **Appendix G**). Targeted feral animal monitoring was undertaken during 2019 as part of the UCML fauna monitoring program, the results of which are detailed in the 2019 Annual fauna monitoring report (ELA 2020).

# 4. Summary and assessment of performance criteria

The UCML BMP provides a set of performance criteria to be achieved for the management of biodiversity within the UCML complex. These have been discussed within previous sections, however, the following section provides a specific summary of progress against each of the performance criteria for all MZs. A Trigger Action Response Plan has been developed and is presented below in Table 23. The assessment or each MZ is give in Table 24 to Table 30.

**Table 23: Trigger Action Response Plan (TARP) for Management Zone performance criteria**

| Colour | Definition |
|---|---|
| Green | Trend positive, or performance criteria achieved. |
| Amber | Some adaption of management maybe needed, or too early to make a judgement. |
| Red | Management intervention is required. |

**Table 24: MZ1 and MZ4b performance criteria**

| Management Zone 1 and MZ4b<br>Benchmark Vegetation | Performance Criteria/Management Aim - | Assessment against Criteria |
|---|---|---|
| Erosion | Protect from on-going impacts (BMP, p42) | No significant erosion observed |
| Weeds | Monitor changes in weeds (BMP, p42) | Weeds as defined by Central Tablelands LLS (2018) at low levels (exotic groundcover is <3%) and can be treated by spot spraying. |
| Feral animals | Monitor changes in feral animals and control as appropriate (BMP, p42) | Presence of feral animals recorded within MZ1 and MZ4b.<br>Addressed within the 2019 annual fauna monitoring report (ELA 2020). |

**Table 25: MZ2 performance criteria**

| Management Zone 2<br>Natural Regeneration | Performance Criteria/Management Aim - | Assessment Against Criteria |
|---|---|---|
| Natural Regeneration | Monitor that natural regeneration is occurring (UCML MOP, p97). Determine where targeted plantings may be required, change these areas to MZ3, (UCML BMP, p43) | Natural regeneration is occurring particularly at the fringes of existing woodland/open forest areas, and some isolated paddock trees. System of mapping natural regeneration has been developed. Baseline data being collected. |
| | | Analysis still needs to be undertaken of which areas show no likelihood of naturally regenerating. |

| Management Zone 2<br>Natural Regeneration | Performance Criteria/Management Aim - | Assessment Against Criteria |
|---|---|---|
| Floristic diversity | Monitoring indicates upward trend in species diversity and density towards analogue sites within the targeted community. (MOP, p97) By YR15 (2025) benchmark condition to be achieved (BMP, p70). | Benchmark native plant species diversity achieved. |
| Habitat | A range of fauna habitat is available (MOP, p97) | Below benchmark scores on fauna habitat features (LWS and HBTs). However, a wide range of native fauna utilizes the area. Fauna surveys in MZ2 starting Spring 2020 will help measure fauna value of area. |
| Erosion | Visual monitoring indicates that there is no erosion present that compromises land capability or the intended final land use (MOP, p97) | Minor erosion not sufficient to compromise land capability or the intended final land use. |
| Weeds | Reduced presence of weeds (BMP, p67) Weed presence does not pose a risk to the establishment of the rehabilitation area. (MOP, p97) | St John's Wort is common in open areas, varying with season. No MZ wide measure of changes in St John's Wort affected areas. Most other listed weed populations isolated and can be controlled by spot spraying. |
| | | Exotic plant presence is concentrated in more fertile areas, with a cover approaching but not exceeding the Year 9 benchmark limit of 15%.<br>No evidence exotic cover is inhibiting rehabilitation. |
| Feral animals | Pest animal presence does not pose a risk to the establishment of rehabilitation areas (MOP, p97) | No significant presence of vertebrate pests identified that are posing risk to establishment of rehabilitation areas. |
| | Long term stable or downward trend in pest animal population size. (MOP, p97) | Not assessed in this Flora Report. See 2019 annual fauna report (ELA 2020). |

**Table 26: MZ3 performance criteria**

| Management Zone 3<br>Revegetation | Performance Criteria/Management Aim - | Comment |
|---|---|---|
| Natural Regeneration | Monitoring to indicate upward trend in species diversity and density towards analogue sites within the targeted vegetation community (MOP, p97) | MZ3 is focussed towards revegetation by plantings. Natural regeneration is occurring sporadically near woodland edges. Baseline mapping of natural regeneration warranted. |
| Revegetation | Species diversity and density to be re representative of analogue sites within the targeted vegetation community (MOP, p97) | Canopy species types and current stem density of plantings sufficient to form target vegetation communities, which are dominated by White Box Grassy Woodland. |
| Floristic diversity | Monitoring indicates upward trend in species diversity and density towards analogue sites within the targeted community. (MOP, p97) By | Native plant species richness generally below benchmark. |

| Management Zone 3 Revegetation | Performance Criteria/Management Aim - | Comment |
|---|---|---|
| | YR15 (2025) benchmark condition to be achieved (BMP, p70). | At this stage, native species richness trend to analogue not discernible. Increased data set available with Voluntary Conservation Agreement monitoring will assist insight. |
| Habitat | A range of fauna habitat is available (MOP, p97) | MZ3 falls below benchmarks for fauna habitat features. Fauna surveys commencing in Spring 2020 will give better data for recommending habitat improvements. |
| Erosion | Visual monitoring indicates that there is no erosion present that compromises land capability or the intended final land use (MOP, p97) | Very limited occurrences of erosion seen during flora monitoring. |
| Weeds | Reduced presence of weeds (BMP, p67) | Noxious weeds limited to isolated occurrences. Exception is St John's Wort which occurs as outbreaks in various areas. Exotic plant cover is above Year 9 (2020) target (<15%) for the box-gum grassy woodland areas. |
| | Weed presence does not pose a risk to the establishment of the rehabilitation area. (MOP, p97) | No evidence that exotic plant species inhibiting revegetation in MZ3. |
| Feral animals | Pest animal presence does not pose a risk to the establishment of rehabilitation areas (MOP, p97) | No significant presence of vertebrate pests identified that are posing risk to establishment of rehabilitation areas |
| | Long term stable or downward trend in population size. (MOP, p97) | Not currently assessed. See 2019 annual fauna report (ELA 2020). |

**Table 27: MZ4a performance criteria**

| Management Zone 4a Salinity Offset Area – cleared areas | Performance Criteria/Management Aim | Comment |
|---|---|---|
| Natural Regeneration | Natural regeneration is shown through monitoring to be occurring (BMP, p44) | Natural regeneration has occurred extensively in recent decades, and young saplings indicate it is on-going. |
| Erosion | Stable to increasing groundcover. No significant erosion is present (BMP, p44) | Low occurrence of erosion indicating cover is sufficient. In some areas, macropod grazing has left the ground bare. |
| Weeds | No significant noxious weeds infestations and weeds do not comprise a significant proportion of the species in any stratum (BMP, p44). | Noxious weeds present but in defined limited areas. St John's Wort is the main challenge within portions of some paddocks. |
| Feral animals | Long term stable or downward trend in population size. (MOP, p97) | Not currently assessed. See 2019 annual fauna report. |

**Table 28: MZ5 performance criteria**

| Management Zone 5 (Open Cut) | Performance Criteria/Management Aim - | Comment |
|---|---|---|
| Natural Regeneration | Rehabilitation monitoring verifies that second generation tree seedlings are present or likely to be, based on comparable older rehabilitation sites (MOP, p91) | Second generation seedlings observed in older rehabilitation areas (approx. 20 years), but they are not numerically high. Significant regeneration of second-generation seedlings would not be expected without some disturbance. |
| Revegetation | Establish self-sustaining native vegetation communities of Grey Box Woodland and Ironbark Open Forest Complex on Sandstone communities which are characteristic of the pre-mining composition in Secondary Domain D | Second generation seedlings observed in older rehabilitation areas (approx. 20 years), but in low density. Significant regeneration of second-generation seedlings would not be expected without some disturbance. |
| | Woodland to be established in Secondary Domain B (MOP, p42) | Vegetation structure of Secondary Domain B is woodland to open forest dominated by either eucalypts or *Acacia meariifolia*. Only the ground layer has exotic plant species and their cover is below the benchmark limit. Current mapping program will itemize areas of various vegetation types.<br>Monitoring plots in Secondary Domain B are very strongly dominated by native plant species found in the local Kerrabee IBRA sub- region. |
| Vegetation density | The density of shrubs and trees is within the range gauged at analogue Woodland sites (MOP, p92) This to be assessed 5 years post rehabilitation establishment (MOP, p72) | Overall, density of shrubs and trees comparable to woodland and open forest, however a revision of monitoring method recommended to improve the robustness of the assessment (**Section 3.6.1**). |
| Habitat | Monitoring confirms rehabilitated areas provide a range of vegetation structural habitats (e.g. eucalypts, shrubs, ground cover, developing litter layer, etc.) to encourage use by native fauna species (MOP, p92) | Vegetation structure improving, however many key habitat features absent. There is scope for improving habitat features through actions such as LWD and rock emplacement. Fauna studies indicate good populations of birds, and these studies should be the primary guidance for management actions. |
| Erosion | Visual monitoring indicates that there is no erosion present that compromises land capability or the intended final land use. (MOP, p89) | No significant erosion in monitoring plots that compromises intended final land use. Walkover has indicated specific occurrences of erosion for which targeted actions have been recommended. |
| Weeds | Weeds do not pose a risk to the establishment of the revegetation area (MOP, p89) | Weeds not preventing the establishment of woodland vegetation. |
| Feral animals | Pest animal presence does not pose a risk to the establishment of the rehabilitation area (MOP, p89) | Vertebrate pests are not preventing the establishment of woodland vegetation. |

**Table 29: Threatened flora performance criteria**

| Threatened flora *Acacia ausfeldii* | Performance Criteria/Management Aim | Comment |
|---|---|---|
| *Acacia ausfeldii* | On-going protection of Highett Road area to maintain *Acacia ausfeldii* in seedbank.<br>Use of *Acacia ausfeldii* seed in open cut. (BMP, p14 and p62) | Highett Road *Acacia ausfeldii* Conservation Area was monitored in 2019 with results indicating a decline in abundance and condition upon previous monitoring. Fifty per cent (50%) of 100 tagged individuals that were alive in 2011 have now died. This is an expected outcome for this short-lived acacia.<br>*Acacia ausfeldii* has been successfully seeded in the open cut. |
| | | Seedbank of Highett Road has not been tested. Recommend soil samples be taken and seed bank germination tested. |

**Table 30: Subsidence performance criteria**

| Subsidence | Performance Criteria/Management Aim | Comment |
|---|---|---|
| Areas over active underground mining | >10% negative movement in vegetation cover and abundance over two or more monitoring periods outside of normal seasonal fluctuation | No sites have recorded a >10% negative movement in vegetation cover. |
| | A >10% negative change in vegetation between the White Box Woodland communities located above LW1 and LW2 and analogue vegetation sites | Neither site FBS5 or FBS6 has recorded >10% negative change in overstorey cover. |

# 5. Recommendations

## 5.1 Management Recommendations

### 5.1.1 Natural regeneration

This is good historic evidence of natural regeneration of tree cover occurring within the Ulan complex. The increased tree cover due to natural regeneration is likely to be one of the most significant contributors to improved biodiversity status within the Ulan complex. The presence of young saplings recorded during monitoring is an indication that natural regeneration is an ongoing process. To better manage and enhance the regeneration process, the following is required:

- Improved knowledge of the nature of natural regeneration of tree cover and what factors favour it at Ulan
- Investigations to assess the effectiveness and cost benefit of methods for enhancing or accelerating natural regeneration
- Modelling to provide predictions of those areas where natural regeneration is most likely to occur and those areas where natural regeneration is likely to be inhibited for which other strategies will be required.

It is recommended that an action plan be formulated for natural regeneration which includes:

- Baseline mapping of the natural regeneration front be undertaken so that the rate of change can be monitored in coming years
- A literature search of methods for enhancing or accelerating natural regeneration with a view to establishing some small trials to assess their effectiveness and cost benefit
- Developing a decision support framework for determining whether passive natural regeneration, enhanced natural revegetation or active revegetation should be used for a target area that currently has no or limited tree cover.

### 5.1.2 Improving native plant species richness

Native plant species richness in MZ3 is generally below benchmark, and the BMP has an objective that areas should be trending to analogue/benchmark level. There is a limited amount of data available and this is preventing assessment of trends.

It is recommended that:

- Data from the Voluntary Conservation Agreements surveys in conjunction with that from the annual flora survey be used to provide a more statistically robust analysis as to whether there is any increasing trend in native plant species richness towards the benchmark.
- Differences in native plant species assemblages between remnant vegetation communities representative of those in MZ3 and those of monitoring sites within MZ3 be examined to identify key missing indicator species or plant functional groups.
- A literature search be conducted to determine management methods for the introduction or provision of habitat conditions for missing plant species and conduct small trials on how to introduce those plant species.

### 5.1.3 Weeds - St John's Wort

Literature indicates that St John's Wort can be outcompeted by both pasture and shade (Parsons and Cutherbertson, 2001). Examination should be undertaken as to whether tree planting/natural regeneration is helping reduce the presence of St John's Wort. Similar observations should be made for other exotic species.

Recommended to use the opportunity of planned Voluntary Conservation Agreement walkover to gain an understanding of patterns of weed (noxious and environmental) occurrence with view to identifying appropriate management actions that will reduce occurrence.

### 5.1.4 *Acacia ausfeldii* at Highett Road

The decline of the population of *Acacia ausfeldii* at Highett Road can be explained through its ecology and is not a reflection of an increase in degrading or threatening processes caused by mine operations.

It is recommended that:

- The value of further monitoring of *A. ausfeldii* population is reviewed to determine if it is warranted.
- To meet the BMP requirements of maintaining *A. ausfeldii* in the seedbank, a soil seedbank germination assessment should be undertaken. This will demonstrate that viable seed is still present and provides for the re-establishment of the population once conditions are favourable.
- During monitoring of rehabilitation on the open cut area the presence of *A. ausfeldii* is documented so that this information can be used to demonstrate that the BMP requirements to establish the species in rehabilitation areas is being achieved.

### 5.1.5 Subsidence

To date no effect of subsidence has been detected. It is recommended that current subsidence monitoring program, focusing on canopy health, be continued.

### 5.1.6 Open Cut Rehabilitation

A program of mapping the status of rehabilitation on areas of the open cut is currently underway. The outcomes of this program will then be integrated with flora and fauna monitoring data.

It is recommended that the results of the program be used to improve the rehabilitation monitoring program to ensure it provides appropriate information to assist in determining management priorities. Walkover assessments should continue to be used to locate various occurrences of weeds, erosion or other management issues.

### 5.1.7 Fauna Habitat

Results of measurement of fauna habitat for structural features in flora plots are below BVT benchmark for MZ2, MZ3, MZ4a, and MZ5. However, there is still measurable fauna value in these areas, as evidenced by fauna studies in MZ5. A similar situation would be expected in MZ2, MZ3, and MZ4a based on opportunistic observations. Planned fauna surveys programs in MZ2, MZ3, MZ4a, and MZ5 will be better placed to develop assessment of fauna status and recommendations for action.

It is recommended that the data and recommendations coming from these more detailed fauna surveys is used to guide habitat enhancement actions rather than the limited habitat data generated by flora surveys.

## 5.2 Floristic monitoring recommendations

Until fauna surveys are undertaken in MZ2 and MZ3, the value of habitat being created by natural regeneration in MZ2 cannot to be evaluated. Fauna is often an early indicator of structural and floristic change and as such, surveys should provide the means to evaluate the progression of fauna habitat values in these management zones. See recommendations within the 2017 Fauna monitoring report (ELA 2018) in this regard.

Results from 2019 indicate that MZ1 sites are producing consistent results for native species diversity and exotic ground cover for each monitoring period. As such, the necessity of monitoring these sites to their current schedule should be reviewed. Most sites within MZ1 have been monitored for five (5) years, with the current monitoring schedule involving an alternative two-year rolling program of rapid assessment and full floristic assessment. ELA recommends that monitoring for these sites be undertaken every four (4) years with the residual workload placed on establishing more monitoring sites within MZ2 and MZ3. These MZs have an inadequate number of plots within respective BVTs to allow robust comparison against benchmark values and assessment of trends.

## 5.3 Completion criteria recommendations

Appendix B of the MOP (UCML 2017) details the following completion criteria for vegetation density which is to be assessed from 5 years post rehabilitation establishment:

> *The density of shrubs and trees is within the range gauged at analogue Woodland sites*.

As detailed in **Section 3.6.1**, there are issues with the assessment of this criteria associated with:

- the use of a relatively small plot size (400 m2 as per the standard BioMetric methodology)
- difficulties of comparing a 5-year old planting against vegetation in a mature condition.

It is recommended that a new method of assessment be considered which utilises a plot size that can more accurately capture canopy stem density establishment observed across rehabilitation areas. Two suitable methods of assessment include the NSW Biodiversity Assessment Method (OEH 2017), which uses 1000 $m^2$ plots for assessing tree stem classes and numbers of large trees, and the Queensland BioCondition assessment system (Kelly and Eyre 2006) which makes an assessment over 5000 $m^2$.

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# Appendix A Methodology

The 2019 floristic monitoring program was undertaken by ELA ecologists David Allworth, Tomas Kelly, Justin Russell and Rebecca Croake between 6 to 23 May and between 29 October to 20 November 2019. The full list of sites which underwent monitoring during autumn and spring 2019 are presented below in Table A-1, and Figure A-1.

**Table A-1: 2019 monitoring sites**

| Site | Season | Eastings | Northings | MZ | Methodology |
|---|---|---|---|---|---|
| ACQ1 | Spring | 754772 | 6426460 | MZ1 | Full Floristic |
| ACQ2 | Spring | 754805 | 6426308 | MZ1 | Full Floristic |
| BB1 | Spring | 752979 | 6436748 | MZ1 | Full Floristic |
| BOB11B | Autumn | 757763 | 6435530 | MZ1 | Rapid Assessment |
| BOB13B | Autumn | 757568 | 6437408 | MZ2 | Full Floristic |
| BOB16 | Spring | 760009 | 6437426 | MZ1 | Rapid Assessment |
| BOB18 | Autumn | 756647 | 6436098 | MZ2 | Full Floristic |
| BOB19 | Spring | 756837 | 6437680 | MZ3 | Full Floristic |
| BOB20 | Autumn | 757314 | 6437370 | MZ2 | Full Floristic |
| BOB22 | Spring | 759734 | 6437111 | MZ2 | Full Floristic |
| BOB23 | Spring | 758151 | 6437261 | MZ3 | Full Floristic |
| BOB3 | Autumn | 756811 | 6435162 | MZ1 | Rapid Assessment |
| BOB4B | Autumn | 756438 | 6435642 | MZ1 | Rapid Assessment |
| BOB6 | Autumn | 758268 | 6436473 | MZ1 | Rapid Assessment |
| BOB8 | Autumn | 759573 | 6436953 | MZ1 | Rapid Assessment |
| BOBC1 | Autumn | 760985 | 6435924 | MZ1 | Full Floristic |
| BOBC10 | Autumn | 761488 | 6435967 | MZ2 | Full Floristic |
| BOBC7 | Autumn | 762168 | 6435805 | MZ3 | Full Floristic |
| BOBC9 | Autumn | 761496 | 6436033 | MZ1 | Rapid Assessment |
| BOBE1 | Spring | 762711 | 6436839 | MZ2 | Full Floristic |
| BOBE13 | Spring | 762986 | 6436740 | MZ2 | Floristic Based Subsidence – Biometric |
| BOBE2 | Spring | 763900 | 6438071 | MZ1 | Full Floristic |
| BOBE3 | Autumn | 763267 | 6438323 | MZ2 | Rapid Assessment |
| BOBE5 | Autumn | 763267 | 6438323 | MZ2 | Full Floristic |
| FBS10 | Autumn | 759789 | 6439841 | MZ1 | Floristic Based Subsidence – Biometric |
| FBS9 | Autumn | 755953 | 6434083 | MZ1 | Full Floristic |
| OC11 | Autumn | 758565 | 6429077 | MZ5 | Full Floristic |
| OC2B | Spring | 760013 | 6428001 | MZ5 | Full Floristic |
| OC3A | Autumn | 759862 | 6427772 | MZ5 | Full Floristic |

| Site | Season | Eastings | Northings | MZ | Methodology |
| --- | --- | --- | --- | --- | --- |
| OC4B | Autumn | 759494 | 6429388 | MZ5 | Full Floristic |
| OC5B | Autumn | 757562 | 6429388 | MZ5 | Full Floristic |
| OC6B | Autumn | 757549 | 6428635 | MZ5 | Rapid Assessment |
| OC7A | Autumn | 758121 | 6429140 | MZ5 | Full Floristic |
| OC7B | Autumn | 758121 | 6429140 | MZ5 | Full Floristic |
| OC8A | Spring | 756649 | 6430129 | MZ5 | Full Floristic |
| RPA11 | Spring | 754032 | 6438140 | MZ1 | Rapid Assessment |
| RPA14A | Autumn | 754096 | 6442103 | MZ2 | Rapid Assessment |
| RPA16 | Spring | 753548 | 6433146 | MZ1 | Full Floristic |
| RPA17 | Autumn | 757530 | 6440873 | MZ1 | Full Floristic |
| RPA3A | Autumn | 758392 | 6430116 | MZ1 | Full Floristic |
| RPA4 | Autumn | 756179 | 6431403 | MZ1 | Full Floristic |
| RPA5 | Autumn | 757763 | 6432243 | MZ1 | Full Floristic |
| RPA6 | Autumn | 760118 | 6432303 | MZ1 | Rapid Assessment |
| RPA9 | Spring | 757088 | 6433489 | MZ1 | Full Floristic |
| SI3B | Autumn | 761984 | 6438069 | MZ2 | Full Floristic |
| SOA4 | Autumn | 755998 | 6435455 | MZ4a | Natural Regeneration |
| SOA5 | Autumn | 757743 | 6439308 | MZ4a | Natural Regeneration |
| SOA6 | Autumn | 757265 | 6439675 | MZ4a | Natural Regeneration |
| UG LWW4-L1 | Autumn and spring | 756436 | 6438066 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L10 | Autumn and spring | 755842 | 6437829 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L2 | Autumn and spring | 756421 | 6437966 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L3 | Autumn and spring | 756287 | 6438061 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L4 | Autumn and spring | 756288 | 6437967 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L5 | Autumn and spring | 756151 | 6438091 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L6 | Autumn and spring | 756169 | 6437972 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L7 | Autumn and spring | 755935 | 6437746 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L8 | Autumn and spring | 755927 | 6437826 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW4-L9 | Autumn and spring | 755832 | 6437739 | MZ1 | Floristic Based Subsidence – Canopy health |

| Site | Season | Eastings | Northings | MZ | Methodology |
|---|---|---|---|---|---|
| UG LWW5-L1 | Autumn and spring | 756439 | 6438165 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L10 | Autumn and spring | 755399 | 6438290 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L2 | Autumn and spring | 756438 | 6438275 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L3 | Autumn and spring | 756297 | 6438173 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L4 | Autumn and spring | 756291 | 6438277 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L5 | Autumn and spring | 756160 | 6438175 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L6 | Autumn and spring | 756148 | 6438269 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L7 | Autumn and spring | 755516 | 6438185 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L8 | Autumn and spring | 755504 | 6438282 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW5-L9 | Autumn and spring | 755397 | 6438185 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L1 | Autumn and spring | 755746 | 6438986 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L10 | Autumn and spring | 754976 | 6438923 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L2 | Autumn and spring | 755754 | 6438883 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L3 | Autumn and spring | 755359 | 6438985 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L4 | Autumn and spring | 755377 | 6438903 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L5 | Autumn and spring | 755288 | 6438983 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L6 | Autumn and spring | 755301 | 6438925 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L7 | Autumn and spring | 755047 | 6438994 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L8 | Autumn and spring | 755060 | 6438918 | MZ1 | Floristic Based Subsidence – Canopy health |
| UG LWW6 L9 | Autumn and spring | 754963 | 6438996 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L1 | Autumn and spring | 755518 | 6431784 | MZ1 | Floristic Based Subsidence – Canopy health |

| Site | Season | Eastings | Northings | MZ | Methodology |
|---|---|---|---|---|---|
| UW LW4-L10 | Autumn and spring | 755477 | 6433838 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L2 | Autumn and spring | 755400 | 6431769 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L3 | Autumn and spring | 755207 | 6432864 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L4 | Autumn and spring | 755335 | 6432880 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L5 | Autumn and spring | 755551 | 6433204 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L6 | Autumn and spring | 755416 | 6433204 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L7 | Autumn and spring | 755223 | 6433490 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L8 | Autumn and spring | 755320 | 6433521 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW4-L9 | Autumn and spring | 755562 | 6433838 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L1 | Autumn and spring | 755165 | 6436029 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L10 | Autumn and spring | 754856 | 6433184 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L2 | Autumn and spring | 755049 | 6436022 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L3 | Autumn and spring | 754808 | 6435517 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L4 | Autumn and spring | 754902 | 6435509 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L5 | Autumn and spring | 755149 | 6435292 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L6 | Autumn and spring | 755038 | 6435276 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L7 | Autumn and spring | 755116 | 6433547 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L8 | Autumn and spring | 755014 | 6433534 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW5-L9 | Autumn and spring | 754749 | 6433196 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L1 | Autumn and spring | 754391 | 6436791 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L10 | Autumn and spring | 754479 | 6434488 | MZ1 | Floristic Based Subsidence – Canopy health |

