

27 August 2026

Department of Planning, Housing and Infrastructure
Locked Bag 5022
Parramatta NSW 2124

Attention: Gen Lucas, Team Leader – Resource Assessments

Via NSW Planning Portal

Dear Gen,

RE: MOOLARBEN COAL COMPLEX – UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT

The UG4 Longwalls 401 to 408 (LW401-408) Extraction Plan was approved by the New South Wales (NSW) Department of Planning, Housing and Infrastructure (DPHI) in July 2022 (subject to conditions) and secondary extraction of LW401 commenced in shortly after. An End of Panel Report for UG4 Longwalls 401 to 403 was subsequently lodged with DPHI in December 2023.

As an outcome of the UG4 LW401-403 End of Panel Report, DPHI requested Moolarben Coal Operations (MCO) prepare an additional End of Panel Report following completion of secondary extraction of LW407 (as per correspondence dated 16 February 2024):

The Department requests that in accordance with the advice, you provide an End of Panel Report after the extraction of LW407 (and before the completion of LW408) including:

- *an assessment of subsidence predictions and actual impacts,*
- *data and trends for all underlying groundwater systems, and an assessment of impacts to the Triassic sandstone aquifer and its environmental and cultural assets adjacent to and downstream of the UG4 area,*
- *surface water data and trends for the Goulburn River adjacent to and downstream of the UG4 area, and*
- *an assessment of cultural heritage impacts.*

Secondary extraction of LW407 was completed in January 2026. Accordingly, MCO has prepared a UG4 LW401-407 End of Panel Report (refer to **Enclosure 1**), which presents monitoring data, describes observed impacts during mining of LW401-407 and compares these results to predictions and relevant performance measures and performance indicators as described in the approved UG4 LW401-408 Extraction Plan.

Monitoring undertaken in accordance with the UG4 LW401-408 Extraction Plan during extraction of LW401-407, included visual inspections, survey lines, Global Navigation Satellite System (GNSS) units, groundwater piezometers, surface water flow and quality monitoring sites, annual biodiversity monitoring and heritage management.

The UG4 LW401-407 End of Panel Report, has been prepared with input from technical specialists endorsed by DPHI for the UG4 LW401-408 Extraction Plan (provided in Appendices A to E of **Enclosure 1**) including:

1. Subsidence – Peter Debono, Mine Subsidence Engineering Consultants (MSEC).
2. Groundwater – Dr Andrew Durick, Australasian Groundwater & Environment (AGE).
3. Surface Water – David Newton, WRM Water & Environment (WRM).
4. Aboriginal Cultural Heritage – Jamie Reeves, Niche Environment and Heritage (Niche).

Note that for completeness, annual biodiversity monitoring reporting undertaken by Niche in accordance with the requirements of the UG4 LW401-408 Extraction Plan has also been considered in the UG4 LW401-407 End of Panel Report.

In addition, as requested by DPHI (as per correspondence dated 7 May 2026), Dr Lloyd Townley has undertaken an independent review of observed groundwater and surface water impacts from LW401-407 to address independent audit requirements in Condition 9, Schedule 5 of the Stage 1 Project Approval (05_0117).

Dr Townley's review is provided in Appendix F of **Enclosure 1** and concludes:

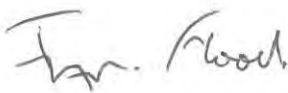
Two reports have been prepared to compare predicted and observed groundwater and surface water impacts on relevant features due to mining of LW401-407. They provide good summaries and explanations of data that have been collected during mining. The reports present observed monitoring data and discuss trends related to groundwater drawdown, specifically in the Triassic sandstone aquifer, and surface water quality and flow in the Goulburn River and other ephemeral drainage lines. The reports show no evidence of impact on water supply to The Drip due to mining of LW401-407.

Overall, observed data are consistent with predictions. Agreement between predicted subsidence and LiDAR measurements is remarkably good, suggesting that the methods used by MSEC are mature and reliable. Predictions related to mine inflows and drawdown of groundwater are supported by observations, and the belief that there would be no impact of mining at LW401-407 and groundwater quality is confirmed by data. The prediction that mining at LW401-407 would affect neither surface water flow nor surface water quality has also been confirmed by observations, the only exceedances of water quality thresholds in the Goulburn River in two consecutive months being explained by activities upstream of LW401-407.

A consolidated summary of the assessment of environmental performance of LW401-407 for all relevant natural, heritage and built features is provided in Tables E1 and E2 of the UG4 LW401-407 End of Panel Report (**Enclosure 1**). All relevant performance measures and performance indicators were complied with during extraction of LW401-407.

Should you have any queries regarding the UG4 LW401-407 End of Panel Report, please do not hesitate to contact the undersigned.

Yours sincerely,



Ian Flood

Environment and Community Manager
Moolarben Coal Operations Pty Ltd

Enclosure 1: Moolarben Coal Complex UG4 Longwalls 401 to 407 End of Panel Report

ENCLOSURE 1

MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT



Moolarben Coal Complex UG4 Longwalls 401 to 407 End of Panel Report

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DOCUMENT CONTROL

Applicant	Moolarben Coal Operations Pty Ltd
Mine	Moolarben Coal Complex
Development Consent	Stage 1 Project Approval (05_0117) as modified
Mining Leases	ML 1605 and ML 1628
Title	Moolarben Coal Complex UG4 Longwalls 401 to 407 End of Panel Report
Document No.	MCO_UG4_LW401-407_EOP
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EXECUTIVE SUMMARY

This End of Panel (EoP) Report for Moolarben Coal Complex Underground 4 (UG4) Longwalls 401 to 407 (LW401-407) has been prepared to satisfy a request from the NSW Department of Planning, Housing and Infrastructure post-review of the UG4 LW401-403 EoP Report.

This EoP Report presents monitoring data, describes observed impacts during mining of LW401-407 and compares these results to predictions and relevant impact assessment criteria (i.e. performance measures and performance indicators) described in the approved UG4 LW401-408 Extraction Plan.

Management and monitoring measures for natural, heritage and built features within and in the vicinity of LW401-408, including associated trigger levels, trigger events and trigger action response plans (TARPs), are described in the approved UG4 LW401-408 Extraction Plan and associated Management Plans.

A summary of the assessment of monitoring outcomes against relevant performance measures and performance indicators for natural, heritage and built features is provided in **Tables E1** and **E2**.

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MCO_UG4_LW401-407_EOP	1	August 2026	FINAL	MCO

Table E1: Assessment of Environmental Performance of LW401-407 – Natural and Heritage Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Features with Subsidence Impact and/or Water Management Performance Measures in Project Approval (05_0117)							
The Drip and Corner Gorge	<i>Nil impact or environmental consequences.</i>	<i>n/a</i> – no specific subsidence performance indicator developed for the Drip and Corner Gorge; however, relevant criteria are included in the approved UG4 LW409-414 Extraction Plan and will apply to future assessments of environmental performance where relevant.	Baseline visual inspection at sites GRP-101 to GRP-113 Baseline monitoring of far-field movement at GNSS units NPWS_G01 to NPWS_G09	<i>n/a – Baseline monitoring only.</i> No trigger event/level for Drip or Corner Gorge as no predicted impacts from LW401-407. Notwithstanding, no physical impacts due to extraction of LW401-407 observed during visual inspections and baseline far-field movements at GNSS units consistent with predictions.	MSEC	<i>n/a</i>	Yes
The Drip	<i>Nil impact on the water supply to the Drip.</i>	Unpredicted loss of water supply to the Drip during LW401 to 408.	Baseline visual inspection at sites GRP-101 to GRP-113	<i>n/a – Baseline monitoring only.</i> No trigger event/level for Drip or Corner Gorge as no predicted impacts from LW401-407. Notwithstanding, no physical impacts due to extraction of LW401-407 observed during visual inspections.	WRM	Yes	Yes
Goulburn River and the bed of the Goulburn River	<i>Negligible impact or environmental consequences.</i>	Unpredicted impacts on Goulburn River (cracking and or noticeable changes in erosion or pools).	Visual inspection at sites GR-10 to GR-30 Surface water flow and quality monitoring at sites SW01, SW02 and SW22 Surface water flow monitoring at site Ulan SW01 Surface water flow and quality monitoring of controlled releases from the water treatment plant	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed surface water flow consistent with predictions (i.e. no loss of flow). Two trigger events for surface water quality in Goulburn River were recorded. Further investigation confirmed the exceedances were not due to extraction of LW401-407. The TARP for Goulburn River surface water quality was triggered during mining of LW401-407, however this did not result in an exceedance of performance indicators or performance measures.	WRM	Yes	Yes
	<i>Remain outside the zone of recorded subsidence damage for longwall mining.</i>		Observed subsidence movements at GNSS units MCO04, MCO07 to MCO09, and MCO20 to MCO24 located between LW407 and the Goulburn River	Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Goulburn River and the bed of the Goulburn River was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Cliff Line (CL) 3	<i>Minimise subsidence damage.</i>	CL3 impacts due to LW401-408 are less than 1.9 m vertical conventional subsidence and 60 mm/m conventional tilt.	Visual inspection at sites CL3-01 to CL3-20 Baseline monitoring of subsidence movements at GNSS units MCO06, MCO18, MCO19 located at CL3	No physical impacts due to extraction of LW401-407 observed during visual inspections and subsidence movements at GNSS units consistent with predictions. The TARP for CL3 was not triggered during mining of LW401-407.	MSEC	Yes	Yes

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Table E1 (Continued): Assessment of Environmental Performance of LW401-407 – Natural and Heritage Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Aboriginal heritage site 280	<i>Reduce the likelihood of subsidence damage to moderate.</i>	Revised subsidence likelihood reduced to moderate.	Subsidence monitoring at ‘early warning’ monitoring site (ground transect lines MG402A, MG402b and MG402C) Subsidence monitoring at ground transect lines S1MC280A, S1MC280B and S1MC280C Daily visual inspections during relevant periods of mining of LW402 and LW403 Slot width monitoring across vertical stress relief slots Stress change monitoring boreholes and camera inspections Tilt, temperature and closure monitoring of the overhang	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements at stress relief slots and tilt due to extraction of LW401-407 consistent with predictions. An exceedance of the Level 1 trigger in both the site monitoring TARP and subsidence monitoring TARP for S1MC280 was observed during mining of LW401-407. The TARPs for Aboriginal heritage site S1MC280 were triggered during mining of LW401-407, however this did not result in an exceedance of performance indicators or performance measures. Therefore, the S1MC280 Subsidence Monitoring and Mitigation Plan was successfully implemented.	MSEC Niche	Yes	Yes
Features with Nominated Performance Indicators in UG4 LW401-408 Extraction Plan							
Minor Cliffs in Goulburn River National Park within 400 m of LW401-408 (including CL7)	n/a	Negligible impact due to longwall mining for Minor Cliffs in Goulburn River National Park.	Visual inspection of minor cliffs in GRNP within 400m of LW401-408 and CL7 Observed subsidence movements at GNSS unit MCO17 located at CL7	No physical impacts due to extraction of LW401-407 observed during visual inspections and subsidence movements at GNSS units consistent with predictions. The TARP for minor cliffs in the GRNP within 400 m of LW401-408 was not triggered during mining of LW401-407.	MSEC	Yes	n/a
Land in General	n/a	Subsidence parameters and environmental consequences as predicted.	Opportunistic visual observations of access tracks/other surface features during mining Observed subsidence movements and visual inspection at subsidence monitoring lines Observed subsidence movements at various GNSS units above and within the vicinity of LW401-407	Minor observed physical impacts due to extraction of LW401-407 consistent with predictions. Subsidence movements at GNSS units and monitoring lines consistent with predictions. The TARP for land in general was not triggered during mining of LW401-407.	MSEC	Yes	n/a

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Table E1 (Continued): Assessment of Environmental Performance of LW401-407 – Natural and Heritage Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Bora Creek	n/a	- Change in visible bed or bank erosion. - Development of or change in headcut erosion along Bora Creek. - Change in vegetation character such as vegetation loss through erosion or drowning by ponded water. - Extent and duration of water ponding. - Appearance of unsealed surface cracking across the bed of Bora Creek.	Visual inspection at sites UG4-BC101 to UG4-BC112 Analysis of pre- and post-mining LiDAR data	Subsidence movements consistent with predictions. Minor observed cracking due to extraction of LW401-407 consistent with predictions. The TARP for Bora Creek was not triggered during mining of LW401-407.	MSEC WRM	Yes	n/a
		Receiving water quality.	Surface water flow and quality monitoring of receiving watercourses (i.e. Goulburn River, refer above)	Observed surface water flow in receiving watercourses consistent with predictions (i.e. no loss of flow). Two trigger events for surface water quality in receiving watercourses (i.e. Goulburn River) were recorded. Further investigation confirmed the exceedances were not due to extraction of LW401-407. The TARP for surface water quality in receiving watercourses for Bora Creek was triggered during mining of LW401-407, however this did not result in an exceedance of the performance indicator.	WRM	Yes	n/a
Drainage Line DL1	n/a	Subsidence parameters and environmental consequences as predicted.	Visual inspection along upper reaches of DL1 Surface water flow and quality monitoring at site SW23 (DL1) if flowing	Subsidence movements consistent with predictions. Minor observed cracking and potential ponding areas due to extraction of LW401-407 consistent with predictions. Surface water flow/quality data unable to be recorded as no periods of flow. The TARP for DL1 was not triggered during mining of LW401-407.	WRM	Yes	n/a
Groundwater Level and Quality	n/a	Subsidence impacts from Longwalls 401 - 408 do not result in impact or environmental consequences greater than approved.	Groundwater level and quality monitoring at relevant piezometer sites in UG4 monitoring network, including trigger investigation bores PZ101C, PZ103C, PZ105C and PZ129 VWP	Observed groundwater levels and quality did not exceed trigger investigation levels due to extraction of LW401-407. The TARPs for groundwater levels and quality were not triggered during mining of LW401-407.	AGE	Yes	n/a

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Table E1 (Continued): Assessment of Environmental Performance of LW401-407 – Natural and Heritage Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Threatened Ecological Communities	n/a	- No significant reduction in vegetation integrity score greater than observed at reference sites (decrease of vegetation integrity score by 20% for two consecutive survey periods post-mining) combined with observed subsidence impacts; or - No significant reduction in species diversity greater than observed at reference sites (a significance reduction being greater than 5 species consistently absent from established monitoring plots for 4 consecutive years) combined with observed subsidence impacts.	Annual spring monitoring of floristic monitoring plots and photo monitoring points	Minor observed cracking due to extraction of LW401-407 consistent with predictions. No reduction in vegetation integrity or species diversity greater than observed at reference sites, therefore no impacts due to extraction of LW401-407. The TARP for threatened ecological communities was not triggered during mining of LW401-407.	Niche	Yes	n/a
Threatened Fauna (cave-dwelling bat species)	n/a	No significant reduction in threatened species presence greater than observed at reference sites (at least 1 species absent from acoustic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.	Annual spring acoustic monitoring	No reduction in species presence greater than observed at reference sites, therefore no impacts due to extraction of LW401-407. The TARP for threatened fauna (cave dwelling bat species) was not triggered during mining of LW401-407.	Niche	Yes	n/a
Threatened Flora (<i>Androcalva procumbens</i>)	n/a	Threatened flora remains present within the Study Area.	Annual spring visual inspection and population count of recorded threatened flora locations	No physical subsidence impacts observed within threatened flora habitat. No significant change to population due to extraction of LW401-407. The TARP for threatened flora (<i>Androcalva procumbens</i>) was not triggered during mining of LW401-407.	Niche	Yes	n/a
Aboriginal Cultural Heritage Rock Shelter Sites Subject to Ongoing Monitoring	n/a	Subsidence parameters and environmental consequences as predicted.	Pre- and post-mining visual monitoring inspection	Observed physical impacts due to extraction of LW401-407 consistent with predictions. No further management actions or monitoring required for Aboriginal cultural heritage rock shelters above/adjacent to LW401-407.	Niche	Yes	n/a

Note: MSEC = Mine Subsidence Engineering Consultants, WRM = WRM Water & Environment, Niche = Niche Environment and Heritage, AGE = Australasian Groundwater & Environment.

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Table E2: Assessment of Environmental Performance of LW401-407 – Built Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Features with Subsidence Impact Performance Measures in Project Approval (05_0117)							
Key Public Infrastructure							
Gulgong-Sandy Hollow Railway Line	<i>Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</i>	- No defects or deformation of the rail track and associated infrastructure due to UG4 mining. - No visual displacement at joints or cracks in culverts due to UG4 mining.	Subsidence monitoring at 'ARTC2 Line' ground transect line along Rail Line Visual inspection of the alignment and condition of ARTC infrastructure	No observed or reported defects, deformation or displacement of joints in culverts due to the extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Gulgong-Sandy Hollow Railway Line was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Wollar-Wellington 330kV Transmission Line	<i>Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</i>	n/a – no performance indicator developed for the Wollar-Wellington 330kV transmission line.	n/a	No trigger event/level for Wollar-Wellington 300kV transmission line as no predicted impacts from LW401-407.	n/a	n/a	Yes
Roads							
Ulan Road	<i>Safe, serviceable and repairable unless the owner agrees otherwise in writing.</i>	No joint displacement or cracking or other defects of the drainage structure (e.g. pipes/culverts) in excess of 5 mm (when compared against baseline condition) due to UG4 mining.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of Ulan Road pavements, culverts, cuttings and other furniture within 400m of LW401-408	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for Ulan Road was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Ulan Road Bridge over the Sandy-Hollow Rail Line Ulan Road Bridge over the Goulburn River	<i>Safe, serviceable and repairable unless the owner agrees otherwise in writing.</i>	n/a – no performance indicators developed for the Ulan Road bridges.	n/a	No trigger event/level for Ulan Road bridges as no predicted impacts from LW401-407.	n/a	n/a	Yes

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Table E2 (Continued): Assessment of Environmental Performance of LW401-407 – Built Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Other Built Features and Improvements, including Fences							
Telstra optical fibre telecommunication cable Telstra copper telecommunication cable Telstra telecommunication tower	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	- Negligible transmission loss from mine subsidence impacts. - Negligible impacts on structural integrity of the cable lines from mine subsidence. - Negligible impacts on structural integrity of the communications tower from mine subsidence.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of telecommunication tower	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for Telstra assets was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Essential Energy 66 kV/22kV line and power poles	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	The structural integrity of the powerline (power poles and transmission lines) is maintained.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of powerline (e.g. pole foundations, integrity and function of support clamps or other items)	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Essential Energy 66 kV / 22kV line and power poles was not triggered during mining of LW401-407.	MSEC	Yes	Yes
UCMPL Millers Dam Compound and associated infrastructure, Bridge, Bore and Monitoring Piezometers	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	Subsidence monitoring indicates subsidence is consistent with approved impacts.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of UCMPL infrastructure within 400m of LW401-408	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for UCMPL infrastructure was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Dronvisa Quarry	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	- Subsidence monitoring indicates subsidence is consistent with approved impacts. - Compensation Agreement between MCO and Dronvisa in place for predicted impacts to Dronvisa infrastructure serviceability and damage to the Quarry.	Observed subsidence movements at GNSS units MCO10 to MCO16 located at Dronvisa Quarry Visual inspection of Quarry and Quarry Infrastructure	Observed impacts and subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for Dronvisa Quarry was not triggered during mining of LW401-407.	MSEC	Yes	Yes
Public Safety							
Public safety	<i>Negligible additional risk</i>	No more than negligible additional risk to public safety.	Monitoring program for cliffs, land in general and public utilities & privately-owned built features (refer above)	Observed physical impacts due to extraction of LW401-407 consistent with predictions. Subsidence movements at GNSS units and monitoring lines consistent with predictions. No TARPs relevant to public safety were triggered during mining of LW401-407.	MSEC	Yes	Yes

Note: MSEC = Mine Subsidence Engineering Consultants.

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1.0 INTRODUCTION

1.1 UG4 LONGWALLS 401 TO 408 OVERVIEW

The Moolarben Coal Complex is an open cut and underground coal mining operation located approximately 40 kilometres (km) north of Mudgee in the Western Coalfield of New South Wales (NSW) (**Figure 1**).

Moolarben Coal Operations Pty Ltd (MCO) is the operator of the Moolarben Coal Complex on behalf of the Moolarben Joint Venture. MCO is a wholly owned subsidiary of Yancoal Australia Limited.

Mining operations at the Moolarben Coal Complex are currently approved until 31 December 2038 in accordance with Project Approval (05_0117) (Moolarben Coal Project Stage 1) (as modified) and Project Approval (08_0135) (Moolarben Coal Project Stage 2) (as modified).

The UG4 Underground Mine (UG4) is a component of the approved Moolarben Coal Complex (**Figure 2**). The UG4 Longwalls 401 to 408 (LW401-408) Extraction Plan was approved in July 2022 (**Figure 3**) and secondary extraction of LW401 commenced shortly afterwards. Secondary extraction of LW407 was completed in January 2026.

1.2 PURPOSE AND SCOPE

This End of Panel (EoP) Report for LW401-407 has been prepared to satisfy a request from the NSW Department of Planning, Housing and Infrastructure (DPHI) post-review of the UG4 LW401-403 EoP Report.

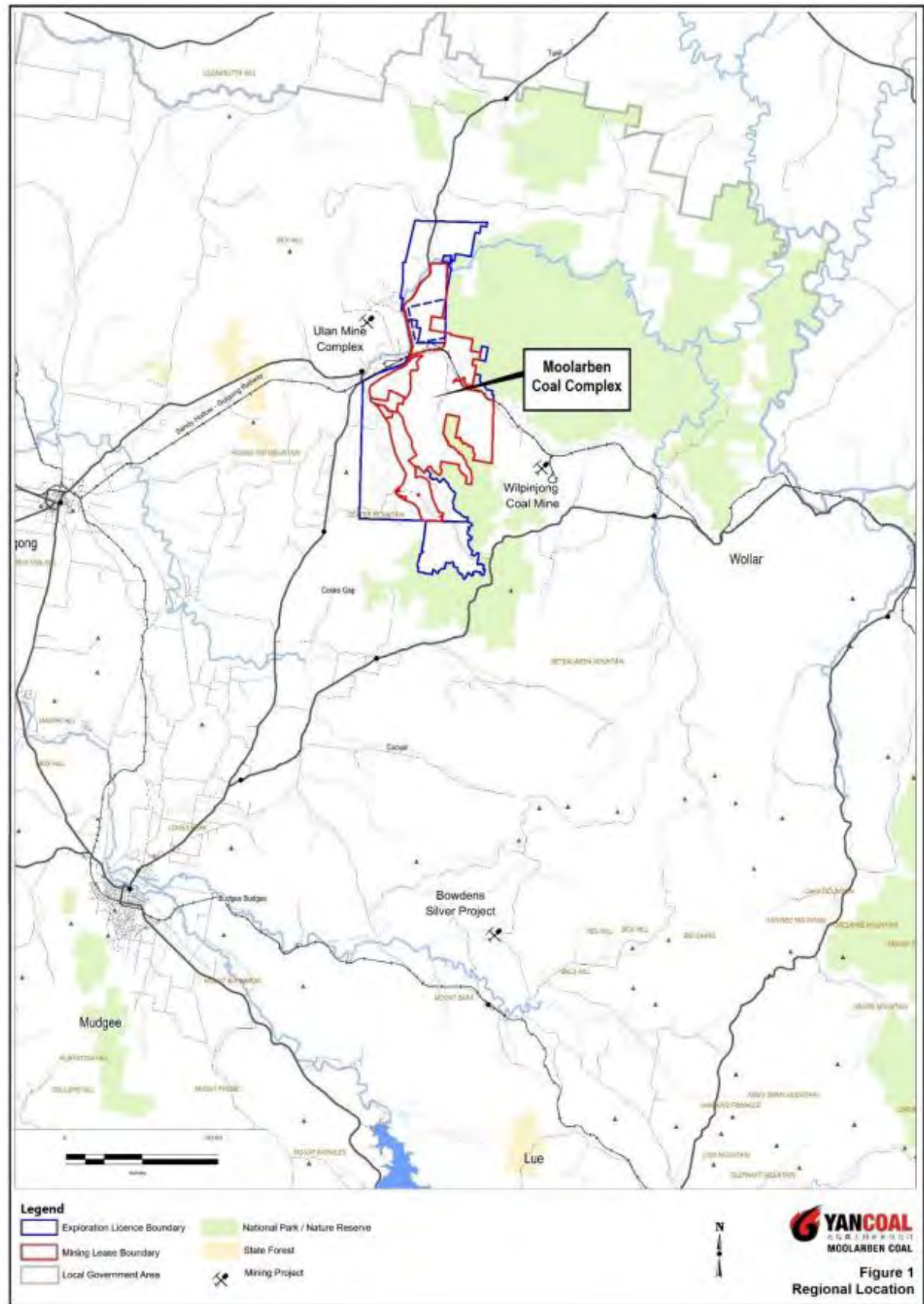
This EoP Report presents monitoring data, describes observed impacts during mining of LW401-407 and compares these results to predictions and relevant impact assessment criteria (i.e. performance measures and performance indicators) described in the approved UG4 LW401-408 Extraction Plan.