 

| Site | Season | Eastings | Northings | MZ | Methodology |
|---|---|---|---|---|---|
| UW LW6-L2 | Autumn and spring | 754454 | 6436799 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L3 | Autumn and spring | 754743 | 6436548 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L4 | Autumn and spring | 754653 | 6436509 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L5 | Autumn and spring | 754372 | 6435721 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L6 | Autumn and spring | 754463 | 6435694 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L7 | Autumn and spring | 754359 | 6435289 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L8 | Autumn and spring | 754444 | 6435272 | MZ1 | Floristic Based Subsidence – Canopy health |
| UW LW6-L9 | Autumn and spring | 754326 | 6434475 | MZ1 | Floristic Based Subsidence – Canopy health |

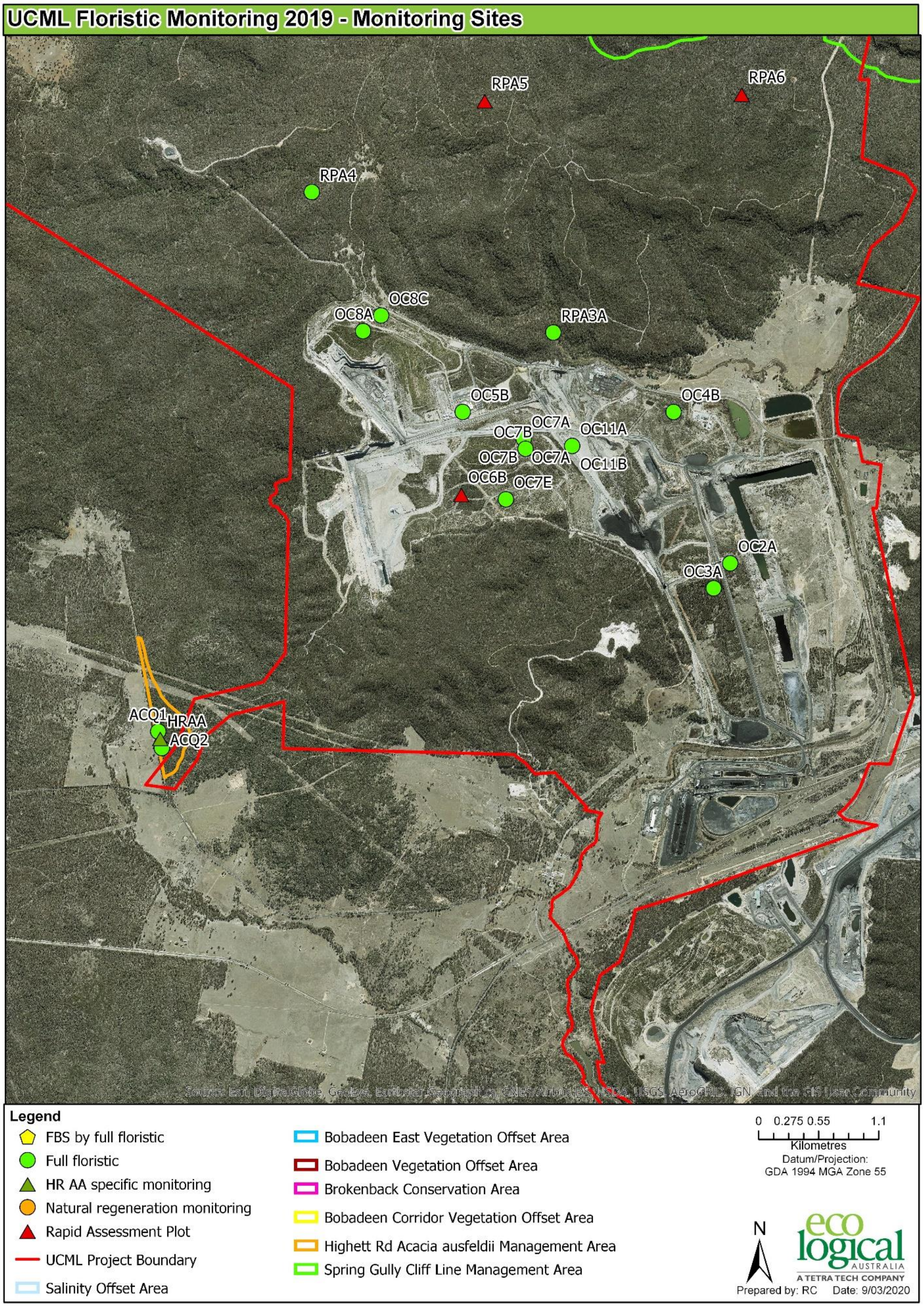


**Figure A-1: Monitoring locations**

## A1 Floristic Monitoring Methodology

Floristic monitoring during 2019 was undertaken in accordance with the revised methodology outlined in Section 8 of the BMP (UCML 2018). Monitoring was undertaken at 43 sites (autumn and spring) across the UCML complex consisting of:

- 19 full floristic sites (biometric plots) and 10 rapid assessment sites surveyed in autumn 2019
- 12 full floristic sites and 2 rapid assessment sites surveyed in spring 2019.

## A2 Full floristic (biometric) monitoring

Full floristic monitoring involved monitoring of floristic quadrats (20 m x 20 m) and collection of cover (from 1-5% and then to nearest 5%) and abundance (1-10, 20, 50, 100, 500, 1000 or specified greater number of individuals) for each species. Biometric plot data was also collected using the BioBanking assessment methodology (OEH, 2014) within a 20 m x 50 m plot.

In addition, within the permanent 20 m x 20 m quadrats, the following data were also collected:

- floristic composition and structure
- progress of revegetation/regeneration towards target native vegetation community
- general health of vegetation
- evidence of natural regeneration
- requirements for species-specific planting or thinning
- success of management actions implemented following previous monitoring inspections;
- non-vascular ground cover (litter, cryptogam, logs >10 cm diameter, rocks >5 cm diameter, bare soil) (% cover)
- the occurrence and abundance of weeds, evidence of animal disturbance and observable impacts.

## A3 Rapid assessment monitoring

Rapid assessments were undertaken at residual monitoring sites that had previously been identified as being in good and stable condition and therefore no longer requiring full floristic monitoring. Rapid assessment involved recording the following characteristics:

- floristic composition (including cover and abundance of up to three dominant species in each stratum) and structure
- general health of vegetation
- evidence of natural regeneration
- occurrence and abundance of weed species
- presence of threatened or other significant species
- signs of disturbance, either by stock or humans
- evidence of feral animals
- any observable impacts of the Project, such as the effectiveness of fencing and weed control

## A4 Floristic based subsidence monitoring

Sites were established at Ulan West LW6 and Ulan No. 3 LWW6 during autumn 2019, with sites monitored at Ulan West LW4, Ulan No. 3 LWW4, Ulan West LW5 and Ulan No. 3 LWW5 during both autumn and spring, as listed in Table A-1**,** above and shown in Figure A-2. The following data was collected from each site:

- Projected foliage cover (5% increments) of upper canopy;
- Canopy health and defoliation (all in 5% increments):
- Percentage of epicormic foliage in relation to total tree foliage;
- Proportion of primary branches within canopy that have died back;
- Percentage of current canopy foliage as a proportion of the estimated canopy foliage volume/potential canopy; and
- Percentage of canopy foliage discoloured.
- Photograph of the canopy (camera placed on top of the star picket, facing up); photograph facing due north, south, east and west from the north-west star picket.

Any evidence of subsidence opportunistically observed was also recorded with a handheld GPS.

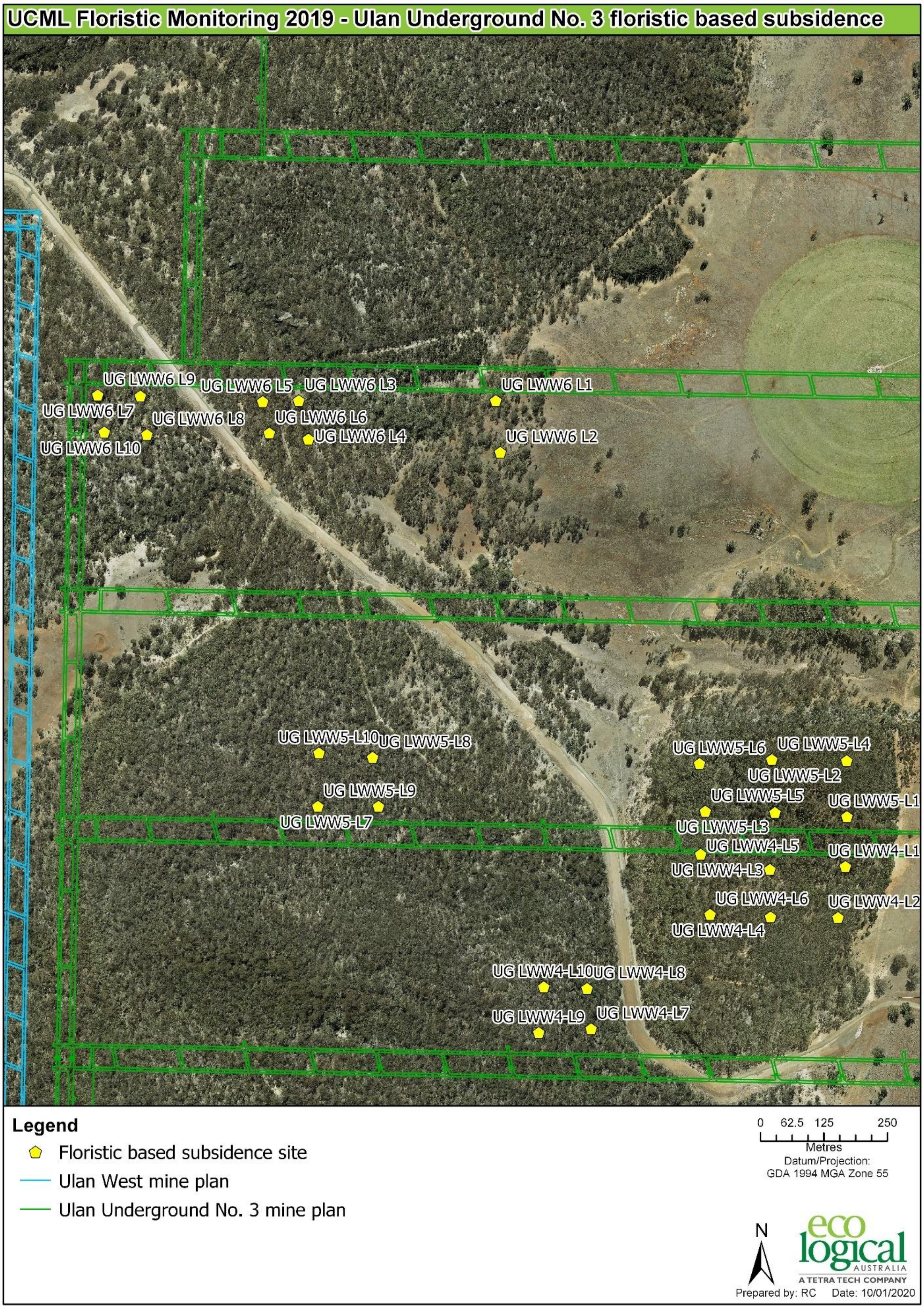


**Figure A-2: Ulan No. 3 floristic based subsidence monitoring plots**

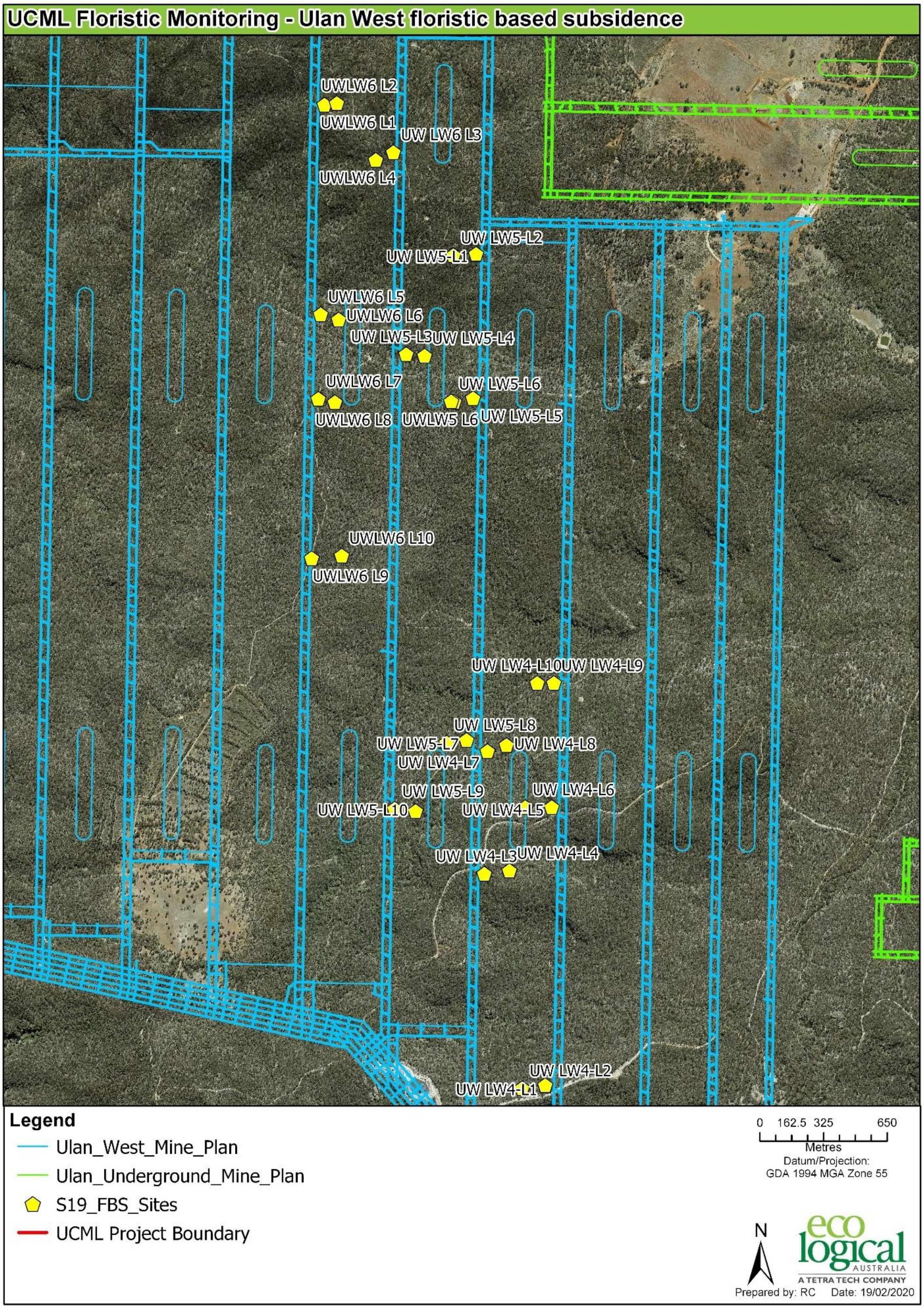


**Figure A-3: Ulan West floristic based subsidence monitoring plots**

Monitoring of natural regeneration continued with the MZ4a areas of the SOAs with three new 100 m transects established. The principal approach for monitoring is currently to establish quadrats that included going from existing young natural regeneration out into areas without natural regeneration. Measures are then made every second year to determine whether there has been either:

1. An increased density of regenerating trees, and
2. Areas that were previously did not have trees now have young regeneration.

Each transect was traversed, with occurrences of canopy regeneration recorded with a handheld GPS unit 20 m either side of the transect.

Individual plants were recorded in two categories, <5 cm diameter at breast height (DBH) and 5-15 cm DBH, with the species of the plant also noted.

This methodology allows for the calculation of natural regeneration density and the spatial representation of natural regeneration progression over successive years.

## A5 Open Cut rehabilitation monitoring methodology

Open Cut rehabilitation monitoring was undertaken at four newly established sites and utilised both the Biometric plot methodology and Rapid assessment methodology detailed above. Erosion transects (50 m) were established at each site to monitor landform stability. Additional information was collected at each plot with regards to erosion and landform stability and fauna habitat values, including the following:

- Slope and land use;
- Photographs along the transect;
- Erosion - including the type, width, depth and position (distance from start, m) along the transect. Erosion identified will be rated using the following:
  - 1 – no erosion
  - 2 – sheet erosion
  - 3 – rill erosion < 0.3 m deep
  - 4 – gully erosion > 0.3 m, < 1 m deep
  - 5 – gully

Observations relating to fauna habitat were recorded at each monitoring site, including:

- Opportunistic fauna observations
- Habitat features, including micro-habitat present for threatened species. Examples of micro-habitat include large woody debris, hollow-bearing trees, rock outcrops/caves and Koala feed trees.

## A6 *Acacia ausfeldii* monitoring methodology

Floristic monitoring was undertaken at two monitoring sites (ACQ1 and ACQ2) within the Highett Road Offset Area. Monitoring within sites ACQ1 and ACQ2 was conducted during spring 2017 and followed the full floristic methodology outlined above and in Section 8 of the BMP (UCML 2018).

Targeted surveys of 100 tagged individuals and germination transect surveys were also undertaken. These surveys targeted 100 previously tagged *A. ausfeldii* individuals and recorded the height, diameter at base and growth stage (seedling, sapling or mature shrub). Additional information was collected for each individual, including reproductive ratings and condition ratings. Table A-2 below outlines the definition of the ratings.

Germination transect surveys were also undertaken along three previously established 50 m transects and 20 randomly places 1m x 1m quadrats. All occurrences of *A. ausfeldii* seedlings along each transect and within the quadrats were recorded using a handheld GPS.

**Table A-2: *Acacia ausfeldii* condition rating definitions**

| | Condition Rating | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Condition Rating | Severe damage/dieback | Many dead stems | Some dead branches | Minor damage | Healthy |
| Reproductive Rating | Nil | Sparse - occasional flowers/fruit only) | Low – under 25% of potential | Moderate – 25 – 75% of potential | High – 75 – 100% of potential |

## A7 Weather conditions

Weather conditions recorded during the monitoring periods are found below in Table A-3.

**Table A-3: Weather conditions for the duration of the survey; autumn and spring 2019**

| Date | Min Temp (°C) | Max Temp (°C) | Rainfall (mm) |
|---|---|---|---|
| **Autumn survey** | | | |
| 6-May-19 | 16 | 33.2 | 0 |
| 7-May-19 | 13.3 | 23.5 | 0 |
| 8-May-19 | 14 | 33.8 | 0 |
| 9-May-19 | 20.2 | 29.4 | 0 |
| 10-May-19 | 19.5 | 33.8 | 0 |
| 11-May-19 | 15.4 | 33 | 0 |
| 12-May-19 | 14.9 | 32 | 1.5 |
| 13-May-19 | 20.8 | 29.2 | 0 |
| 14-May-19 | 20.2 | 32 | 0 |

| Date | Min Temp (°C) | Max Temp (°C) | Rainfall (mm) |
|---|---|---|---|
| 15-May-19 | 8.5 | 28.6 | 0 |
| 16-May-19 | 14.6 | 26.3 | 0 |
| 17-May-19 | 15.7 | 23.3 | 14 |
| 18-May-19 | 14.2 | 24.6 | 1 |
| 19-May-19 | 11.3 | 27.8 | 0 |
| 20-May-19 | 14.3 | 29.3 | 0 |
| 21-May-19 | 16 | 30.2 | 0 |
| 22-May-19 | 14.9 | 30.2 | 15.5 |
| 23-May-19 | 13 | 34.2 | 1.3 |

**Spring survey**

| 29-Oct-19 | 7.0 | 30.2 | 0.0 |
|---|---|---|---|
| 30-Oct-19 | 9.2 | 30.2 | 0.0 |
| 31-Oct-19 | 8.5 | 33.3 | 0.0 |
| 1-Nov-19 | 10.2 | 33.0 | 0.0 |
| 2-Nov-19 | 10.3 | 31.3 | 0.0 |
| 3-Nov-19 | 15.0 | 26.5 | 16.5 |
| 4-Nov-19 | 12.9 | 24.3 | 1.8 |
| 5-Nov-19 | 8.8 | 20.7 | 0.8 |
| 6-Nov-19 | 4.0 | 25.7 | 0.0 |
| 7-Nov-19 | 10.0 | 27.1 | 0.0 |
| 8-Nov-19 | 5.7 | 26.2 | 0.0 |
| 9-Nov-19 | 7.5 | 18.4 | 0.0 |
| 10-Nov-19 | 6.5 | 24.0 | 0.0 |
| 11-Nov-19 | 4.8 | 28.0 | 0.0 |
| 12-Nov-19 | 3.9 | 33.0 | 0.0 |
| 13-Nov-19 | 9.8 | 22.5 | 0.0 |
| 14-Nov-19 | 3.0 | 26.1 | 0.0 |
| 15-Nov-19 | 5.1 | 29.2 | 0.0 |
| 16-Nov-19 | 6.2 | 28.5 | 0.0 |
| 17-Nov-19 | 7.7 | 27.2 | 0.0 |
| 18-Nov-19 | 12.0 | 28.7 | 0.0 |
| 19-Nov-19 | 6.1 | 34.4 | 0.0 |

| | | | |
|---|---|---|---|
| **29-Oct-19** | **7.0** | **30.2** | **0.0** |
| 20-Nov-19 | 9.8 | 33.1 | 0.0 |

# Appendix B Rapid Assessment Data

| Site | Structural layer | Total Stratum | | Dominant species | Litter | Bare soil | Other | Logs | Regeneration |
|---|---|---|---|---|---|---|---|---|---|
| | | Native % | Exotic % | | | | | | |
| BOB11B | Tree / Overstorey | 10 | | *Eucalyptus blakelyi* | 60 | 10 | 0 | 35 | Yes |
| | Shrub / Mid storey | 1 | | *Cassinia sifton* | | | | | |
| | Groundcover | 25 | 0.1 | *Microleana stipoides, Aristida vagans, Lomandra confertifolia* | | | | | |
| BOB3 | Tree / Overstorey | 5 | | *Eucalyptus fibrosa* | 90 | 2 | 0.5% cryptogam | 2 | Yes |
| | Small tree | 15 | | *Allocasuarina gymnanthera, Eucalyptus dwyeri* | | | | | |
| | Shrub / Mid storey | 2 | | *Leucopogon muticus, Persoonia linearis* | | | | | |
| | Groundcover | 3 | | *Pomax umbellate, Lomandra filliformis, Microleana stipoides* | | | | | |
| BOB4B | Tree / Overstorey | 20 | | *E. albens* | 80 | 16 | 2% rock | 4 | Yes |
| | Small tree | 2 | | *E. albens* | | | | | |
| | Shrub / Mid storey | 0.5 | | *E. albens* | | | | | |
| | Groundcover | 7 | 0.1 | *Austrostipa scabra, A. ramosa, Lomandra sp.* | | | | | |
| BOB6 | Tree / Overstorey | 10 | | *E. crebra* | 50 | 45 | 0.5% rock 0.25% cryptogam | 20 | Yes |
| | Small tree | 1 | | *E. crebra, E. blakelyi, Allocasuarina gymnanthera* | | | | | |
| | Shrub / Mid storey | 2 | | *C. sifton, Lissanthe stigosa, Acacia decora* | | | | | |
| | Groundcover | 1 | | *A. vagans, Lomandra filliformis, Gahnia aspera* | | | | | |

| Site | Structural layer | Total Stratum Native % | Total Stratum Exotic % | Dominant species | Litter | Bare soil | Other | Logs | Regeneration |
|---|---|---|---|---|---|---|---|---|---|
| BOB8 | Tree / Overstorey | 20 | | *Eucalyptus sparisfolia, Eucalyptus macrorhyncha* | 40 | 35 | 2% rock | 35 | No |
| | Small tree | 5 | | *Allocasuarina gymnanthera, Acacia implexa* | | | | | |
| | Shrub / Mid storey | 2 | | *C. sifton, Acrotriche rigida* | | | | | |
| | Groundcover | 15 | | *Gahnia aspera, A. vagans, M. stipoides* | | | | | |
| BOBC9 | Tree / Overstorey | 20 | | *E. blakelyi* | 60 | 0 | 0 | 5 | Yes |
| | Small tree | 2 | | *E. blakelyi* | | | | | |
| | Shrub / Mid storey | 0.1 | | *C. sifton* | | | | | |
| | Groundcover | 60 | 0.1 | *M. stipoides, A. vagans, Carex appressa, Gahnia aspera* | | | | | |
| BOBE3 | Tree / Overstorey | 20 | | *E. crebra, A. linearifolia* | 55 | 45 | 1% cryptogam | 50 | No |
| | Shrub / Mid storey | 10 | | *Cassinia quinquefaria* | | | | | |
| | Groundcover | 0.5 | | *Lomandra filliformis, M. stipoides, Cheilanthes seiberi* | | | | | |
| OC6B | Small tree | 15 | | *E. punctata, A. linearifolia* | 40 | 40 | 5 | 2 | No |
| | Shrub | 2 | | *A. decora, A. deanii* | | | | | |
| | Groundcover | 20 | | *Eragrostis leptostachya, Rytidospema sp., Austrostipa scabra* | | | | | |
| RPA11 | Tree / Overstorey | 3 | | *Eucalyptus albens* | 70 | 23 | | 2 | Yes |
| | Groundcover | 10 | | *Austrostipa scabra, Aristida sp.* | | | | | |
| RPA6 | Tree / Overstorey | 15 | | *Eucalyptus crebra* | 50 | 40 | 2% Cryptogam | 15 | Yes |
| | Small tree | 3 | | *Allocasuarina gymnanthera, Persoonia linearis* | | | | | |
| | Shrub / Mid storey | 30 | | *Leucopogon muticus, Brachyloma daphnoides, C. sifton* | | | | | |
| | Groundcover | 5 | | *G. aspera, Pomax umbellate, Astroloma humifusum* | | | | | |
| SOA4 | Small tree | 2 | | *Eucalyptus fibrosa, Eucalyptus rossii* | 10 | 40 | 0 | 0 | Yes |
| | Shrub / Mid storey | 10 | | *C. sifton, Acacia buxifolia, Acacia ausfeldii* | | | | | |

| Site | Structural layer | Total Stratum | | Dominant species | Litter | Bare soil | Other | Logs | Regeneration |
|---|---|---|---|---|---|---|---|---|---|
| | | Native % | Exotic % | | | | | | |
| | Groundcover | 40 | | *Bothriochloa macra, Aristida ramosa, M. stipoides* | | | | | |
| SOA5 | Shrub / Mid storey | 1 | | *E. crebra, E. moluccana, C. sifton* | 15 | 65 | 25 % rock | 1.5 | Yes |
| | Groundcover | | | *Aristida sp., M. stipoides, Digitaria sp.* | | | | | |
| SOA6 | Small tree | 1 | | *E. blakelyi* | 10 | 60 | 10% rock | 0 | Yes |
| | Ground cover | 5 | 15 | *Hypericum perforatum, B. macra, Aristida sp* | | | | | |
| OC7E | Tree / Overstorey | 7 | | *Acacia linearifolia, Eucalyptus punctata, Eucalytpus albens* | 30 | 40 | 1% rock | 8 | Yes |
| | Shrub / Mid storey | 4 | | *Cassinia sifton, Acacia decora* | | | | | |
| | Groundcover | 1 | | *Austrostipa scabra, Calotis sp, Chloris sp.* | | | | | |
| OC8C | Tree / Overstorey | 20 | | *Acacia linearifolia, Acacia spectabilis* | 45 | 50 | 5% rock | 0 | No |
| | Shrub / Mid storey | 10 | | *Eucalyptus sp., Acacia penninervis* | | | | | |

# Appendix C Natural Regeneration Monitoring – Maps

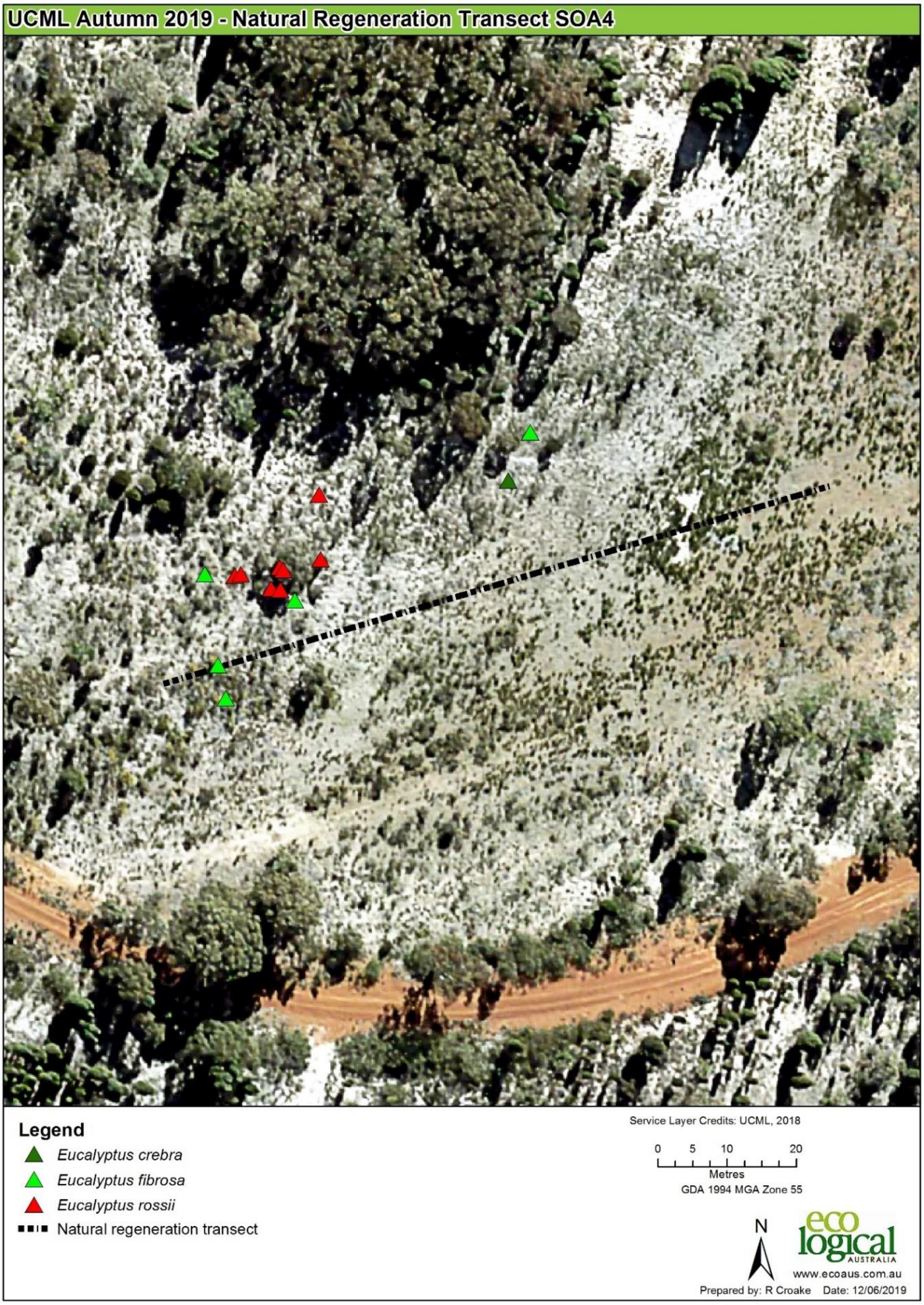


**Figure C-1: Natural regeneration transect SOA4**

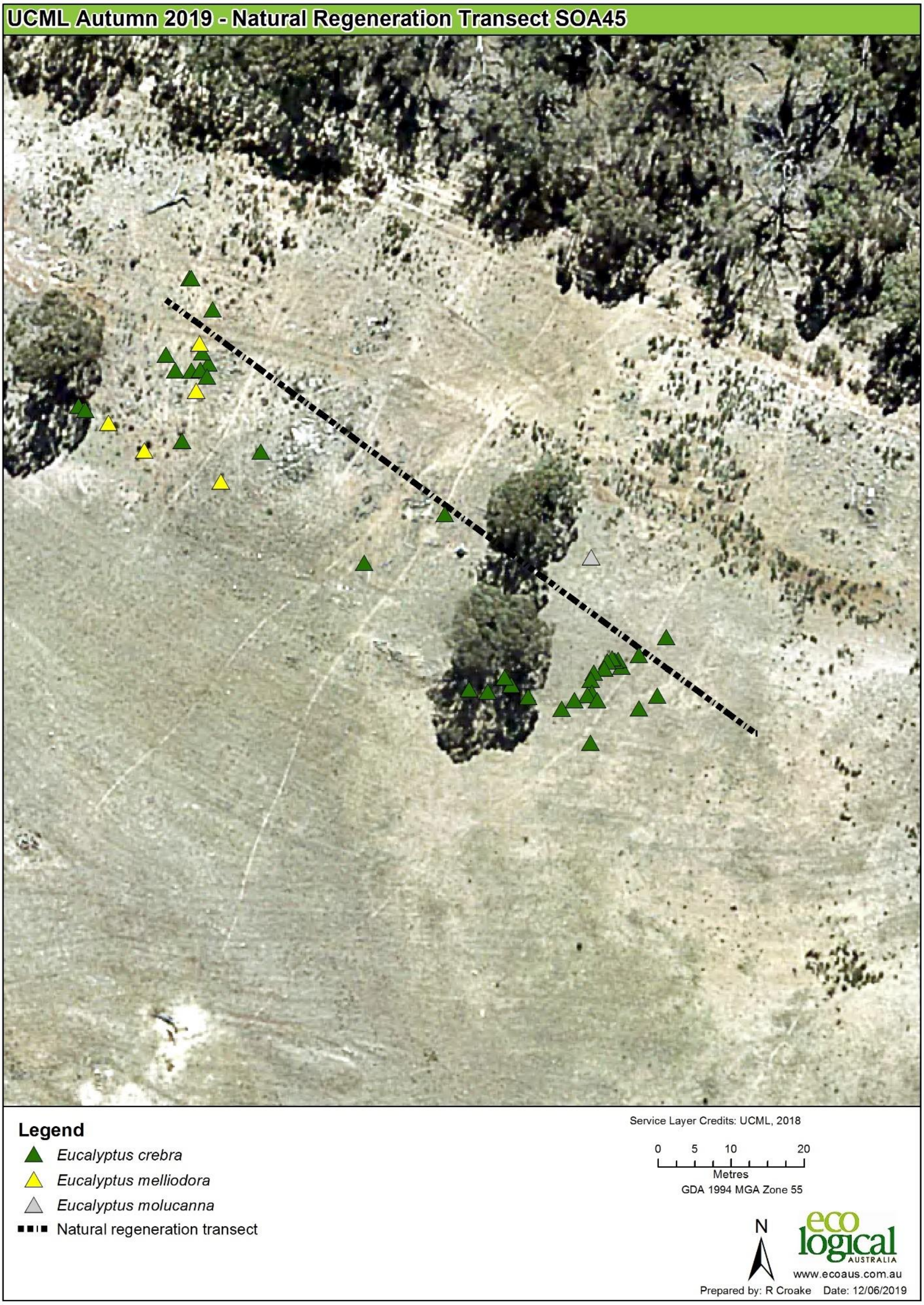


**Figure C-2: Natural regeneration transect SOA5**

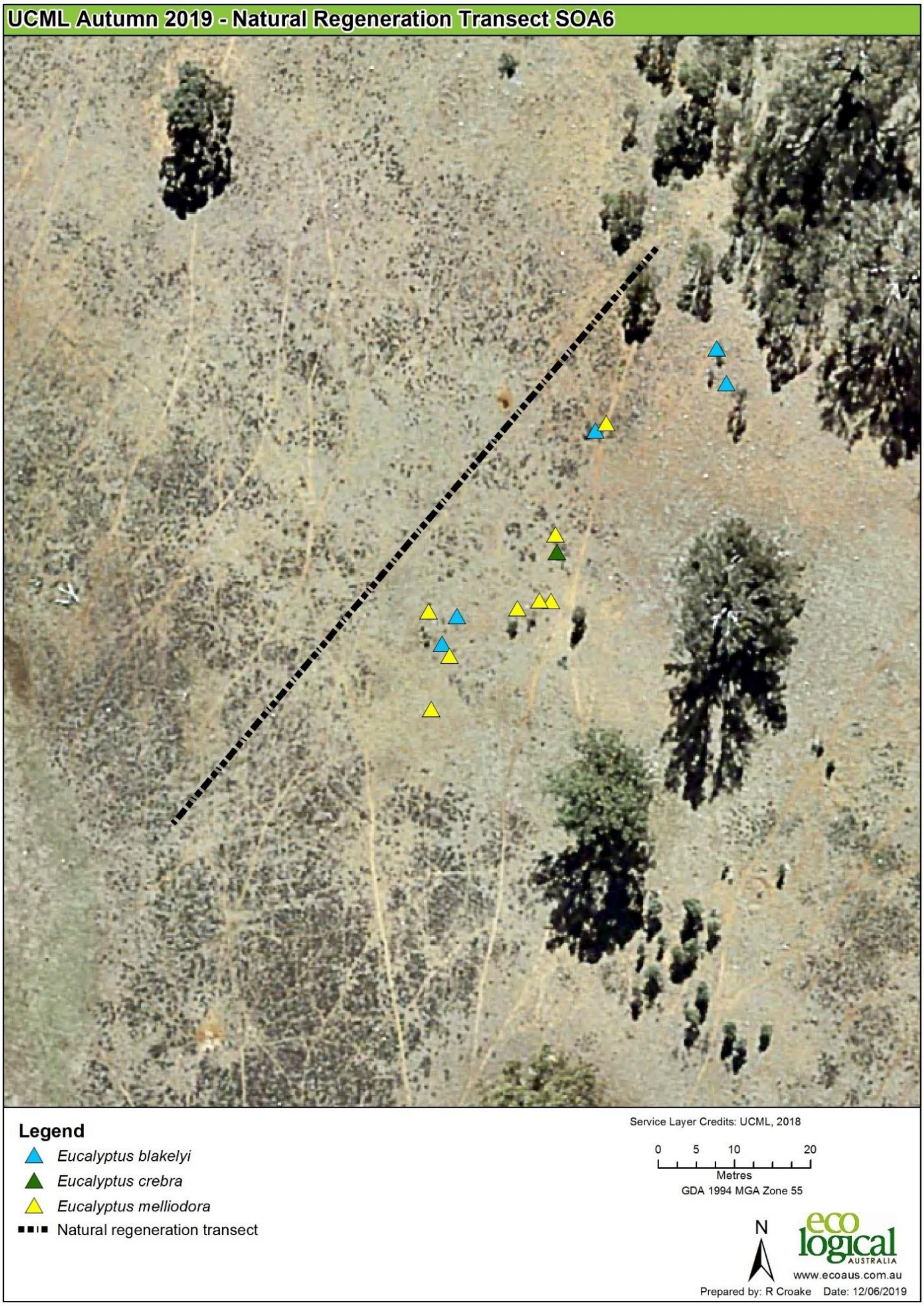


**Figure C-3: Natural regeneration transect SOA6**

# Appendix D BioMetric Monitoring Data 2019

| Site | total spp | native spp | exotic spp | O/storey natives PFC | O/storey exotic PFC | M/storey nat PFC | m/storey exotic PFC | Ground native PFC | Ground exotic PFX | Litter % cover | Bare Soil / Rock % cover | Cryptogam % cover | Logs (m) | HBTs | NR (number of spp in plot) | NR (number of species in zone) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ACQ1 | 23 | 22 | 1 | 20 | 0 | 5.5 | 0 | 2 | 0 | 76 | 2 | 2 | 120 | 1 | 0 | 3 |
| ACQ2 | 12 | 11 | 1 | 11.5 | 0 | 8 | 0 | 2 | 0 | 90 | 8 | 0 | 110 | 0 | 0 | 2 |
| BB1 | 20 | 20 | 0 | 9.5 | 0 | 6.5 | 0 | 2 | 0 | 88 | 10 | 0 | 80 | 4 | 1 | 2 |
| BOB13B | 17 | 17 | 0 | 10 | 0 | 20.6 | 0 | 14 | 0 | 78 | 10 | 0 | 20 | 0 | 3 | 1 |
| BOB18 | 34 | 27 | 4 | 8.5 | 0 | 0 | 0 | 24 | 4 | 48 | 32 | 0 | 15 | 0 | 1 | 2 |
| BOB19 | 12 | 9 | 3 | 0 | 0 | 0 | 0 | 20 | 0 | 46 | 34 | 0 | 0 | 0 | 1 | 1 |
| BOB20 | 37 | 31 | 3 | 0 | 0 | 0 | 0 | 60 | 0 | 10 | 32 | 0 | 0 | 0 | 0 | 3 |
| BOB22 | 15 | 15 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 28 | 42 | 0 | 0 | 0 | 1 | 1 |
| BOB23 | 19 | 19 | 0 | 5 | 0 | 8 | 0 | 16 | 0 | 22 | 26 | 0 | 0 | 0 | 1 | 1 |
| BOBC1 | 33 | 32 | 1 | 22.5 | 0 | 0 | 0 | 10 | 0 | 6 | 86 | 0 | 30 | 1 | 2 | 2 |
| BOBC10 | 39 | 37 | 2 | 3 | 0 | 2 | 0 | 50 | 0 | 22 | 28 | 2 | 10 | 0 | 1 | 1 |
| BOBC7 | 41 | 24 | 12 | 0 | 0 | 2.5 | 0 | 22 | 30 | 8 | 40 | 0 | 0 | 0 | 3 | 3 |
| BOBE13 | 14 | 10 | 4 | 10 | 0 | 0 | 0 | 32 | 0 | 50 | 20 | 0 | 15 | 1 | 1 | 1 |
| BOBE5 | 37 | 29 | 8 | 18 | 0 | 0 | 0 | 62 | 2 | 28 | 24 | 0 | 40 | 1 | 1 | 2 |
| FBS10 | 18 | 18 | 0 | 26 | 0 | 0 | 0 | 2 | 0 | 92 | 6 | 0 | 150 | 0 | 2 | 5 |
| FBS9 | 50 | 48 | 2 | 17.5 | 0 | 7 | 0 | 14 | 0 | 70 | 20 | 0 | 75 | 1 | 0 | 3 |
| OC3A | 50 | 48 | 2 | 17.5 | 0 | 0 | 0 | 22 | 0 | 76 | 0 | 2 | 5 | 0 | 0 | 0 |
| OC4B | 24 | 15 | 9 | 18.5 | 0 | 0 | 0 | 10 | 0 | 82 | 6 | 2 | 10 | 0 | 0 | 0 |
| OC5B | 41 | 38 | 3 | 24.5 | 0 | 0 | 0 | 0 | 0 | 86 | 14 | 2 | 0 | 0 | 0 | 0 |

| Site | total spp | native spp | exotic spp | O/storey natives PFC | O/storey exotic PFC | M/storey nat PFC | m/storey exotic PFC | Ground native PFC | Ground exotic PFX | Litter % cover | Bare Soil / Rock % cover | Cryptogam % cover | Logs (m) | HBTs | NR (number of spp in plot) | NR (number of species in zone) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OC7A | 32 | 26 | 6 | 22 | 0 | 4.5 | 0 | 0 | 0 | 32 | 66 | 2 | 0 | 0 | 0 | 0 |
| OC7B | 33 | 31 | 2 | 39 | 0 | 2 | 0 | 0 | 0 | 62 | 38 | 0 | 0 | 0 | 0 | 0 |
| OC11 | 7 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 88 | 0 | 0 | 0 | 0 | 0 |
| RPA16 | 18 | 18 | 0 | 6.5 | 0 | 0 | 0 | 0 | 0 | 80 | 20 | 0 | 20 | 0 | 0.66 | 1 |
| RPA17 | 28 | 26 | 2 | 29.1 | 0 | 0 | 0 | 2 | 2 | 0 | 94 | 2 | 20 | 1 | 1 | 2 |
| RPA3A | 43 | 33 | 10 | 13 | 0 | 32.5 | 0 | 10 | 0 | 40 | 0 | 0 | 0 | 60 | 0 | 0 |
| RPA9 | 22 | 22 | 0 | 12 | 0 | 0.7 | 0 | 22 | 0 | 70 | 6 | 4 | 25 | 2 | 0 | 0 |
| SI3B | 31 | 10 | 21 | 3.5 | 0 | 0 | 0 | 38 | 12 | 38 | 14 | 0 | 20 | 1 | 0 | 1 |

# Appendix E Full Floristic Monitoring Data 2019

| Scientific name | Exotic/native |
|---|---|
| *Acacia ausfeldii* | Native |
| *Acacia buxifolia* | Native |
| *Acacia deanei* | Native |
| *Acacia decora* | Native |
| *Acacia doratoxylon* | Native |
| *Acacia gladiiformis* | Native |
| *Acacia implexa* | Native |
| *Acacia leucolobia* | Native |
| *Acacia linearifolia* | Native |
| *Acacia neriifolia* | Native |
| *Acacia paradoxa* | Native |
| *Acacia penninervis* | Native |
| *Acacia sp.* | Native |
| *Acacia spectabilis* | Native |
| *Acacia verniciflua* | Native |
| *Acacia caesiella* | Native |
| *Acaena ovina* | Native/exotic |
| *Acetosella vulgaris* | Native |
| *Acrotriche rigida* | Native |
| *Adiantum ethiopium* | Native |
| *Ailanthus sp.* | Native |
| *Allocasuarina gymnanthera* | Native |
| *Alternanthera nana* | Native |
| *Alternanthera nodosa* | Native |
| *Amyema miquelli* | Native |
| *Amyema quandang var. quandang* | Exotic |
| *Amyema sp.* | Exotic |
| *Anagallis arvensis* | Native |
| *Angophora floribunda* | Native |
| *Aristida ramosa* | Native |
| *Aristida sp.* | Native |
| *Aristida vagans* | Native |
| *Aristida warburgii* | Native/exotic |
| *Arundinella nepalensis* | Native |

| Scientific name | Exotic/native |
|---|---|
| *Asperula conferta* | Native |
| *Astroloma humifusum* | Native |
| *Austrostipa aristiglumis* | Native |
| *Austrostipa scabra* | Exotic |
| *Austrostipa sp.* | Native |
| *Bidens subalternans* | Native |
| *Boerhavia dominii* | Native |
| *Bossiaea rhombifolia* | Native |
| *Bothriochloa macra* | Native |
| *Brachyloma daphnoides* | Native |
| *Bursaria spinosa* | Native |
| *Callitris endlicheri* | Native |
| *Callitris glaucophylla* | Native |
| *Calotis cuneifolia* | Native |
| *Calotis lappulacea* | Native |
| *Calytrix tetragona* | Native |
| *Carex appressa* | Native |
| *Carex inversa* | Native |
| *Carex sp.* | Native |
| *Carthamus lanatus* | Native |
| *Caryophyllaceae* | Native |
| *Cassinia quinquefaria* | Native |
| *Cassinia sifton* | Native |
| *Casuarina cunninghamiana* | Native |
| *Centella sp.* | Native |
| *Centipeda minima* | Native/exotic |
| *Cheilanthes distans* | Native |
| *Cheilanthes sieberi* | Native |
| *Chloris truncata* | Native |
| *Chloris ventricosa* | Native |
| *Chrysocephalum semipapposum* | Native |
| *Cirsium vulgare* | Native |
| *Conyza bonariensis* | Native |
| *Correa reflexa var. reflexa* | Native |

| Scientific name | Exotic/native |
|---|---|
| *Corymbia maculata* | Native |
| *Corymbia trachyploia* | Native |
| *Cyclospermum leptophyllum* | Native |
| *Cymbonotus lawsonianus* | Native |
| *Cymbopogon refractus* | Native |
| *Cynodon dactylon* | Native |
| *Cynodon sp.* | Native |
| *Cynoglossum australe* | Native |
| *Cyperaceae sp.* | Native |
| *Cyperus gracilis* | Native |
| *Cyperus sp.* | Native |
| *Daviesia genistifolia* | Native |
| *Desmodium varians* | Native |
| *Dianella caerulea* | Exotic |
| *Dianella sp.* | Native |
| *Dichanthium sericeum* | Exotic |
| *Dichondra repens* | Exotic |
| *Digitaria breviglumis* | Native |
| *Digitaria brownii* | Native |
| *Digitaria diffusa* | Native |
| *Digitaria sp.* | Native/exotic |
| *Dittrichia graveolans* | Native/exotic |
| *Dodonaea viscosa* | Native |
| *Dysphania pumilio* | Native |
| *Echinochloa crus-galli* | Native |
| *Echinopogon ovatus* | Native |
| *Echium plantagineum* | Native |
| *Echium vulgare* | Native |
| *Einadia nutans* | Native |
| *Einadia polygonoides* | Native |
| *Einadia sp.* | Native/exotic |
| *Einadia trigonos* | Exotic |
| *Eleusine sp.* | Native |
| *Elymus scaber* | Native |
| *Entolasia sp.* | Native |
| *Eragrostis brownii* | Native |