An overview of the main text sections of the UG4 LW401-407 EoP Report is presented below:

Section 1	Provides an introduction to this UG4 LW401-407 EoP Report, including the purpose and scope of the Report.
Section 2	Outlines the approval requirements and performance measures and indicators relevant to this UG4 LW401-407 EoP Report.
Section 3	Presents observed subsidence monitoring data compared to predicted subsidence movements.
Section 4	Presents the observed monitoring outcomes for natural and heritage features and assesses them against the relevant Trigger Action Response Plans (TARPs), performance measures and performance indicators.
Section 5	Presents the observed monitoring outcomes for built features and assesses them the relevant TARPs, performance measures and performance indicators.
Section 6	Assesses public safety against the relevant TARPs, performance measures and performance indicators and describes any management measures implemented during the LW401-407 extraction period.
Section 7	Lists the references cited in this UG4 LW401-407 EoP Report.

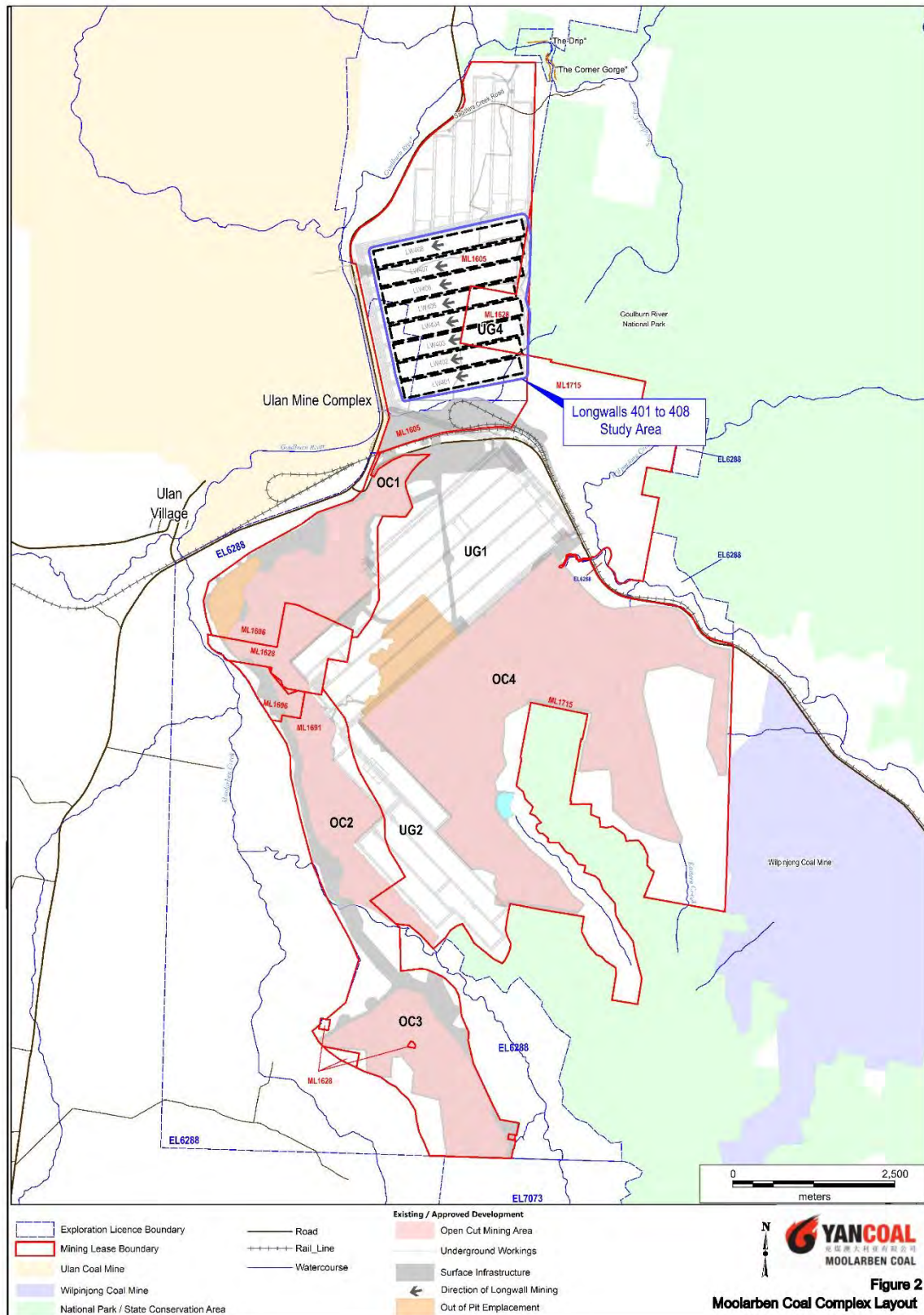
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Figure 1: Regional Location



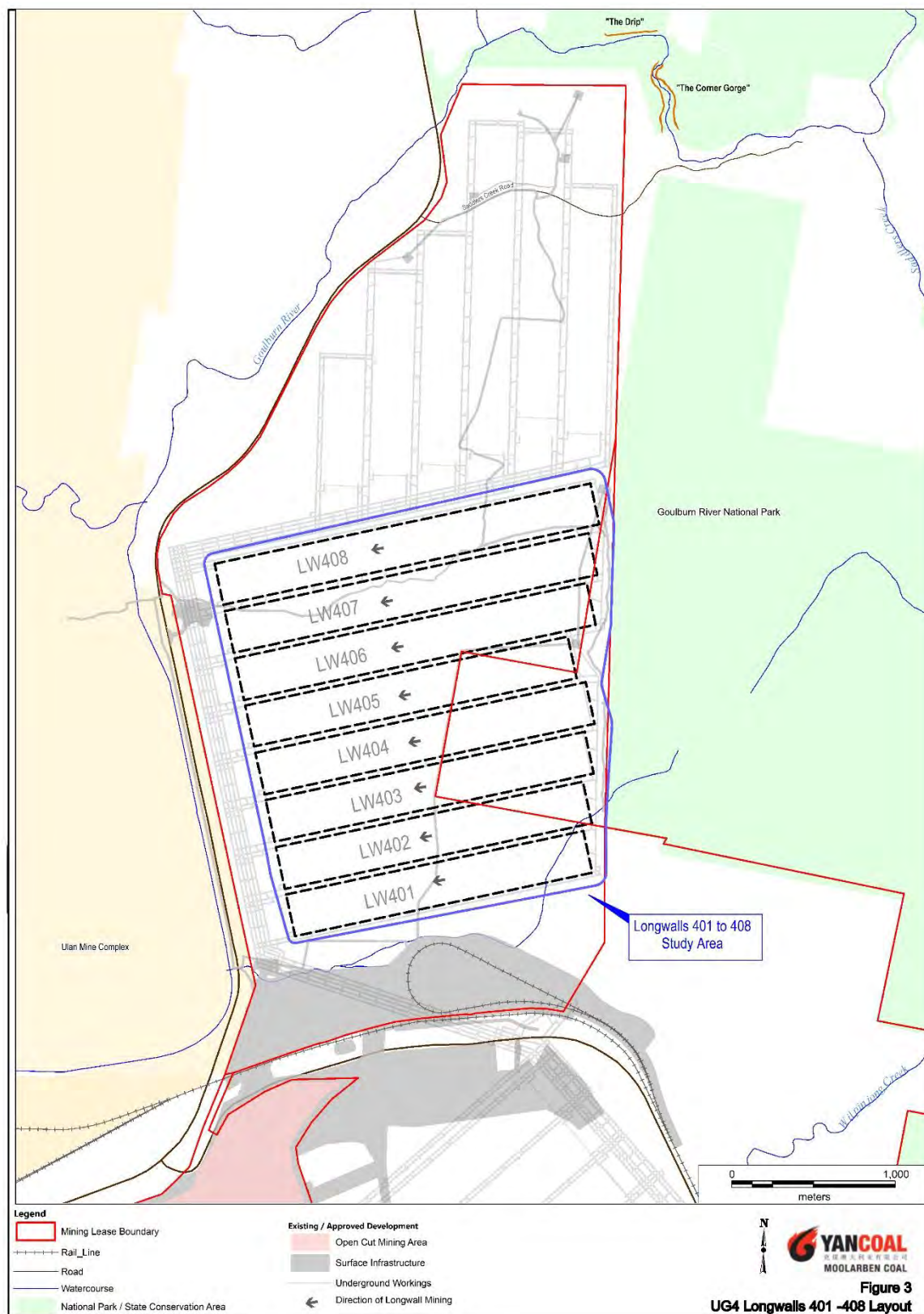
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Figure 2: Moolarben Coal Complex Layout



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Figure 3: UG4 Longwalls 401-408 Layout



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This UG4 LW401-407 EoP Report has been prepared by MCO with input from technical specialists endorsed by DPHI for the approved UG4 LW401-408 Extraction Plan and UG4 LW409-414 Extraction Plan.

Supporting technical specialist reports and review are provided in **Appendices A to F** of this Report:

- Appendix A** Subsidence Report prepared by Mine Subsidence Engineering Consultants (MSEC)
- Appendix B** Groundwater Report prepared by Australasian Groundwater & Environment (AGE)
- Appendix C** Surface Water Report prepared by WRM Water & Environment (WRM)
- Appendix D** Biodiversity Monitoring Report prepared Niche Environment and Heritage (Niche)
- Appendix E** Aboriginal Cultural Heritage Report prepared by Niche
- Appendix F** Independent Review of Groundwater and Surface Water Impacts prepared by Dr Lloyd Townley

1.3 MINE LAYOUT AND SCHEDULE

The LW401-408 Study Area¹ is defined in the UG4 LW401-408 Extraction Plan as the surface area that is likely to be affected by mining of LW401-408 (**Figure 3**).

Secondary extraction of each longwall panel in the LW401-408 mining area occurred from east to west, commencing with the southernmost panel (i.e. LW401). The longwall layout includes approximately 260 metre (m) panel widths (void) with 35 m width pillars (solid).

The extraction schedule for LW401-407 is provided in **Table 1**. Secondary extraction of LW408 commenced in February 2026 and is ongoing.

Table 1: LW401-407 Extraction Schedule

Longwall	Start Date	End Date
LW401	14/07/2022	29/11/2022
LW402	22/02/2023	4/07/2023
LW403	31/07/2023	9/12/2023
LW404	15/01/2024	18/05/2024
LW405	19/06/2024	26/10/2024
LW406	24/01/2025	15/07/2025
LW407	15/08/2025	30/01/2026

¹ LW401-408 and the area of land within the furthest extent of the 26.5 degree angle of draw and 20 millimetres (mm) predicted subsidence contour.

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2.0 APPROVAL REQUIREMENTS

The requirements of the UG4 LW401-407 EoP Report are summarised in **Table 2** along with the relevant section(s) of this Report in which the requirement is addressed and reference to any relevant technical reports.

Table 2: UG4 LW401-407 EoP Report Requirements

Requirement	Relevant Section(s)/Reports
<i>The Department requests that in accordance with the advice, you provide an End of Panel Report after the extraction of LW407 (and before the completion of LW408) including:</i>	This Report
an assessment of subsidence predictions and actual impacts,	Sections 3, 4 and 5 and Appendix A
data and trends for all underlying groundwater systems, and an assessment of impacts to the Triassic sandstone aquifer and its environmental and cultural assets adjacent to and downstream of the UG4 area,	Sections 4.6 and 4.7 and Appendices B and F
surface water data and trends for the Goulburn River adjacent to and downstream of the UG4 area, and	Sections 4.4 to 4.5 and Appendices C and F
an assessment of cultural heritage impacts.	Sections 3.3 and 4.9 and Appendix E

For completeness, annual biodiversity monitoring reporting undertaken by Niche in accordance with the requirements of the approved UG4 LW401-408 Extraction Plan has been considered in this UG4 LW401-407 End of Panel Report and the monitoring report is provided in **Appendix D**.

In addition, as requested by DPHI (as per correspondence dated 7 May 2026), Dr Lloyd Townley has undertaken an independent review of observed groundwater and surface water impacts from LW401-407 to address independent audit requirements in Condition 9, Schedule 5 of the Stage 1 Project Approval (05_0117). Dr Townley's review is provided in **Appendix F** and summarised in **Section 4.7**.

2.1 PERFORMANCE MEASURES AND PERFORMANCE INDICATORS

The Stage 1 Project Approval (05_0117) requires MCO to ensure the mining of LW401-407 does not cause any exceedances of the subsidence impact performance measures for natural, heritage and built features outlined in Conditions 73 and 75, Schedule 3.

The water management performance measure for the Drip as outlined in Condition 32, Schedule 3 of Project Approval (05_0117) is also relevant to UG4 secondary extraction and is considered in this UG4 LW401-407 EoP Report.

The performance measures outlined in Project Approval (05_0117) and performance indicators developed for the approved UG4 LW401-408 Extraction Plan are provided in **Table 3** and **Table 4**.

While **Table 3** and **Table 4** include all natural, heritage and built features with performance measures in the Stage 1 Project Approval (05_0117), those that are not relevant to secondary extraction of LW401-407 are not considered further in this UG4 LW409-414 EoP Report.

Further detail regarding management and monitoring measures for natural, heritage and built features within and in the vicinity of LW401-408, including associated trigger levels, trigger events and TARPs, are described in the approved UG4 LW401-408 Extraction Plan and associated Management Plans.

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Table 3: Performance Measures and Indicators for Natural and Heritage Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator
The Drip and Corner Gorge	<i>Nil impact or environmental consequences</i>	<i>n/a</i> – no specific subsidence performance indicator developed for the Drip and Corner Gorge; however, relevant criteria are included in the approved UG4 LW409-414 Extraction Plan and will apply to future assessments of environmental performance where relevant.
The Drip	<i>Nil impact on the water supply to the Drip</i>	Unpredicted loss of water supply to the Drip during LW401 to 408.
Goulburn River and the bed of the Goulburn River	<i>Negligible impact or environmental consequences. Remain outside the zone of recorded subsidence damage for longwall mining.</i>	Unpredicted impacts on Goulburn River (cracking and or noticeable changes in erosion or pools).
Cliff Line (CL) 3	<i>Minimise subsidence damage</i>	CL3 impacts due to LW401-408 are less than 1.9 m vertical conventional subsidence and 60 mm/m conventional tilt.
Aboriginal heritage sites 264, 282, 283, 286 and 287*	<i>Reduce the likelihood of subsidence damage to low.</i>	<i>n/a</i> - no performance indicators developed for Aboriginal heritage sites 264, 282, 283, 286 and 287 as no predicted impacts due to extraction of LW401-408.
Aboriginal heritage site 280	<i>Reduce the likelihood of subsidence damage to moderate</i>	Revised subsidence likelihood reduced to moderate.
Historic heritage sites*	<i>No greater subsidence impact or environmental consequences than predicted in the EA</i>	<i>n/a</i> – no performance indicator developed for historic heritage sites as no historic heritage sites within or in the vicinity of the LW401-408 Study Area.

* Not relevant to this UG4 LW401-407 EoP Report and therefore not considered further.

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Table 4: Performance Measures and Indicators for Built Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator
Key Public Infrastructure		
Gulgong-Sandy Hollow Railway Line	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable and must be fully repaired.	- No defects or deformation of the rail track and associated infrastructure due to UG4 mining. - No visual displacement at joints or cracks in culverts due to UG4 mining.
Wollar-Wellington 330 kV Transmission Line		n/a – no performance indicator developed.
Roads		
Ulan Road	Safe, serviceable and repairable unless the owner agrees otherwise in writing.	No joint displacement or cracking or other defects of the drainage structure (e.g. pipes/culverts) in excess of 5 mm (when compared against baseline condition) due to UG4 mining.
Ulan Road Bridge over the Sandy-Hollow Rail Line Ulan Road Bridge over the Goulburn River		n/a – no performance indicators developed.
Other Built Features and Improvements, including Fences		
Telstra optical fibre telecommunication cable Telstra copper telecommunication cable Telstra telecommunication tower	Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.	- Negligible transmission loss from mine subsidence impacts. - Negligible impacts on structural integrity of the cable lines from mine subsidence. - Negligible impacts on structural integrity of the communications tower from mine subsidence.
Essential Energy 66 kV/22kV line and power poles		The structural integrity of the powerline (power poles and transmission lines) is maintained.
UCMPL Millers Dam Compound and associated infrastructure, Bridge, Bore and Monitoring Piezometers		Subsidence monitoring indicates subsidence is consistent with approved impacts.
Dronvisa Quarry		- Subsidence monitoring indicates subsidence is consistent with approved impacts. - Compensation Agreement between MCO and Dronvisa in place for predicted impacts to Dronvisa infrastructure serviceability and damage to the Quarry.
Public safety	Negligible additional risk	No more than negligible additional risk to public safety.

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2.2 OTHER RELEVANT NATURAL FEATURES

A number of natural and heritage features without performance measures in Project Approval (05_0117) have nominated performance indicators in the approved UG4 LW401-408 Extraction Plan. These features and their nominated performance indicators are provided in **Table 5**.

Table 5: Nominated Performance Indicators for other Natural and Heritage Features

Feature	Performance Indicator
Minor Cliffs in Goulburn River National Park within 400 m of LW401-408 (including CL7)	Negligible impact due to longwall mining for minor cliffs in the Goulburn River National Park.
Land in General	Subsidence parameters and environmental consequences as predicted.
Bora Creek	- Change in visible bed or bank erosion. - Development of or change in headcut erosion along Bora Creek. - Change in vegetation character such as vegetation loss through erosion or drowning by ponded water. - Extent and duration of water ponding. - Appearance of unsealed surface cracking across the bed of Bora Creek. - Receiving water quality.
Drainage Line DL1	Subsidence parameters and environmental consequences as predicted.
Groundwater Level and Quality	Subsidence impacts from Longwalls 401 - 408 do not result in impact or environmental consequences greater than approved.
Threatened Ecological Communities	- No significant reduction in vegetation integrity score greater than observed at reference sites (decrease of vegetation integrity score by 20% for two consecutive survey periods post-mining) combined with observed subsidence impacts; or - No significant reduction in species diversity greater than observed at reference sites (a significance reduction being greater than 5 species consistently absent from established monitoring plots for 4 consecutive years) combined with observed subsidence impacts.
Threatened Fauna (cave-dwelling bat species)	No significant reduction in threatened species presence greater than observed at reference sites (at least 1 species absent from acoustic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.
Threatened Flora (<i>Androcalva procumbens</i>)	Threatened flora remains present within the Study Area.
Aboriginal Cultural Heritage Rock Shelter Sites Subject to Ongoing Monitoring	Subsidence parameters and environmental consequences as predicted.

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3.0 PREDICTED AND MEASURED SUBSIDENCE MOVEMENTS

Subsidence movements resulting from the extraction of LW401-407 were monitored along subsidence monitoring lines and points within and in the vicinity of LW401-408, in addition to real-time monitoring using a network of Global Navigation Satellite System (GNSS) monitors (**Figure 4**).

Specifically, the subsidence monitoring program associated with LW401-407 included:

- Monitoring lines across LW401-408 (K, L, M, N and S Lines).
- Monitoring lines for S1MC280 (X and Y Lines).
- Monitoring line along Ulan Road (R Line).
- Monitoring line along Sandy Hollow-Gulgong Railway Line (ARTC2 Line).
- Monitoring points along the Essential Energy 66 kV/22 kV line and power poles.
- Network of GNSS units.

The subsidence predictions were determined by MSEC using the Incremental Profile Method and are presented in the UG4 LW401-408 Subsidence Report (MSEC, 2021). A comparison of the predicted and measured movements has been prepared by MSEC and is included in **Appendix A**.

3.1 SUBSIDENCE MONITORING LINES AND POINTS

3.1.1 Monitoring Lines Across LW401-408 (K, L, M, N and S Lines)

The K Line and L Line are 3D ground monitoring lines located along the centreline of LW401 at the longwall finishing end and commencing end, respectively, and were surveyed prior to and following the completion of secondary extraction of LW401.

The M Line is a 3D ground monitoring line located along the centreline of LW402 at the longwall finishing end and was surveyed prior to and following the completion of secondary extraction of LW402.

The N Line is a 3D ground monitoring line located along the centreline of LW406 at the longwall finishing end and was surveyed prior to and following the completion of secondary extraction of LW406.

The S Line is a 3D ground monitoring line that is orientated transverse to LW401-408 and was surveyed prior to secondary extraction of LW401 and following the completion of LW407.