| Scientific name | Exotic/native |
|---|---|
| *Eragrostis curvula* | Native |
| *Eragrostis leptostachya* | Native |
| *Eragrostis sp.* | Native |
| *Eriochilus sp.* | Native/exotic |
| *Eriochloa crebra* | Native |
| *Eucalyptus albens* | Native |
| *Eucalyptus blakelyi* | Native |
| *Eucalyptus bridgesiana* | Native/exotic |
| *Eucalyptus crebra* | Exotic |
| *Eucalyptus dealbata* | Native |
| *Eucalyptus dwyeri* | Native |
| *Eucalyptus fibrosa* | Native |
| *Eucalyptus macrorhyncha* | Native |
| *Eucalyptus melliodora* | Exotic |
| *Eucalyptus moluccana* | |
| *Eucalyptus parramattensis* | Native |
| *Eucalyptus rossii* | Native |
| *Eucalyptus sp.* | Exotic |
| *Eucalyptus sparsifolia* | Exotic |
| *Euphorbia drummondii* | Native |
| *Exocarpos cupressiformis* | Exotic |
| *Exocarpos strictus* | Native |
| *Fimbristylis dichotoma* | Native/exotic |
| *Fimbristylis sp.* | Native |
| *Gahnia aspera* | Native |
| *Galium sp.* | Native/exotic |
| *Gamochaeta sp.* | Native |
| *Geranium solanderi* | Exotic |
| *Geranium sp.* | Exotic |
| *Glycine clandestina* | Exotic |
| *Glycine tabacina* | Exotic |
| *Gonocarpus sp.* | Native |
| *Goodenia hederacea* | Native |
| *Goodenia hederacea subsp. hederacea* | Exotic |
| *Grevillea sericea* | Native |
| *Haloragis heterophylla* | Exotic |

| Scientific name | Exotic/native |
|---|---|
| *Hardenbergia violacea* | Native |
| *Hibbertia circumdans* | Exotic |
| *Hibbertia obtusifolia* | Native/exotic |
| *Hibbertia riparia* | Native/exotic |
| *Hovea sp.* | Native |
| *Hydrocotyle laxiflora* | Native |
| *Hypericum perforatum* | Exotic |
| *Hypochaeris radicata* | Native |
| *Indigofera australis* | Exotic |
| *Isopogon petiolaris* | Native |
| *Juncus sp.* | Native |
| *Juncus sp. 2* | Native/exotic |
| *Kunzea ericoides* | Native |
| *Laxmannia gracilis* | Exotic |
| *Lepidium africanum* | Native |
| *Lepidium sp.* | Exotic |
| *Lepidosperma laterale* | Native |
| *Lepidosperma sp.* | Native |
| *Leptospermum parvifolium* | Native |
| *Leucopogon muticus* | Native |
| *Leucopogon sp.* | Exotic |
| *Leucopogon virgatus* | Native |
| *Lissanthe strigosa* | Exotic |
| *Lolium perenne* | Exotic |
| *Lomandra confertifolia* | Native |
| *Lomandra filiformis* | Native |
| *Lomandra glauca* | Exotic |
| *Lomandra leucocephala* | Native |
| *Lomandra multiflora* | Exotic |
| *Lomandra multiflora subsp. multiflora* | Native |
| *Lomandra sp.* | Native |
| *Loranthaceae sp.* | Exotic |
| *Macrozamia secunda* | Native |
| *Macrozamia sp.* | Native |
| *Marrubium vulgare* | Native |
| *Medicago sp.* | Native |

| Scientific name | Exotic/native |
|---|---|
| *Melaleuca thymifolia* | Native |
| *Melichrus erubescens* | Native |
| *Melichrus urceolatus* | Exotic |
| *Mentha satureioides* | Native |
| *Microlaena stipoides* | Native |
| *Modiola caroliniana* | Exotic |
| *Monotoca scoparia* | Exotic |
| *Oncinocalyx betchei* | Native |
| *Opuntia sp.* | Native |
| *Orchidaceae sp.* | Native |
| *Oxalis perennans* | Native |
| *Oxalis sp.* | Native |
| *Panicum decompositum* | Native |
| *Panicum effusum* | Native |
| *Paspalidium sp.* | Native |
| *Paspalum dilatatum* | Native |
| *Persoonia curvifolia* | Native |
| *Persoonia linearis* | Native |
| *Phyllanthus hirtellus* | Native |
| *Phyllanthus occidentalis* | Native |
| *Pimelea linifolia* | Exotic |
| *Plantago debilis* | Native/exotic |
| *Plantago lanceolata* | Exotic |
| *Plantago sp.* | Native |
| *Podolobium ilicifolium* | Native |
| *Pomaderis sp.* | Exotic |
| *Pomax umbellata* | Native |
| *Poranthera corymbosa* | Native/exotic |
| *Poranthera microphylla* | Native |
| *Pteridium esculentum* | Native |
| *Pterostylis sp.* | Native |
| *Pultenaea microphylla* | Native/exotic |
| *Rubus sp.* | Native |
| *Rumex brownii* | Native |
| *Rumex sp.* | Native |
| *Rytidosperma sp.* | Native |

| Scientific name | Exotic/native |
|---|---|
| *Salvia verbenaca* | Native |
| *Sannantha cunninghamii* | Native |
| *Scleranthus pungens* | Native |
| *Senecio quadridentatus* | Native |
| *Senecio sp.* | Native |
| *Setaria sp.* | Native |
| *Sida corrugata* | Native |
| *Sida sp.* | Native |
| *Sigesbeckia orientalis* | Native |
| *Silybum marianum* | Native |
| *Solanum nigrum* | Native |
| *Solanum sp.* | Native |
| *Solenogyne sp.* | Native |
| *Sonchus oleraceus* | Exotic |
| *Sonchus sp.* | Native |
| *Sporobolus creber* | Native |
| *Sporobolus elongatus* | Native |
| *Stackhousia monogyna* | Exotic |
| *Stackhousia sp.* | Native |
| *Stackhousia viminea* | Native |
| *Stellaria media* | #N/A |

| Scientific name | Exotic/native |
|---|---|
| *Stellaria pungens* | Native |
| *Styphelia triflora* | Native |
| *Swainsona galegifolia* | Native |
| *Taraxacum officinale* | Native |
| *Trifolium repens* | Native |
| *Trifolium sp.* | Native |
| *Trifolium sp. 2* | Native |
| *Urochloa sp.* | Exotic |
| *Urtica incisa* | Native |
| *Verbascum virgatum* | Native |
| *Verbena bonariensis* | Native |
| *Veronica plebeia* | Native |
| *Vittadinia cuneata* | Native |
| *Vittadinia sp.* | Native |
| *Vittadinia muelleri* | Native |
| *Vulpia sp.* | Native |
| *Wahlenbergia sp.* | Exotic |
| *Wahlenbergia sp. 2* | Native |
| *Xanthium spinosum* | Exotic |

# Appendix F FBS Monitoring Data

**Table F-1: UW LW4 autumn**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 |
| L1 | Transition | 15 | 15 | 15 | 5 | 5 | 1 | 15 | 15 | 5 | 85 | 80 | 80 | 5 | 5 | 1 |
| L2 | Longwall | 15 | 15 | 10 | 5 | 5 | 5 | 15 | 10 | 10 | 80 | 80 | 80 | 5 | 5 | 1 |
| L3 | Transition | 20 | 10 | 15 | 5 | 5 | 5 | 10 | 15 | 10 | 90 | 75 | 75 | 5 | 5 | 5 |
| L4 | Longwall | 15 | 20 | 20 | 5 | 10 | 5 | 10 | 10 | 10 | 85 | 80 | 80 | 5 | 5 | 5 |
| L5 | Transition | 20 | 20 | 20 | 10 | 10 | 10 | 10 | 25 | 5 | 85 | 70 | 70 | 5 | 5 | 1 |
| L6 | Longwall | 20 | 20 | 15 | 5 | 5 | 10 | 25 | 25 | 15 | 75 | 70 | 70 | 5 | 5 | 5 |
| L7 | Transition | 20 | 20 | 20 | 5 | 5 | 5 | 5 | 10 | 5 | 90 | 80 | 80 | 5 | 5 | 5 |
| L8 | Longwall | 10 | 10 | 10 | 5 | 5 | 5 | 15 | 15 | 15 | 80 | 75 | 70 | 5 | 5 | 5 |
| L9 | Transition | 20 | 20 | 15 | 10 | 5 | 5 | 10 | 30 | 15 | 85 | 80 | 75 | 5 | 5 | 5 |
| L10 | Longwall | 20 | 20 | 15 | 5 | 5 | 5 | 20 | 15 | 10 | 80 | 70 | 70 | 5 | 5 | 5 |
| | | | | | | | | | | | | | | | | |

PFC = Percentage Foliage Cover of upper canopy; EF/TF = Epicormic Foliage in relation to Total Foliage; PBCDB = Primary Branches within the Canopy which have Died Back; CCF/PCF = Current Canopy Foliage as a proportion of Potential Canopy Foliage; CFD = Canopy Foliage Discolouration

**Table F-2: UW LW4 spring**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 |
| L1 | Transition | 15 | 15 | 20 | 5 | 1 | 5 | 15 | 5 | 15 | 85 | 80 | 85 | 5 | 1 | 5 |
| L2 | Longwall | 15 | 10 | 20 | 5 | 5 | 5 | 10 | 10 | 25 | 80 | 80 | 75 | 5 | 1 | 5 |

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 |
| L3 | Transition | 20 | 15 | 20 | 5 | 5 | 5 | 15 | 10 | 40 | 90 | 75 | 85 | 5 | 5 | 5 |
| L4 | Longwall | 15 | 20 | 15 | 5 | 5 | 5 | 15 | 10 | 45 | 80 | 80 | 75 | 5 | 5 | 5 |
| L5 | Transition | 20 | 20 | 15 | 10 | 10 | 5 | 25 | 5 | 50 | 70 | 70 | 70 | 5 | 1 | 5 |
| L6 | Longwall | 20 | 15 | 20 | 5 | 10 | 50 | 25 | 15 | 40 | 70 | 70 | 80 | 5 | 5 | 5 |
| L7 | Transition | 20 | 20 | 15 | 5 | 5 | 10 | 5 | 5 | 60 | 90 | 80 | 40 | 5 | 5 | 15 |
| L8 | Longwall | 10 | 10 | 15 | 5 | 5 | 5 | 15 | 15 | 15 | 75 | 70 | 85 | 5 | 5 | 5 |
| L9 | Transition | 20 | 15 | 20 | 5 | 5 | 10 | 30 | 15 | 20 | 80 | 75 | 80 | 5 | 5 | 5 |
| L10 | Longwall | 20 | 15 | 15 | 5 | 5 | 5 | 15 | 10 | 20 | 75 | 70 | 80 | 5 | 5 | 5 |

PFC = Percentage Foliage Cover of upper canopy; EF/TF = Epicormic Foliage in relation to Total Foliage; PBCDB = Primary Branches within the Canopy which have Died Back; CCF/PCF = Current Canopy Foliage as a proportion of Potential Canopy Foliage; CFD = Canopy Foliage Discolouration

**Table F-3: UW LW5 autumn and spring**

| Site | Zone | PFC (%) | | | | EF/TF (%) | | | | PBCDB (%) | | | | CCP/PC (%) | | | | CFD (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 |
| L1 | Transition | 20 | 15 | 20 | 15 | 10 | 5 | 5 | 5 | 30 | 25 | 25 | 30 | 70 | 60 | 60 | 55 | 10 | 5 | 5 | 5 |
| L2 | Longwall | 25 | 20 | 20 | 25 | 5 | 5 | 5 | 5 | 20 | 15 | 15 | 25 | 75 | 80 | 80 | 75 | 5 | 5 | 5 | 5 |
| L3 | Transition | 20 | 15 | 15 | 15 | 5 | 3 | 3 | 5 | 20 | 15 | 15 | 20 | 70 | 75 | 75 | 75 | 5 | 5 | 5 | 5 |
| L4 | Longwall | 20 | 10 | 15 | 20 | 10 | 1 | 1 | 10 | 20 | 15 | 15 | 15 | 70 | 80 | 80 | 75 | 5 | 5 | 5 | 5 |
| L5 | Transition | 25 | 15 | 20 | 25 | 0 | 2 | 5 | 5 | 10 | 15 | 20 | 15 | 80 | 75 | 75 | 85 | 0 | 5 | 5 | 0 |
| L6 | Longwall | 20 | 20 | 20 | 25 | 0 | 2 | 2 | 5 | 15 | 20 | 20 | 10 | 75 | 70 | 70 | 80 | 5 | 5 | 5 | 0 |
| L7 | Transition | 20 | 10 | 10 | 15 | 10 | 10 | 10 | 10 | 15 | 20 | 20 | 20 | 65 | 50 | 50 | 70 | 5 | 5 | 5 | 10 |
| L8 | Longwall | 25 | 15 | 15 | 20 | 5 | 10 | 10 | 10 | 15 | 5 | 5 | 20 | 65 | 70 | 70 | 40 | 5 | 5 | 5 | 10 |
| L9 | Transition | 25 | 15 | 15 | 15 | 5 | 5 | 5 | 10 | 10 | 10 | 10 | 30 | 85 | 75 | 75 | 70 | 5 | 10 | 10 | 10 |

| Site | Zone | PFC (%) | | | | EF/TF (%) | | | | PBCDB (%) | | | | CCP/PC (%) | | | | CFD (%) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 | A18 | S18 | A19 | S19 |
| L10 | Longwall | 15 | 15 | 15 | 15 | 5 | 5 | 5 | 5 | 15 | 5 | 5 | 15 | 75 | 80 | 80 | 85 | 5 | 5 | 5 | 5 |

PFC = Percentage Foliage Cover of upper canopy; EF/TF = Epicormic Foliage in relation to Total Foliage; PBCDB = Primary Branches within the Canopy which have Died Back; CCF/PCF = Current Canopy Foliage as a proportion of Potential Canopy Foliage; CFD = Canopy Foliage Discolouration

**Table F-4: UG LWW4 autumn**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 |
| L1 | Transition | | 20 | 15 | | 10 | 5 | | 10 | 10 | | 80 | 80 | | 0 | 5 |
| L2 | Longwall | | 40 | 25 | | 0 | 0 | | 20 | 20 | | 80 | 80 | | 5 | 5 |
| L3 | Transition | | 10 | 10 | | 5 | 5 | | 30 | 30 | | 80 | 80 | | 5 | 5 |
| L4 | Longwall | | 20 | 20 | | 15 | 10 | | 40 | 40 | | 70 | 65 | | 5 | 5 |
| L5 | Transition | | 15 | 15 | | 5 | 5 | | 40 | 40 | | 60 | 60 | | 5 | 5 |
| L6 | Longwall | | 20 | 15 | | 0 | 0 | | 20 | 20 | | 70 | 70 | | 5 | 5 |
| L7 | Transition | | 15 | 15 | | 5 | 5 | | 40 | 40 | | 65 | 50 | | 10 | 5 |
| L8 | Longwall | | 10 | 10 | | 10 | 10 | | 30 | 45 | | 65 | 55 | | 5 | 5 |
| L9 | Transition | | 15 | 15 | | 0 | 5 | | 30 | 20 | | 85 | 85 | | 0 | 0 |
| L10 | Longwall | | 10 | 10 | | 5 | 5 | | 20 | 25 | | 75 | 75 | | 5 | 5 |

**Table F-5: UG LWW4 spring**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 |
| L1 | Transition | 15 | 20 | 15 | 10 | 10 | 10 | 10 | 10 | 15 | 80 | 80 | 85 | 0 | 0 | 5 |
| L2 | Longwall | 30 | 40 | 35 | 0 | 0 | 0 | 20 | 20 | 10 | 80 | 80 | 85 | 5 | 5 | 0 |

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 |
| L3 | Transition | 10 | 10 | 15 | 5 | 5 | 0 | 30 | 30 | 15 | 80 | 80 | 85 | 5 | 5 | 5 |
| L4 | Longwall | 15 | 20 | 25 | 10 | 15 | 10 | 40 | 40 | 35 | 70 | 70 | 65 | 5 | 5 | 70 |
| L5 | Transition | 15 | 15 | 20 | 0 | 5 | 5 | 20 | 40 | 25 | 80 | 60 | 70 | 5 | 5 | 10 |
| L6 | Longwall | 20 | 20 | 15 | 0 | 0 | 5 | 20 | 20 | 15 | 70 | 70 | 70 | 0 | 5 | 40 |
| L7 | Transition | 15 | 15 | 15 | 5 | 5 | 5 | 40 | 40 | 10 | 85 | 65 | 85 | 5 | 10 | 0 |
| L8 | Longwall | 10 | 10 | 10 | 10 | 10 | 5 | 30 | 30 | 25 | 70 | 65 | 70 | 5 | 5 | 0 |
| L9 | Transition | 15 | 15 | 20 | 0 | 0 | 0 | 30 | 30 | 20 | 85 | 85 | 80 | 0 | 0 | 0 |
| L10 | Longwall | 10 | 10 | 15 | 5 | 5 | 0 | 20 | 20 | 10 | 80 | 75 | 80 | 5 | 5 | 0 |

**Table F-6: UG LWW5 autumn**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 | A17 | A18 | A19 |
| L1 | Transition | | 5 | 5 | | 0 | 0 | | 5 | 5 | | 80 | 80 | | 0 | 0 |
| L2 | Longwall | | 30 | 25 | | 5 | 5 | | 5 | 5 | | 85 | 85 | | 5 | 5 |
| L3 | Transition | | 25 | 25 | | 5 | 5 | | 5 | 5 | | 85 | 85 | | 5 | 5 |
| L4 | Longwall | | 30 | 20 | | 5 | 5 | | 10 | 10 | | 85 | 85 | | 5 | 5 |
| L5 | Transition | | 30 | 25 | | 10 | 10 | | 15 | 15 | | 80 | 75 | | 5 | 5 |
| L6 | Longwall | | 25 | 25 | | 25 | 10 | | 10 | 15 | | 80 | 65 | | 5 | 10 |
| L7 | Transition | | 20 | 15 | | 5 | 5 | | 20 | 20 | | 85 | 85 | | 5 | 5 |
| L8 | Longwall | | 20 | 15 | | 0 | 0 | | 10 | 10 | | 90 | 85 | | 5 | 5 |
| L9 | Transition | | 20 | 15 | | 5 | 5 | | 15 | 20 | | 80 | 75 | | 5 | 5 |
| L10 | Longwall | | 15 | 10 | | 5 | 5 | | 20 | 35 | | 75 | 65 | | 5 | 5 |

**Table F-7: UG LWW5 spring**

| Site | Zone | PFC (%) | | | EF/TF (%) | | | PBCDB (%) | | | CCP/PC (%) | | | CFD (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 | S17 | S18 | S19 |
| L1 | Transition | 5 | 5 | 10 | 0 | 0 | 0 | 5 | 5 | 5 | 80 | 80 | 85 | 0 | 0 | 5 |
| L2 | Longwall | 30 | 25 | 30 | 5 | 0 | 2 | 5 | 5 | 5 | 85 | 85 | 85 | 5 | 5 | 5 |
| L3 | Transition | 20 | 25 | 25 | 5 | 5 | 5 | 5 | 5 | 5 | 80 | 85 | 80 | 5 | 5 | 5 |
| L4 | Longwall | 30 | 20 | 30 | 5 | 5 | 5 | 10 | 10 | 5 | 85 | 85 | 90 | 5 | 5 | 5 |
| L5 | Transition | 30 | 25 | 30 | 10 | 10 | 20 | 15 | 15 | 15 | 80 | 75 | 75 | 5 | 5 | 5 |
| L6 | Longwall | 25 | 25 | 25 | 10 | 25 | 15 | 10 | 15 | 10 | 80 | 65 | 85 | 5 | 10 | 5 |
| L7 | Transition | 20 | 15 | 20 | 5 | 5 | 1 | 20 | 20 | 5 | 85 | 85 | 80 | 5 | 5 | 5 |
| L8 | Longwall | 20 | 15 | 15 | 0 | 0 | 1 | 10 | 10 | 5 | 90 | 90 | 90 | 5 | 5 | 0 |
| L9 | Transition | 20 | 15 | 15 | 5 | 5 | 0 | 15 | 20 | 10 | 80 | 75 | 85 | 5 | 5 | 5 |
| L10 | Longwall | 15 | 15 | 15 | 0 | 5 | 0 | 30 | 30 | 20 | 75 | 75 | 80 | 5 | 5 | 5 |

Table F-8: UW LW6 spring and autumn

| Site | Zone | PFC (%) | | EF/TF (%) | | PBCDB (%) | | CCP/PC (%) | | CFD (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A19 | S19 | A19 | S19 | A19 | S19 | A19 | S19 | A19 | S19 |
| L1 | Transition | 15 | 5 | 5 | 5 | 20 | 50 | 75 | 85 | 5 | 5 |
| L2 | Longwall | 20 | 15 | 10 | 5 | 30 | 30 | 65 | 75 | 5 | 10 |
| L3 | Transition | 20 | 15 | 20 | 5 | 40 | 50 | 55 | 65 | 5 | 5 |
| L4 | Longwall | 25 | 10 | 10 | 10 | 30 | 80 | 70 | 45 | 5 | 25 |
| L5 | Transition | 20 | 20 | 10 | 5 | 15 | 5 | 75 | 80 | 10 | 5 |
| L6 | Longwall | 20 | 15 | 10 | 5 | 10 | 20 | 75 | 75 | 5 | 5 |
| L7 | Transition | 20 | 15 | 5 | 5 | 20 | 40 | 70 | 70 | 5 | 5 |
| L8 | Longwall | 30 | 25 | 5 | 5 | 10 | 10 | 85 | 80 | 5 | 5 |
| L9 | Transition | 20 | 25 | 5 | 5 | 15 | 10 | 80 | 85 | 5 | 5 |
| L10 | Longwall | 25 | 15 | 20 | 5 | 30 | 15 | 65 | 90 | 10 | 5 |

Table F-9: UG LWW6 spring and autumn

| Site | Zone | PFC (%) | | EF/TF (%) | | PBCDB (%) | | CCP/PC (%) | | CFD (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | A19 | S19 | A19 | S19 | A19 | S19 | A19 | S19 | A19 | S19 |
| L1 | Transition | 30 | 15 | 5 | 5 | 5 | 10 | 90 | 95 | 5 | 10 |
| L2 | Longwall | 25 | 10 | 20 | 5 | 30 | 60 | 60 | 60 | 5 | 35 |
| L3 | Transition | 35 | 20 | 5 | 5 | 10 | 30 | 85 | 85 | 5 | 5 |
| L4 | Longwall | 25 | 25 | 0 | 0 | 10 | 10 | 85 | 95 | 5 | 5 |
| L5 | Transition | 25 | 20 | 20 | 5 | 25 | 15 | 70 | 85 | 5 | 5 |
| L6 | Longwall | 20 | 20 | 5 | 5 | 20 | 25 | 70 | 75 | 5 | 5 |
| L7 | Transition | 15 | 20 | 30 | 5 | 25 | 40 | 70 | 85 | 5 | 5 |
| L8 | Longwall | 30 | 15 | 5 | 5 | 10 | 45 | 80 | 75 | 5 | 5 |
| L9 | Transition | 10 | 15 | 60 | 5 | 30 | 50 | 60 | 70 | 10 | 5 |
| L10 | Longwall | 20 | 20 | 40 | 5 | 10 | 40 | 65 | 80 | 15 | 5 |