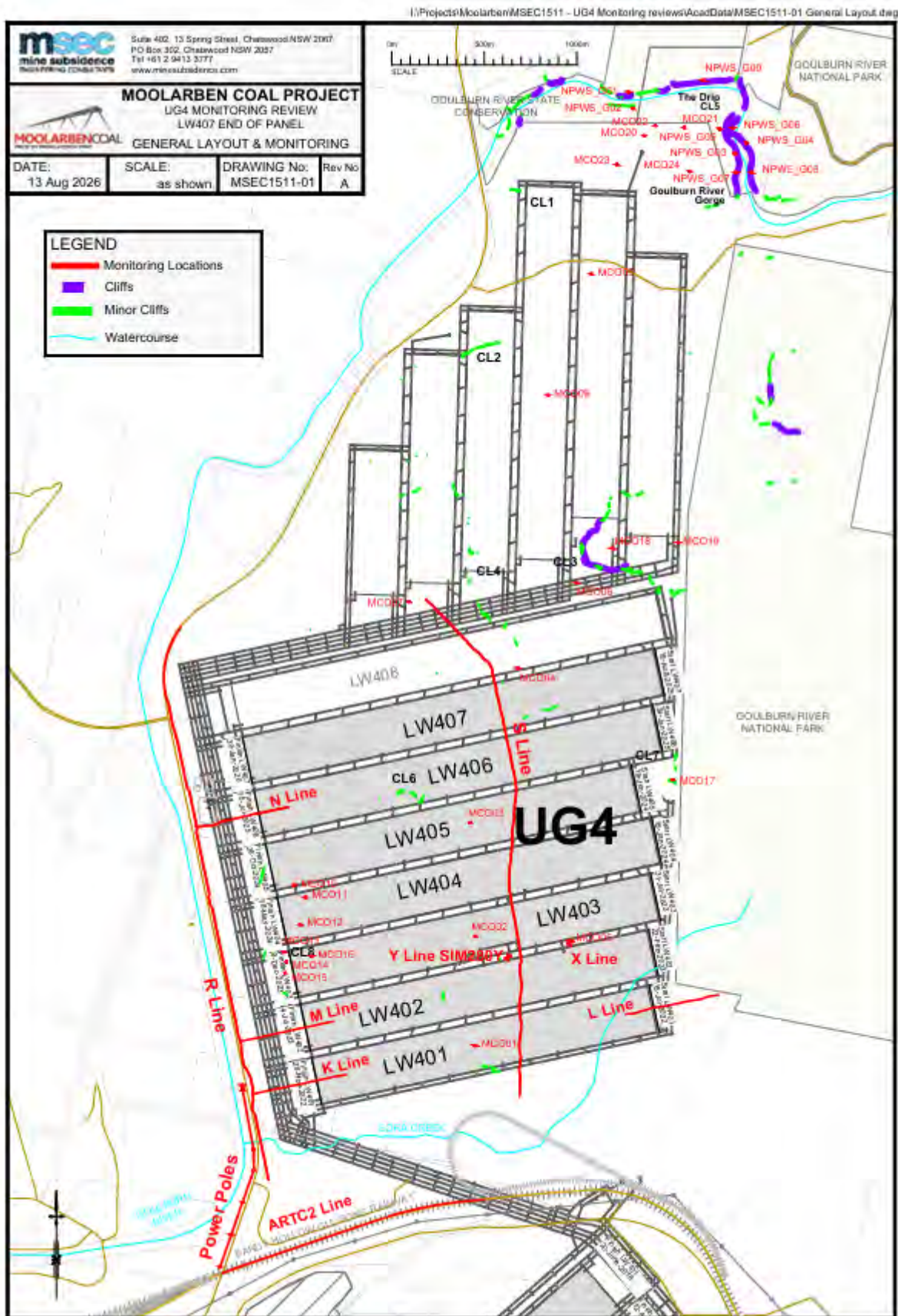
A comparison of the maximum predicted and measured subsidence parameters for these monitoring lines is provided in **Table 6**.

MSEC considers that the ground movements measured using the monitoring lines across LW401-408 during mining of LW401-407 are generally consistent with the predictions provided in MSEC (2021) (**Appendix A**).

The maximum measured subsidence parameters were less than predicted with the exception of the maximum compressive strain measured along the S line during mining of LW407 (**Table 6**). The measured compressive strain along the S line is not considered significant due to the shallow mining conditions and did not result in an exceedance of any TARP triggers or performance measures (**Appendix A**).

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Figure 4: Subsidence Monitoring Locations Relevant to LW401-407 (Source: MSEC [2026])



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Table 6: Comparison of Maximum Measured and Predicted Subsidence Parameters for Monitoring Lines Across LW401-407 (Source: after Appendix A)

Monitoring Line	Location	Type	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)
K Line	LW401 finishing end	Predicted	1,800	70	> 30*	> 30*
		Measured	1,582	49	13	17
L Line	LW401 commencing end	Predicted	1,800	35	12*	13*
		Measured	1,233	26	11	2.6
M Line	LW402 finishing end	Predicted	1,800	50	23*	26*
		Measured	1,778	39	4	13
N Line	LW406 finishing end	Predicted	1,800	65	> 30*	> 30*
		Measured	1,670	40	7.5	11.0
S Line	Transverse LW401-408	Predicted	1,900	35	13*	9*
		Measured	1,627	31	10	15

Note: Exceedances of predictions are indicated in **bold** text.

* Denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

3.1.2 Monitoring Line Along Ulan Road (R Line)

The R Line is a 3D ground monitoring line that follows Ulan Road to the west of LW401-408 and was surveyed prior to secondary extraction of LW401 and following the completion of each of LW401-407.

A summary of the maximum predicted and measured subsidence parameters for the R line is provided in **Table 7**.

Table 7: Comparison of Maximum Measured and Predicted Subsidence Parameters for Monitoring Line Along Ulan Road (Source: after Appendix A)

Monitoring Line	Location	Type	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)
R Line	Along Ulan Road	Predicted	< 20	< 0.5	< 0.5*	< 0.5*
		Measured	14	1.2	0.9	0.9

Note: Exceedances of predictions are indicated in **bold** text.

* Denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence is less than the survey accuracy (i.e. ± 30 mm). The measured maximum tilt and strains were higher than predicted (but generally in the order of survey tolerance of ± 0.5 mm/m), which is considered to be related to the disturbance of survey marks due to vehicles along Ulan Road (**Appendix A**).

MSEC considers that the ground movements measured along the R Line are generally consistent with the predictions in MSEC (2021) (**Appendix A**).

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3.1.3 Monitoring Line Along Sandy Hollow-Gulgong Railway Line (ARTC2 Line)

The ARTC2 Line is a 3D ground monitoring line that follows the Sandy Hollow-Gulgong Railway Line south of LW401, and was surveyed prior to and following the completion of secondary extraction of LW401.

A summary of the maximum predicted and measured subsidence parameters for the ARTC2 line is provided in **Table 8**.

Table 8: Comparison of Maximum Measured and Predicted Subsidence Parameters for Monitoring Line along Sandy Hollow-Gulgong Railway Line (Source: after Appendix A)

Monitoring Line	Location	Type	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)	Maximum Tensile Strain (mm/m)	Maximum Compressive Strain (mm/m)
ARTC2 Line	South of LW401	Predicted	< 20	< 0.5	< 0.5*	< 0.5*
		Measured	5	0.3	0.6	0.5

Note: Exceedances of predictions are indicated in **bold** text.

* Denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

Only low-level vertical subsidence was measured along the ARTC2 Line (i.e. less than approximately 5 mm which is less than survey tolerance of ± 30 mm) (**Appendix A**).

MSEC considers that the ground movements measured along the ARTC2 Line are consistent with the predictions in MSEC (2021) (**Appendix A**).

3.1.4 Monitoring Points Along the Essential Energy 66 kV/22 kV Line and Power Poles

Monitoring of the Essential Energy 66 kV/22 kV line and power poles comprises reflectorless survey of selected marks identified at the base and top of the power poles. A total of six poles were surveyed prior to secondary extraction of LW401 and following the completion of each of LW401 and LW402.

Only low-level vertical subsidence of 10 mm or less was measured at the poles, which is within survey accuracy (i.e. ± 30 mm). Changes in pole tilt, observed horizontal movements at the tops of the poles and changes in bay length between poles were also within survey accuracy.

One larger horizontal movement of 42 mm was recorded at a single pole; however, this pole was noted during surveys as leaning due to extreme wet weather, and it is not considered to be related to mine subsidence given its distance from the longwalls (i.e. over 680 m) and the smaller movements recorded at closer poles (**Appendix A**).

MSEC considers that the ground movements measured at the Essential Energy 66 kV/22 kV line and power poles are consistent with the predictions in MSEC (2021) (**Appendix A**).

3.1.5 Monitoring Points at the Telstra Telecommunications Tower

The Telstra telecommunications tower is located approximately 400 m to the west of LW401.

Measured vertical and horizontal movements at the Telstra Telecommunications Tower were less than survey accuracy, consistent with predictions in MSEC (2021) (**Appendix A**).

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3.2 GNSS MONITORING

In accordance with the UG4 LW401-408 Subsidence Monitoring Program, MCO installed and monitored GNSS units during mining of LW401-407. The locations of the GNSS units at UG4 are shown in **Figure 4**.

A comparison of the maximum predicted and observed total subsidence for each GNSS unit and a summary of the observed movements at each of the GNSS monitoring locations are provided in **Appendix A**.

The observed total subsidence at the GNSS units during mining of LW401-407 is less than the predictions and the vertical subsidence measurements at the GNSS units are consistent with the predictions (**Appendix A**).

3.2.1 Horizontal Movements

The maximum observed total subsidence movement above the extracted longwalls was 588 mm at MCO12 above LW404, which is consistent with the predictions. The horizontal movements outside the longwall panels reduce with increasing distance from the longwalls (**Appendix A**).

3.2.2 Far-Field Movements

Far-field horizontal movements in UG4 were measured by survey marks and GNSS units shown in **Figure 5**. Survey data at Moolarben Coal Complex is generally within the range of data from other regions in NSW. The majority of the GNSS monitoring data points indicate horizontal movements significantly less than the upper limits of the observed data (**Appendix A**).

The measured GNSS data from UG4 provides a more accurate representation of potential horizontal movements within and surrounding the UG4 area for future longwall extraction. A plot of the GNSS data as total horizontal movement versus distance from extracted longwalls is presented in **Figure 5**.

A red dashed upper bound line shown in **Figure 6** identifies the maximum observed total far-field horizontal movements for UG4 from GNSS monitoring data from LW401-407. The red solid upper bound line shown in **Figure 6** represents a previous update to the data conducted in June 2025 (prior to secondary extraction of LW407). It can be seen that the maxima have increased slightly from June 2025 to March 2026, which is expected at low magnitudes of movement and with the accumulation of data (**Appendix A**).

Using the observed GNSS monitoring data from secondary extraction of LW401-407, MSEC has reviewed the preliminary predictions of expected far-field movements for similar distances from LW409-414 mining from the Drip and Corner Gorge. At the minimum distance to the Drip and Corner Gorge of 450 m or more, the maximum observed far-field horizontal movements at GNSS units from LW401-407 are approximately 40 mm (**Appendix A**).

MSEC has also reviewed observed data at GNSS units installed at the Drip and Corner Gorge and confirmed the features currently experience a level of baseline natural and tolerance horizontal movements of up to ± 10 mm. These observed baseline movements are considered to represent background variation from seasonal and atmospheric changes and equipment tolerance as LW401-407 are further than 2.5 km from the Drip and Corner Gorge (**Appendix A**).

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Figure 5: Observed Incremental Horizontal Movements versus Distance to Active Longwall divided by Depth of Cover – all Moolarben Monitoring compared to NSW Survey Data (Source: Appendix A)

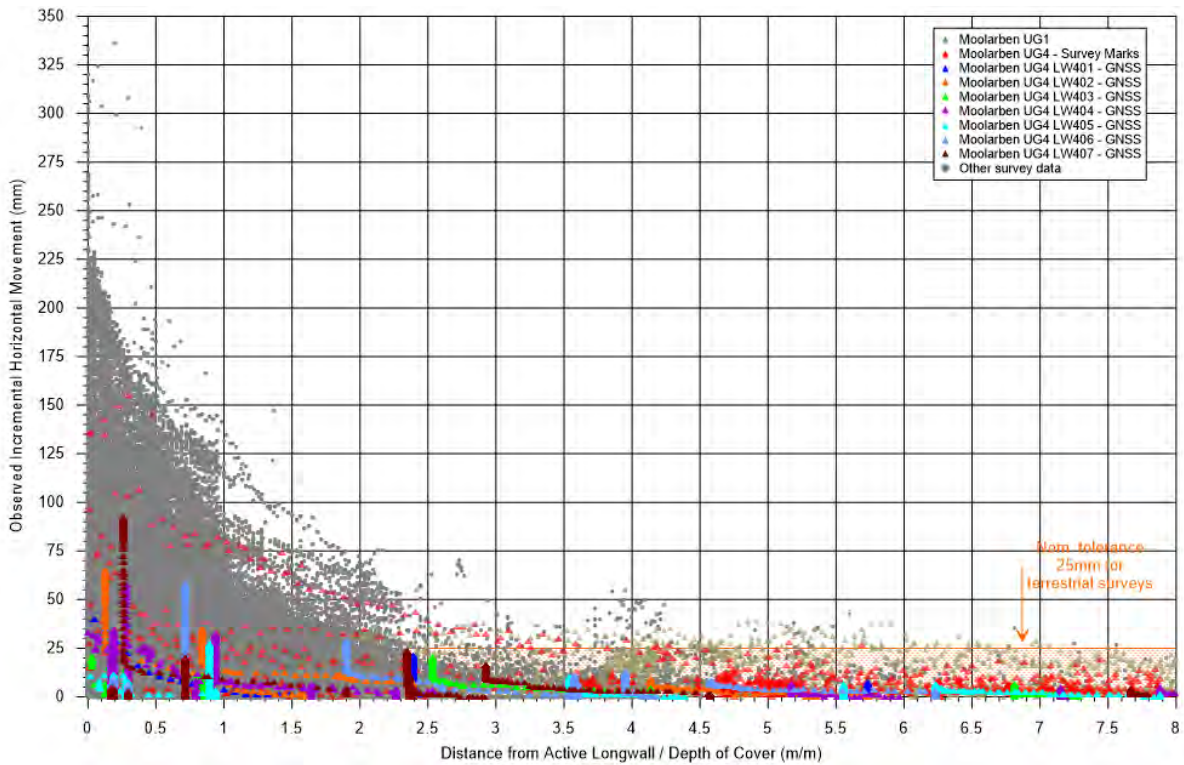
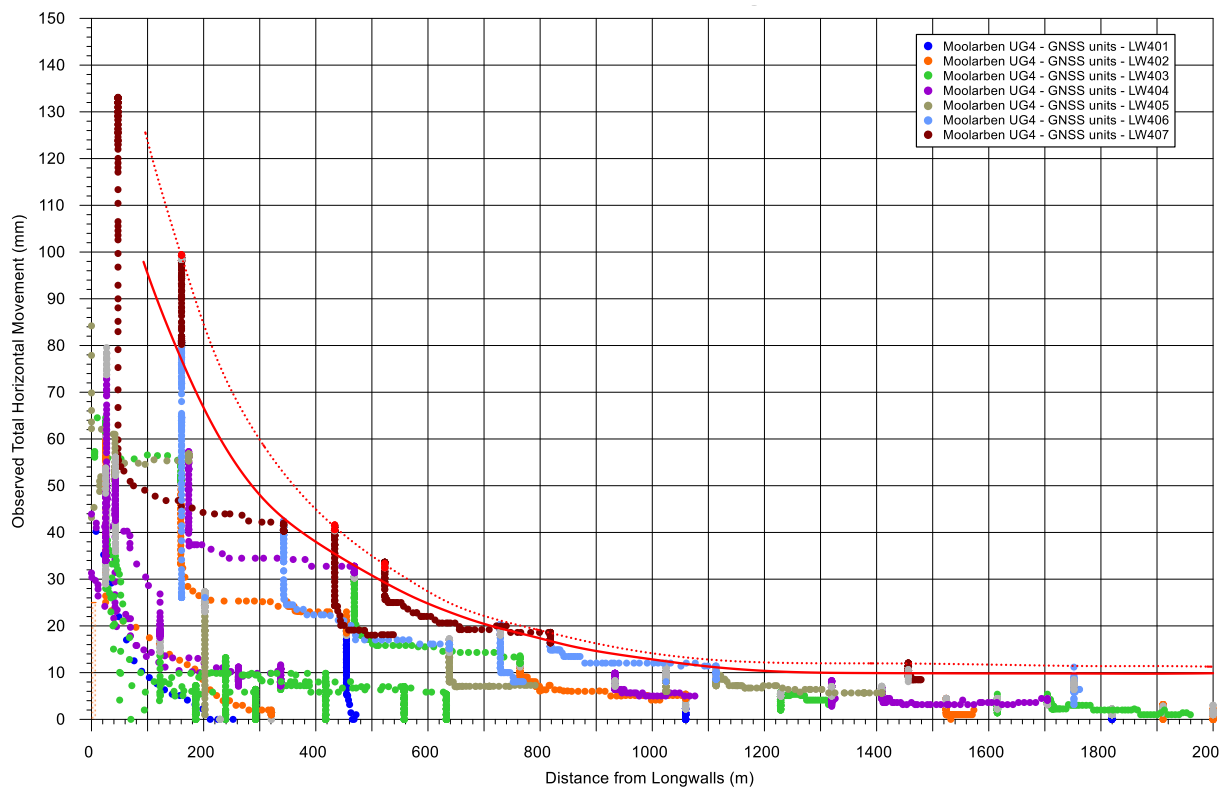


Figure 6: Observed Total Horizontal Movements versus Distance to Active Longwall – UG4 GNSS Monitoring Data (Source: Appendix A)



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3.2.3 Opening and Closure Movements

The Drip and Corner Gorge

The observed opening and closing movements between GNSS units NPWS_G01 to NPWS_G09 (installed at the Drip and Corner Gorge in 2023) are presented in **Figure 7** for movements across the alignment of the Goulburn River and in **Figure 8** for movements along the alignments of the cliff lines. These movements are considered to represent baseline data without influence from extraction of LW401-407 as the GNSS units are located over 2.5 km from LW401-407 (**Appendix A**).

Except for movements between NPWS_G06 to NPWS_G03, the opening and closing movements across the Goulburn River vary from approximately 7 mm (closing) to -4 mm (opening), which is predominantly within the limits of accuracy of the GNSS units (i.e. ± 5 mm for each unit, or ± 10 mm in total).

An opening movement of -11 mm was observed between NPWS_G06 to NPWS_G03 during mining of LW407; however, given no similar movements were observed across the Goulburn River between the other GNSS units and NPWS_G03 was repaired during this time, this data is not considered representative of the overall opening/closing movements observed (**Appendix A**).

The opening and closing movements along the alignments of the Drip and Corner Gorge vary from approximately 12 mm (closing) to -9 mm (opening), which is predominantly within the limits of accuracy of the GNSS units (i.e. ± 5 mm for each unit, or ± 10 mm in total).

The maximum observed closure of 12 mm is shown as a spike in the data of NPWS_G04 to NPWS_G08 and is likely due to a short term loss of accuracy. The maximum opening of -9 mm occurs between NPWS_G01 to NPWS_G09. Given no similar movements were observed between the other GNSS units and NPWS_G09 was repaired during this time, this data is not considered representative of the overall opening/closing movements observed (**Appendix A**).

Cliff Line CL3

Observed differential movements (i.e. opening and closure) between MCO06, MCO18 and MCO19 installed at CL3 are shown in **Figure 9**. The distance of approximately 430 to 530 m from LW407 to these GNSS units at CL3 represents similar distances of the Drip and Corner Gorge from the LW409-414.

Monitoring of differential movements at CL3 commenced during LW405. The observed differential movements show minor development of opening during mining of LW407, with a maximum of approximately -7 mm between MCO06 and MCO18 (**Appendix A**).

This magnitude of differential movement is small and within the limits of accuracy of the GNSS units (i.e. ± 5 mm for each unit, or ± 10 mm in total); however, given horizontal movements were observed at these GNSS units, it is considered that the observed minor opening is accurately represented (**Appendix A**).

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Figure 7: Baseline Monitoring of Total Observed Opening and Closure Movements across the Goulburn River (November 2023 - March 2026) (Source: Appendix A)

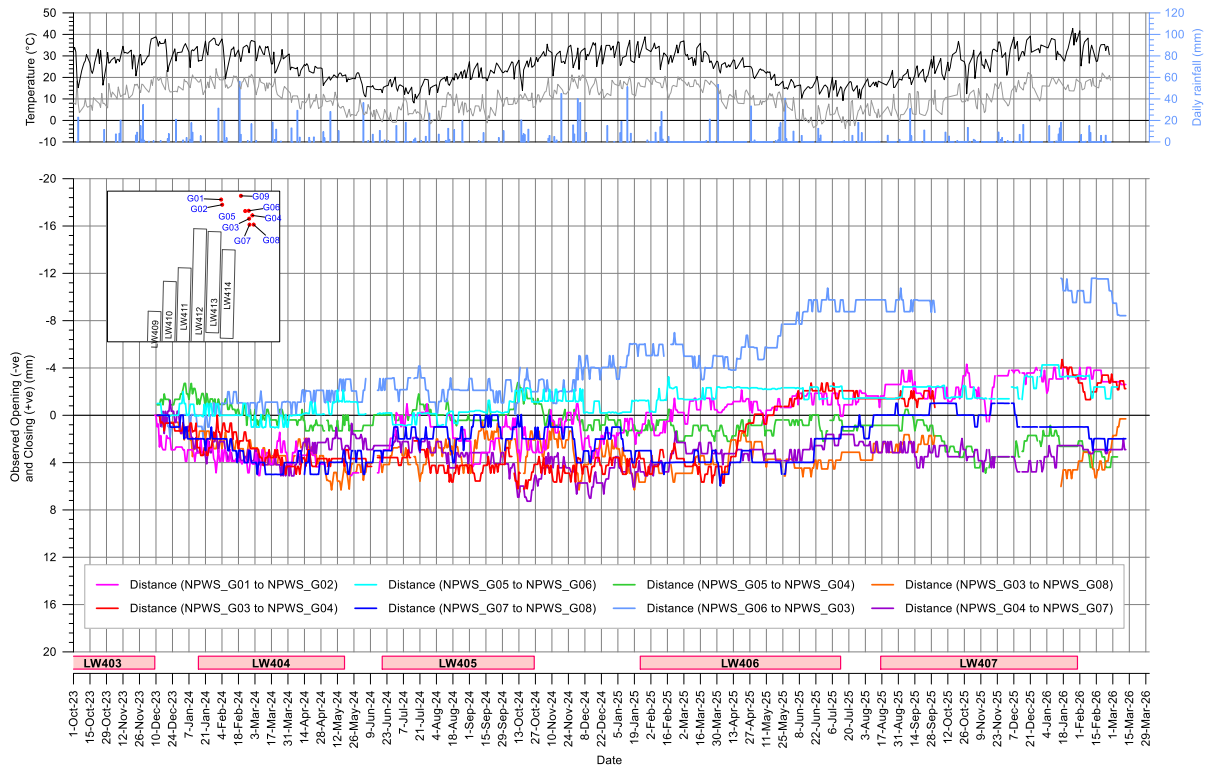
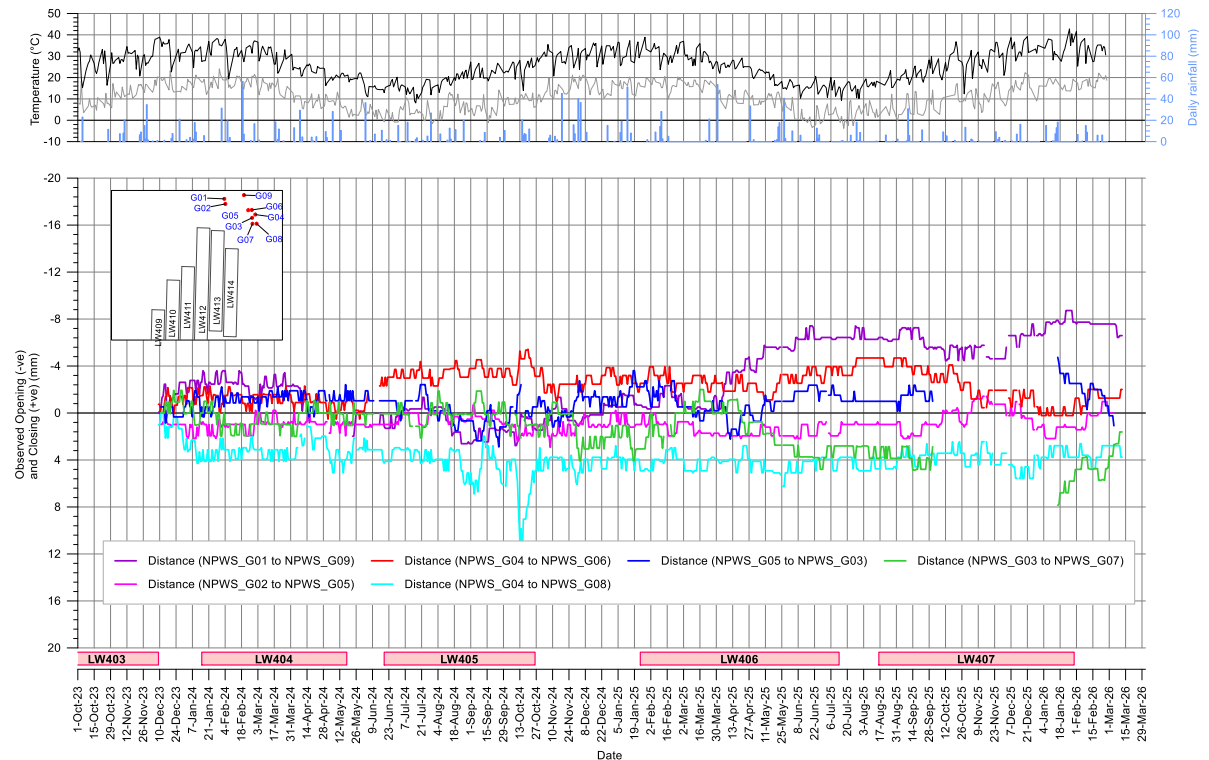
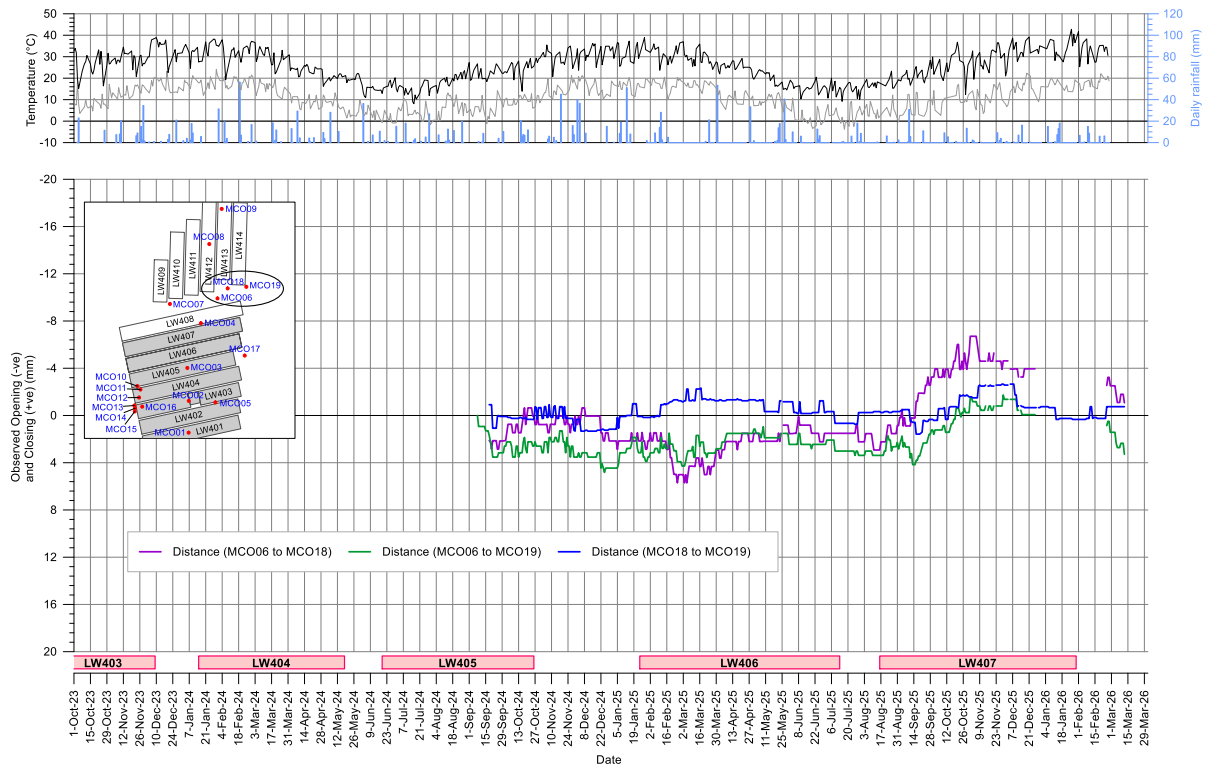


Figure 8: Baseline Monitoring of Total Observed Opening and Closure Movements along the alignment of the Drip and Corner Gorge (November 2023 - March 2026) (Source: Appendix A)



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**Figure 9: Monitoring of Total Observed Opening and Closure Movements at CL3
(September 2024 - March 2026) (Source: Appendix A)**



3.3 SUBSIDENCE MONITORING OF S1MC280

3.3.1 Site-specific Monitoring and Reporting Program

S1MC280 is an Aboriginal cultural heritage site assessed as being of high scientific significance containing a Shelter with Art, Artefacts and Grinding Grooves, and is located centrally above the chain pillar between LW402 and LW403.

A site-specific monitoring and reporting program was developed and implemented for S1MC280 (i.e. the UG4 LW401-408 S1MC280 Subsidence Monitoring and Mitigation Program) to address the requirements of the conditional approval for the UG4 LW401-408 Extraction Plan.

To further reduce the likelihood of potential damage from subsidence movements, additional mitigation measures and engineering controls were implemented during mining, including construction of a stress-relief slot system around the overhanging sandstone shelter and implementation of a tailored longwall design incorporating a barrier pillar and tailgate shortening adjacent to the site.

The specific subsidence monitoring implemented for S1MC280 included:

- an 'early warning' monitoring site comprised of subsidence monitoring lines;
- daily visual inspections while LW402 and LW403 are mining within 200m inbye and 200m outbye of the site itself;
- slot width monitoring across the vertical relief slots;

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- overhang tilt and closure monitoring; and
- subsidence monitoring lines adjacent to S1MC280.

The UG4 LW401-408 S1MC280 Subsidence Monitoring and Mitigation Program also includes TARPs for S1MC280 and its early warning monitoring site and outlines Technical Committee and Steering Committee process implemented during extraction of LW402 and LW403.

Further assessment of the monitoring outcomes for S1MC280 against the relevant performance measure and performance indicator is provided in **Section 4.9**. A summary of the subsidence monitoring outcomes for S1MC280 is provided below.

3.3.2 Monitoring Lines for S1MC280 (X Line and Y Line)

The X Line and Y Line were installed prior to secondary extraction of LW402 to monitor the S1MC280 Early Warning Site and S1MC280, respectively.

The X Line and Y Line are short 3D ground monitoring lines positioned above the longwall pillar between LW402 and LW403 with orientations along, across and diagonal to the pillar. The survey monitoring results represent the extraction of LW402-403 in relation to S1MC280 in accordance with the UG4 LW401-408 S1MC280 Subsidence Monitoring and Mitigation Program.

The X Line is an 'early warning' monitoring site (approximately 375 m inbye of S1MC280) and the Y Line is located adjacent to S1MC280 (**Figure 4**).

A summary of the maximum measured and predicted subsidence parameters for the X Line and Y Line is provided in **Table 9**.

Table 9: Comparison of Maximum Measured and Predicted Subsidence Parameters for Monitoring Lines for S1MC280 (Source: after Appendix A)

Monitoring Line	Location	Type	Maximum Vertical Subsidence (mm)	Maximum Tilt (mm/m)
X Line	Approx. 375 m inbye of S1MC280, between LW402-203	Predicted	150	4.0
		Measured	120	2.8
Y Line	Adjacent to S1MC280, between LW402-203	Predicted	100	5.0
		Measured	130	3.5

*Note: Exceedances of predictions are indicated in **bold** text.*

The maximum measured subsidence parameters for the X Line were generally consistent with the predictions. With the exception of the measured vertical subsidence along the Y Line close to the LW402 goaf, the measured vertical subsidence and tilt are generally consistent with the predictions (**Appendix A**).

The observed maximum vertical subsidence along the Y Line resulted in an exceedance of the Level 1 trigger in the subsidence monitoring TARP for S1MC280. Subsequent review by the Technical and Steering Committees determined that the trigger event did not result in an exceedance of the performance indicators or performance measure for S1MC280.

Overall, MSEC considers that the ground movements measured along the X Line and Y Line are reasonably consistent with the predictions in MSEC (2021) (**Appendix A**).

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3.3.3 Other Subsidence Monitoring for S1MC280

Monitoring results indicate that the management measures performed as intended and that observed ground movements remained within predicted and acceptable limits.

Slot monitoring demonstrated that the stress-relief slot effectively accommodated subsidence-related ground movements, with the majority of movement occurring during extraction of LW402 and a reduced rate of change recorded during LW403, consistent with predictions associated with the modified panel design.

The maximum observed closure of stress-relief slots during extraction of LW402 and LW403 was 2.04 mm, which resulted in an exceedance of the Level 1 trigger (i.e. < 2 mm closure) of the site monitoring TARP for S1MC280. Subsequent review by the Technical and Steering Committees determined that the trigger event did not result in an exceedance of the performance indicators or performance measure for S1MC280.

Monitoring of tilt, convergence and site conditions identified no material change from baseline conditions, no evidence of damage to the overhang, and therefore the other components of the site monitoring TARP for S1MC280 were not triggered during extraction of LW401-407.

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4.0 OBSERVED IMPACTS TO NATURAL AND HERITAGE FEATURES

Monitoring of impacts from secondary extraction of LW401-407 to relevant natural and heritage features was conducted in accordance with the approved UG4 LW401-408 Subsidence Monitoring Program and other associated Management Plans. Relevant natural and heritage features include:

- The Drip and Corner Gorge.
- Cliff Line CL3.
- Minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7).
- Land in general.
- Goulburn River.
- Bora Creek and Drainage Line DL1.
- Groundwater level and quality.
- Surface water quality.
- Biodiversity (threatened ecological communities, threatened fauna and threatened flora).
- Aboriginal cultural heritage rock shelter sites, including S1MC280.

Monitoring results and reviews undertaken by other specialist consultants are provided in **Appendices A to F**.

A summary of the monitoring outcomes and assessment of observed impacts during the extraction of LW401-407 is provided in the following sections.

4.1 THE DRIP AND CORNER GORGE

The Drip and Corner Gorge are located further than 2.5 km north of LW407. On this basis, no specific performance indicators, trigger level/events or TARPs were developed for these features as there were no predicted impacts from mining of LW401-408.

Notwithstanding, baseline subsidence movements (i.e. natural and tolerance movements) were monitored during mining of LW401-407 at GNSS units installed at the features (refer to **Section 3.2**).

Visual inspections and photographic monitoring of the Drip has also been undertaken every two months since commencement of pre-mining monitoring in July 2022. Monitoring locations are shown in **Figure 10**, along with the location of other relevant observations identified during monitoring.

No physical impacts due to extraction of LW401-407 were identified during visual inspections, consistent with predictions (**Appendix A**).

Other observations during the visual inspections not related to LW401-407 include (**Figure 10**):

- Laden water behind the southern bank of the river alongside the cliff face was observed during the January 2024 inspection, which had not previously been observed. Subsequent inspections recorded the area as either dry or containing pooled water and therefore considered to have resulted from rainfall/storm events.

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Figure 10: The Drip Visual Monitoring Points and Location of other Observations



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- New rock falls on the south cliff edge of the Drip near monitoring point GRP-110 were identified during the March 2024 inspection. These appeared to be the result of natural separation as no material movements were observed in the GNSS monitoring data and no subsequent changes to the rock fall or the surrounding area were observed during later inspections.
- The ‘drip’ location near the first signpost along the walking track (not affiliated with the cliff face feature known as “the Drip”) was identified as dry during the November 2024 inspection. Subsequent inspections recorded this location as either dry or actively dripping and therefore this observation is considered to be a result of climatic conditions.
- Fallen vegetation was observed during various inspections, including a stag tree at GRP-105b in January 2025 and notable fallen trees in proximity to monitoring locations GRP-102 and GRP-108 in January 2026. These observations identified as associated with storm events.

A summary of the assessment of monitoring outcomes against relevant performance measures and indicators for the Drip and Corner Gorge is provided in **Table 10**.

Table 10: Assessment of Environmental Performance of LW401-407 – the Drip and Corner Gorge

Feature	The Drip and Corner Gorge	The Drip
Performance Measure	<i>Nil impact or environmental consequences.</i>	<i>Nil impact on the water supply to the Drip.</i>
Performance Indicator	<i>n/a</i> – no specific subsidence performance indicator developed for the Drip and Corner Gorge; however, relevant criteria are included in the approved UG4 LW409-414 Extraction Plan and will apply to future assessments of environmental performance where relevant.	Unpredicted loss of water supply to the Drip during LW401 to 408.
Monitoring Site(s) and Parameter(s)	Baseline visual inspection at sites GRP-101 to GRP-113. Baseline monitoring of far-field movement at GNSS units NPWS_G01 to NPWS_G09.	Baseline visual inspection at sites GRP-101 to GRP-113.
Highest Recorded Trigger Event/Trigger Level	<i>n/a – Baseline monitoring only.</i> No trigger event/level for Drip or Corner Gorge as no predicted impacts from LW401-407. Notwithstanding, no physical impacts due to extraction of LW401-407 observed during visual inspections and baseline far-field movements at GNSS units consistent with predictions.	<i>n/a – Baseline monitoring only.</i> No trigger event/level for Drip or Corner Gorge as no predicted impacts from LW401-407. Notwithstanding, no physical impacts due to extraction of LW401-407 observed during visual inspections.
Monitoring Data Reviewed By?	MSEC (Appendix A)	WRM (Appendix C)
Compliance With Performance Indicator?	<i>n/a</i>	Yes
Compliance With Performance Measure?	Yes	Yes

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4.2 CLIFF LINES

4.2.1 CL3

CL3 is located over 165 m to the north of LW408 (**Figure 4**) and impacts to the cliff due to the extraction of LW401-408 were considered unlikely to occur (MSEC, 2021).

Subsidence movements at CL3 were monitored during mining of LW401-407 at GNSS units installed at the feature (refer to **Section 3.2**). The measured subsidence movements were consistent with predictions and did not exceed the performance indicator for CL3 (**Appendix A**).

Visual inspections of CL3 were undertaken prior to secondary extraction of LW401 and following the completion of LW407 at the monitoring locations shown in **Figure 11**. No physical impacts due to the extraction of LW401-407 were observed at CL3 during visual inspections and therefore the TARP for CL3 was not triggered (**Appendix A**).

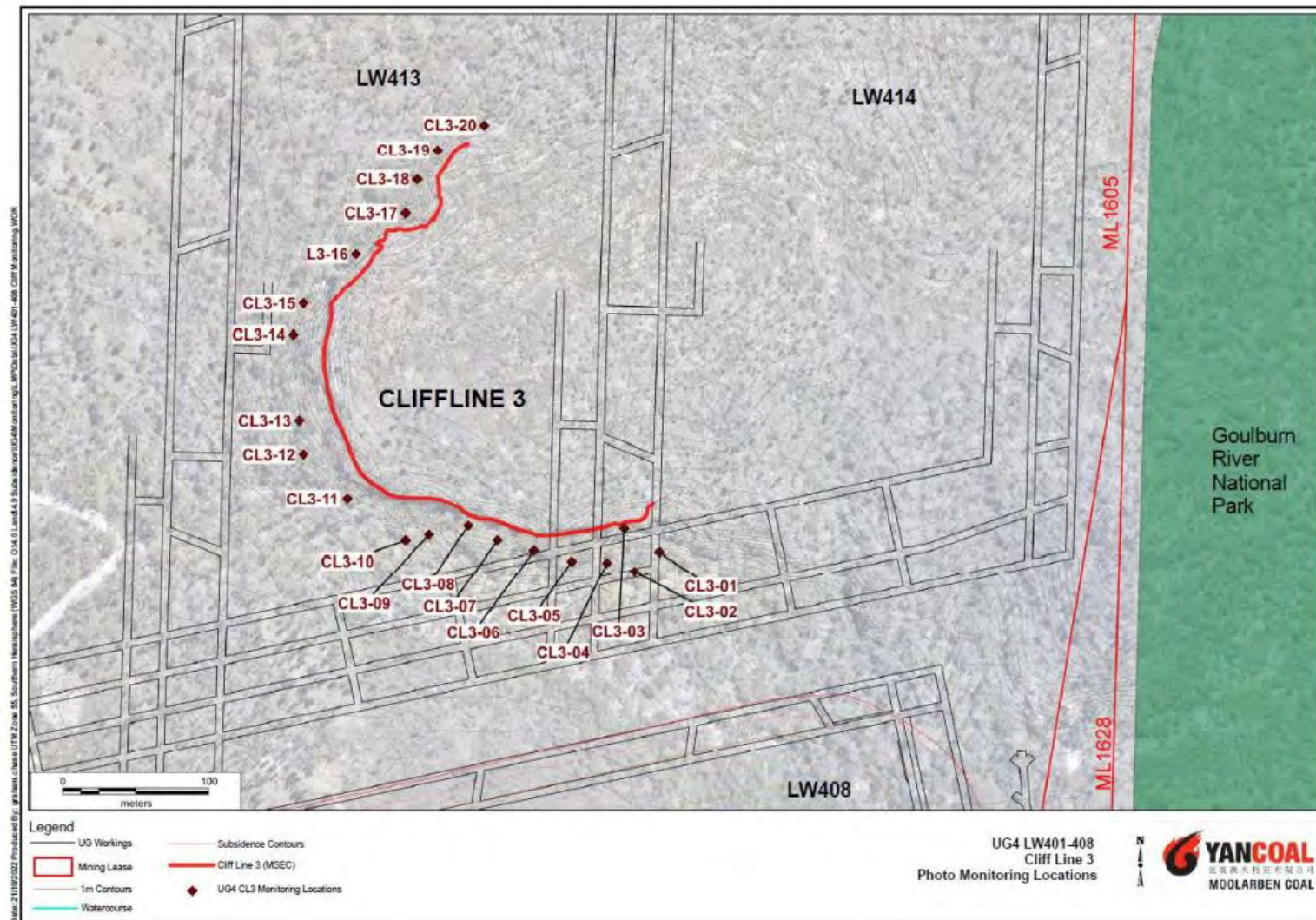
A summary of the assessment of monitoring outcomes against the relevant performance measure and indicator for CL3 is provided in **Table 11**.

Table 11: Assessment of Environmental Performance of LW401-407 - CL3

Feature	Cliff Line CL3		
Performance Measure	<i>Minimise subsidence damage</i>		
Performance Indicator	Cliff Line 3 impacts due to LW401-408 are less than 1.9 m vertical conventional subsidence and 60 mm/m conventional tilt.		
Monitoring Site(s) and Parameter(s) Being Assessed	Visual inspection at sites CL3-01 to CL3-20. Monitoring of subsidence movements at GNSS units MCO06, MCO18, MCO19 located at CL3.		
Highest Recorded Trigger Event/Trigger Level	No physical impacts due to extraction of LW401-407 observed during visual inspections and observed subsidence movements at GNSS units consistent with predictions. The TARP for CL3 was not triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	MSEC (Appendix A)		
Compliance With Performance Indicator?	Yes	Compliance With Performance Measure?	Yes

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Figure 11: CL3 Visual Monitoring Locations



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4.2.2 Minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7)

While Project Approval (05_0117) does not include any specific performance measures for the Goulburn River National Park, a performance indicator was nominated in the approved UG4 LW401-408 Extraction Plan for minor cliffs in the Goulburn River National Park within 400 m of LW401-408, in consultation with the NSW National Parks and Wildlife Service.

Observed subsidence movements at GNSS unit MCO17 installed at minor cliff CL7 show horizontal movement of approximately 100 mm towards LW405 and LW406 (i.e. in a north-west direction) and no developing vertical subsidence (**Appendix A**).

Visual inspection of minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7) were undertaken prior to the commencement of LW403 and following all secondary extraction within 400 m of minor cliffs in the Goulburn River National Park. Monitoring locations are shown in **Figure 12**.

No physical impacts due to the extraction of LW401-407 were observed at minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7) during visual inspections and therefore the TARP was not triggered (**Appendix A**).

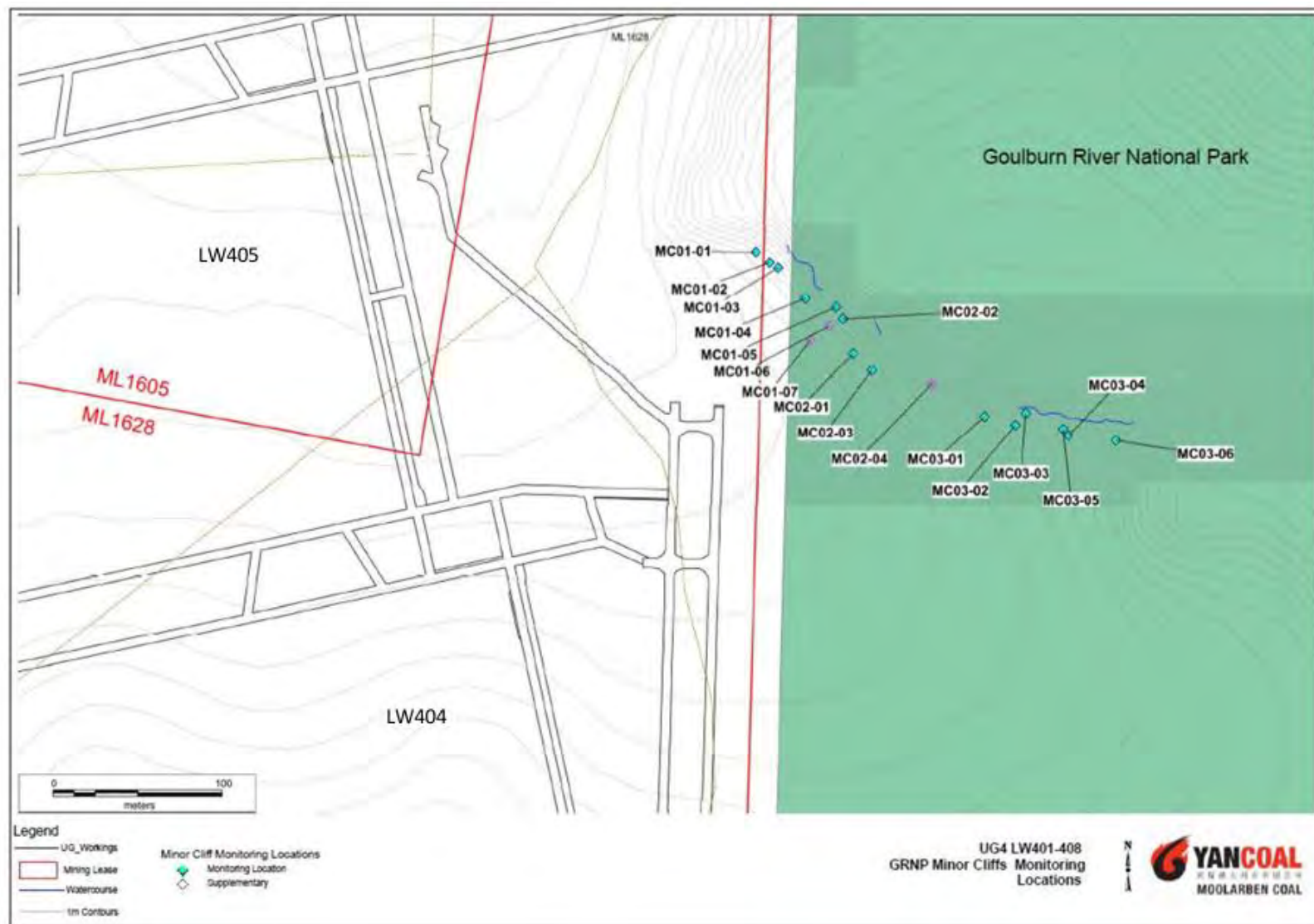
A summary of the assessment of monitoring outcomes against the nominated performance indicator for minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7) is provided in **Table 12**.