# Appendix G Management Issues

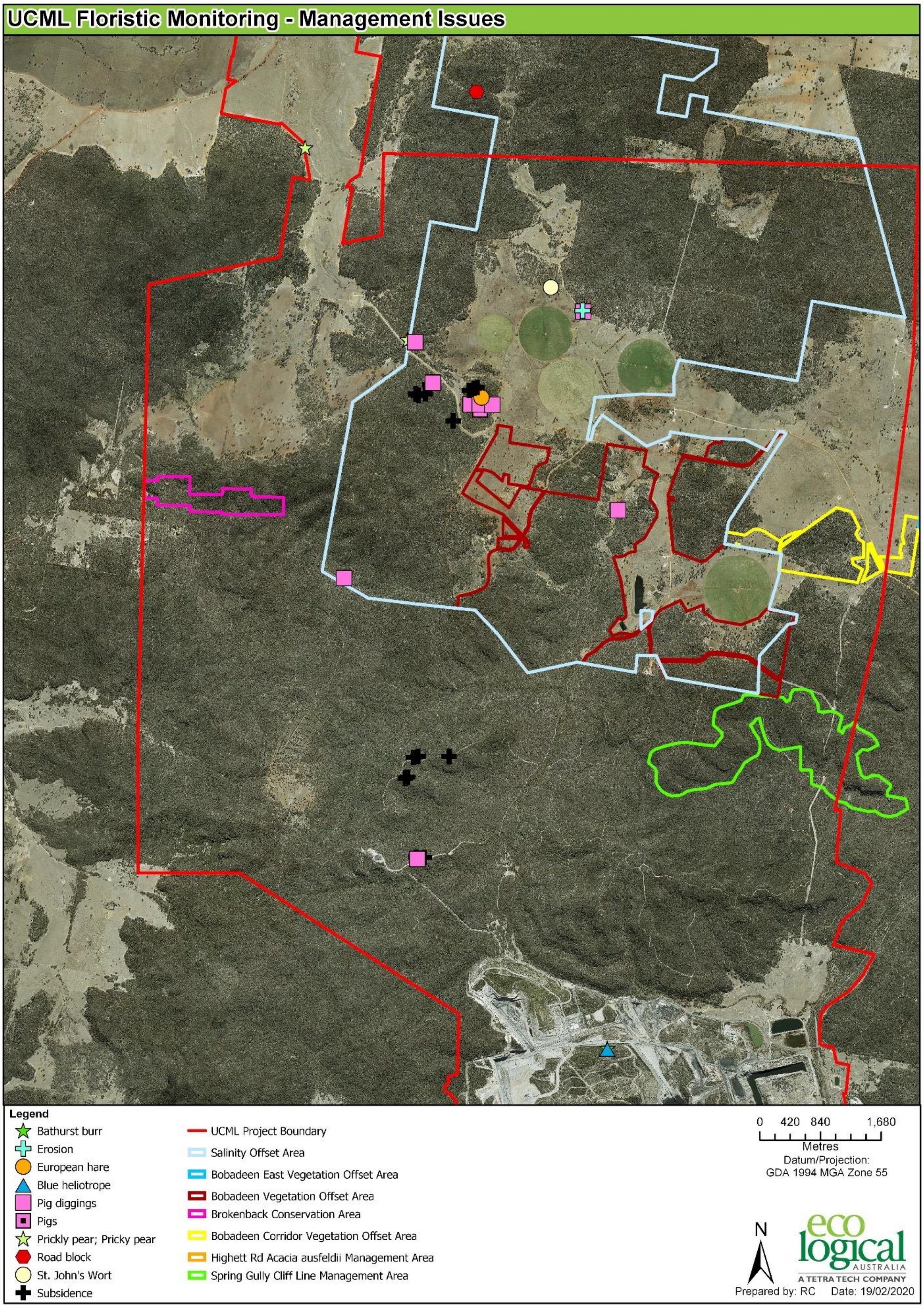


**Figure G-1: Management issues 2019**

# *Microbat Monitoring of the Ulan Coal Mine Lease during 2019*

A report to Ulan Coal Mines Limited

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# 1 INTRODUCTION

This report details the results of microbat monitoring undertaken during 2019 to fulfil monitoring requirements associated with approval conditions for previous and recently approved extensions within the Ulan Coal Mine lease. The Project Area comprises a total of 13,435 hectares and includes areas referred to in the Environmental Assessment (Umwelt 2009) and the subsequent Biodiversity Management Plan (BMP). This area consists of the Ulan West and No. 3 underground areas, as well as the open cut. They include:

- Previous Open Cut Mining Areas – covers approximately 475 hectares of previously open cut mining areas that have been rehabilitated and final voids that remain to support future mining activities (i.e. water storage, tailings disposal, underground access etc.);

- Surface Infrastructure Area – the 169 hectare disturbance area required for construction of underground service infrastructure;

- Residual Project Area – the remainder of the Project Area that is not subject to the current project. This includes large areas that have been previously undermined, agricultural grazing land, irrigation pivots and large areas of remnant native vegetation; and

- Biodiversity Offset and Management Areas – land that has been approved for Biodiversity Offset and Management Areas for the Project, being:

    1. Bobadeen Vegetation Offset Area including Bobadeen Corridor and Bobadeen East Vegetation Offset Area (1369.8 hectares);

    2. Brokenback Conservation Area (58 hectares)

    3. Spring Gully Cliff Line Management Area (273 hectares); and

    4. Highett Rd *Acacia ausfeldii* Management Area – (21 hectares).

The BMP was prepared (in part) to document the existing ecological and rehabilitation monitoring commitments for the Project Area, considering current and approved operations. The aims of the ecological and rehabilitation monitoring program are to:

- demonstrate compliance in regards to the relevant federal and state approvals that apply to the project area;
- provide the scientific basis for defining rehabilitation objectives and for developing closure criteria and a rehabilitation program that will facilitate lease relinquishment following closure; and

assess the long-term stability and functioning of re-established ecosystems within post-mining rehabilitation areas, as well as revegetated areas within the Biodiversity Offset and Management Areas.

Monitoring continued at eight control sites situated along sandstone clifflines at Brokenback Spring Gully and Ulan Creek and at twelve sites subject to subsidence situated above longwalls at Ulan West and Ulan Underound. Additional sites will be added as clifflines are examined prior to mining in future years.

Conditions 3 and 5 of the EPBC Approval 2009/5252 requires UCML to undertake a monitoring program for the Large-eared Pied Bat and its response to management actions implemented in the Bobadeen and Bobadeen East BOAs, as well as the Brokenback Conservation Area and Spring Gully Cliff Line Management Area, which were specifically created to offset impacts to Large-eared Pied Bat habitat. In addition to this, the Project Approval (PA 08_0184) requires UCML to have negligible impacts upon threatened species, population and habitat. This monitoring program is also required to monitor any effects of subsidence, and subsidence remediation that may occur upon the Large-eared Pied Bat in the Bobadeen and Bobadeen East BOAs. Each site will be surveyed with an Anabat device/s, with a harp trap to be used at selected sites to collect data on Large-eared Pied Bat activity and demographics at the site. Data will be analysed for Large-eared Pied Bat presence/absence and may be used for other analyses such as activity indexing.

*Table 1*

Statutory requirements of the BMP and their relevant methods of assessment and performance measures

| Statutory Requirements | Performance Measures | Assessment Methodology | Triggers for investigation specified in Management Plans |
|---|---|---|---|
| NSW Project Approval – PA 08_0184, Schedule 3 Condition 24: The proponent shall ensure that the project does not cause any exceedances of the performance measure: Negligible impact on threatened species, populations habitat or ecological communities | Negligible impact on threatened species, populations habitat or ecological communities (PA08_0184, S3, c24, Table 14) | Targeted threatened microbat monitoring<br>- Echolocation and Harp trapping<br>- Targeted microbat species activity | Ref: Ulan West EP Appendix C BMP LW1 to LW6 (ULNCX-111515275-2783), s 4.3, Table 3 - Analysis of micro-bat monitoring data identifies decreasing activity levels (>10% population decline) of endangered micro-bats species during cliff line monitoring within the Application Area over two or more monitoring periods outside of seasonal variations |
| NSW Project Approval – PA 08_0184, Schedule 3, Condition 41A: The proponent shall ensure that the offset areas contain suitable habitat for | None specified | 2009 Environment Assessment and confirmatory ecological assessments, as documented in Conservation Area | No triggers established |

| Statutory Requirements | Performance Measures | Assessment Methodology | Triggers for investigation specified in Management Plans |
|---|---|---|---|
| any significant and / or threatened species identified in areas to be cleared, removed or disturbed | | Agreements | |
| NSW Project Approval – PA 08_0184, Schedule 3 Condition 42: The Proponent shall ensure that at least 244 hectares within the Bobadeen Vegetation Offset Area and 169 hectares within the Bobadeen East Offset Area includes the re-establishment and/or improvement of:<br>(c) habitat for significant and/or threatened animal species | 'A range of habitat features relevant to the identified threatened species is available throughout offset areas' (BMP, (ULNCX-111515275-225), pg 117) | Monitoring consistent with the Bobadeen Conservation Agreement (7 May 2019) | No triggers established |
| Commonwealth Approval - EPBC Ref: 2009/5252 Condition 3: To offset the impacts on … foraging habitat of the listed … Large-eared Pied Bat, the person taking the action must, before commencement of operations (excluding first workings), obtain the Minister's approval of an Offset Management Plan for the Bobadeen and Bobadeen East Offset Area. The plan must include details of:…<br>h) the development and implementation of a monitoring program | 'A range of habitat features relevant to the identified threatened species is available throughout offset areas' (BMP, (ULNCX-111515275-225), pg 117) - | Monitoring consistent with the Bobadeen Conservation Agreement (7 May 2019) | No triggers established |
| Commonwealth Approval - EPBC Ref: 2009/5252 Condition 5: To offset the impacts on the Large-eared Pied Bat, the person taking the action must, before commencement of operations (excluding first workings), obtain the Minister's approval of an Offset Management Plan for the Brokenback Conservation Area and Spring Gully Cliff Line Management Area. The | None specified | Annual microbat monitoring within the Brokenback and Spring Gully areas, specifically:<br>Acoustic Bat detection – 2 recording nights (November and December)<br>Harp trapping – up to 3 Trap nights (November and December)<br>- Presence absence assessment | Ref: BMP (ULNCX-111515275-225), s7.11.4: A species of threatened microbat previously identified within a BOA for two or more consecutive monitoring years not detected in BOA during subsequent annual monitoring. |

| Statutory Requirements | Performance Measures | Assessment Methodology | Triggers for investigation specified in Management Plans |
|---|---|---|---|
| plan must include details of:…<br>e) the development and implementation of a monitoring program | | | |

# 2 SURVEY METHODOLOGY

## a General Fauna Sites

Twenty sites were sampled for bats through captures using collapsible harp traps (Tidemann & Woodside, 1978) as well as recording and subsequent analysis of echolocation calls via Anabat detectors (models Anabat 2, SD1, SD2 & Anabat Express). Each site was sampled for two consecutive nights with harp traps and had echolocation call recording undertaken for a minimum of two complete nights. Echolocation calls were recorded for subsequent analysis. Bats captured in harp traps were identified, measured and fitted with an identification band. Survey for bats in forest above existing and planned underground workings was undertaken from 18th to 28th November 2019.

The location of the twenty general fauna monitoring sites (Figure 1) are as follows:

| | | | |
|---|---|---|---|
| Bobadeen Corridor 1 (BC1) | 761520E | 6436115N | E |
| Bobadeen Corridor 1 (BC2) | 760491E | 6436143N | E |
| Bobadeen Offset 1 (BO1) | 757171E | 6435205N | H,E |
| Bobadeen Offset 2 (BO2) | 760452E | 6435200N | E |
| Bobadeen Offset 3 (BO3) | 757453E | 6436742N | E |
| Bobadeen Offset 4 (BO4) | 759186E | 6436912N | E |
| Bobadeen East 1 (BE1) | 762922E | 6436183N | H,E |
| Bobadeen East 2 (BE2) | 763374E | 6438349N | H,E |
| Spring Gully 1 (CR) | 760096E | 6433625N | E |
| Infrastructure 1 (INF1) | 754636E | 6431861N | E |
| Infrastructure 2 (INF2) | 755148E | 6437151N | E |
| Infrastructure 3 (INF3) | 755352E | 6438919N | E |
| Infrastructure 4 (INF4) | 758717E | 6439744N | H,E |
| Residual 1 (RES1) | 758719E | 6432538N | E |
| Residual 2 (RES2) | 756620E | 6433058N | E |
| Residual 3 (RES3) | 752509E | 6434120N | E |
| Residual 4 (RES4) | 759263E | 6439041N | E |
| Residual 5 (RES5) | 755562E | 6442346N | E |
| Open Cut 1 (OC1) | 759955E | 6426893N | H,E |
| Open Cut 3 (OC3) | 758345E | 6428917N | E |

KEY
H Harp trap
E Echolocation call detection

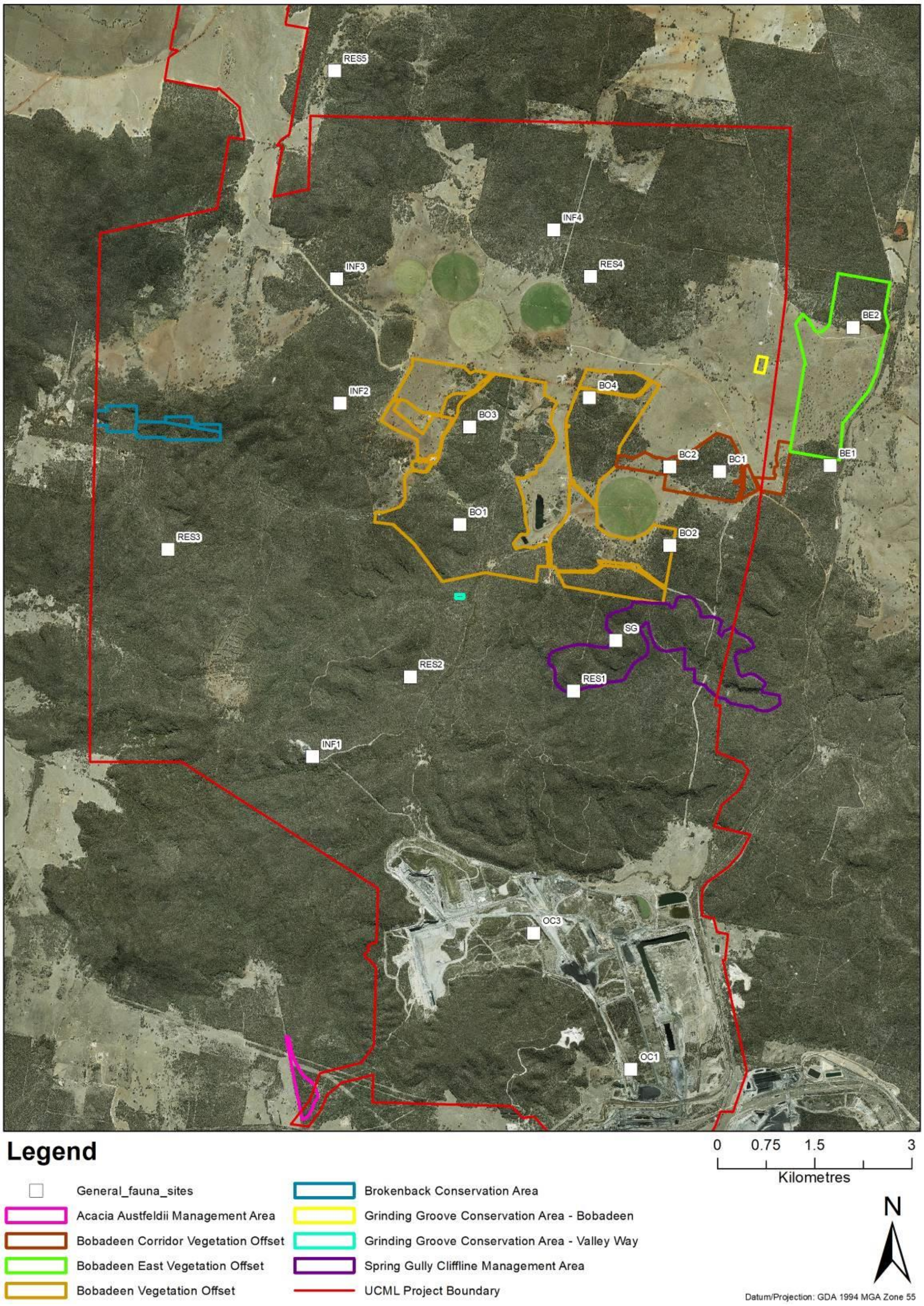


*Figure 1* General fauna sites sampled for microbats during 2019.

b Targeted Microbat Sites

Thirty five sites were sampled for microbats at control and impact target microbat sites through captures using collapsible harp traps (Tidemann & Woodside, 1978) and/or the recording and subsequent analysis of echolocation calls via Anabat detectors (models Anabat 2, SD1, SD2 & Anabat Express). Each site had echolocation call recording undertaken for two complete nights. Bats were captured in harp traps at select sites where captures of target species has previously taken place. Bats captured in harp traps were identified and measured. Survey for microbats at the targeted cliffline sites was undertaken from 18th to 28th November 2019. Eight control sites were sampled that have not been undermined by longwalls. The location of the eight control targeted microbat cliffline sites (Figure 2) is as follows:

| | | | | | |
|---|---|---|---|---|---|
| BD6 | 753428E | 6436595N | Narragamba | 8833-4-S | E |
| BD7 | 753052E | 6436594N | Narragamba | 8833-4-S | E |
| BD8 | 752671E | 6436618N | Narragamba | 8833-4-S | E |
| BD9 | 751864E | 6436925N | Narragamba | 8833-4-S | E |
| SG5 | 761877E | 6432689N | Durridgere | 8833-1-S | E |
| SG7 | 761427E | 6432729N | Durridgere | 8833-1-S | H,E |
| SG8 | 761438E | 6432916N | Durridgere | 8833-1-S | E |
| UG1 | 756847E | 6431191N | Durridgere | 8833-1-S | H,E |

KEY
H Harp trap
E Echolocation call detection

An additional twenty four sites (Figure 2) above the first seven panels of Ulan West and three sites above three panels of UG3 were monitored for the ongoing effects of longwall mining as recommended (Fly By Night 2018b):

| | | | | | |
|---|---|---|---|---|---|
| UWLW3a | 755843E | 6434283N | Narragamba | 8833-4-S | E |
| UWLW3b | 755684E | 6434134N | Narragamba | 8833-4-S | E |
| UWLW3c | 755656E | 6431663N | Narragamba | 8833-4-S | E |
| UWLW4a | 755519E | 6433521N | Narragamba | 8833-4-S | E |
| UWLW4b | 755273E | 6432108N | Narragamba | 8833-4-S | E |
| UWLW5a | 756330E | 6438584N | Narragamba | 8833-4-S | E |
| UWLW5b | 754881E | 6432899N | Narragamba | 8833-4-S | E |
| UWLW5c | 754702E | 6432687N | Narragamba | 8833-4-S | E |
| UWLW5d | 754881E | 6438584N | Narragamba | 8833-4-S | E |
| UWLW5h | 754702E | 6432687N | Narragamba | 8833-4-S | E |
| UWLW5j | 754728E | 6432751N | Narragamba | 8833-4-S | E |
| UWLW5k | 754869E | 6433739N | Narragamba | 8833-4-S | E |

| | | | | | |
|---|---|---|---|---|---|
| UWLW5m | 754983E | 6433786N | Narragamba | 8833-4-S | E |
| UWLW6c | 754581E | 6432440N | Narragamba | 8833-4-S | E |
| UWLW6d | 754507E | 6433372N | Narragamba | 8833-4-S | E |
| UWLW6e | 754429E | 6433323N | Narragamba | 8833-4-S | E |
| UWLW6m | 754509E | 6436519N | Narragamba | 8833-4-S | E |
| UWLW6o | 754402E | 6436604N | Narragamba | 8833-4-S | E |
| UWLW6p | 754403E | 6436297N | Narragamba | 8833-4-S | E |
| UWLW7a | 754202E | 6436095N | Narragamba | 8833-4-S | E |
| UWLW7b | 754259E | 6436457N | Narragamba | 8833-4-S | E |
| UWLW7d | 754179E | 6436616N | Narragamba | 8833-4-S | E |
| UWLW7e | 754071E | 6436611N | Narragamba | 8833-4-S | E |
| UWLW7h | 754346E | 6436576N | Narragamba | 8833-4-S | E |
| UGLWW3a | 755427E | 6437440N | Narragamba | 8833-4-S | H,E |
| UGLWW4a | 755205E | 6437865N | Narragamba | 8833-4-S | H,E |
| UGLWW5b | 756308E | 6438326N | Narragamba | 8833-4-S | E |

KEY
H Harp trap
E Echolocation call detection

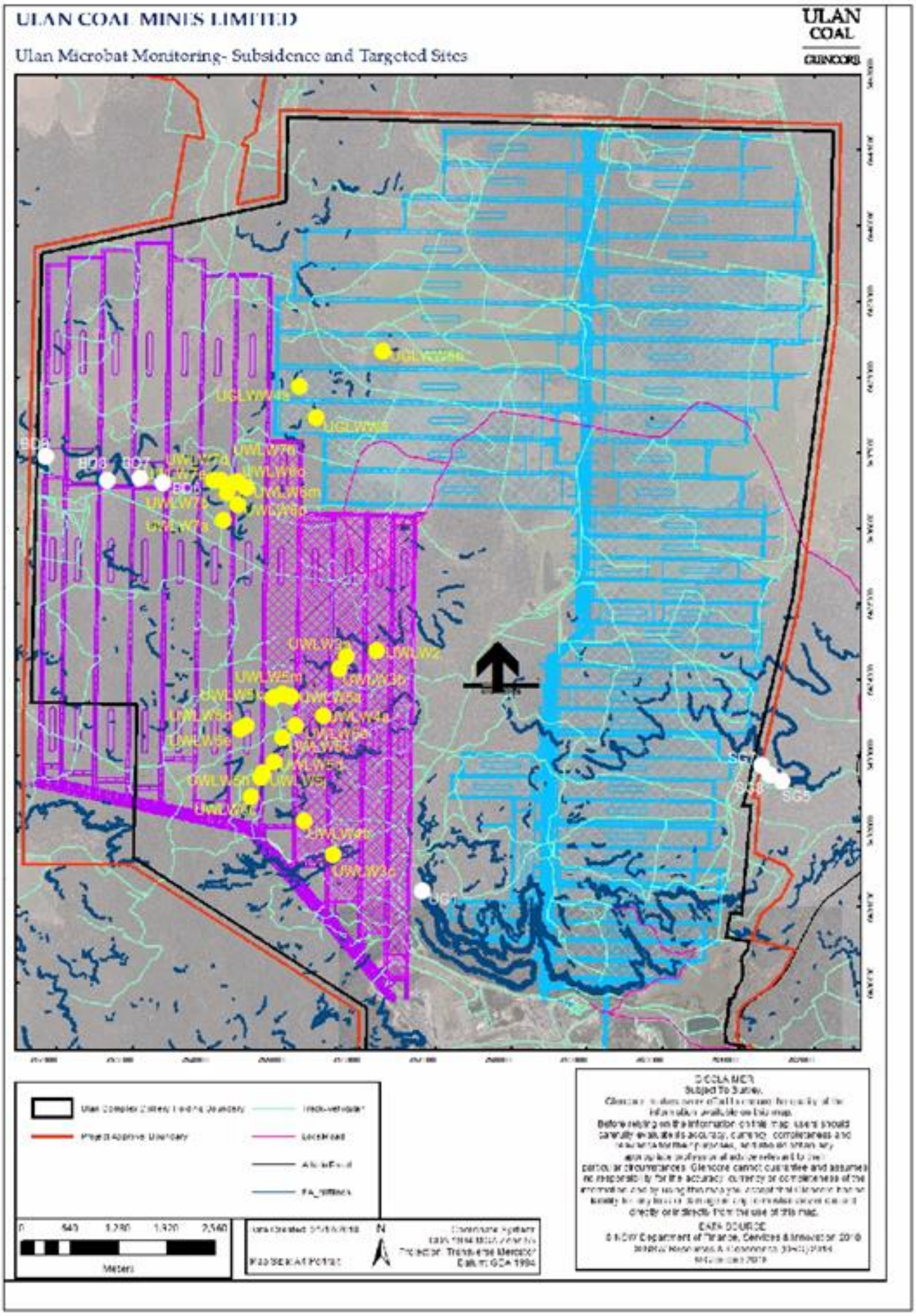


*Figure 2* Control (white dots) and impact microbat cliffline sites (yellow dots) surveyed during 2019.

*Figure 3* Harp trap set in cave overhang at site BO1.

*Figure 4* Large-eared Pied Bats in a roost at UGLWW3.

c Weather Conditions during Survey

Weather experienced during the 2019 target microbat surveys was warm to hot. Minimum temperatures varied from 7.8 to 21.5$^{0}$C while maximum temperatures ranged from 29.2 to 36.5$^{0}$C (refer to *Table 2*). Light rain fell on the eighth day of the survey.

Temperatures; Gulgong Post Office (Site 62013), Latitude: 32.36°S, Longitude: 149.53°E, Elevation: 475m.

Rainfall; Bobadeen Shearers Quarters courtesy of R. Kearen.

*Table 2*

Weather conditions during the 2019 microbat monitoring.

| Date | Minimum temperature (°C) | Maximum temperature (°C) | Rainfall (mm) |
|---|---|---|---|
| 18/11/2019 | 11.5 | 29.7 | 0 |
| 19/11/2019 | 10.9 | 34.6 | 0 |
| 20/11/2019 | 15.7 | 33.8 | 0 |
| 21/11/2019 | 13.9 | 37 | 0 |
| 22/11/2019 | 21.5 | No data | 0 |
| 23/11/2019 | No data | No data | 0 |
| 24/11/2019 | No data | 36.5 | 0 |
| 25/11/2019 | 16.7 | 32 | 6 |
| 26/11/2019 | 18.5 | 32.7 | 1 |
| 27/11/2019 | 7.8 | 29.2 | 1 |
| 28/11/2019 | 12.3 | 33.8 | 0 |
| 29/11/2019 | 16.7 | No data | 0 |

# 3 SURVEY RESULTS

## a General Fauna Sites

As seen in *Table 3*, fifteen microbat species were recorded in total at the general fauna sites during the 2019 surveys. This is similar to that recorded during previous monitoring. The number of species recorded at each site varied from five to eleven.