Table 12: Assessment of Environmental Performance of LW401-407 – Minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7)

Feature	Minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7)		
Performance Measure	n/a		
Performance Indicator	Negligible impact due to longwall mining for Minor Cliffs in Goulburn River National Park.		
Monitoring Site(s) and Parameter(s) Being Assessed	Visual inspection of minor cliffs in GRNP within 400m of LW401-408 and CL7. Observed subsidence movements at GNSS unit MCO17 located at CL7.		
Highest Recorded Trigger Event/Trigger Level	No physical impacts due to extraction of LW401-407 observed during visual inspections and subsidence movements at GNSS units consistent with predictions. The TARP for minor cliffs in the GRNP within 400 m of LW401-408 was not triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	MSEC (Appendix A)		
Compliance With Performance Indicator?	Yes	Compliance With Performance Measure?	n/a

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Figure 12: Minor cliffs in the Goulburn River National Park within 400 m of LW401-408 (including CL7) Visual Monitoring Locations



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4.3 LAND IN GENERAL

Land in general includes other land features such as fire trails and unsealed vehicular tracks located above LW401-408.

Surface cracking above LW401-407 was observed during opportunistic inspections undertaken throughout the mining period. Remediation measures were implemented as required (e.g. infill) where surface cracks intersected unsealed internal access roads and tracks.

The observed physical impacts to land in general due to the extraction of LW401-407 were consistent with predictions and therefore the TARP was not triggered.

A summary of the assessment of the nominated performance indicator for land in general is outlined in **Table 13**.

Table 13: Assessment of Environmental Performance of LW401-407 – Land in General

Feature	Land in General		
Performance Measure	n/a		
Performance Indicator	Subsidence parameters and environmental consequences as predicted.		
Monitoring Site(s) and Parameter(s) Being Assessed	Opportunistic visual observations of access tracks/other surface features during mining. Observed subsidence movements and visual inspection at subsidence monitoring lines. Observed subsidence movements at various GNSS units above and within the vicinity of LW401-407.		
Highest Recorded Trigger Event/Trigger Level	Minor observed physical impacts due to extraction of LW401-407 consistent with predictions. Subsidence movements at GNSS units and monitoring lines consistent with predictions. The TARP for land in general was not triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	MSEC (Appendix A)		
Compliance With Performance Indicator?	Yes	Compliance With Performance Measure?	n/a

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4.4 GOULBURN RIVER

The Goulburn River flows in a northerly direction on the western side of LW401-407 and is approximately 425 m from the finishing end of LW406 at its nearest point (**Figure 4**).

A summary of the assessment of monitoring outcomes against relevant performance measures and performance indicators for the Goulburn River is provided in **Table 14**. Further detail regarding review of subsidence and surface water monitoring data relevant to the Goulburn River is provided below.

Table 14: Assessment of Environmental Performance of LW401-407 – Goulburn River and the Bed of the Goulburn River

Feature	Goulburn River and the bed of the Goulburn River	
Performance Measure	Negligible impact or environmental consequences.	Remain outside the zone of recorded subsidence damage for longwall mining.
Performance Indicator	Unpredicted impacts on Goulburn River (cracking and or noticeable changes in erosion or pools) during LW401 to 408.	
Monitoring Site(s) and Parameter(s) Being Assessed	Visual inspection at sites GR-10 to GR-30. Surface water flow and quality monitoring at sites SW01, SW02 and SW22. Surface water flow monitoring at site Ulan SW01. Surface water flow and quality monitoring of controlled releases from the water treatment plant.	Observed subsidence movements at GNSS units MCO04, MCO07 to MCO09, and MCO20 to MCO24 located between LW407 and the Goulburn River*.
Highest Recorded Trigger Event/Trigger Level	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed surface water flow consistent with predictions (i.e. no loss of flow). Two trigger events for surface water quality in Goulburn River were recorded. Further investigation confirmed the exceedances were not due to extraction of LW401-407. The TARP for Goulburn River surface water quality was triggered during mining of LW401-407, however this did not result in an exceedance of performance indicators or performance measures.	Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARPs for the Goulburn River and the bed of the Goulburn River was not triggered during mining of LW401-407.
Monitoring Data Reviewed By?	WRM (Appendix C)	MSEC (Appendix A)
Compliance With Performance Indicator	Yes	Yes
Compliance With Performance Measure	Yes	Yes

* Additional monitors for differential movements (i.e. valley closure) for the section of the Goulburn River adjacent to LW409-412 will be installed prior to commencement of LW409.

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4.4.1 Subsidence Monitoring

Visual inspections along the section of the Goulburn River adjacent to LW401-408 were undertaken every six months during secondary extraction of LW401-407 at the locations shown in **Figure 13**.

No physical impacts due to the extraction of LW401-407 were observed during visual inspections (consistent with predictions) and therefore the subsidence TARP for the Goulburn River was not triggered (**Appendix C**).

Drop structure conditions were generally consistent with previous monitoring and no mining-related subsidence impacts were observed. One drop structure monitoring location shows signs of continued erosion and settlement however this is consistent with pre-mining conditions (**Appendix C**).

MSEC (2026) has also confirmed that the Goulburn River remained outside the zone of recorded subsidence damage from secondary extraction of LW401-407, consistent with predictions.

4.4.2 Surface Water Monitoring

Surface water monitoring of the Goulburn River includes flow and quality measurements at the locations shown in **Figure 14**, both upstream (i.e. Ulan SW01) and downstream (i.e. Moolarben sites SW01, SW02 and SW24) of LW401-408.

The TARP for surface water quality (i.e. two consecutive monthly values which exceed the trigger level) was triggered on two occasions:

- In July and August 2022 due to elevated turbidity levels. Further investigation confirmed the exceedance corresponded to a period of high rainfall and surface water quality measurements from further upstream also showed elevated turbidity levels for the same period.
- In December 2022 and January 2023 due to elevated EC levels. Further investigation confirmed surface water quality measurements from further upstream also showed elevated EC levels for the same period.

On this basis, both trigger events were not due to mining of LW401-407, and therefore there was no exceedance of the performance indicators or performance measures for the Goulburn River (**Appendix C**).

WRM has also analysed surface water flow data for the period from December 2023 to December 2025 and concluded that there is generally a gain in flow along the reach of the Goulburn River adjacent to LW401-408, which is consistent with predictions (i.e. no loss of flow) (**Appendix C**).

4.5 DRAINAGE LINES

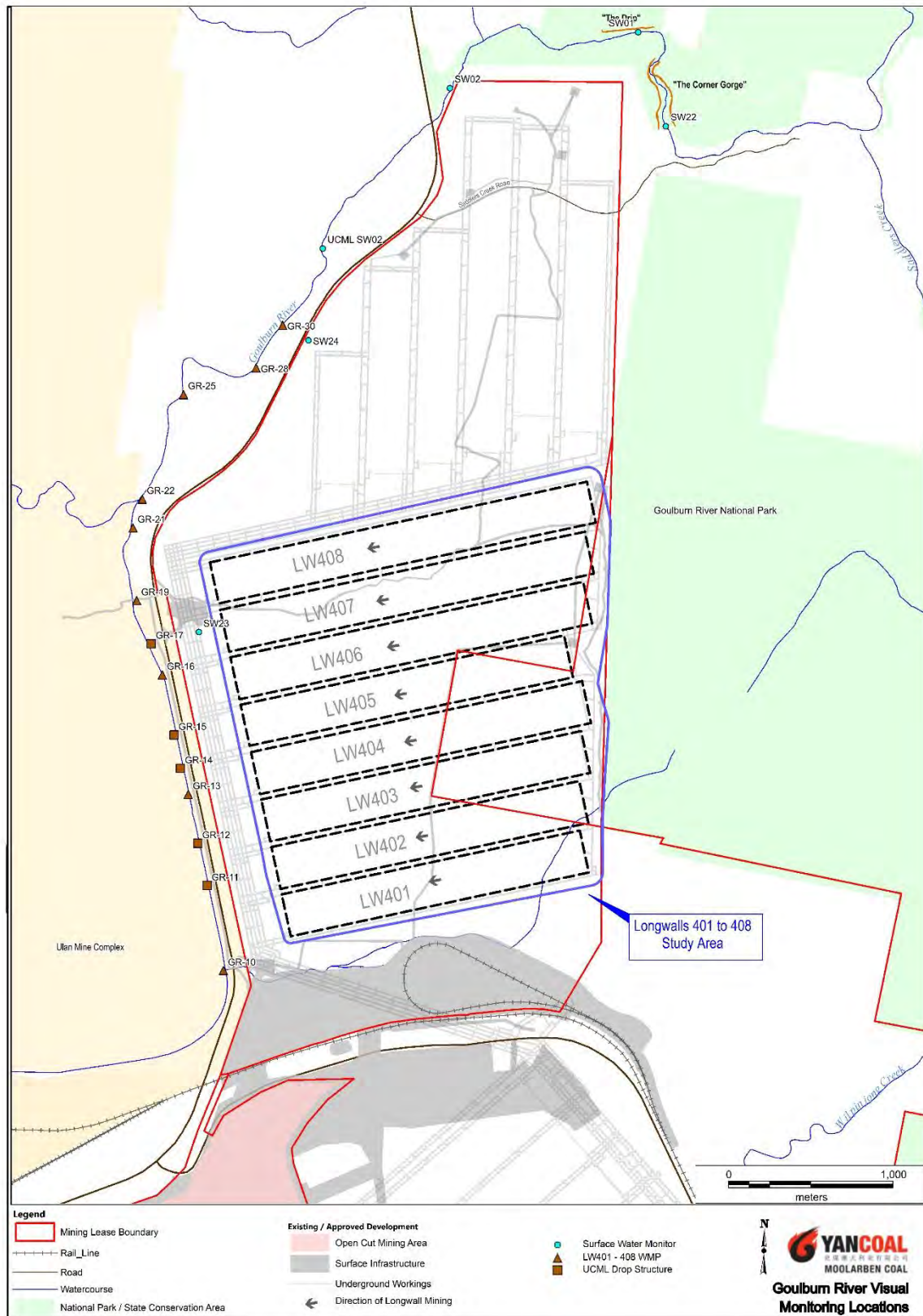
4.5.1 Bora Creek

Bora Creek is an ephemeral stream located above the commencing ends of LW401 and LW402 (**Figure 4**).

WRM has reviewed pre- and post-mining LiDAR data and confirmed the extent and magnitude of observed subsidence movements along Bora Creek are consistent with the predictions in MSEC (2021) (**Appendix C**).

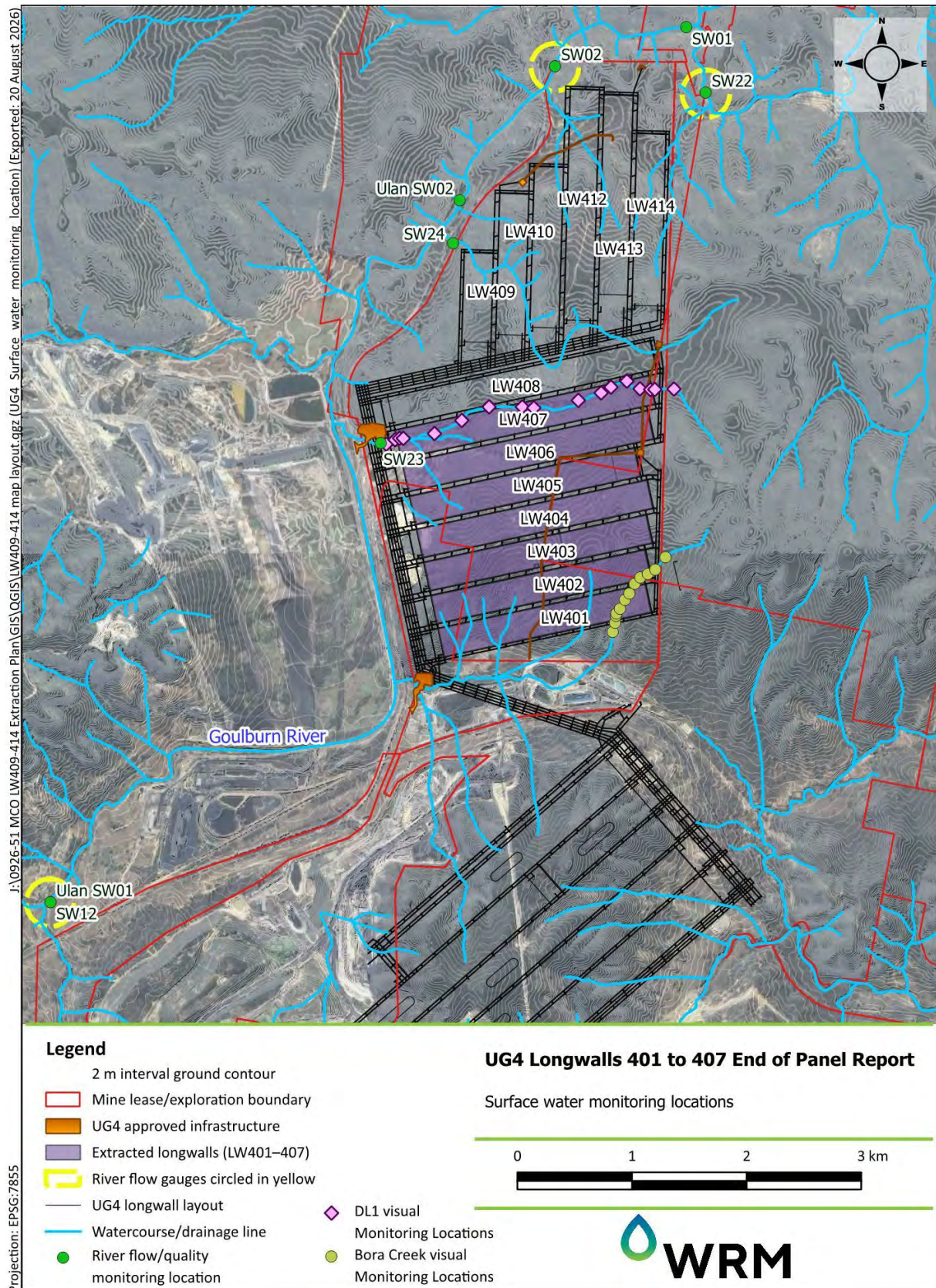
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Figure 13: Goulburn River Visual Monitoring Locations



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Figure 14: UG4 Surface Water Monitoring Locations (Source: Appendix C)



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Visual inspections along Bora Creek were undertaken prior to and during undermining, as well as every six months for one year after secondary extraction was completed, at the locations shown in **Figure 15**.

Minor cracking was observed at three of the 12 monitoring sites (i.e. BC104, BC105 and BC108) during visual inspections. A small amount of ponding was also identified upstream of BC106 which was attributed to rainfall prior to the monitoring event. Potential headcut erosion was observed during inspections at BC105, however this section of Bora Creek experienced a reduction in grade due to subsidence (not an increase) and therefore the changes in erosion characteristics are considered to be due to natural variability and not mining-related (**Appendix C**).

Overall WRM concluded that the monitoring outcomes from the visual inspections are consistent with predictions (i.e. negligible impact or environmental consequences) and therefore the TARP for Bora Creek was not triggered during mining of LW401-407 (**Appendix C**).

As described in **Section 4.4.2**, the TARP for surface water quality in receiving watercourses (i.e. the Goulburn River) was triggered on two occasions. Further investigation confirmed both exceedances were not due to mining of LW401-407, and therefore there was no exceedance of the performance indicators or performance measures for the Goulburn River (**Appendix C**).

A summary of the assessment of monitoring outcomes against the nominated performance indicator for Bora Creek is outlined in **Table 15**.

4.5.2 DL1

Drainage Line 1 (DL1) is an ephemeral watercourse which crosses LW407 (**Figure 4**).

DL1 only flows for a short period during and immediately after significant rainfall. Consequently, it has not been possible to collect any surface water samples from SW23 over the LW401-407 extraction period (**Appendix C**).

WRM has reviewed pre- and post-mining LiDAR data and confirmed the extent and magnitude of observed subsidence movements along DL1 are consistent with the predictions in MSEC (2021) (**Appendix C**).

Visual inspections along drainage line DL1 were undertaken prior to and within three months of undermining of DL1 at the monitoring locations shown in **Figure 16**.

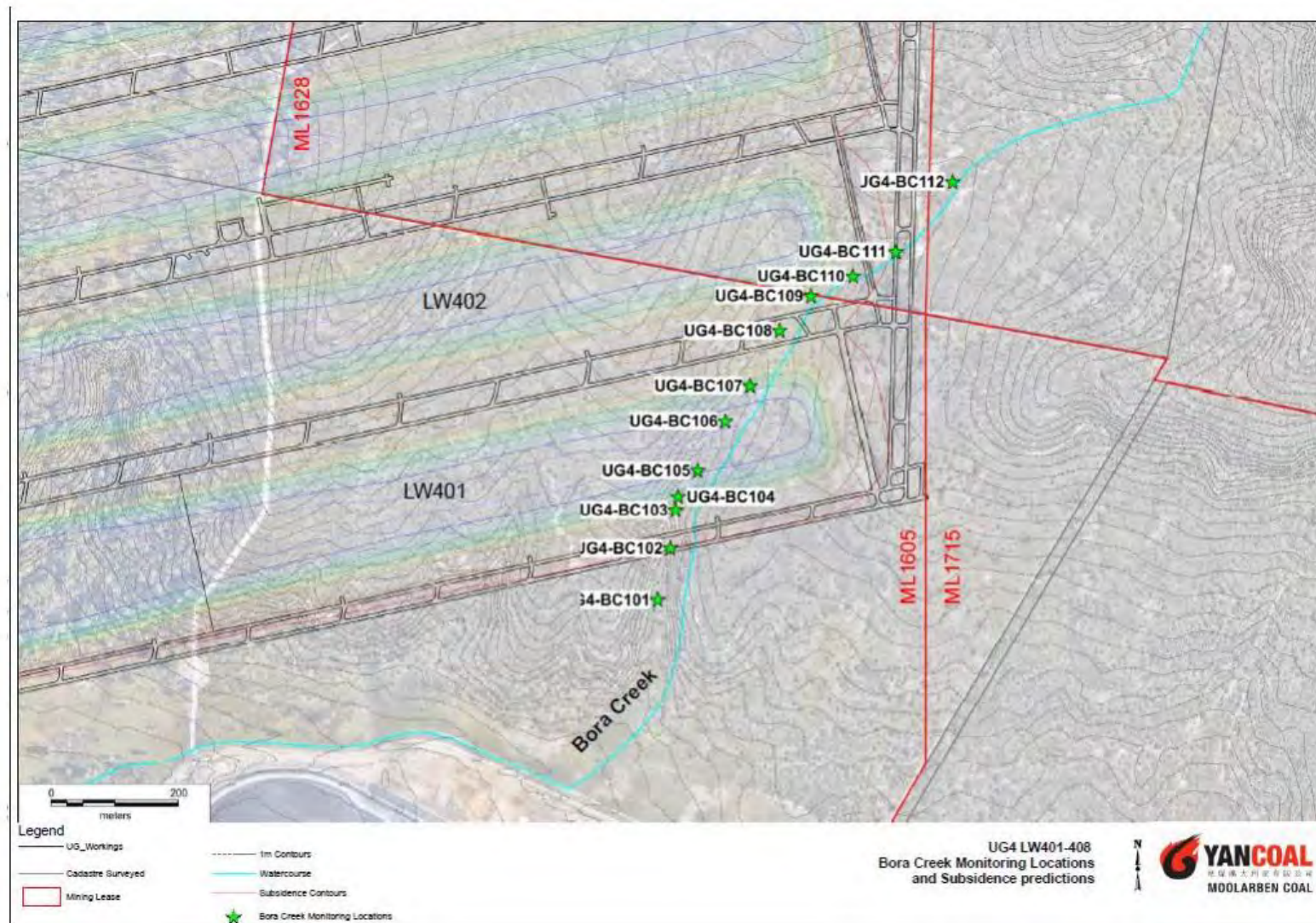
Conditions observed during visual inspections were generally consistent with pre-mining conditions considering drier seasonal conditions experienced during the extraction period. Some minor surface cracking was observed at and between various monitoring locations along DL1, in addition to potential ponding areas upstream from DL01-03 which were dry at the time of inspection (**Appendix C**).

Overall WRM concluded that the monitoring outcomes from the visual inspections are consistent with predictions (i.e. negligible impact or environmental consequences) and therefore the TARP for DL1 was not triggered during mining of LW401-407 (**Appendix C**).

A summary of the assessment of monitoring outcomes against the nominated performance indicator for DL1 is outlined in **Table 16**.

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Figure 15: Bora Creek Visual Monitoring Locations



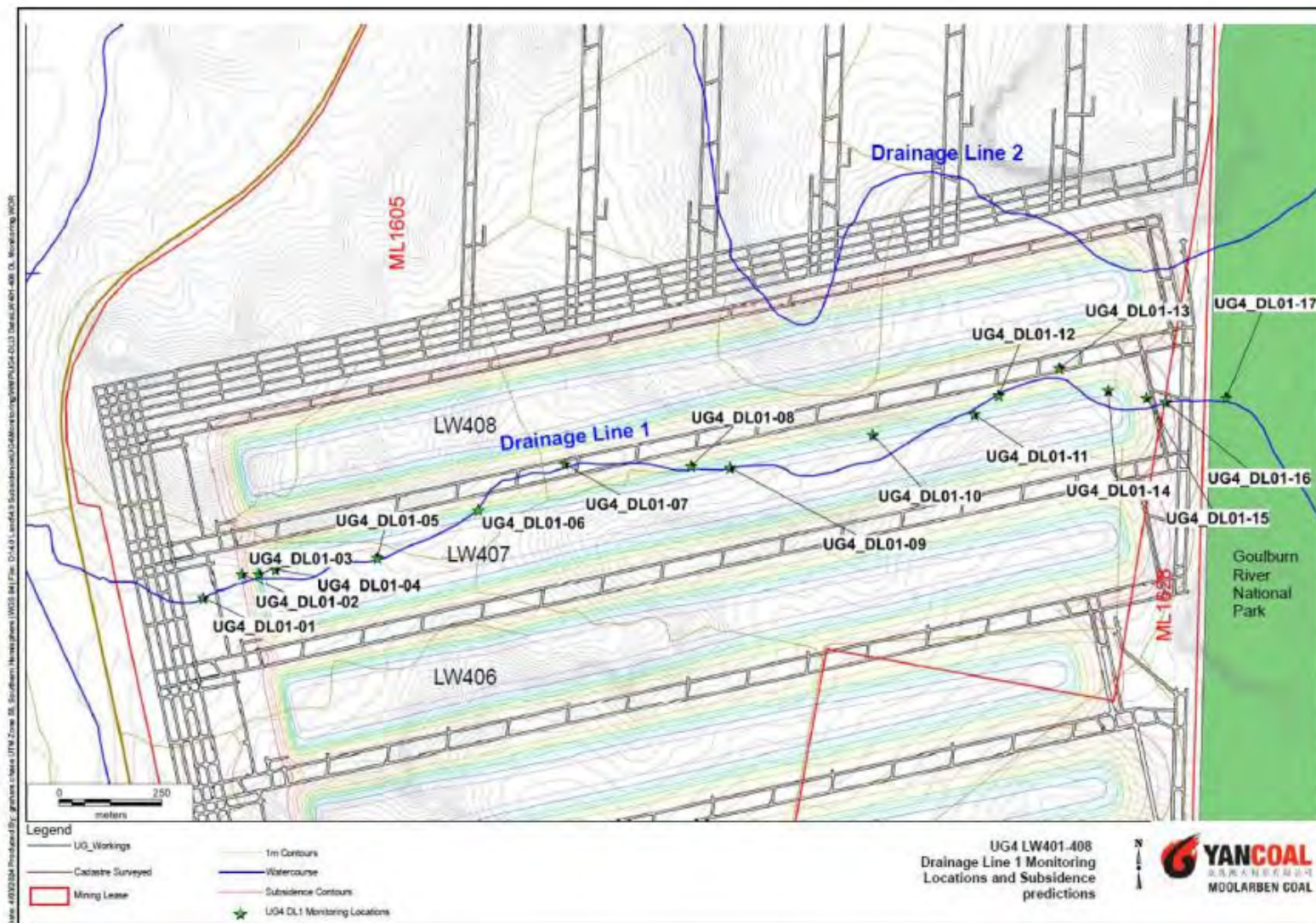
Document	Version	Issue	Status	Author
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Table 15: Assessment of Environmental Performance of LW401-407 – Bora Creek

Feature	Bora Creek	
Performance Measure	n/a	
Performance Indicator	Change in visible bed or bank erosion. Development of or change in headcut erosion along Bora Creek. Change in vegetation character such as vegetation loss through erosion or drowning by ponded water. Extent and duration of water ponding. Appearance of unsealed surface cracking across the bed of Bora Creek.	Receiving water quality.
Monitoring Site(s) and Parameter(s) Being Assessed	Visual inspection at sites UG4-BC101 to UG4-BC112. Analysis of pre- and post-mining LiDAR data.	Surface water flow and quality monitoring of receiving watercourses (i.e. Goulburn River, refer to Section 4.4)
Highest Recorded Trigger Event/Trigger Level	Subsidence movements consistent with predictions. Minor observed cracking due to extraction of LW401-407 consistent with predictions. The TARP for Bora Creek was not triggered during mining of LW401-407.	Observed surface water flow in receiving watercourses consistent with predictions (i.e. no loss of flow). Two trigger events for surface water quality in receiving watercourses (i.e. Goulburn River) were recorded. Further investigation confirmed the exceedances were not due to extraction of LW401-407. The TARP for surface water quality in receiving watercourses for Bora Creek was triggered during mining of LW401-407, however this did not result in an exceedance of the performance indicator.
Monitoring Data Reviewed By?	MSEC (Appendix A), WRM (Appendix C)	WRM (Appendix C)
Compliance With Performance Indicator?	Yes	Yes
Compliance With Performance Measure?	n/a	n/a

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Figure 16: Drainage Line DL1 Visual Monitoring Points



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Table 16: Assessment of Environmental Performance of LW401-407 – DL1

Feature	Drainage Line DL1		
Performance Measure	n/a		
Performance Indicator	Subsidence parameters and environmental consequences as predicted.		
Monitoring Site(s) and Parameter(s) Being Assessed	Visual inspection along upper reaches of DL1. Surface water flow and quality monitoring at site SW23 (DL1) if flowing.		
Highest Recorded Trigger Event/Trigger Level	Subsidence movements consistent with predictions. Minor observed cracking and potential ponding areas due to extraction of LW401-407 consistent with predictions. Surface water flow/quality data unable to be recorded as no periods of flow. The TARP for DL1 was not triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	WRM (Appendix C)		
Compliance With Performance Indicator	Yes	Compliance With Performance Measure	n/a

4.6 GROUNDWATER

MCO monitors a network of piezometers comprising standpipe bores and vibrating wire piezometers (VWPs) in accordance with the UG4 LW401-408 Water Management Plan and the complex-wide Water Management Plan (**Figure 17**).

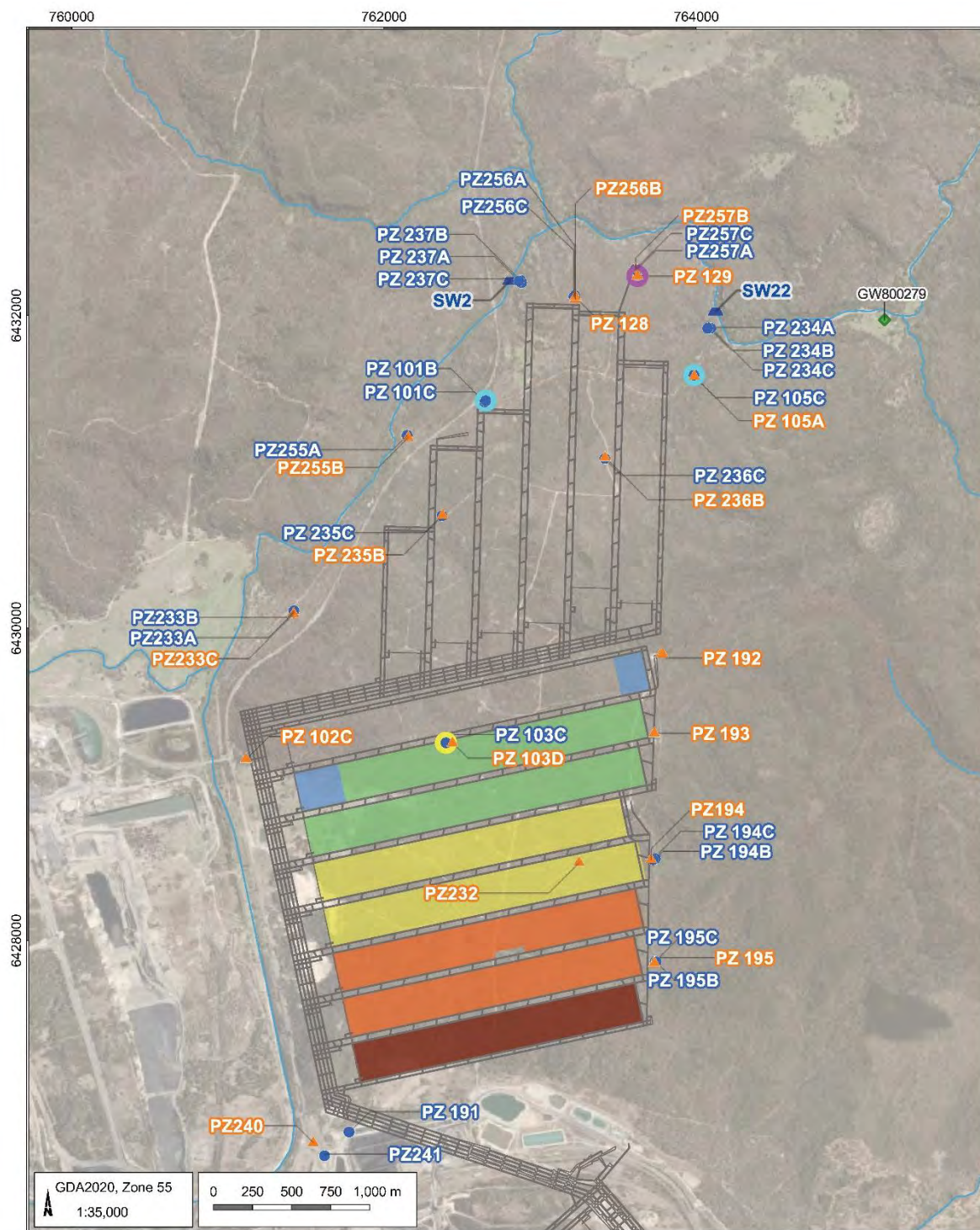
A summary of the assessment of monitoring outcomes against the nominated performance indicator for groundwater level and quality is provided in **Table 17**.

Table 17: Assessment of Environmental Performance of LW401-407 – Groundwater Level and Quality

Feature	Groundwater Level and Quality		
Performance Measure	n/a		
Performance Indicator	Subsidence impacts from LW401-408 do not result in impact or environmental consequences greater than approved.		
Monitoring Site(s) and Parameter(s) Being Assessed	Groundwater level and quality monitoring at relevant piezometer sites in UG4 monitoring network, including trigger investigations bores PZ101C, PZ103C, PZ105C and PZ129 VWP.		
Highest Recorded Trigger Event/Trigger Level	Observed groundwater levels and quality did not exceed trigger investigation levels due to extraction of LW401-407. The TARPs for groundwater levels and quality were not triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	AGE (Appendix B)		
Compliance With Performance Indicator?	Yes	Compliance With Performance Measure?	n/a

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Figure 17: UG4 Groundwater Monitoring Network (Source: Appendix B)



- LEGEND**
- UG4 Mine Plan
 - Drainage
 - Registered private bore
 - Flow Gauging Station
 - Groundwater Monitoring Site**
 - Standpipe
 - VWP
 - Trigger site**
 - Groundwater levels and groundwater quality
 - Groundwater levels
 - Groundwater quality
 - Mine progression (Year)**
 - 2022
 - 2023
 - 2024
 - 2025
 - 2026

Moolarben Mine - End of Panel Reporting - UG4
LW401 to LW407 (MOO5018.002)

UG4 groundwater monitoring network



DATE
13/08/2026

FIGURE No:
2.1

Document	Version	Issue	Status	Author
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4.6.1 Mine Inflows

Mine inflows into underground working areas (i.e. UG1 and UG4) are estimated indirectly via a comparison between other inflow terms (e.g. water supply for dust suppression, recirculation) and the total outflow and incorporates site water balance reconciliations, recirculation to underground and water take for the period. Indirect or passive take is based on modelling predictions for the relevant period.

Table 18 presents estimated actual and model predicted groundwater inflows prior to commencement of secondary extraction of LW401 to completion of secondary extraction of LW407 (i.e. January 2026).

Table 18: Comparison of Estimated Actual and Model Predicted Mine Inflows During LW401-407 Extraction Period (Source: after Appendix B)

Review period	Estimated Actual Groundwater Inflows (UG1 and UG4) (ML)	Model Predicted Groundwater Inflows (ML)*	
		UG4 only	UG4 and UG1
July 2020 - June 2021	2,834	296	2,015
July 2021 - June 2022	3,338	692	2,472
July 2022 - June 2023	4,453	2,813	3,041
July 2023 - June 2024	2,714	3,471	3,710
July 2024 - June 2025	2,247	3,626	3,861
July 2025 – January 2026	948	776	920
Total	16,534	11,674	16,019

Note: ML = megalitres; * Source: Moolarben Coal Complex Groundwater Model 2023 (AGE, 2023).

Estimated actual inflows exceeded the combined UG4 and UG1 model predictions during July 2020 to June 2021 which is attributed to above average rainfall experienced during this period. During July 2023 to June 2024 and July 2024 to June 2025, estimated actual inflows were lower than the combined UG4 and UG1 model predictions. This is attributed to differences between the planned and actual progression of mining (**Appendix B**).

MCO obtains and holds volumetric water licenses to account for groundwater inflows and surface water take associated with the development and operation of the Moolarben Coal Complex in accordance with the requirements of the *Water Management Act 2000* and the *Water Act 1912*.

4.6.2 Groundwater Drawdown

Table 19 summarises the groundwater level investigation triggers developed for the approved UG4 LW401-408 Extraction Plan and the minimum observed groundwater levels for these trigger bores during the LW401-407 extraction period.

Table 19: Comparison between Groundwater Level Investigation Triggers and Minimum Observed Levels at Trigger Monitoring Bores during Mining of LW401-407

Monitoring Bore	Investigation Trigger Level (mAHD)	Minimum Observed Level (mAHD)
PZ101C	378.0	379.2
PZ105C	371.7	373.5
PZ129 VWP	386.0	389.9

Note: mAHD = metres Australian Height Datum

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No exceedances of the groundwater level investigation trigger values were recorded during extraction of LW401-407 (**Appendix B**).

Localised drawdown around the LW401 to LW407 mining areas aligns with model predictions, which predict drainage of the Triassic immediately above and adjacent to the goaf, but do not predict extensive drawdown away from the goaf in the Triassic strata. In the Ulan Seam and Permian more laterally extensive drawdown away from the goaf area is observed, which also aligns with model predictions (**Appendix B**).

4.6.3 Groundwater Quality

Monitoring of groundwater quality is undertaken at three monitoring bores (i.e. PZ101C, PZ103C and PZ105C) screened in the Triassic strata for acidity (pH) and electrical conductivity (EC). Investigation trigger levels were developed for these monitoring bores considering pre-mining baseline conditions.

Observed monitoring data confirms that groundwater quality conditions have not been affected by mining of LW401-407 and are generally consistent with pre-mining conditions. On this basis, the TARP for groundwater quality was not triggered during mining of LW401-407 (**Appendix B**)

4.7 INDEPENDENT REVIEW OF SURFACE WATER AND GROUNDWATER IMPACTS

Dr Lloyd Townley has undertaken an independent review of observed groundwater and surface water impacts from LW401-407. This independent review addresses a request from DPHI (as per correspondence dated 7 May 2026) in order to ensure this UG4 LW401-407 EoP Report addresses independent audit requirements in Condition 9, Schedule 5 of the Stage 1 Project Approval (05_0117).

Dr Townley has reviewed the assessment of predicted and observed groundwater and surface water impacts due to mining of LW401-407 presented in the Groundwater Report (**Appendix B**) and Surface Water Report (**Appendix C**) and concludes:

... They provide good summaries and explanations of data that have been collected during mining. The reports present observed monitoring data and discuss trends related to groundwater drawdown, specifically in the Triassic sandstone aquifer, and surface water quality and flow in the Goulburn River and other ephemeral drainage lines. The reports show no evidence of impact on water supply to The Drip due to mining of LW401-407.

Overall, observed data are consistent with predictions. Agreement between predicted subsidence and LiDAR measurements is remarkably good, suggesting that the methods used by MSEC are mature and reliable. Predictions related to mine inflows and drawdown of groundwater are supported by observations, and the belief that there would be no impact of mining at LW401-407 and groundwater quality is confirmed by data. The prediction that mining at LW401-407 would affect neither surface water flow nor surface water quality has also been confirmed by observations, the only exceedances of water quality thresholds in the Goulburn River in two consecutive months being explained by activities upstream of LW401-407.

A copy of Dr Townley's review is provided in **Appendix F**.

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4.8 BIODIVERSITY

Biodiversity values subject to ongoing monitoring and management in accordance with the approved UG4 LW401-408 Biodiversity Management Plan include threatened ecological communities (TECs), threatened fauna (cave-dwelling bat species) and threatened flora (*Androcalva procumbens*) (Figure 18).

A baseline survey of the biodiversity values was undertaken in May 2021 (i.e. prior to secondary extraction of LW401) to inform establishment of monitoring sites for the duration of mining of LW401-408. Annual surveys are undertaken in Spring in accordance with the approved UG4 LW401-408 Biodiversity Management Plan. A description of biodiversity survey methods and results is provided in survey reporting prepared by Niche (Appendix D).

A summary of the assessment of monitoring outcomes against nominated performance indicators for biodiversity values is provided in Table 20. Further detail regarding review of biodiversity monitoring data from the annual survey program is provided below.

4.8.1 Threatened Ecological Communities

Following direct undermining of the mapped threatened ecological community by LW406, annual surveys identified numerous subsidence holes and cracks across the area. Despite these observed physical impacts, the Vegetation Integrity Score (VIS) at the relevant monitoring site (UG4_06a) declined only marginally between 2024 and 2025. Similar marginal declines were also recorded at reference sites. Species diversity remained stable at UG4_06a, while the reference sites recorded only marginal decreases (Appendix D).

The observed impacts were consistent with predictions and therefore the TARP for threatened ecological communities was not triggered during mining of LW401-407 (Appendix D).

4.8.2 Threatened Fauna (Cave-dwelling Bat Species)

Acoustic monitoring for cave-dwelling microbat species includes four sites above LW401-408 and one reference site (Figure 18). Two threatened cave-dwelling microbat species (Large Bent-winged Bat and Large-eared Pied Bat) have been recorded during annual surveys since monitoring began. Both species were recorded above LW401-408 and at reference sites. There was no significant reduction in species presence in sites above LW401-408 than observed at the reference sites (Appendix D).

The observed impacts were consistent with predictions and therefore the TARP for threatened fauna was not triggered during mining of LW401-407 (Appendix D).

4.8.3 Threatened Flora (*Androcalva procumbens*)

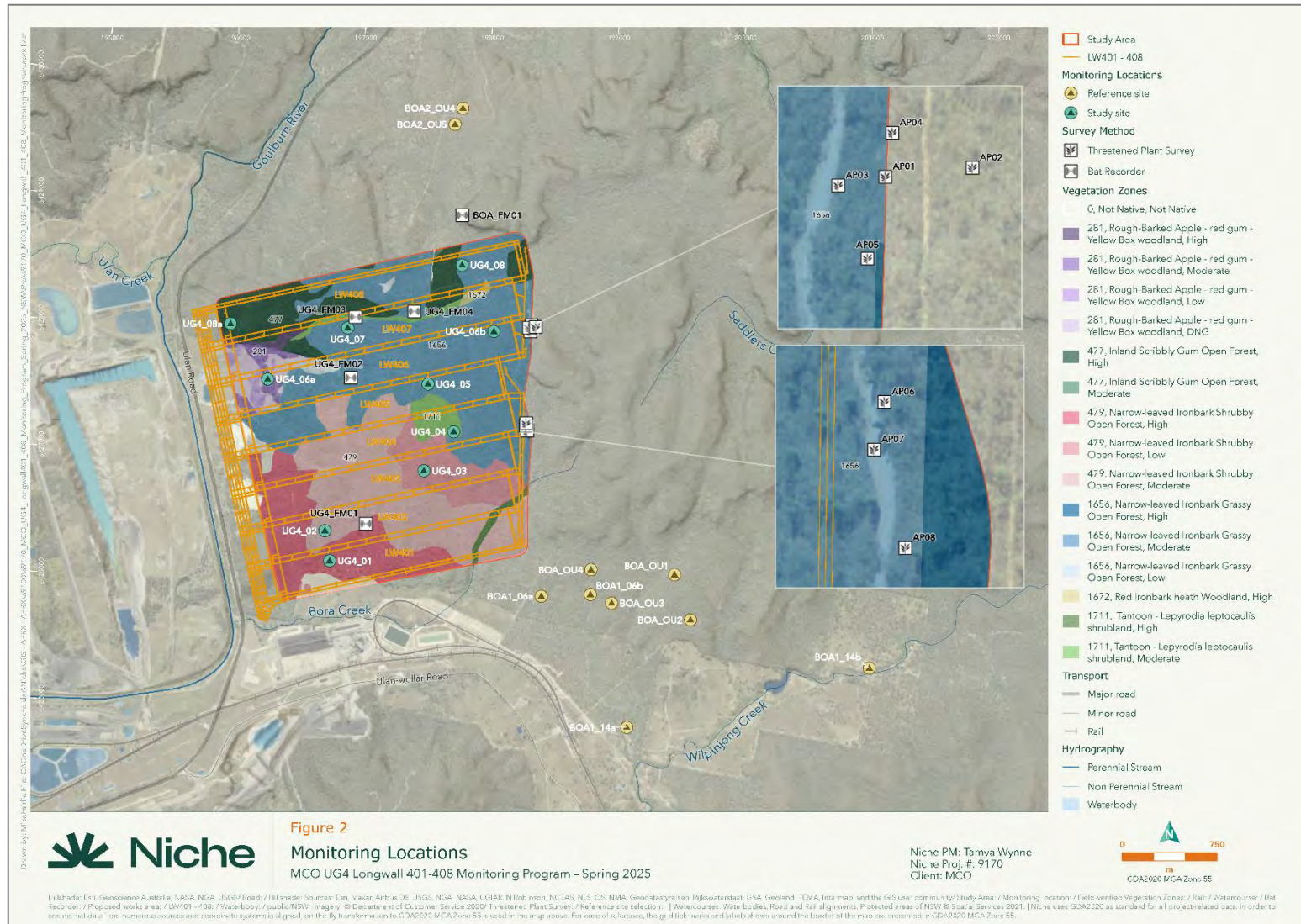
Annual monitoring of *Androcalva procumbens* includes undertaking an estimated population count during the Spring period at each of the eight known locations of the species adjacent to LW401-408 (Figure 18).

There was a decrease in the total number of recorded *Androcalva procumbens* individuals between 2024 and 2025 while it experienced an increase between 2023 and 2024. The observation of both a reduction and an increase is likely due to natural changes in population dynamics. There is no visual indication of subsidence in the species habitat, and the species remains present within the Study Area.

The observed impacts were consistent with predictions and therefore the TARP for threatened flora was not triggered during mining of LW401-407 (Appendix D).