12 individuals of five species were captured in harp traps; the Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Long-eared Bat (*Nyctophilus gouldi*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Southern Freetail Bat (*Mormopterus planiceps*) and Little Forest Bat (*Vespadelus vulturnus*). One additional species, the Large-eared Pied Bat (*Chalinolobus dwyeri*), recorded 47 captures in harp traps at control and cliffline monitoring areas.

A total of 5399 identifiable echolocation call passes were recorded across the general fauna sites during the November 2019 survey. Thirteen microbat species were confidently recorded from echolocation calls during these surveys; the Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*), White Striped Mastiff Bat (*Austronomus australis*), Southern Freetail Bat (*Mormopterus planiceps*), Eastern Freetail Bat (*Mormopterus ridei*), Eastern Horseshoe Bat (*Rhinolophus megaphyllus*), Large-eared Pied Bat (*Chalinolobus dwyeri*), Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Little Pied Bat (*Chalinolobus picatus*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*) [formerly Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)], Unidentified Long-eared Bat (*Nyctophilus sp.*), Inland Broad-nosed Bat (*Scotorepens balstoni*) and Little Forest Bat (*Vespadelus vulturnus*).

Four microbat species listed as Vulnerable under the NSW Biodiversity Conservation Act 2016 were recorded from the general fauna sites during the 2019 surveys. Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) was not captured at any of the general fauna sites but was confidently recorded through echolocation call detection at four sites (BC1, BO4, CR & INF2). The Large-eared Pied Bat *(Chalinolobus dwyeri)* was not captured at any of the general fauna sites but was confidently recorded through echolocation call detection at six sites (BO1, BO2, BE1, BE2, INF1 & INF3) and tentatively recorded from call at another two sites (BC2 & RES4).

The Little Pied Bat (*Chalinolobus picatus*) was confidently recorded through echolocation call detection at six sites (BC1, BO4, BE2, INF2, INF3 & RES4) and tentatively recorded from call at another two sites (BC2 & OC3). The South-eastern Long-eared Bat (*Nyctophilus corbeni*) was not recorded during the November 2019 survey. The Eastern Bent-wing Bat (*Miniopterus o. oceanensis*) was confidently recorded from echolocation call at ten of the monitoring sites (BO1, CR, INF1, RES1, RES2, RES3, RES4, RES5, OC1 & OC3).

*Table 3*

Microbat species recorded from all general monitoring sites during the 2019 monitoring period. Threatened species in bold.

| | **General Monitoring Sites** | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Forest** | | | | | | | | | | | | | | | | | | **Regen** | |
| **Bat Species** | **BC1** | **BC2** | **BO1** | **BO2** | **BO3** | **BO4** | **BE1** | **BE2** | **CR** | **INF1** | **INF2** | **INF3** | **INF4** | **RES1** | **RES2** | **RES3** | **RES4** | **RES5** | **OC1** | **OC3** |
| ***Saccolaimus flaviventris*** | **E** | | | | | **E** | | | **E** | | **E** | | | | | | | | | |
| *Austronomus australis* | E | E | | E | E | E | E | E | E | E | E | E | E | | | E | E | E | E | E |
| *Mormopterus planiceps* | E | E | | E | E | E | E | E | | | E | E | E | H | | E | E | | | E |
| *Mormopterus ridei* | E | E | E | E | E | E | E | | | | E | E | E | | | | E | | | E |
| *Rhinolophus megaphyllus* | | E | | | | | E | | | | | | | E | E | | | | | |
| ***Chalinolobus dwyeri*** | | **E?** | **E** | **E** | | | **E** | **E** | | **E** | | **E** | | | | | **E?** | | | |
| *Chalinolobus gouldii* | E | E | | E | E | | E | E | | | E | E | E | | E | | E | | | E |
| *Chalinolobus morio* | E | E | E | E | E | E | E | E | E | E | E | E | H | E | E | E | E | E | E | E |
| ***Chalinolobus picatus*** | **E** | **E?** | | | | **E** | | **E** | | | **E** | **E** | | | | | **E** | | | **E?** |
| ***Miniopterus o. oceanensis*** | | | **E** | | | | | | **E** | **E** | | | | **E** | **E** | **E** | **E** | **E** | **E** | **E** |
| *Nyctophilus geoffroyi* | | | | | | | | H | | | | | | | | | | | | |
| *Nyctophilus gouldi* | | | | | | | | | | | | | H | | | | | | | |
| *Nyctophilus sp.* | E | E | E | E | | E | E | E | | | E | E | | E | | | E | E | E | E |
| *Scotorepens balstoni* | E | | E | E? | | E | E | E | E | | E | E | | | | E | E | E | | E |
| *Vespadelus vulturnus* | E | E | E | E | E | E | H,E | H,E | H,E | E | E | E | H,E | H,E | E | E | E | E | H,E | E |
| *TOTAL SPECIES* | 10 | 10 | 7 | 9 | 6 | 9 | 10 | 10 | 6 | 5 | 10 | 10 | 7 | 6 | 5 | 6 | 11 | 6 | 5 | 10 |

KEY
H Captured in harp traps E Recorded from echolocation call E? Tentatively recorded from echolocation call
Threatened and locally significant bat species are marked in bold

b Targeted Microbat Sites

***Control Sites***

As seen in *Table 4*, a total of fourteen microbat species were recorded during 2019 surveys of the target control microbat cliffline sites. The number of species recorded at each site varied from three to twelve. Most of these bat species were recorded from at least half of the sites: including the White-striped Mastiff Bat (*Austronomus australis*), Southern Freetail Bat (*Mormopterus planiceps*), Eastern Freetail Bat (*Mormopterus ridei*), Eastern Horseshoe Bat (*Rhinolophus megaphyllus*), Large-eared Pied Bat *(Chalinolobus dwyeri)*, Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*), Inland Broad-nosed Bat (*Scotorepens balstoni*) and Little Forest Bat (*Vespadelus vulturnus*).

Three targeted microbat species were recorded at control target sites during the 2019 surveys. The Eastern Horseshoe Bat *(Rhinolophus megaphyllus)* was confidently recorded through echolocation call detection at seven sites (BD6, BD7, BD8, BD9, SG5, SG7 & UG1). The Large-eared Pied Bat *(Chalinolobus dwyeri)* was captured at SG7 and UG1 and was confidently recorded through echolocation call detection at seven of the eight sites. Lactating females as well as free-flying young were captured at SG7 while free-flying young were captured at UG1. This indicates that breeding by this species is still being undertaken in the vicinity of these two sites. While breeding has been recorded at UG1 in recent years, the breeding at the Spring Gully Domain is the first recorded since November 2004. The Large Bent-winged Bat (*Miniopterus orianae oceanensis*) was confidently recorded from echolocation call at four sites (BD6, BD7, BD8 & UG1).

***Impact Sites***

As seen in *Table 5*, a total of thirteen microbat species were recorded during 2019 surveys of the target impact microbat cliffline sites. The number of species recorded at each site varied from five to twelve. Many of these microbat species were recorded from at least half of the sites: including the White-striped Mastiff Bat (*Austronomus australis*), Southern Freetail Bat (*Mormopterus planiceps*), Eastern Horseshoe Bat (*Rhinolophus megaphyllus*), Large-eared Pied Bat *(Chalinolobus dwyeri)*, Gould's Wattled Bat (*Chalinolobus gouldii*), Chocolate Wattled Bat (*Chalinolobus morio*), Little Pied Bat (*Chalinolobus picatus*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*) and Little Forest Bat (*Vespadelus vulturnus*).

Three targeted microbat species were recorded at impact target sites during the 2019 surveys. The Eastern Horseshoe Bat *(Rhinolophus megaphyllus)* was confidently recorded through echolocation call detection at twenty sites (UWLW3a, UWLW3c, UWLW4b, UWLW5b, UWLW5c, UWLW5g, UWLW5h, UWLW5j, UWLW5m, UWLW6b, UWLW6m, UWLW6o, UWLW7a, UWLW7b, UWLW7d, UWLW7e, UWLW7h, UGLWW3, UGLWW4a &

UGLWW5b). The Large-eared Pied Bat *(Chalinolobus dwyeri)* was captured at one site (UGLWW3) and confidently recorded through echolocation call detection at fifteen sites (UWLW3c, UWLW4b, UWLW5a, UWLW5g, UWLW5h, UWLW5j, UWLW5m, UWLW6m, UWLW6o, UWLW7d, UWLW7e, UWLW7h, UGLWW3, UGLWW4a & UGLWW5b). The capture of lactating females at site UGLWW3 confirms the continued breeding of the Large-eared Pied Bat at this site. The Large Bent-winged Bat (*Miniopterus orianae oceanensis*) was confidently recorded from echolocation call at twenty sites (UWLW3a, UWLW3b, UWLW3c, UWLW4a, UWLW4b, UWLW5b, UWLW5c, UWLW5g, UWLW5h, UWLW5j, UWLW5k, UWLW5m, UWLW6a, UWLW6b, UWLW6m, UWLW6o, UWLW7a, UWLW7b, UWLW7e & UGLWW4a).

*Table 4*

Microbat species recorded from all targeted control microbat cliffline sites during the 2019 monitoring period. Target species in bold.

| | **Control Sites** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Bat Species** | **BD6** | **BD7** | **BD8** | **BD9** | **SG5** | **SG7** | **SG8** | **UG1** |
| *Saccolaimus flaviventris* | | | E? | | | E | | E |
| *Austronomus australis* | E | E | E | E | E | E | | E |
| *Mormopterus planiceps* | E | E | E | E | E | E | E | |
| *Mormopterus ridei* | E | E | E | E | | | | E |
| ***Rhinolophus megaphyllus*** | **E** | **E** | **E** | **E** | **E** | | | **E** |
| ***Chalinolobus dwyeri*** | **E** | | **E** | **E** | **E** | **H,E** | **E** | **H,E** |
| *Chalinolobus gouldii* | E | | E | E | E? | E? | | E |
| *Chalinolobus morio* | E | E | | E | E | E | E | E |
| *Chalinolobus picatus* | E | | E | E | E | | | E |
| ***Miniopterus o. oceanensis*** | **E** | **E** | **E** | | | | | **E** |
| *Nyctophilus sp.* | E | E | | E | | E | | |
| *Scotorepens balstoni* | E | E? | E | E | E | E | | E |
| *Vespadelus vulturnus* | E | E | E | E | E | E | | E |
| *TOTAL SPECIES* | 12 | 9 | 11 | 11 | 9 | 9 | 3 | 11 |

KEY
H Captured in harp traps
E Recorded from echolocation call
E? Tentatively recorded from echolocation call
Target microbat species are marked in bold.

*Table 5*

Microbat species recorded from all targeted impact microbat cliffline sites during the 2019 monitoring period. Target species in bold.

| | **Ulan West** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bat Species** | **UWLW3a** | **UWLW3b** | **UWLW3c** | **UWLW4a** | **UWLW4b** | **UWLW5a** | **UWLW5b** | **UWLW5c** | **UWLW5g** | **UWLW5h** | **UWLW5j** | **UWLW5k** | **UWLW5m** |
| *S. flaviventris* | | E | | | E? | | | E | E? | | | | |
| *A. australis* | E | E | E | E | | E | | E | E | E | E | E | |
| *M. planiceps* | E | E | E | E | E | E | | E | E | E | E | E | E |
| *M. ridei* | | | E | | E? | | | E | E? | E | E | | |
| ***R. megaphyllus*** | **E** | | **E** | | **E** | | **E** | **E** | **E** | **E** | **E** | | **E** |
| ***C. dwyeri*** | | | **E** | | **E** | **E** | | | **E** | **E** | **E** | | **E** |
| *C. gouldii* | E | | E | | E | | E? | E? | | E | E | E | |
| *C.morio* | | E | E | | | E | E | E | E | E | E | E | E |
| *C.picatus* | | | | | | | | | | | | | |
| ***M. o. oceanensis*** | **E** | **E** | **E** | **E** | **E** | | **E** | **E** | **E** | **E** | **E** | **E** | **E** |
| *N. sp.* | | E | E | E? | | E | E | E | | E | E | | |
| *S. balstoni* | | | E | | E | | E | | | | E | E | |
| *V. vulturnus* | E? | E | E | E | E | E | E | E | E | E | E | E | E |
| *TOTAL SPECIES* | 6 | 7 | 11 | 5 | 9 | 6 | 7 | 10 | 9 | 10 | 11 | 7 | 6 |

KEY
H Captured in harp traps E Recorded from echolocation call E? Tentatively recorded from echolocation call
Target microbat species are marked in bold

*Table 5 cont.*

Microbat species recorded from all targeted impact microbat cliffline sites during the 2019 monitoring period. Target species in bold

| | **Ulan West** | | | | | | | | | **UG3** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Bat Species** | **UWLW6a** | **UWLW6b** | **UWLW6m** | **UWLW6o** | **UWLW7a** | **UWLW7b** | **UWLW7d** | **UWLW7e** | **UWLW7h** | **UGLWW3** | **UGLWW4a** | **UGLWW5b** |
| *S. flaviventris* | | | | | | | | | | | | |
| *A. australis* | E | | E | | E | E | E | E | E | E | E | E |
| *M. planiceps* | E | E? | E | E | | E | E | E? | E? | E? | H,E | E |
| *M. ridei* | | E | E? | | | | E | | | | | E? |
| ***R. megaphyllus*** | | **E** | **E** | **E** | **E** | **E** | **E** | **E** | **E** | **E** | **E** | **E** |
| ***C. dwyeri*** | | | **E** | **E** | | | **E** | **E** | **E** | **H,E** | **E** | **E** |
| *C. gouldii* | E? | | E | | E | | E | E | | E? | E | E |
| *C.morio* | E | | E | | E | E | E | E | E | E | E | E |
| *C.picatus* | | E | E? | | E | | E? | E | E | | | |
| ***M. o. oceansensis*** | **E** | **E** | **E** | **E** | **E** | **E** | | **E** | | | **E** | |
| *N. sp.* | E | | E | E | E? | | E | E | | E? | E | E |
| *N. geoffroyi* | | | | | | | | | | | H | |
| *N.gouldi* | | | | | | | | | | | H | |
| *S. balstoni* | | | E | | E | | E? | E | | | | E |
| *V. vulturnus* | E | E | E | E | E | E | E | E | E | H,E | H,E | E |
| *TOTAL SPECIES* | 7 | 6 | 12 | 6 | 9 | 6 | 11 | 11 | 7 | 8 | 10 | 10 |

KEY
H Captured in harp traps E Recorded from echolocation call E? Tentatively recorded from echolocation call
Target microbat species are marked in bold

# 4 DISCUSSION

## a General Fauna Sites

Fourteen microbat species were recorded during microbat surveys of the twenty general fauna monitoring sites for the Ulan Coal Mine lease during the 2019 monitoring period. Four microbat species listed as Vulnerable on Schedule 1 of the Biodiversity Conservation Act 2016 were confidently recorded during the surveys. The Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) was recorded from echolocation call at four sites. The Large-eared Pied Bat *(Chalinolobus dwyeri)* was confidently recorded through echolocation call detection at six sites. The Large Bent-winged Bat (*Miniopterus o. oceanensis*) was not captured at the general fauna sites during 2019 but was confidently recorded from echolocation call at sixteen sites. This threatened species is usually only recorded sporadically, particularly at this time of year. The Little Pied Bat (*Chalinolobus picatus*) was recorded confidently from echolocation call at six sites and was recorded tentatively from calls at a further two. The South-eastern Long-eared Bat (*Nyctophilus corbeni*) was not recorded during 2019. Two other threatened species tentatively recorded from echolocation call during previous surveys, the Southern Myotis (*Myotis macropus*) and Greater Broad-nosed Bat (*Scoteanax rueppellii*) were not recorded during 2019. Table 6 summaries the historical records of threatened species in relation to triggering the TARP as per Table 1 (Table 7.13 of the Ulan BMP [Eco Logical Australia 2019]). As no threatened species recorded for two or more consecutive years was absent in 2019, the TARP has not been triggered.

*Table 6*
Threatened microbat species recorded during monitoring periods from 2011 to 2019.

| **Species** | **2011** | **2012** | **2013** | **2014** | **2015** | **2017** | **2018** | **2019** | **TARP triggered in 2019?** |
|---|---|---|---|---|---|---|---|---|---|
| *S. flaviventris* | | | | E | E | | E | E | No |
| *C. dwyeri* | H,E | H,E | H,E | H,E | H,E | H,E | E | H,E | No |
| *C. picatus* | | | | | | | E | E | No |
| *M. o. oceanensis* | E | H,E | H,E | E | E | E | E | E | No |
| *N. corbeni* | H | | H | | H | | | | No |
| *S. rueppellii* | E | | | | | | | | No |

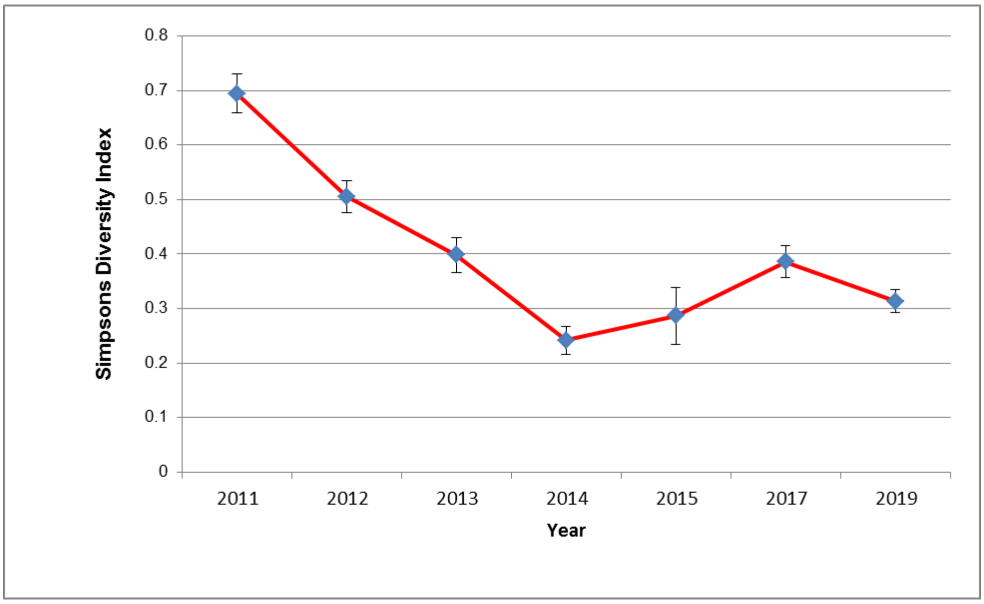


*Figure 5* Simpsons Diversity Index for echolocation call detection at the general monitoring sites from 2011 to 2019.

*Figure 5* shows the species diversity of bats recorded from echolocation call at the general fauna monitoring sites during 2019 and previous monitoring periods since these sites were designated in 2011, with error bars showing Standard Error. While overall diversity declined substantially from 2011 until 2014 it appears to have stabilised at lower levels since 2013. Low Simpson's Diversity can be driven by low Evenness (i.e. a high number of one species).

b Targeted Microbat Sites

Three predominantly cave roosting microbats occur within the lease that could potentially be impacted through mining induced subsidence and associated impacts: the Large-eared Pied Bat (*Chalinolobus dwyeri*), Large Bent-winged Bat (*Miniopterus orianae oceanensis*) and Eastern Horseshoe Bat (*Rhinolophus megaphyllus*). These species are being monitored at selected sites in the lease that contain well developed sandstone escarpments where roosts of the species are most likely to occur. *Tables 4 and 5* detail the results of survey at the sites during 2019.

Large-eared Pied Bat *Chalinolobus dwyeri*

The Large-eared Pied Bat was captured at control sites SG7 and UG1 and confidently recorded from echolocation call at seven of the eight control sites. It was also captured at UGLWW3 and recorded confidently from echolocation call at fifteen of the twenty five impact sites. Lactating females and/or free-flying juveniles were captured at impact site UGLWW3 as well as at control sites SG7 and UG1, confirming breeding had taken place at these sites by the Large-eared Pied Bat during the 2019/2020 season. Breeding had previously been recorded at control site UG1 including in recent years but no breeding had been recorded from the Spring Gully Domain since November 2004. Site UGLWW3 was undermined in July 2016 so the continued presence of breeding at this site is positive.

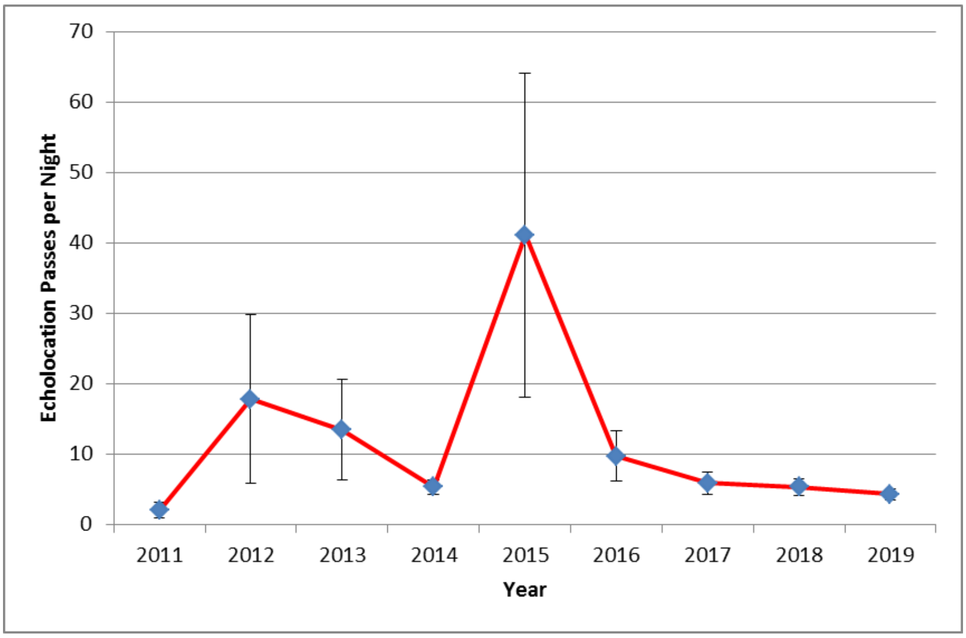


*Figure 6* Mean activity levels of Large-eared Pied Bats at cliffline sites from 2011 to 2019.

*Figure 6* shows the mean echolocation call rate of Large-eared Pied Bats at all cliffline sites for each year since 2011 when monitoring at these sites commenced. Activity at control and impact sites are pooled in this graph. Mean call activity rates have varied substantially between 1.8 and 41.1 passes per night. The high activity recorded during 2015 may be due to surveys being undertaken in April when juvenile bats would be present in the population. Activity levels during 2019 were slightly down on that recorded during the previous year.

Large Bent-winged Bat *Miniopterus orianae oceanensis*

A second threatened cave-roosting species, the Large Bent-winged Bat was not captured during the surveys but was confidently recorded from echolocation call at four of the eight control sites and twenty of the twenty five impact sites. Females migrate to select maternity roosts in spring to give birth (Hoye & Hall, 2008). These are normally located within limestone caves, but in recent years smaller groups of breeding females have been recorded using disused underground coal mines (Hoye & Hall, 2008; Hoye, 2000). During the survey, females would be preparing to leave overwintering sites for their maternity roosts.

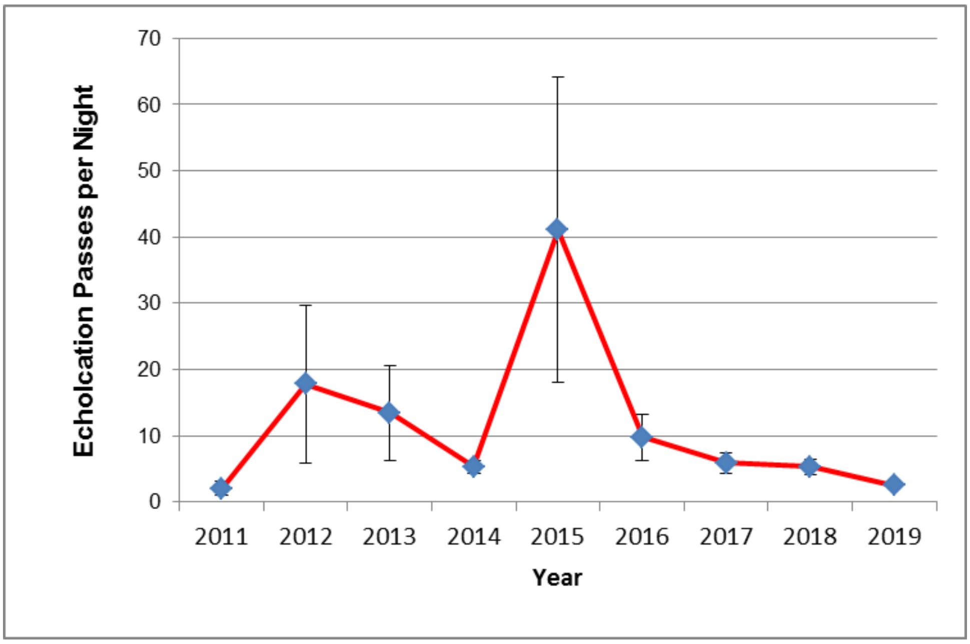


*Figure 7* Mean activity levels of Large Bent-winged Bats at cliffline sites from 2011 to 2019.