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MCO_UG4_LW401-407_EOP	1	August 2026	FINAL	MCO

Figure 18: Biodiversity Monitoring Locations (Source: Niche [2025])



Document	Version	Issue	Status	Author
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Table 20: Assessment of Environmental Performance of LW401-407 – Biodiversity

Feature	Threatened Ecological Communities	Threatened Fauna (cave-dwelling bat species)	Threatened Flora (<i>Androcalva procumbens</i>)
Performance Measure	n/a	n/a	n/a
Performance Indicator	No significant reduction in vegetation integrity score greater than observed at reference sites (decrease of vegetation integrity score by 20% for two consecutive survey periods post-mining) combined with observed subsidence impacts. No significant reduction in species diversity greater than observed at reference sites (a significance reduction being greater than 5 species consistently absent from established monitoring plots for 4 consecutive years) combined with observed subsidence impacts.	No significant reduction in threatened species presence greater than observed at reference sites (at least 1 species absent from acoustic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.	Threatened flora remains present within the Study Area.
Monitoring Site(s) and Parameter(s) Being Assessed	Annual spring monitoring of floristic monitoring plots and photo monitoring points	Annual spring acoustic monitoring	Annual spring visual inspection and population count of recorded threatened flora locations
Highest Recorded Trigger Event/Trigger Level	Minor observed cracking due to extraction of LW401-407 consistent with predictions. No reduction in vegetation integrity or species diversity greater than observed at reference sites, therefore no impacts due to extraction of LW401-407. The TARP for threatened ecological communities was not triggered during mining of LW401-407.	No reduction in species presence greater than observed at reference sites, therefore no impacts due to extraction of LW401-407. The TARP for threatened fauna (cave dwelling bat species) was not triggered during mining of LW401-407.	No physical subsidence impacts observed within threatened flora habitat. No significant change to population due to extraction of LW401-407. The TARP for threatened flora (<i>Androcalva procumbens</i>) was not triggered during mining of LW401-407.
Monitoring Data Reviewed By?	Niche (Appendix D)	Niche (Appendix D)	Niche (Appendix D)
Compliance With Performance Indicator?	Yes	Yes	Yes
Compliance With Performance Measure?	n/a	n/a	n/a

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4.9 ABORIGINAL HERITAGE SITES

There are 11 Aboriginal cultural heritage sites located within the LW401-407 mining area requiring ongoing management and monitoring in accordance with the approved UG4 LW401-408 Heritage Management Plan and UG4 LW401-408 S1MC280 Subsidence Monitoring and Mitigation Program (**Figure 19**).

All 11 sites were visually inspected and subject to baseline recording by Niche in 2021 and 2022, prior to commencement of secondary extraction. Post-mining inspections were undertaken by Niche in December 2025.

As an outcome of the post-mining inspections, Niche concluded (**Appendix E**):

- Observed impacts to all the Aboriginal cultural heritage sites considered are consistent with the subsidence predictions.
- Five sites (i.e. S1MC358b, S1MC468, S1MC475, S1MC484, S1MC494) were identified with observed mining or subsidence-related impacts from LW401-407 (**Figure 19**). Although impacts can occur naturally, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions.
- No mining or subsidence-related impacts were observed for the remaining six sites (i.e. S1MC271, S1MC280, S1MC472, S1MC474, S1MC488, S1MC491) due to the extraction of LW401-407.
- No further monitoring/inspections are required for any of the 11 sites assessed.

Overall, Niche conclude that the observed impacts are consistent with predictions. Further detail of observations during post-mining inspections of these sites is provided in **Appendix E**.

Section 3.3.23 presents the assessment of observed subsidence parameters for monitoring locations relevant to S1MC280. Overall, MSEC concluded the observed subsidence movements were generally consistent with predictions (**Appendix A**). An exceedance of the Level 1 trigger in both the site monitoring TARP and the subsidence monitoring TARP for S1MC280 was observed during mining of LW401-407, however it was determined that the trigger events did not result in an exceedance of the performance indicators or performance measure for S1MC280.

Overall, MSEC considers that the ground movements measured along the X Line and Y Line are reasonably consistent with the predictions in MSEC (2021) (**Appendix A**).

Niche also conclude that the UG4 LW401-408 S1MC280 Subsidence Monitoring and Mitigation Program has been successfully implemented and the performance measure of 'reduce the likelihood of subsidence damage to moderate' for S1MC280 has been met (**Appendix E**).

A summary of the assessment of monitoring outcomes against relevant performance measures and nominated performance indicators for Aboriginal cultural heritage sites within the LW401-407 mining area is provided in **Table 21**.

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MCO_UG4_LW401-407_EOP	1	August 2026	FINAL	MCO

Table 21: Assessment of Environmental Performance of LW401-407 – Aboriginal Heritage Sites

Feature	Aboriginal heritage site 280	Rock Shelter Sites Subject to Ongoing Monitoring
Performance Measure	<i>Reduce the likelihood of subsidence damage to moderate.</i>	<i>n/a</i>
Performance Indicator	Revised subsidence likelihood reduced to moderate.	Subsidence parameters and environmental consequences as predicted.
Monitoring Site(s) and Parameter(s)	Subsidence monitoring at ‘early warning’ monitoring site (ground transect lines MG402A, MG402b and MG402C). Subsidence monitoring at ground transect lines S1MC280A, S1MC280B and S1MC280C. Daily visual inspections during relevant periods of mining of LW402 and LW403. Slot width monitoring across vertical stress relief slots. Stress change monitoring boreholes and camera inspections. Tilt, temperature and closure monitoring of the overhang.	Pre- and post-mining visual monitoring inspection.
Highest Recorded Trigger Event/Trigger Level	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements at stress relief slots and tilt due to extraction of LW401-407 consistent with predictions. An exceedance of the Level 1 trigger in both the site monitoring TARP and the subsidence monitoring TARP for S1MC280 was observed during mining of LW401-407. The TARPs for Aboriginal heritage site S1MC280 were triggered during mining of LW401-407, however this did not result in an exceedance of performance indicators or performance measures. Therefore, the S1MC280 Subsidence Monitoring and Mitigation Plan was successfully implemented.	Observed physical impacts due to extraction of LW401-407 consistent with predictions. No further management actions or monitoring required for Aboriginal cultural heritage rock shelters above/adjacent to LW401-407.
Monitoring Data Reviewed By?	MSEC (Appendix A), Niche (Appendix E)	MSEC (Appendix A), Niche (Appendix E)
Compliance With Performance Indicator?	Yes	Yes
Compliance With Performance Measure?	Yes	<i>n/a</i>

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5.0 OBSERVED IMPACTS TO BUILT FEATURES

Monitoring of impacts from secondary extraction of LW401-407 to relevant built features was undertaken in accordance with the approved UG4 LW401-408 Built Features Management Plans and approved UG4 LW401-408 Subsidence Monitoring Program. Relevant built features include:

- Sandy Hollow-Gulgong Railway Line.
- Ulan Road and Bridges.
- Telstra infrastructure
- Essential Energy 66 kV/22kV line and power poles.
- Ulan Mine Built Features.
- Dronvisa Quarry.

Monitoring results and reviews undertaken by MSEC for the built features are provided in **Appendix A**.

The TARPs for built features were not triggered during secondary extraction of LW401-407. MSEC considers that the observed impacts on the built features due to the extraction of LW401-407 are less than those predicted in MSEC (2021) (**Appendix A**).

A summary of the assessment of monitoring outcomes against relevant performance measures and performance indicators for the built features is provided in **Table 22**.

Document	Version	Issue	Status	Author
MCO_UG4_LW401-407_EOP	1	August 2026	FINAL	MCO

Table 22: Assessment of Environmental Performance of LW401-407 – Built Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Key Public Infrastructure							
Gulgong-Sandy Hollow Railway Line	<i>Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</i>	- No defects or deformation of the rail track and associated infrastructure due to UG4 mining. - No visual displacement at joints or cracks in culverts due to UG4 mining.	Subsidence monitoring at 'ARTC2 Line' ground transect line along Rail Line Visual inspection of the alignment and condition of ARTC infrastructure	No observed or reported defects, deformation or displacement of joints in culverts due to the extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Gulgong-Sandy Hollow Railway Line was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes
Wollar-Wellington 330kV Transmission Line	<i>Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired.</i>	n/a – no performance indicator developed for the Wollar-Wellington 330kV transmission line.	n/a	No trigger event/level for Wollar-Wellington 300kV transmission line as no predicted impacts from LW401-407.	n/a	n/a	Yes
Roads							
Ulan Road	<i>Safe, serviceable and repairable unless the owner agrees otherwise in writing.</i>	No joint displacement or cracking or other defects of the drainage structure (e.g. pipes/culverts) in excess of 5 mm (when compared against baseline condition) due to UG4 mining.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of Ulan Road pavements, culverts, cuttings and other furniture within 400m of LW401-408	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Ulan Road was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes
Ulan Road Bridge over the Sandy-Hollow Rail Line Ulan Road Bridge over the Goulburn River	<i>Safe, serviceable and repairable unless the owner agrees otherwise in writing.</i>	n/a – no performance indicators developed for the Ulan Road bridges.	n/a	No trigger event/level for Ulan Road bridges as no predicted impacts from LW401-407.	n/a	n/a	Yes

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Table 22 (Continued): Assessment of Environmental Performance of LW401-407 – Built Features

Feature	Performance Measure (Project Approval [05_0117])	Performance Indicator	Monitoring Site(s) and Parameter(s) Being Assessed	Highest Recorded Trigger Event / Trigger Level	Monitoring Data Reviewed By?	Compliance With Performance Indicator?	Compliance With Performance Measure?
Other Built Features and Improvements, including Fences							
Telstra optical fibre telecommunication cable Telstra copper telecommunication cable Telstra telecommunication tower	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	- Negligible transmission loss from mine subsidence impacts. - Negligible impacts on structural integrity of the cable lines from mine subsidence. - Negligible impacts on structural integrity of the communications tower from mine subsidence.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of telecommunication tower	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for Telstra assets was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes
Essential Energy 66 kV/22 kV line and power poles	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	The structural integrity of the powerline (power poles and transmission lines) is maintained.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of powerline (e.g. pole foundations, integrity and function of support clamps or other items)	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for the Essential Energy 66 kV / 22 kV line and power poles was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes
UCMPL Millers Dam Compound and associated infrastructure, Bridge, Bore and Monitoring Piezometers	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	Subsidence monitoring indicates subsidence is consistent with approved impacts.	Subsidence monitoring at 'R Line' ground transect line along Ulan Road Visual inspection of UCMPL infrastructure within 400m of LW401-408	No physical impacts due to extraction of LW401-407 observed during visual inspections. Observed subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for UCMPL infrastructure was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes
Dronvisa Quarry	<i>Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.</i>	- Subsidence monitoring indicates subsidence is consistent with approved impacts. - Compensation Agreement between MCO and Dronvisa in place for predicted impacts to Dronvisa infrastructure serviceability and damage to the Quarry.	Observed subsidence movements at GNSS units MCO10 to MCO16 located at Dronvisa Quarry Visual inspection of Quarry and Quarry Infrastructure	Observed impacts and subsidence movements due to extraction of LW401-407 consistent with predictions. The TARP for Dronvisa Quarry was not triggered during mining of LW401-407.	MSEC (Appendix A)	Yes	Yes

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6.0 PUBLIC SAFETY MANAGEMENT

In accordance with the approved UG4 LW401-408 Public Safety Management Plan, the monitoring program was conducted for cliffs, land in general and built features.

No subsidence impacts were identified during the LW401-407 extraction period that were considered to pose a risk to public safety. A summary of the assessment of monitoring outcomes against the performance measure and performance indicator for public safety is provided in **Table 23**.

Table 23: Summary of Monitoring Outcomes Against Performance Measures and Indicators for Public Safety

Performance Measure	<i>Negligible additional risk</i>		
Performance Indicator	No more than negligible additional risk to public safety.		
Monitoring Site(s) and Parameter(s) Being Assessed	As outlined for the Drip, cliff lines and land in general (Sections 4.1 to 4.3)		
Highest Recorded Trigger Event/Trigger Level	Observed physical impacts due to extraction of LW401-407 consistent with predictions. Subsidence movements at GNSS units and monitoring lines consistent with predictions. No TARPs relevant to public safety were triggered during mining of LW401-407.		
Monitoring Data Reviewed By?	MSEC (Appendix A)		
Compliance With Performance Indicator	Yes	Compliance With Performance Measure	Yes

Document	Version	Issue	Status	Author
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7.0 REFERENCES

- Australasian Groundwater and Environment (2026) *UG4 LW401 to LWW407 – End of Panel Report - Groundwater Review*.
- Mine Subsidence Engineering Consultants (2021) *Moolarben Project Stage 1 – Longwalls 401 to 408 Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan*
- Mine Subsidence Engineering Consultants (2026) *Moolarben Coal Operations – Longwall 401-407 End of Panel Subsidence Review Report*.
- Niche Environment and Heritage (2025) *Moolarben UG4: Longwalls 401 408 Spring Monitoring Program Spring 2025*.
- Niche Environment and Heritage (2026) *Moolarben UG4 LW401-407 EoP Aboriginal Cultural Heritage Assessment*.
- WRM Water & Environment (2026) *Moolarben Coal Project: LW401-407 End-of-Panel, Surface Water Report*.

Document	Version	Issue	Status	Author
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APPENDIX A

**MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT
– SUBSIDENCE REPORT (MSEC, 2026)**



MOOLARBEN COAL COMPLEX:

Moolarben Coal Operations

Longwalls 401-407 End of Panel Subsidence Review Report

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	PD	-	23 Mar 2026
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A	Final Issue	PD		20 Aug 2026

Report produced to: Support the Moolarben Coal Operations Longwalls 401 to 407 End of Panel Report

Previous reports: Report No. MSEC731 (Rev. A) – Stage 2 of Moolarben Coal Project – Revised Predictions of Subsidence Parameters and Revised Assessments of Subsidence Impacts resulting from the Proposed UG1 Mine Layout Optimisation Modification, dated June 2015

Report No. MSEC1165 (Rev. A) – Moolarben Project Stage 1 – Longwalls 401 to 408 – Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan, dated 04 November 2021

Background reports available at www.minesubsidence.com¹:

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

¹ Direct link: http://www.minesubsidence.com/index_files/page0004.htm

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1.0 INTRODUCTION

1.1. Background

Moolarben Coal Operations Pty Ltd (MCO) operates the Moolarben Coal Complex (MCC), which is located approximately 40 kilometres (km) north-east of Mudgee in the Western Coalfield of New South Wales (NSW). MCO has been granted approval to develop Stages 1 and 2 of the Moolarben Coal Project (MCP) under the *Environmental Planning and Assessment Act 1979*.

Approval for Stage 1 of the MCP (05_0117) was granted by the Minister for Planning on the 6 September 2007. Approval for Stage 2 of the MCP (08_0135) was granted for the Preferred Project Mine Layout on the 30 January 2015.

MCO is currently extracting the 400 series of longwall panels within the UG4 mining domain, which is a component of the MCP Stage 1 Approval (05_0117) (Drawing MSEC1511-01). The UG4 Longwalls 401 to 408 (LW401-408) Extraction Plan was approved in June 2022 and mining of the first longwall (i.e. LW401) commenced in July 2022.

A summary of the commencement and completion dates for the UG4 longwalls at the MCC is provided in Table 1.1.

Table 1.1 Longwall commencement and completion dates

Longwall	Commencement date	Completion date
LW401	15 July 2022	29 November 2022
LW402	22 February 2023	01 July 2023
LW403	31 July 2023	09 December 2023
LW404	15 January 2024	18 May 2024
LW405	19 June 2024	26 Oct 2024
LW406	24 January 2025	15 July 2025
LW407	15 August 2025	30 January 2026

Mine Subsidence Engineering Consultants (MSEC) has prepared this Subsidence Review Report which will support the LW401-407 End of Panel Report. This report provides the review and discussion of the observed and predicted subsidence movements following the completion of LW407 and provides baseline data for LW409-414 (Drawing MSEC1511-01).

1.2. Mining geometry

The layout of the approved longwalls in UG4 is shown in Drawing No. MSEC1511-01. A summary of the as-extracted dimensions for LW401-407 in UG4 is provided in Table 1.2. The longwalls are mining the Ulan Seam.

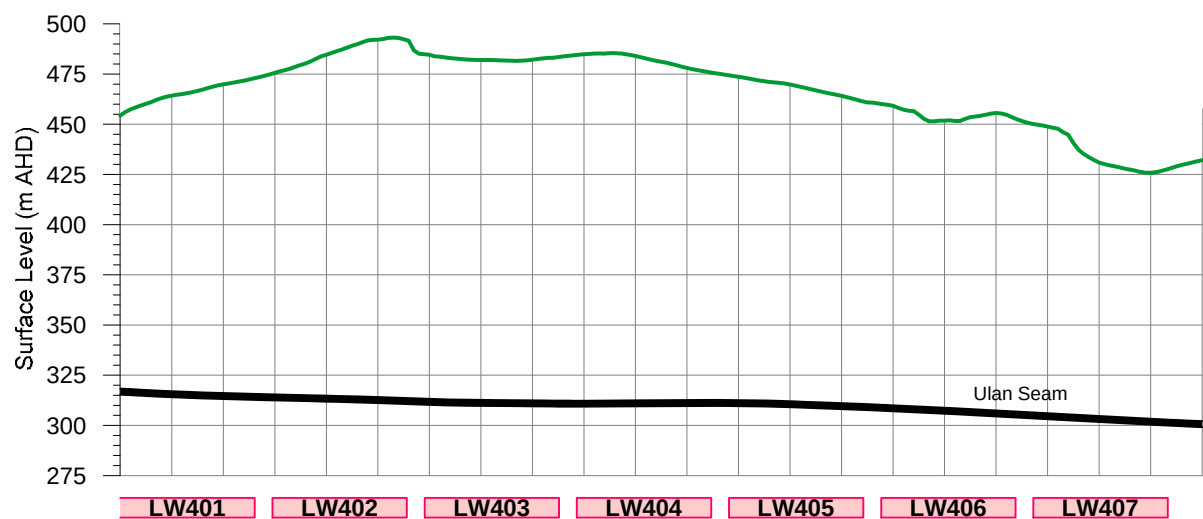
Table 1.2 Mining geometry of the as-extracted longwalls

Longwall	Extracted length (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
LW401	1,854	260	-
LW402	1,912	260	35
LW403	1,982	260/220*	35/75*
LW404	2,046	260	35
LW405	2,014	260	35
LW406	2,196	260	35
LW407	2,275	260	35

Note: m = metres

* Longwall panel width and pillar width modified for protection of Aboriginal cultural heritage site 280

The longwalls have been extracted from the Ulan Seam from east to west. The natural surface and the seam levels across LW401 to LW407 are illustrated in Fig. 1.1. The natural surface and the seam levels along the centreline of LW407 are illustrated in Fig. 1.2.



Note: mAHD = metres Australian Height Datum

Fig. 1.1 Surface and seam levels across LW401 to LW407

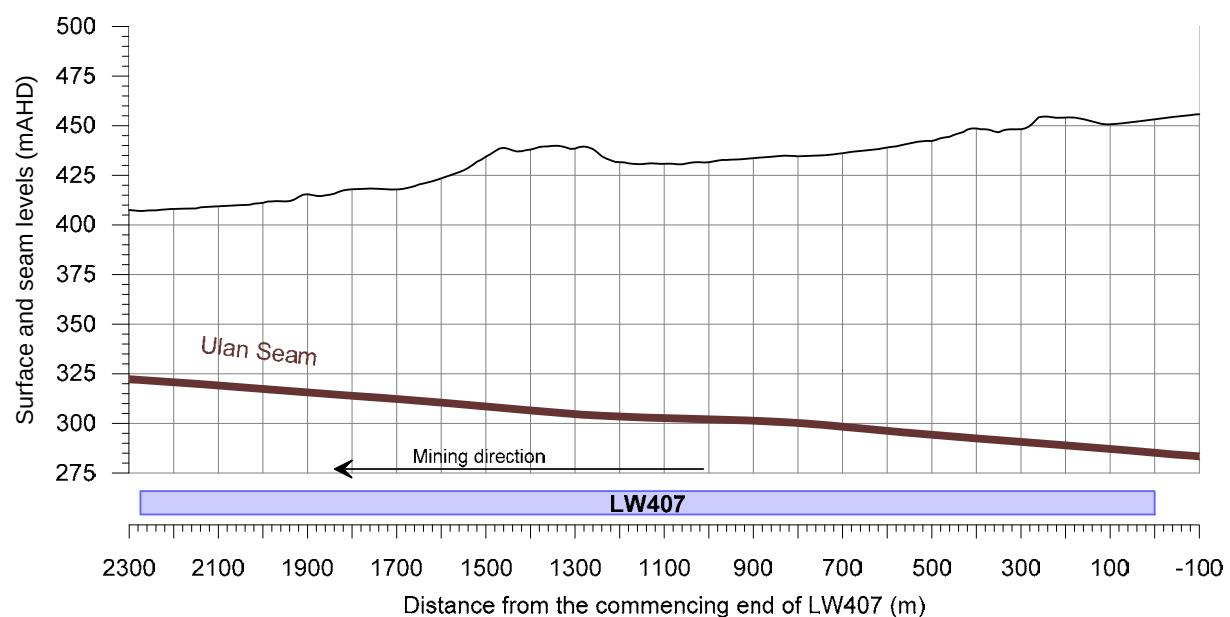


Fig. 1.2 Surface and seam levels along the centreline of LW407

The Ulan Seam dips from the LW401-407 finishing ends towards the commencing ends with an average seam dip over the length of the longwall of approximately 1.7 percent (%) (i.e. 1 in 60). The thickness of the Ulan Seam mined was 3.0 m.

1.3. Natural, heritage and built features

The natural, heritage and built features are shown in Drawings No. MSEC1511-02 and 03. The major surface features relevant to LW401-407 are:

Natural and heritage features:

- Drainage lines (Drainage Line 1 and Bora Creek);
- Goulburn River;
- The Drip and Corner Gorge;
- Cliffs (Cliff Line CL3 and minor cliffs in the Goulburn River National Park);
- Threatened Ecological Communities; and
- Aboriginal cultural heritage site 280.

Drainage Line 2 is located above and to the north of LW408 and flows towards LW409-414 as shown in Drawing No. MSEC1511-04. This report does not include Drainage Line 2 in the following sections as it is not directly relevant to LW401-407.

While Table 14 of Condition 73, Schedule 3 of the MCP Stage 1 Approval (05_0117) includes Aboriginal heritage sites 264, 282, 283, 286 and 287, these sites are located to the north of the Study Area and are unlikely to experience impacts due to the extraction of LW401-408. Therefore, these sites are not considered in the following sections, and only Aboriginal cultural heritage site 280 is considered.

There are no historic heritage sites within the LW401-408 Study Area or within the vicinity of the Study Area.

Built features:

- Sandy Hollow-Gulgong Railway Line;
- Electrical infrastructure;
- Ulan Road and Ulan Road Bridge;
- Telecommunications infrastructure;
- Ulan Coal Mines Pty Limited (UCMPL) infrastructure; and
- Dronvisa Quarry.

Comparisons of the observed and predicted impacts on the natural, heritage and built features are provided in Section 3.

2.1. Introduction

Predicted subsidence contours were previously provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. The predictions were obtained using the Incremental Profile Method (IPM). The subsidence model was calibrated for the local conditions using subsidence monitoring data from other nearby mines with similar geology, as described in Report No. MSEC731.

The predicted subsidence contours due to LW401-407 are shown in Drawing No. MSEC1511-04.

The subsidence monitoring program for LW401-408 comprises subsidence monitoring lines and an array of continuous Global Navigation Satellite System (GNSS) units located at the relevant natural features and between the features and extracted longwalls.

The quoted limits of survey accuracy for three dimensional (3D) survey methods are of the order of ± 30 millimetres (mm) for vertical subsidence, ± 20 mm for horizontal easting and northing movement. Typical accuracies achieved for relative movements are ± 0.5 millimetres per metre (mm/m) for tilt (based on a 20 m bay length) and ± 0.5 mm/m (based on a 20 m bay length) for tensile and compressive strains based on conventional movements.