*Figure 7* shows the mean echolocation call rate of Large Bent-winged Bats at cliffline sites for the each year since 2011 when monitoring at these sites commenced. Activity at control and impact sites are pooled in this graph. Mean call activity rates have varied between 2 and 18 passes per night. The high activity recorded during 2015 may be due to surveys being undertaken in April when juvenile bats would be present in the population. Echolocation call detection rates during 2019 slightly less than that recorded during the previous monitoring period. The number of individuals of this species can change rapidly in a given area as transiting bats move into roosts in their hundreds or even thousands as they disperse from roosts up to 100 kilometres away (Hoye and Spence 2004; Hoye and Hall 2008).

Eastern Horseshoe Bat *Rhinolophus megaphyllus*

The non-threatened but locally significant Eastern Horseshoe Bat was not captured but was confidently recorded from echolocation call at six of the eight control sites and confidently recorded from echolocation call at twenty of the twenty five impact sites.

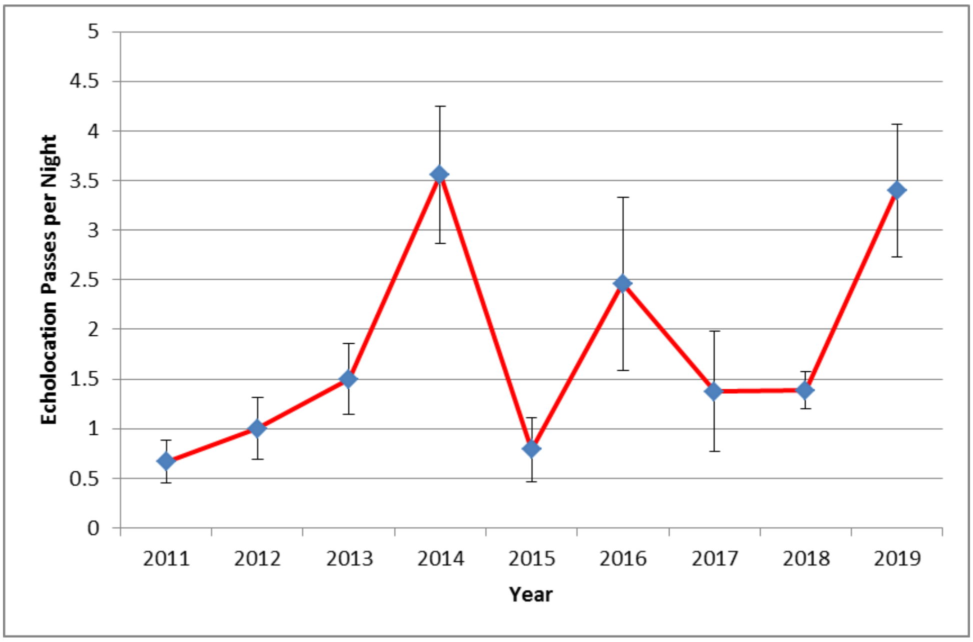


*Figure 8* Mean activity levels of Eastern Horseshoe Bats at cliffline sites from 2011 to 2019.

*Figure 8* shows the mean echolocation call rate of Eastern Horseshoe Bats at cliffline sites throughout the lease for each year since 2011 when monitoring at these sites commenced. Activity at control and impact sites are pooled in this graph. Mean call activity rates have varied between 0.7 and 3.5 passes per night. Detection rates of this species during 2019 were high being similar to that recorded during 2014.

*Effects of Subsidence on Target Microbat Species*

Twenty five sites at cliffline above longwalls at Ulan West and Ulan Underground were monitored for microbat activity during 2019. Seven of these sites have been undermined and experienced subsidence. *Table 7* presents data on percentage changes in target microbat call activity at each of the longwalls assessed with more than two years post-mining data. Declines have been seen in at least one of the target species at all seven impact longwalls analysed post-mining in 2019. UWLW1 was no longer surveyed as there was no noted decline here and it is more than two years post-mining. These declines take into account seasonal changes in control sites over the same period, and are consistent over two monitoring periods.

This data demonstrates microbat activity declines in excess of the performance indicator stated in Table 1: "*Analysis of micro-bat monitoring data identifies decreasing activity levels (>10% population decline) of endangered micro-bats species during cliff line monitoring within the Application Area over two or more monitoring periods outside of seasonal variations*".

*Table 7*

Changes in bat call acitivty (%) in impact sites post mining, relative to changes over the same time period in control sites (results highlighted blue indicate declines in excess of the 10% threshold indicated in Table 1, excluding those where control sites declined over the same period with a magnitude of decline greater than that seen in impact sites)

| Longwall panel | No. monitoring sites | Species (call category) | Mean Impact activity Before | Mean Impact activity After | % decline | 10% decline threshold exceeded? | Mean Control activity Before | Mean Control activity After | % decline | Impact decline exceed Control decline? |
|---|---|---|---|---|---|---|---|---|---|---|
| UWLW2 | 1 | *R. megaphyllus* (confident) | 2 | 0 | 100 | yes | 3.59 | 3.79 | -5.6 | yes |
| | | *R. megaphyllus* (total) | 2.67 | 0 | 100 | yes | 4.05 | 4.08 | -0.9 | yes |
| | | *C. dwyeri* (confident) | 0 | 1.33 | NA | no | 62 | 14.13 | 77.2 | NA |
| | | *C. dwyeri* (total) | 0.33 | 1.67 | -400 | no | 73.09 | 25.29 | 65.4 | NA |
| | | *M. o. oceanensis* (confident) | 1.33 | 3.33 | -150 | no | 7.36 | 8.75 | -18.8 | NA |
| | | *M. o. oceanensis* (total) | 4 | 13.33 | -233 | no | 17.23 | 13.46 | 21.9 | NA |
| UWLW3ab | 2 | *R. megaphyllus* (confident) | 3 | 0.63 | 79.2 | yes | 3.59 | 3.79 | -5.6 | yes |
| | | *R. megaphyllus* (total) | 3 | 0.63 | 79.2 | yes | 4.05 | 4.08 | -0.9 | yes |
| | | *C. dwyeri* (confident) | 2.33 | 1.25 | 46.4 | yes | 62 | 14.13 | 77.2 | no |
| | | *C. dwyeri* (total) | 3.33 | 3.75 | -12.5 | no | 73.09 | 25.29 | 65.4 | NA |

| Longwall panel | No. monitoring sites | Species (call category) | Mean Impact activity Before | Mean Impact activity After | % decline | 10% decline threshold exceeded? | Mean Control activity Before | Mean Control activity After | % decline | Impact decline exceed Control decline? |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *M. o. oceanensis* (confident) | 1.67 | 10.5 | -530 | no | 7.36 | 8.75 | -18.8 | NA |
| | | *M. o. oceanensis* (total) | 7.83 | 16.38 | -109 | no | 17.23 | 13.46 | 21.9 | NA |
| UWLW3c | 1 | *R. megaphyllus* (confident) | 34 | 2 | 94.1 | yes | 3.59 | 3.79 | -5.6 | yes |
| | | *R. megaphyllus* (total) | 35 | 2.33 | 93.3 | yes | 4.05 | 4.08 | -0.9 | yes |
| | | *C. dwyeri* (confident) | 2.33 | 0.67 | 71.4 | yes | 62 | 14.125 | 77.2 | no |
| | | *C. dwyeri* (total) | 8.67 | 1.67 | 80.8 | yes | 73.09 | 25.29 | 65.4 | yes |
| | | *M. o. oceanensis* (confident) | 0.33 | 23.33 | -6900 | no | 7.36 | 8.75 | -18.8 | NA |
| | | *M. o. oceanensis* (total) | 2.33 | 38.67 | -1557 | no | 17.23 | 13.46 | 21.8 | NA |
| UWLW4 | 2 | *R. megaphyllus* (confident) | 0.33 | 4.75 | -1325 | no | 3.03 | 4.9 | -61.5 | NA |
| | | *R. megaphyllus* (total) | 0.33 | 5 | -1400 | no | 3.4 | 5.25 | -54.4 | NA |
| | | *C. dwyeri* (confident) | 1.83 | 1 | 45.5 | yes | 47.87 | 13.55 | 71.7 | no |
| | | *C. dwyeri* (total) | 5.5 | 1 | 81.8 | yes | 57.6 | 24.55 | 57.4 | yes |

| Longwall panel | No. monitoring sites | Species (call category) | Mean Impact activity Before | Mean Impact activity After | % decline | 10% decline threshold exceeded? | Mean Control activity Before | Mean Control activity After | % decline | Impact decline exceed Control decline? |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *M. o. oceanensis* (confident) | 17.83 | 3.25 | 81.8 | yes | 6.7 | 9.2 | -37.3 | yes |
| | | *M. o. oceanensis* (total) | 42.3 | 17.5 | 58.7 | yes | 15.1 | 15.95 | -5.6 | yes |
| UGLWW3 | 1 | *R. megaphyllus* (confident) | 13.5 | 19.75 | -46.3 | NA | 3.59 | 3.79 | -5.6 | NA |
| | | *R. megaphyllus* (total) | 13.5 | 20.25 | -50 | NA | 4.05 | 4.08 | -0.9 | NA |
| | | *C. dwyeri* (confident) | 6 | 19 | -210.6 | NA | 62 | 14.13 | 77.2 | NA |
| | | *C. dwyeri* (total) | 12.5 | 42.25 | -238 | NA | 73.09 | 25.29 | 65.3 | NA |
| | | *M. o. oceanensis* (confident) | 4 | 0.75 | 81.3 | NA | 7.36 | 8.75 | -18.8 | NA |
| | | *M. o. oceanensis* (total) | 6.5 | 6.25 | 3.8 | NA | 17.2 | 13.46 | 21.9 | NA |
| UGLWW4 | 1 | *R. megaphyllus* (confident) | 12 | 8.33 | 30.5 | NA | 3.59 | 3.79 | -5.6 | NA |
| | | *R. megaphyllus* (total) | 13 | 8.33 | 35.9 | NA | 4.05 | 4.08 | -0.9 | NA |
| | | *C. dwyeri* (confident) | 39.33 | 37.67 | 4.2 | NA | 62 | 14.13 | 77.2 | NA |
| | | *C. dwyeri* (total) | 70.33 | 53.67 | 23.7 | NA | 73.09 | 25.29 | 65.4 | NA |

| Longwall panel | No. monitoring sites | Species (call category) | Mean Impact activity Before | Mean Impact activity After | % decline | 10% decline threshold exceeded? | Mean Control activity Before | Mean Control activity After | % decline | Impact decline exceed Control decline? |
|---|---|---|---|---|---|---|---|---|---|---|
| | | *M. o. oceanensis* (confident) | 1 | 3.67 | -266.7 | no | 7.36 | 8.75 | -18.8 | NA |
| | | *M. o. oceanensis* (total) | 12.67 | 18.67 | -47.4 | no | 17.23 | 13.46 | 21.8 | NA |

# 4 CONCLUSIONS & RECOMMENDATIONS

The Biodiversity Management Plan (BMP) was prepared in part to document the existing ecological and rehabilitation monitoring commitments for the Project Area, considering current and approved operations. This area consists of the Ulan West and Ulan Underground areas, as well as the Surface Operations.

General monitoring of microbat species across the Ulan complex shows no trigger relating to the presence/absence of threatened species (Table 1). No species of threatened microbat previously identified within the BOA for two or more consecutive monitoring years was not detected in BOA during 2019 annual (in the case of target cliffline and control sites) or biennial (in the case of general sites) monitoring.

Monitoring at the targeted microbat sites during 2019 has provided information on the continued presence and abundance of the three target microbat species within these areas. The Large-eared Pied Bat was captured at one and recorded from call at fifteen impact sites and captured at one and recorded from echolocation call at seven of the eight control sites. It was also recorded from echolocation call at eight of the general monitoring sites. Mean activity of this species at the sites was equivalent to that recorded during 2018. Capture of lactating females at UGLWW3, UG1 and SG7 confirmed continued breeding in these areas. In the case of SG7 this represented the first evidence of breeding at the Spring Gully Domain since 2004. Large Bent-winged Bat were recorded at 20 impact sites, four control sites, and 10 general monitoring sites. Eastern Horseshoe Bat was recorded from 20 impact sites and six control sites.

Four threatened bat species were recorded in 2019. On top of the target Large-eared Pied Bat and Large Bent-winged Bat, the Yellow-bellied Sheath-tailed Bat and Little Pied Bat were also recorded from echolocation call. Yellow-bellied Sheath-tailed Bat was recorded at four impact sites, three control sites and four general monitoring sites. Little Pied Bat was recorded from calls at six impact sites, five control sites and eight general monitoring sites.

There were a number of declines in target microbat species activity at impact sites above the longwalls of Ulan West and Ulan Underground. This included declines in excess of 10% of the average pre mining activity as recorded by echolocation call, and was referenced against changes in activity at control sites over the same time period. Only declines greater than 10% at impact sites in excess of declines seen in control sites were considered to be relevant to the performance indicator (see Table 1). Table 8 summarises the individual longwalls that have exceeded the performance indicator (>10% reduction in activity) on Ulan West Longwalls UWLW2, UWLW3, UWLW4 and Ulan Underground Longwalls UGLWW3 and UGLWW4, and specify the relevant target species involved. Lactating female Large-eared Pied Bats were captured in the 2019 survey at sites Ulan Underground LWW3 indicating that maternity roosts are still persisting in this area post-mining.

*Table 8*
Recorded changes to targeted microbat species during the 2019 monitoring period that extend over a two year period.

| **Longwall panel** | **Number of monitoring sites** | **Detectable change in activity of any of the target microbats** |
|---|---|---|
| UWLW2 | 1 | Yes – *R. megaphyllus* 100% decline |
| UWLW3 | 3 | Yes – *R. megaphyllus* 79-94% decline<br>Yes - *C. dwyeri* 81% decline |
| UWLW4 | 2 | Yes – *C. dwyeri* 82% decline<br>Yes - *M. o. oceanensis* 59-82% decline |
| UGLWW3 | 1 | Yes – *M. o. oceanensis* 81% decline |
| UGLWW4 | 1 | Yes – *R. megaphyllus* 31-36% decline |

Given the significant and sustained declines for these species across individual longwalls, further investigation such as that detailed in the Trigger Action Response Plan (TARP) detailed in the UCML Extraction Plan Plan BMP will need to be enacted for longwalls UWLW2, UWLW3 and UWLW4 (UCML 2019). The following section provides recommendations for undertaking such actions in response to these results.

*Recomendations*
Currently, impacted longwall sites are monitored for two years post-mining. This should be reconsidered for those longwalls for which a decline in the target bat species has been detected, in excess of the threshold detailed in *Table 1* . It is uncertain when, or if, declines in activity detected at longwalls during the current monitoring will return to pre-mining levels. Analyses undertaken for this report indicate that the Large-eared Pied Bat has declined for at least four years post-mining across the impact sites monitored. There is justification for monitoring of this species for a longer interval to determine if activity of this species returns to pre-mining levels. A reasonable approach for longwalls where a decline has been measured may be to monitor annually for five years post-mining, then contine monitoring at five yearly intervals. The aim of this would be to see if the disturbance caused my undermining is permanent or temporary in nature.

The actual cause of the declines is not currently known and may be difficult to determine under the current monitoring program. Noted declines up to at least four years post-mining indicate that other processes may be causing a reduction in activity. Additional monitoring will assist in determining what processes (including mining impacts) may be resulting in decreased activity.

The above monitoring will give us information on how long until bats return to disturbed clifflines (if at all), but doesn't solve the problem of temporary habitat displacement/loss. Measures that could be implemented to arrest declines include augmentation of roosts at overhangs at clifflines above longwalls where activity reduction has been recorded. A small trial of artificial roost boxes for the Large-eared Pied Bat has been undertaken since January 2017. This has shown some promise with microbat scats observed in several of the boxes. This could be expanded to include the longwalls where declines have occurred.

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27 March 2020

# 6 APPENDIX 1

*Table A*

Raw data from target threatened microbat cliffline monitoring

| Site | Date Surveyed | Year | Treatment (mining) | Date Undermined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BD6 | 17/05/2013 | 2013 | Control | NA | | | 753401 | 6436590 | 1 | 0 | 0 | 1 | 3 | 0 | 0 | 3 | 1 | 0 | 0 | 1 |
| BD6 | 15/11/2013 | 2013 | Control | NA | | | 753401 | 6436590 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 |
| BD6 | 7/04/2014 | 2014 | Control | NA | | | 753401 | 6436590 | 8 | 0 | 2 | 10 | 4 | 11 | 3 | 18 | 0 | 3 | 7 | 10 |
| BD6 | 8/04/2014 | 2014 | Control | NA | | | 753401 | 6436590 | 9 | 0 | 0 | 9 | 7 | 5 | 4 | 16 | 5 | 5 | 9 | 19 |
| BD6 | 2/05/2015 | 2015 | Control | NA | | | 753401 | 6436590 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BD6 | 3/05/2015 | 2015 | Control | NA | | | 753401 | 6436590 | 2 | 0 | 0 | 2 | 1 | 0 | 1 | 2 | 0 | 0 | 0 | 0 |
| BD6 | 12/12/2017 | 2017 | Control | NA | | | 753401 | 6436590 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| BD6 | 13/12/2017 | 2017 | Control | NA | | | 753401 | 6436590 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| BD6 | 19/11/2018 | 2018 | Control | NA | | | 753401 | 6436590 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 5 | 4 | 4 | 13 |
| BD6 | 20/11/2018 | 2018 | Control | NA | | | 753401 | 6436590 | 0 | 0 | 0 | 0 | 0 | 2 | 5 | 7 | 0 | 0 | 3 | 3 |
| BD6 | 21/11/2019 | 2019 | Control | NA | | | 753401 | 6436590 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 5 | 0 | 1 | 6 |
| BD6 | 22/11/2019 | 2019 | Control | NA | | | 753401 | 6436590 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 31 | 0 | 6 | 37 |
| BD7 | 17/05/2013 | 2013 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 0 | 0 | 7 | 0 | 1 | 8 | 0 | 0 | 0 | 0 |
| BD7 | 14/11/2013 | 2013 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 0 | 0 | 3 | 3 | 0 | 6 | 1 | 4 | 0 | 5 |
| BD7 | 15/11/2013 | 2013 | Control | NA | | | 753110 | 6436647 | 2 | 0 | 0 | 2 | 4 | 5 | 7 | 16 | 0 | 0 | 0 | 0 |
| BD7 | 7/04/2014 | 2014 | Control | NA | | | 753110 | 6436647 | 9 | 0 | 1 | 10 | 2 | 2 | 4 | 8 | 0 | 0 | 0 | 0 |
| BD7 | 8/04/2014 | 2014 | Control | NA | | | 753110 | 6436647 | 6 | 0 | 0 | 6 | 12 | 5 | 4 | 21 | 0 | 0 | 0 | 0 |
| BD7 | 1/05/2015 | 2015 | Control | NA | | | 753110 | 6436647 | 2 | 0 | 1 | 3 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| BD7 | 2/05/2015 | 2015 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 1 | 1 | 2 | 1 | 2 | 5 | 1 | 0 | 0 | 1 |
| BD7 | 12/12/2017 | 2017 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| BD7 | 13/12/2017 | 2017 | Control | NA | | | 753110 | 6436647 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 1 |
| BD7 | 19/11/2018 | 2018 | Control | NA | | | 753110 | 6436647 | 2 | 0 | 0 | 2 | 2 | 2 | 1 | 5 | 9 | 0 | 0 | 9 |
| BD7 | 20/11/2018 | 2018 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 0 | 0 | 3 | 1 | 3 | 7 | 1 | 0 | 1 | 2 |
| BD7 | 21/11/2019 | 2019 | Control | NA | | | 753110 | 6436647 | 3 | 0 | 0 | 3 | 0 | 1 | 0 | 1 | 15 | 0 | 1 | 16 |
| BD7 | 22/11/2019 | 2019 | Control | NA | | | 753110 | 6436647 | 0 | 0 | 1 | 1 | 0 | 1 | 5 | 6 | 18 | 0 | 2 | 20 |
| BD8 | 14/05/2013 | 2013 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 27 | 4 | 18 | 49 | 0 | 1 | 0 | 1 |
| BD8 | 14/11/2013 | 2013 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 60 | 7 | 0 | 67 | 0 | 1 | 0 | 1 |
| BD8 | 15/11/2013 | 2013 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 423 | 11 | 0 | 434 | 20 | 20 | 8 | 48 |
| BD8 | 6/12/2014 | 2014 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| BD8 | 7/12/2014 | 2014 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| BD8 | 30/04/2015 | 2015 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 1 | 1 | 50 | 6 | 9 | 65 | 2 | 1 | 0 | 3 |
| BD8 | 1/05/2015 | 2015 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 1 |
| BD8 | 6/12/2015 | 2015 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 376 | 12 | 12 | 400 | 8 | 0 | 3 | 11 |

| Site | Date Surveyed | Year | Treatment (mining) | Date Undemined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BD8 | 7/12/2015 | 2015 | Control | NA | | | 752671 | 6436618 | 0 | 0 | 0 | 0 | 202 | 7 | 6 | 215 | 16 | 1 | 1 | 18 |
| BD8 | 12/12/2017 | 2017 | Control | NA | | | 752671 | 6436618 | 2 | 0 | 0 | 2 | 4 | 0 | 1 | 5 | 0 | 1 | 2 | 3 |
| BD8 | 13/12/2017 | 2017 | Control | NA | | | 752671 | 6436618 | 2 | 1 | 0 | 3 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 3 |
| BD8 | 19/11/2018 | 2018 | Control | NA | | | 752671 | 6436618 | 1 | 1 | 0 | 2 | 38 | 6 | 7 | 51 | 5 | 0 | 2 | 7 |
| BD8 | 20/11/2018 | 2018 | Control | NA | | | 752671 | 6436618 | 2 | 0 | 0 | 2 | 13 | 1 | 3 | 17 | 0 | 0 | 1 | 1 |
| BD8 | 21/11/2019 | 2019 | Control | NA | | | 752671 | 6436618 | 6 | 0 | 0 | 6 | 10 | 6 | 5 | 21 | 0 | 0 | 1 | 1 |
| BD8 | 22/11/2019 | 2019 | Control | NA | | | 752671 | 6436618 | 1 | 0 | 0 | 1 | 11 | 2 | 4 | 17 | 0 | 0 | 1 | 1 |
| BD9 | 14/11/2013 | 2013 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 3 | 1 | 0 | 4 | 0 | 2 | 0 | 2 |
| BD9 | 15/11/2013 | 2013 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 0 | 4 | 1 | 5 | 0 | 0 | 1 | 1 |
| BD9 | 7/12/2014 | 2014 | Control | NA | | | 751863 | 6436925 | 1 | 1 | 0 | 2 | 1 | 0 | 2 | 3 | 20 | 14 | 29 | 63 |
| BD9 | 8/12/2014 | 2014 | Control | NA | | | 751863 | 6436925 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 1 | 4 | 7 |
| BD9 | 9/12/2014 | 2014 | Control | NA | | | 751863 | 6436925 | 3 | 0 | 0 | 3 | 2 | 1 | 5 | 8 | 32 | 24 | 51 | 108 |
| BD9 | 30/04/2015 | 2015 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 18 | 0 | 0 | 18 |
| BD9 | 1/05/2015 | 2015 | Control | NA | | | 751863 | 6436925 | 2 | 0 | 0 | 2 | 2 | 0 | 1 | 3 | 25 | 0 | 1 | 26 |
| BD9 | 13/12/2017 | 2017 | Control | NA | | | 751863 | 6436925 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 | 1 | 4 | 15 |
| BD9 | 14/12/2017 | 2017 | Control | NA | | | 751863 | 6436925 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 11 | 2 | 9 | 22 |
| BD9 | 19/11/2018 | 2018 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 8 | 1 | 3 | 12 | 1 | 0 | 0 | 1 |
| BD9 | 20/11/2018 | 2018 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 4 |
| BD9 | 21/11/2019 | 2019 | Control | NA | | | 751863 | 6436925 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 42 | 5 | 8 | 55 |
| BD9 | 22/11/2019 | 2019 | Control | NA | | | 751863 | 6436925 | 1 | 0 | 0 | 1 | 4 | 2 | 3 | 9 | 28 | 4 | 11 | 43 |
| SG5 | 6/04/2014 | 2014 | Control | NA | | | 761591 | 6432653 | 2 | 0 | 0 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 1 | 1 |
| SG5 | 7/04/2014 | 2014 | Control | NA | | | 761591 | 6432653 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 | 0 | 0 | 0 | 0 |
| SG5 | 3/12/2014 | 2014 | Control | NA | | | 761591 | 6432653 | 0 | 0 | 0 | 0 | 2 | 2 | 0 | 4 | 0 | 1 | 2 | 3 |
| SG5 | 4/12/2014 | 2014 | Control | NA | | | 761591 | 6432653 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 1 | 0 | 0 | 1 |
| SG5 | 29/04/2015 | 2015 | Control | NA | | | 761591 | 6432653 | 4 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| SG5 | 4/12/2017 | 2017 | Control | NA | | | 761591 | 6432653 | 0 | 0 | 0 | 0 | 9 | 3 | 8 | 20 | 2 | 0 | 0 | 2 |
| SG5 | 5/12/2017 | 2017 | Control | NA | | | 761591 | 6432653 | 0 | 0 | 0 | 0 | 10 | 3 | 10 | 23 | 0 | 0 | 0 | 0 |
| SG5 | 19/11/2018 | 2018 | Control | NA | | | 761591 | 6432653 | 3 | 0 | 0 | 3 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 3 |
| SG5 | 20/11/2018 | 2018 | Control | NA | | | 761591 | 6432653 | 1 | 0 | 0 | 1 | 6 | 3 | 3 | 12 | 0 | 0 | 0 | 0 |
| SG5 | 19/11/2019 | 2019 | Control | NA | | | 761591 | 6432653 | 2 | 1 | 1 | 4 | 27 | 3 | 6 | 36 | 0 | 0 | 0 | 0 |
| SG5 | 20/11/2019 | 2019 | Control | NA | | | 761591 | 6432653 | 3 | 0 | 1 | 4 | 23 | 2 | 6 | 31 | 0 | 0 | 0 | 0 |
| SG7 | 10/05/2013 | 2013 | Control | NA | | | 761427 | 6432729 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SG7 | 11/05/2013 | 2013 | Control | NA | | | 761427 | 6432729 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 |
| SG7 | 27/04/2015 | 2015 | Control | NA | | | 761427 | 6432729 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SG7 | 28/04/2015 | 2015 | Control | NA | | | 761427 | 6432729 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SG7 | 4/12/2017 | 2017 | Control | NA | | | 761427 | 6432729 | 0 | 0 | 0 | 0 | 4 | 1 | 2 | 7 | 0 | 0 | 0 | 0 |
| SG7 | 5/12/2017 | 2017 | Control | NA | | | 761427 | 6432729 | 2 | 0 | 0 | 2 | 1 | 0 | 2 | 3 | 0 | 0 | 0 | 0 |

| Site | Date Surveyed | Year | Treatment (mining) | Date Undemined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SG7 | 19/11/2018 | 2018 | Control | NA | | | 761427 | 6432729 | 1 | 0 | 0 | 1 | 4 | 1 | 0 | 5 | 1 | 0 | 1 | 2 |
| SG7 | 20/11/2018 | 2018 | Control | NA | | | 761427 | 6432729 | 1 | 0 | 0 | 1 | 27 | 6 | 4 | 37 | 0 | 0 | 0 | 0 |
| SG7 | 26/11/2019 | 2019 | Control | NA | | | 761427 | 6432729 | 0 | 0 | 0 | 0 | 17 | 7 | 5 | 29 | 0 | 0 | 0 | 0 |
| SG8 | 10/05/2013 | 2013 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| SG8 | 11/05/2013 | 2013 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SG8 | 6/04/2014 | 2014 | Control | NA | | | 761321 | 6432850 | 3 | 0 | 1 | 4 | 2 | 0 | 3 | 5 | 0 | 0 | 1 | 1 |
| SG8 | 7/04/2014 | 2014 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 0 | 0 | 0 | 0 |
| SG8 | 27/04/2015 | 2015 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| SG8 | 28/04/2015 | 2015 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| SG8 | 4/12/2017 | 2017 | Control | NA | | | 761321 | 6432850 | 1 | 0 | 0 | 1 | 2 | 1 | 0 | 3 | 1 | 0 | 1 | 2 |
| SG8 | 5/12/2017 | 2017 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 1 | 0 | 0 | 1 |
| SG8 | 19/11/2018 | 2018 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 3 | 3 | 8 | 14 | 0 | 0 | 0 | 0 |
| SG8 | 20/11/2018 | 2018 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 32 | 16 | 14 | 62 | 0 | 0 | 0 | 0 |
| SG8 | 19/11/2019 | 2019 | Control | NA | | | 761321 | 6432850 | 0 | 1 | 0 | 1 | 7 | 7 | 15 | 29 | 0 | 0 | 0 | 0 |
| SG8 | 20/11/2019 | 2019 | Control | NA | | | 761321 | 6432850 | 0 | 0 | 0 | 0 | 4 | 5 | 17 | 26 | 0 | 0 | 0 | 0 |
| UG1 | 12/05/2013 | 2013 | Control | NA | | | 756847 | 6431191 | 1 | 0 | 0 | 1 | 1 | 2 | 2 | 5 | 0 | 7 | 2 | 9 |
| UG1 | 13/05/2013 | 2013 | Control | NA | | | 756847 | 6431191 | 7 | 0 | 0 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| UG1 | 18/11/2013 | 2013 | Control | NA | | | 756847 | 6431191 | 15 | 1 | 0 | 16 | 63 | 16 | 0 | 79 | 0 | 0 | 0 | 0 |
| UG1 | 19/11/2013 | 2013 | Control | NA | | | 756847 | 6431191 | 2 | 0 | 0 | 2 | 77 | 42 | 0 | 119 | 0 | 0 | 0 | 0 |
| UG1 | 6/12/2014 | 2014 | Control | NA | | | 756847 | 6431191 | 3 | 0 | 0 | 3 | 6 | 1 | 2 | 9 | 0 | 0 | 0 | 0 |
| UG1 | 7/12/2014 | 2014 | Control | NA | | | 756847 | 6431191 | 0 | 1 | 0 | 1 | 38 | 3 | 2 | 43 | 1 | 1 | 2 | 4 |
| UG1 | 5/12/2015 | 2015 | Control | NA | | | 756847 | 6431191 | 0 | 0 | 0 | 0 | 52 | 9 | 14 | 75 | 6 | 3 | 10 | 19 |
| UG1 | 6/12/2015 | 2015 | Control | NA | | | 756847 | 6431191 | 0 | 0 | 0 | 0 | 12 | 3 | 8 | 23 | 7 | 3 | 5 | 15 |
| UG1 | 10/12/2017 | 2017 | Control | NA | | | 756847 | 6431191 | 1 | 0 | 0 | 1 | 21 | 2 | 3 | 26 | 7 | 0 | 4 | 11 |
| UG1 | 11/12/2017 | 2017 | Control | NA | | | 756847 | 6431191 | 2 | 0 | 0 | 2 | 19 | 4 | 2 | 25 | 6 | 2 | 5 | 13 |
| UG1 | 22/11/2018 | 2018 | Control | NA | | | 756847 | 6431191 | 10 | 0 | 0 | 10 | 9 | 2 | 5 | 16 | 2 | 2 | 0 | 4 |
| UG1 | 23/11/2018 | 2018 | Control | NA | | | 756847 | 6431191 | 22 | 0 | 0 | 22 | 5 | 2 | 8 | 15 | 2 | 1 | 1 | 4 |
| UG1 | 19/11/2019 | 2019 | Control | NA | | | 756847 | 6431191 | 11 | 0 | 0 | 11 | 9 | 2 | 4 | 15 | 2 | 4 | 9 | 15 |
| UG1 | 20/11/2019 | 2019 | Control | NA | | | 756847 | 6431191 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 4 | 1 | 0 | 1 | 2 |
| UGLWW3 | 8/12/2014 | 2014 | Impact | 9/07/2016 | Before | -2.00 | 755431 | 6437443 | 23 | 0 | 0 | 23 | 4 | 1 | 3 | 8 | 1 | 1 | 1 | 3 |
| UGLWW3 | 4/12/2015 | 2015 | Impact | 9/07/2016 | Before | -1.00 | 755431 | 6437443 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| UGLWW3 | 7/12/2015 | 2015 | Impact | 9/07/2016 | Before | -1.00 | 755431 | 6437443 | 3 | 0 | 0 | 3 | 1 | 1 | 1 | 3 | 5 | 0 | 1 | 6 |
| UGLWW3 | 8/12/2015 | 2015 | Impact | 9/07/2016 | Before | -1.00 | 755431 | 6437443 | 1 | 0 | 0 | 1 | 7 | 2 | 5 | 14 | 2 | 1 | 1 | 4 |
| UGLWW3 | 19/11/2016 | 2016 | Impact | 9/07/2016 | After | 1.00 | 755431 | 6437443 | 0 | 0 | 0 | 0 | 13 | 5 | 15 | 33 | 2 | 0 | 0 | 2 |
| UGLWW3 | 20/11/2016 | 2016 | Impact | 9/07/2016 | After | 1.00 | 755431 | 6437443 | 29 | 0 | 1 | 30 | 11 | 2 | 15 | 28 | 1 | 2 | 0 | 3 |
| UGLWW3 | 23/01/2017 | 2016 | Impact | 9/07/2016 | After | 1.00 | 755431 | 6437443 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 | 6 |
| UGLWW3 | 24/01/2017 | 2016 | Impact | 9/07/2016 | After | 1.00 | 755431 | 6437443 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |

| Site | Date Surveyed | Year | Treatment (mining) | Date Undemined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UGLWW3 | 13/12/2017 | 2017 | Impact | 9/07/2016 | After | 2.00 | 755431 | 6437443 | 39 | 0 | 1 | 40 | 32 | 9 | 15 | 56 | 0 | 0 | 0 | 0 |
| UGLWW3 | 14/12/2017 | 2017 | Impact | 9/07/2016 | After | 2.00 | 755431 | 6437443 | 9 | 0 | 0 | 9 | 14 | 6 | 6 | 26 | 0 | 1 | 8 | 9 |
| UGLWW3 | 21/11/2018 | 2018 | Impact | 9/07/2016 | After | 3.00 | 755431 | 6437443 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 3 | 0 | 2 | 4 | 6 |
| UGLWW3 | 22/11/2018 | 2018 | Impact | 9/07/2016 | After | 3.00 | 755431 | 6437443 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 | 0 | 0 | 5 | 5 |
| UGLWW3 | 24/11/2019 | 2019 | Impact | 9/07/2016 | After | 4.00 | 755431 | 6437443 | 0 | 0 | 0 | 0 | 4 | 5 | 12 | 21 | 0 | 0 | 0 | 0 |
| UGLWW3 | 27/11/2019 | 2019 | Impact | 9/07/2016 | After | 4.00 | 755431 | 6437443 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UGLWW4a | 9/12/2014 | 2014 | Impact | 1/10/2017 | Before | -3.00 | 754858 | 6437976 | 1 | 0 | 0 | 1 | 7 | 1 | 4 | 12 | 1 | 2 | 17 | 20 |
| UGLWW4a | 10/12/2014 | 2014 | Impact | 1/10/2017 | Before | -3.00 | 755431 | 6437443 | 2 | 0 | 0 | 2 | 13 | 0 | 2 | 15 | 1 | 0 | 7 | 8 |
| UGLWW4a | 6/12/2015 | 2015 | Impact | 1/10/2017 | Before | -2.00 | 754858 | 6437976 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| UGLWW4a | 7/12/2015 | 2015 | Impact | 1/10/2017 | Before | -2.00 | 754858 | 6437976 | 3 | 0 | 0 | 3 | 3 | 2 | 4 | 9 | 1 | 0 | 3 | 4 |
| UGLWW4a | 19/11/2016 | 2016 | Impact | 1/10/2017 | Before | -1.00 | 755211 | 6437865 | 20 | 1 | 0 | 21 | 63 | 25 | 35 | 123 | 0 | 0 | 3 | 3 |
| UGLWW4a | 20/11/2016 | 2016 | Impact | 1/10/2017 | Before | -1.00 | 755211 | 6437865 | 10 | 1 | 1 | 12 | 32 | 10 | 9 | 51 | 0 | 0 | 2 | 2 |
| UGLWW4a | 23/01/2017 | 2016 | Impact | 1/10/2017 | Before | -1.00 | 755211 | 6437865 | 0 | 0 | 0 | 0 | 21 | 11 | 24 | 56 | 3 | 0 | 1 | 4 |
| UGLWW4a | 24/01/2017 | 2016 | Impact | 1/10/2017 | Before | -1.00 | 755211 | 6437865 | 2 | 0 | 2 | 4 | 14 | 9 | 12 | 35 | 3 | 3 | 8 | 14 |
| UGLWW4a | 13/12/2017 | 2017 | Impact | 1/10/2017 | After | 1.00 | 755211 | 6437865 | 2 | 0 | 0 | 2 | 52 | 10 | 13 | 75 | 1 | 5 | 2 | 8 |
| UGLWW4a | 14/12/2017 | 2017 | Impact | 1/10/2017 | After | 1.00 | 755211 | 6437865 | 5 | 0 | 0 | 5 | 25 | 1 | 7 | 33 | 2 | 0 | 3 | 5 |
| UGLWW4a | 21/11/2018 | 2018 | Impact | 1/10/2017 | After | 2.00 | 755211 | 6437865 | 3 | 0 | 0 | 3 | 15 | 1 | 4 | 20 | 6 | 2 | 9 | 17 |
| UGLWW4a | 22/11/2018 | 2018 | Impact | 1/10/2017 | After | 2.00 | 755211 | 6437865 | 1 | 0 | 0 | 1 | 16 | 4 | 4 | 24 | 1 | 3 | 13 | 17 |
| UGLWW4a | 24/11/2019 | 2019 | Impact | 1/10/2017 | After | 3.00 | 755211 | 6437865 | 4 | 0 | 0 | 4 | 3 | 0 | 0 | 3 | 1 | 0 | 3 | 4 |
| UGLWW4a | 25/11/2019 | 2019 | Impact | 1/10/2017 | After | 3.00 | 755211 | 6437865 | 10 | 0 | 0 | 10 | 2 | 3 | 1 | 6 | 0 | 0 | 5 | 5 |
| UWLW2 | 16/11/2013 | 2013 | Impact | 20/09/2015 | Before | -3.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW2 | 17/11/2013 | 2013 | Impact | 20/09/2015 | Before | -3.00 | 756229 | 6434374 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW2 | 9/12/2014 | 2014 | Impact | 20/09/2015 | Before | -2.00 | 756229 | 6434374 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 4 |
| UWLW2 | 10/12/2014 | 2014 | Impact | 20/09/2015 | Before | -2.00 | 756229 | 6434374 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 3 | 2 | 3 | 8 |
| UWLW2 | 29/04/2015 | 2015 | Impact | 20/09/2015 | Before | -1.00 | 756229 | 6434374 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW2 | 30/04/2015 | 2015 | Impact | 20/09/2015 | Before | -1.00 | 756229 | 6434374 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW2 | 15/11/2016 | 2016 | Impact | 20/09/2015 | After | 1.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW2 | 16/11/2016 | 2016 | Impact | 20/09/2015 | After | 1.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 11 | 12 |
| UWLW2 | 7/12/2017 | 2017 | Impact | 20/09/2015 | After | 2.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 3 | 2 | 5 | 10 |
| UWLW2 | 8/12/2017 | 2017 | Impact | 20/09/2015 | After | 2.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 4 |
| UWLW2 | 19/11/2018 | 2018 | Impact | 20/09/2015 | After | 3.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 3 | 2 | 5 | 10 |
| UWLW2 | 20/11/2018 | 2018 | Impact | 20/09/2015 | After | 3.00 | 756229 | 6434374 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 4 |
| UWLW3a | 18/11/2013 | 2013 | Impact | 27/11/2016 | Before | -3.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW3a | 19/11/2013 | 2013 | Impact | 27/11/2016 | Before | -3.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 13 | 4 | 0 | 17 | 0 | 0 | 0 | 0 |
| UWLW3a | 7/12/2014 | 2014 | Impact | 27/11/2016 | Before | -2.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW3a | 8/12/2014 | 2014 | Impact | 27/11/2016 | Before | -2.00 | 755840 | 6434284 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| UWLW3a | 2/05/2015 | 2015 | Impact | 27/11/2016 | Before | -1.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 |

| Site | Date Surveyed | Year | Treatment (mining) | Date Undemined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UWLW3a | 3/05/2015 | 2015 | Impact | 27/11/2016 | Before | -1.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 5 | 1 | 1 | 7 |
| UWLW3a | 15/11/2016 | 2016 | Impact | 27/11/2016 | After | 1.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 | 0 | 0 | 1 | 1 |
| UWLW3a | 16/11/2016 | 2016 | Impact | 27/11/2016 | After | 1.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 4 | 4 | 11 |
| UWLW3a | 9/12/2017 | 2017 | Impact | 27/11/2016 | After | 2.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 7 | 10 |
| UWLW3a | 10/12/2017 | 2017 | Impact | 27/11/2016 | After | 2.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 6 | 12 |
| UWLW3a | 19/11/2018 | 2018 | Impact | 27/11/2016 | After | 3.00 | 755840 | 6434284 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 3 | 4 |
| UWLW3a | 20/11/2018 | 2018 | Impact | 27/11/2016 | After | 3.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| UWLW3a | 22/11/2019 | 2019 | Impact | 27/11/2016 | After | 4.00 | 755840 | 6434284 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW3a | 23/11/2019 | 2019 | Impact | 27/11/2016 | After | 4.00 | 755840 | 6434284 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| UWLW3b | 18/11/2013 | 2013 | Impact | 4/12/2016 | Before | -3.00 | 755730 | 6434129 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| UWLW3b | 19/11/2013 | 2013 | Impact | 4/12/2016 | Before | -3.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 13 | 10 | 27 |
| UWLW3b | 7/12/2014 | 2014 | Impact | 4/12/2016 | Before | -2.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 3 | 3 |
| UWLW3b | 8/12/2014 | 2014 | Impact | 4/12/2016 | Before | -2.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 4 | 6 |
| UWLW3b | 1/05/2015 | 2015 | Impact | 4/12/2016 | Before | -1.00 | 755730 | 6434129 | 8 | 0 | 0 | 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW3b | 2/05/2015 | 2015 | Impact | 4/12/2016 | Before | -1.00 | 755730 | 6434129 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| UWLW3b | 15/11/2016 | 2016 | Impact | 4/12/2016 | After | 1.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 2 | 6 | 3 | 11 | 0 | 0 | 0 | 0 |
| UWLW3b | 16/11/2016 | 2016 | Impact | 4/12/2016 | After | 1.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| UWLW3b | 9/12/2017 | 2017 | Impact | 4/12/2016 | After | 2.00 | 755730 | 6434129 | 2 | 0 | 0 | 2 | 2 | 1 | 0 | 3 | 1 | 0 | 1 | 2 |
| UWLW3b | 10/12/2017 | 2017 | Impact | 4/12/2016 | After | 2.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| UWLW3b | 23/11/2018 | 2018 | Impact | 4/12/2016 | After | 3.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 3 | 1 | 0 | 1 | 2 |
| UWLW3b | 24/11/2018 | 2018 | Impact | 4/12/2016 | After | 3.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 2 | 3 | 3 | 8 | 3 | 2 | 1 | 6 |
| UWLW3b | 22/11/2019 | 2019 | Impact | 4/12/2016 | After | 4.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 | 0 | 3 | 54 |
| UWLW3b | 23/11/2019 | 2019 | Impact | 4/12/2016 | After | 4.00 | 755730 | 6434129 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 21 | 1 | 1 | 23 |
| UWLW3c | 6/01/2015 | 2014 | Impact | 31/07/2017 | Before | -3.00 | 755663 | 6431667 | 9 | 0 | 0 | 9 | 2 | 0 | 1 | 3 | 0 | 1 | 2 | 3 |
| UWLW3c | 7/01/2015 | 2014 | Impact | 31/07/2017 | Before | -3.00 | 755663 | 6431667 | 52 | 1 | 2 | 55 | 5 | 4 | 7 | 16 | 0 | 1 | 1 | 2 |
| UWLW3c | 5/12/2015 | 2015 | Impact | 31/07/2017 | Before | -2.00 | 755663 | 6431667 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 2 | 0 | 1 | 0 | 1 |
| UWLW3c | 6/12/2015 | 2015 | Impact | 31/07/2017 | Before | -2.00 | 755663 | 6431667 | 5 | 0 | 0 | 5 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| UWLW3c | 17/11/2016 | 2016 | Impact | 31/07/2017 | Before | -1.00 | 755663 | 6431667 | 20 | 0 | 0 | 20 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| UWLW3c | 18/11/2016 | 2016 | Impact | 31/07/2017 | Before | -1.00 | 755663 | 6431667 | 15 | 0 | 0 | 15 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 0 |
| UWLW3c | 8/12/2017 | 2017 | Impact | 31/07/2017 | After | 1.00 | 755663 | 6431667 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 13 | 3 | 7 | 23 |
| UWLW3c | 9/12/2017 | 2017 | Impact | 31/07/2017 | After | 1.00 | 755663 | 6431667 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 2 | 8 | 5 | 2 | 15 |
| UWLW3c | 24/11/2018 | 2018 | Impact | 31/07/2017 | After | 2.00 | 755663 | 6431667 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| UWLW3c | 25/11/2018 | 2018 | Impact | 31/07/2017 | After | 2.00 | 755663 | 6431667 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| UWLW3c | 20/11/2019 | 2019 | Impact | 31/07/2017 | After | 3.00 | 755663 | 6431667 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 23 | 5 | 10 | 38 |
| UWLW3c | 27/11/2019 | 2019 | Impact | 31/07/2017 | After | 3.00 | 755663 | 6431667 | 1 | 0 | 1 | 2 | 1 | 0 | 0 | 1 | 24 | 2 | 11 | 37 |
| UWLW4a | 6/12/2015 | 2015 | Impact | 6/06/2018 | Before | -3.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 | 19 | 4 | 18 | 41 |
| UWLW4a | 7/12/2015 | 2015 | Impact | 6/06/2018 | Before | -3.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 2 | 3 | 11 | 16 | 14 | 2 | 4 | 20 |

| Site | Date Surveyed | Year | Treatment (mining) | Date Undemined | Impact | Years Since Undermining | Easting | Northing | Rm (C) | Rm (P) | Rm (Po) | Rm (T) | Cd (C) | Cd (P) | Cd (Po) | Cd (T) | Mo (C) | Mo(P) | Mo (Po) | Mo (T) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| UWLW4a | 16/11/2016 | 2016 | Impact | 6/06/2018 | Before | -2.00 | 755532 | 6433510 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 2 | 9 | 12 |
| UWLW4a | 17/11/2016 | 2016 | Impact | 6/06/2018 | Before | -2.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 1 | 4 |
| UWLW4a | 9/12/2017 | 2017 | Impact | 6/06/2018 | Before | -1.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15 | 4 | 29 | 48 |
| UWLW4a | 10/12/2017 | 2017 | Impact | 6/06/2018 | Before | -1.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 | 9 | 22 | 48 |
| UWLW4a | 23/11/2018 | 2018 | Impact | 6/06/2018 | After | 1.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 2 |
| UWLW4a | 24/11/2018 | 2018 | Impact | 6/06/2018 | After | 1.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 1 | 3 |
| UWLW4a | 19/11/2019 | 2019 | Impact | 6/06/2018 | After | 2.00 | 755532 | 6433510 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| UWLW4a | 20/11/2019 | 2019 | Impact | 6/06/2018 | After | 2.00 | 755532 | 6433510 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| UWLW4b | 6/12/2015 | 2015 | Impact | 22/10/2018 | Before | -3.00 | 755276 | 6432114 | 1 | 0 | 0 | 1 | 0 | 0 | 2 | 2 | 21 | 10 | 17 | 48 |
| UWLW4b | 7/12/2015 | 2015 | Impact | 22/10/2018 | Before | -3.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 9 | 1 | 2 | 12 | 17 | 5 | 7 | 29 |
| UWLW4b | 17/11/2016 | 2016 | Impact | 22/10/2018 | Before | -2.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 2 |
| UWLW4b | 18/11/2016 | 2016 | Impact | 22/10/2018 | Before | -2.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| UWLW4b | 9/12/2017 | 2017 | Impact | 22/10/2018 | Before | -1.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| UWLW4b | 10/12/2017 | 2017 | Impact | 22/10/2018 | Before | -1.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| UWLW4b | 24/11/2018 | 2018 | Impact | 22/10/2018 | After | 1.00 | 755276 | 6432114 | 5 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| UWLW4b | 25/11/2018 | 2018 | Impact | 22/10/2018 | After | 1.00 | 755276 | 6432114 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 2 |
| UWLW4b | 20/11/2019 | 2019 | Impact | 22/10/2018 | After | 2.00 | 755276 | 6432114 | 4 | 0 | 0 | 4 | 4 | 0 | 0 | 4 | 5 | 13 | 18 | 36 |
| UWLW4b | 21/11/2019 | 2019 | Impact | 22/10/2018 | After | 2.00 | 755276 | 6432114 | 10 | 0 | 0 | 10 | 0 | 0 | 0 | 0 | 3 | 8 | 12 | 23 |

Species: RMEG = Rhinolophus megaphyllus CDWY = Chalinolobus dwyeri MIOO = Miniopterus o. oceanensis
Call confidence level: C = Confident P = Probable Po = Possible T = Total