The real time GNSS survey monitoring marks have been installed at selected locations to monitor subsidence movements from the extracted longwalls. The GNSS system provides continuous 3D position data (i.e. easting, northing and height) to a precision of ± 5 mm.

The locations of GNSS monitoring units and subsidence monitoring lines are shown in Drawing No. MSEC1511-01.

Subsidence monitoring data from the following monitoring components were assessed at the completion of LW401-407:

- K Line - Longitudinal 3D subsidence monitoring line at the finishing end of LW401;
- L Line - Longitudinal 3D subsidence monitoring line at the commencing end of LW401;
- M Line - Longitudinal 3D subsidence monitoring line at the finishing end of LW402;
- N Line - Longitudinal 3D subsidence monitoring line at the finishing end of LW406;
- S Line – Transverse 3D subsidence monitoring line;
- R Line - 3D subsidence monitoring line along the Ulan Road;
- ARTC2 line - 3D ground monitoring line along the Ulan-Wollar Rail line;
- Power poles – 3D ground monitoring points along the 66 kV/22 kV powerline;
- Telstra telecommunications tower;
- Pillar lines X (also referred to as MG402A Line, MG402B Line, and MG402C Line) and Y (also referred to as S1MC280A Line, S1MC280B Line, and S1MC280C Line) for Site S1MC280 monitoring;
- GNSS units MCO01, MCO02, MCO03, MCO05, located above LW401 to LW407;
- GNSS units MCO10 to MCO16 located at Dronvisa Quarry;
- GNSS unit MCO17 located at CL7;
- GNSS units MCO06, MCO18, MCO19 located at CL3;
- GNSS units MCO04, MCO07 to MCO09, and MCO20 to MCO24 located between LW407 and Goulburn River; and
- GNSS units NPWS_G01 to NPWS_G09 located at The Drip, Corner Gorge and Goulburn River.

Discussions on the monitoring data following the completion of LW407 are provided in the following sections. The observed movements have been compared with those predicted using the IPM based on the positions of the longwall face at the times of the last surveys.

2.2. Subsidence monitoring lines

2.2.1. K Line

The K Line is a 3D ground monitoring line located along the centreline of LW401 at the longwall finishing end (Drawing No. MSEC1511-01). The survey dates for the K Line are provided in Table 2.1. The survey monitoring results represent the extraction of LW401.

Table 2.1 Survey dates for K Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (9 July 2022)	Post-mining survey (25 January 2023)

The profiles of measured and predicted vertical subsidence, tilt and strain along the K Line due to the extraction of LW401 are shown in Fig. 2.1.

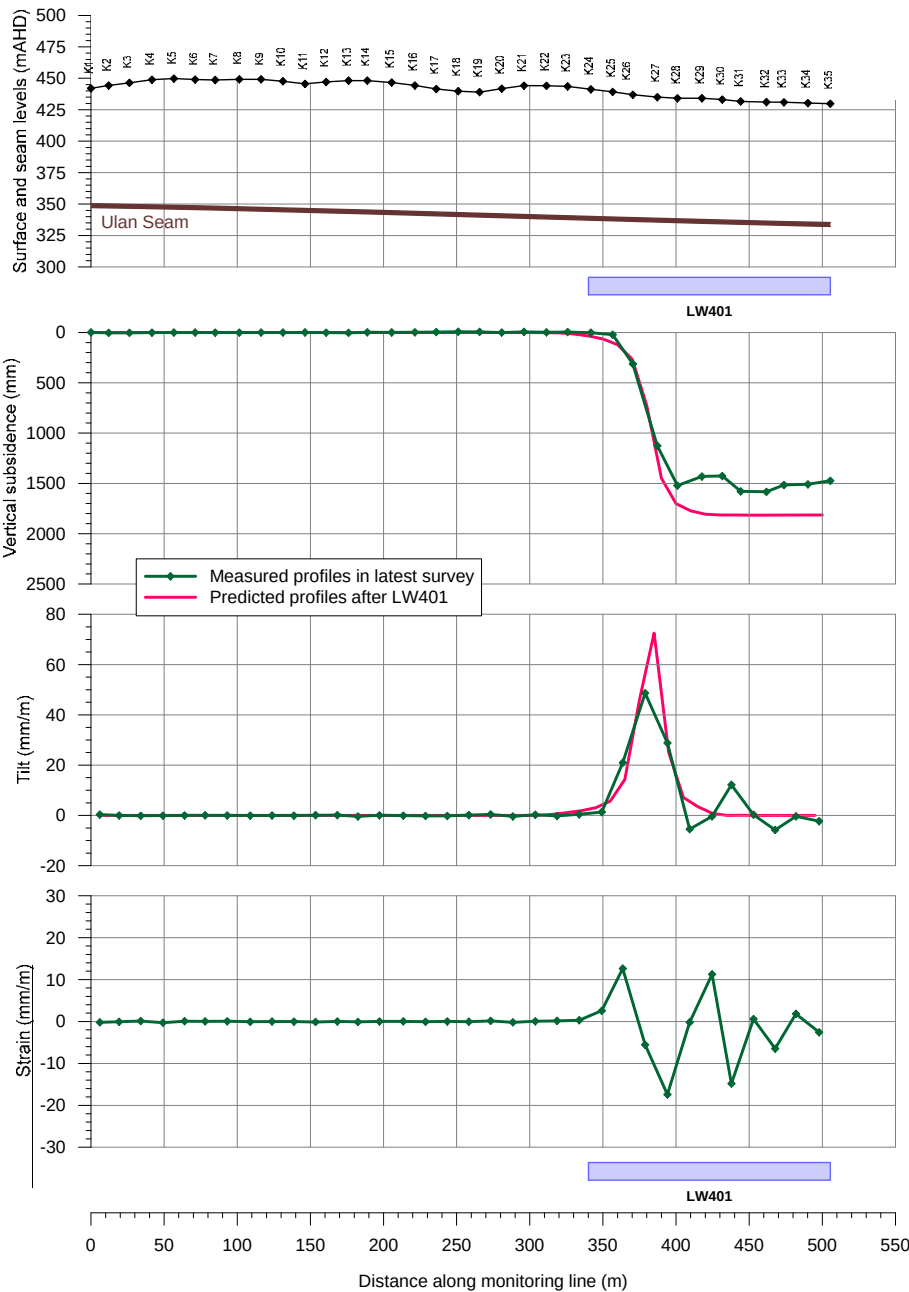


Fig. 2.1 Measured and predicted vertical subsidence, tilt and strain along the K Line

The measured profile of vertical subsidence reasonably matches the predicted profile with the magnitude of the measured vertical subsidence less than that predicted. The magnitude of the maximum measured final tilt (i.e. dark green line in Fig. 2.1) also reasonably coincides with the maximum predicted tilt.

A summary of the maximum measured and maximum predicted subsidence parameters for the K Line is provided in Table 2.2.

Table 2.2 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for K Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	1,584	49	13	17
Predicted	1,800	70	> 30*	> 30*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence of 1,584 mm is less than the maximum predicted value of 1,800 mm. The ratio of the maximum measured to maximum predicted vertical subsidence is 0.88.

It is considered that the ground movements measured along the K Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.2.2. L Line

The L Line is a 3D ground monitoring line located along the centreline of LW401 at the longwall commencing end (Drawing No. MSEC1511-01). The survey dates for the L Line are provided in Table 2.3. The survey monitoring results represent the extraction of LW401.

Table 2.3 Survey dates for L Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (25 June 2022)	Post-mining survey (27 January 2023)

The profiles of measured and predicted vertical subsidence, tilt and strain along the L Line due to the extraction of LW401 are shown in Fig. 2.2.

The measured profile of vertical subsidence reasonably matches the predicted profile with the magnitude of the measured vertical subsidence less than that predicted. The magnitude of the maximum measured final tilt (i.e. dark green line in Fig. 2.2) also reasonably coincides with the maximum predicted tilt.

A summary of the maximum measured and maximum predicted subsidence parameters for the L Line is provided in Table 2.4.

Table 2.4 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for L Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	1,233	26	11	2.6
Predicted	1,800	35	12*	13*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence of 1,233 mm is less than the maximum predicted value of 1,800 mm. The ratio of the maximum measured to maximum predicted vertical subsidence is 0.69. The vertical subsidence near the commencing end of LW401 is greater than predicted due to the measured profile occurring slightly further to the west than the predicted profile.

It is considered that the ground movements measured along the L Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

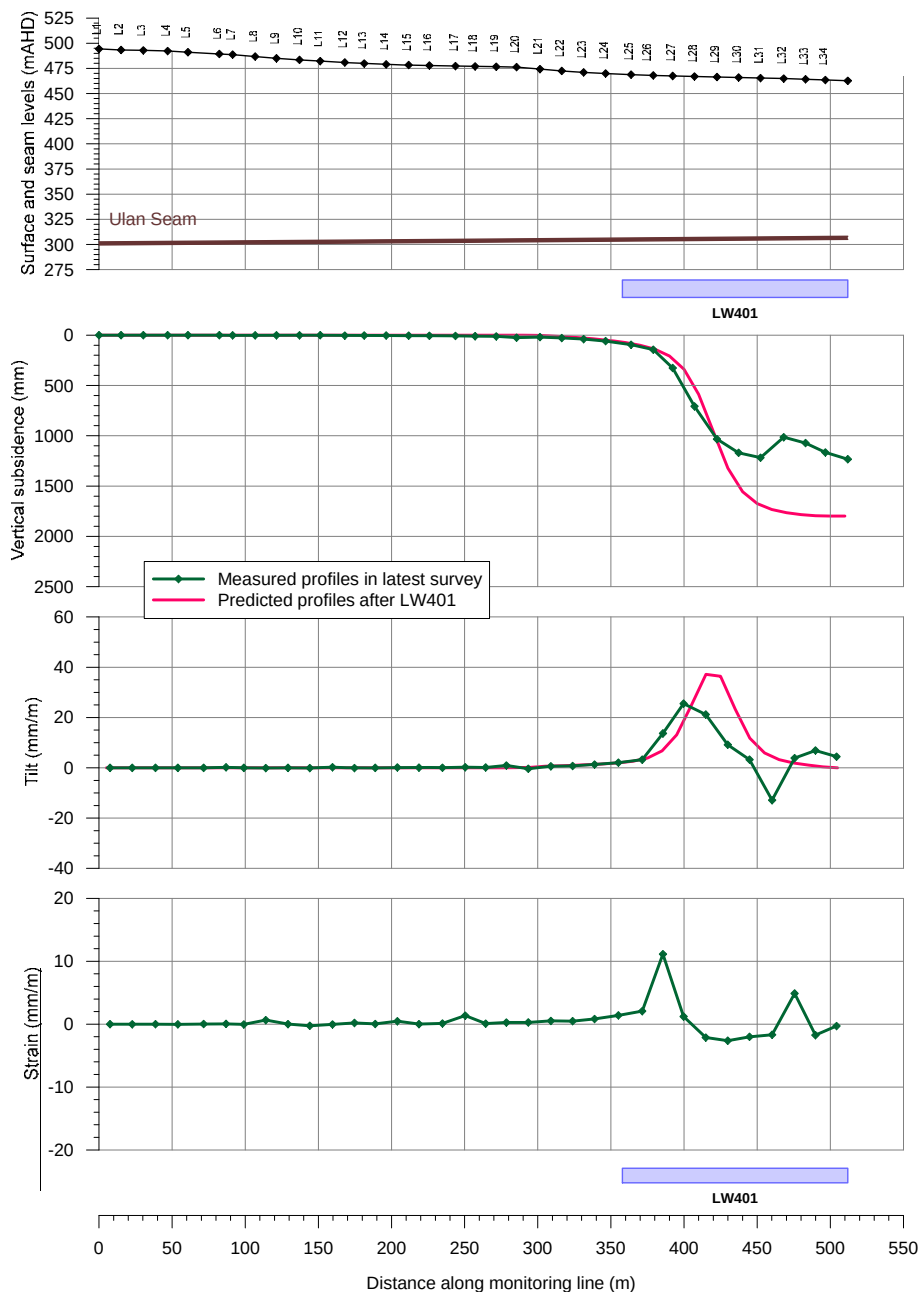


Fig. 2.2 Measured and predicted vertical subsidence, tilt and strain along the L Line

2.2.3. M Line

The M Line is a 3D ground monitoring line located along the centreline of LW402 at the longwall finishing end (Drawing No. MSEC1511-01). The survey dates for the M Line are provided in Table 2.5. The survey monitoring results represent the extraction of LW401 and LW402.

Table 2.5 Survey dates for M Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (9 July 2022)	Post-mining survey (7 November 2023)

The profiles of measured and predicted vertical subsidence, tilt and strain along the M Line due to the extraction of LW401-402 are shown in Fig. 2.3.

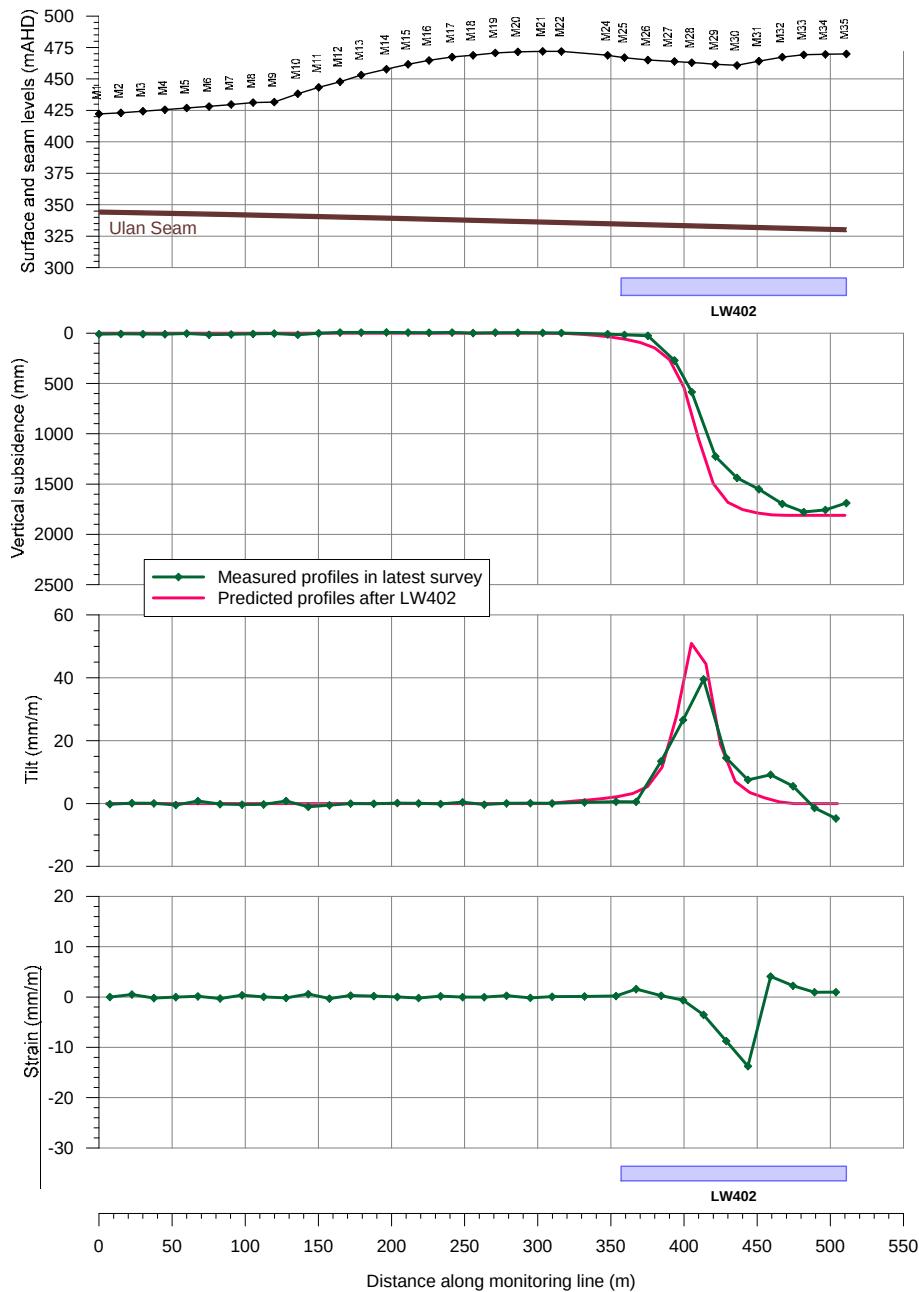


Fig. 2.3 Measured and predicted vertical subsidence, tilt and strain along the M Line

The measured profile of vertical subsidence reasonably matches the predicted profile with the magnitude of the measured vertical subsidence less than that predicted. The magnitude of the maximum measured final tilt (i.e. dark green line in Fig. 2.3) also reasonably coincides with the maximum predicted tilt.

A summary of the maximum measured and maximum predicted subsidence parameters for the M Line is provided in Table 2.6.

Table 2.6 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for M Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	1,778	39	4	13
Predicted	1,800	50	23*	26*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence of 1,778 mm is less than the maximum predicted value of 1,800 mm. The ratio of the maximum measured to maximum predicted vertical subsidence is 0.99.

It is considered that the ground movements measured along the M Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.2.4. N Line

The N Line is a 3D ground monitoring line located along the centreline of LW406 at the longwall finishing end (Drawing No. MSEC1511-01). The survey dates for the N Line are provided in Table 2.7. The survey monitoring results represent the extraction of LW401-406.

Table 2.7 Survey dates for N Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (7 July 2022)	Post-mining survey (20 August 2025)

The profiles of measured and predicted vertical subsidence, tilt and strain along the N Line due to the extraction of LW401-406 are shown in Fig. 2.4. The measured profiles of vertical subsidence and tilt reasonably match the predicted profiles.

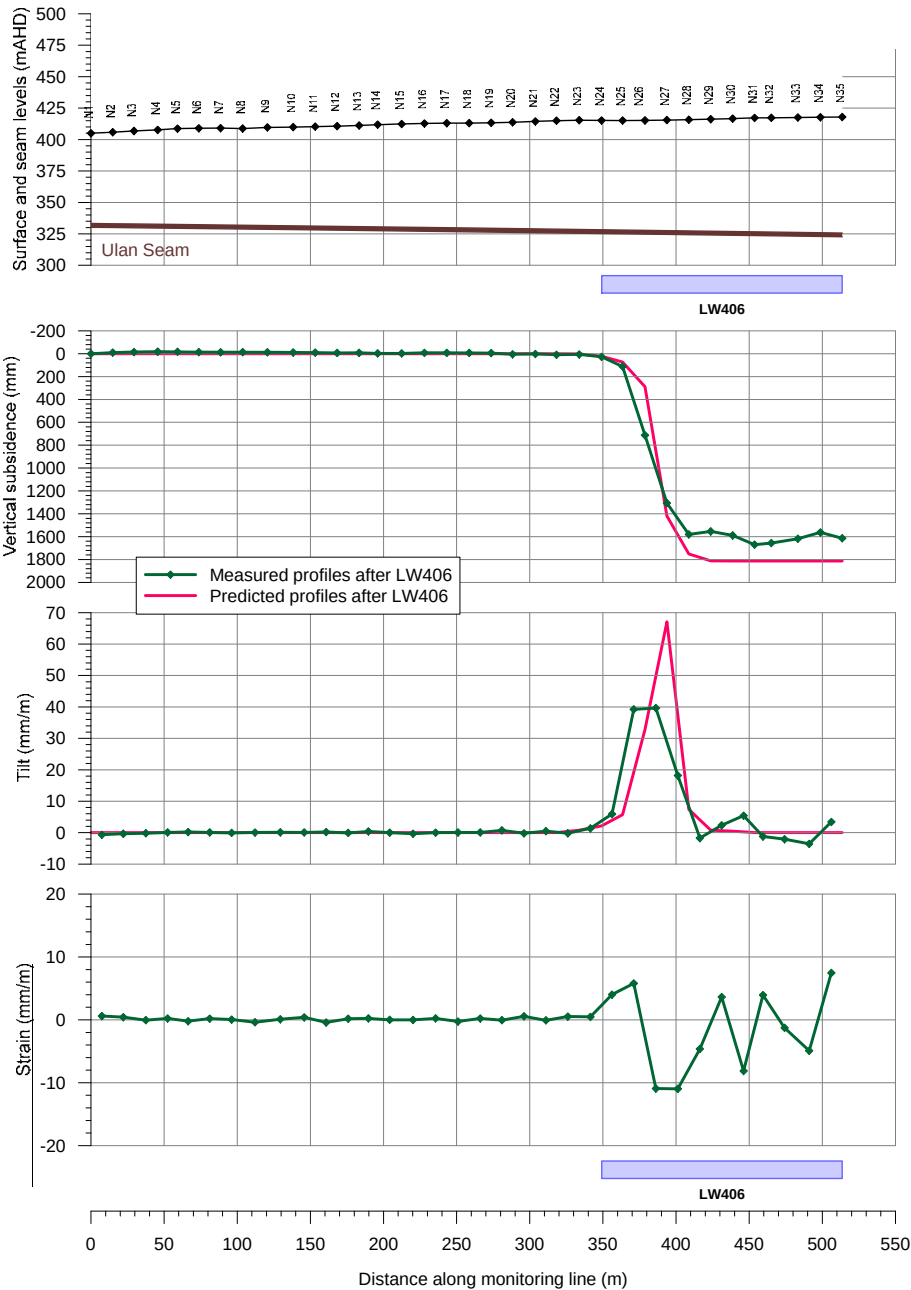


Fig. 2.4 Measured and predicted vertical subsidence, tilt and strain along the N Line

A summary of the maximum measured and maximum predicted subsidence parameters for the N Line is provided in Table 2.8.

Table 2.8 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for N Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	1,670	40	7.5	11.0
Predicted	1,800	65	> 30*	> 30*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence of 1,670 mm is less than the maximum predicted value of 1,800 mm. The ratio of the maximum measured to maximum predicted vertical subsidence is 0.93.

It is considered that the ground movements measured along the N Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.2.5. S Line

The S Line is a 3D subsidence monitoring line that is orientated transverse to LW401-408 (Drawing No. MSEC1511-01). The survey dates for the N Line are provided in Table 2.9.

Table 2.9 Survey dates for S Line

Mining phase commitments	Post-mining phase commitments
	Post-mining surveys (3 February 2023) (8 to 17 November 2023) (26 to 28 February 2024) (13 to 16 August 2024) (20 to 22 December 2024) (14 to 16 August 2025) (26 to 29 March 2026)
Baseline survey (10 July 2022)	

The profiles of measured and predicted vertical subsidence, tilt and strain along the S Line due to LW401-407 are shown in Fig. 2.5. The measured profiles of vertical subsidence and tilt are less than or considered to reasonably match the predicted profiles.

A reduction in vertical subsidence and tilt is observed above LW403 near the tailgate, compared with the observed profiles from the other longwalls. The location of the S Line is close to the widened LW403 pillar as shown in Drawing No. MSEC1511-01. It is likely that the reduced subsidence at this location is the result of the widened pillar with subsidence significantly less than predicted.

A summary of the maximum measured and maximum predicted subsidence parameters for the S Line is provided in Table 2.10.

Table 2.10 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for the S Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	1,627	31	10.0	14.9
Predicted	1,900	35	13*	9*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured vertical subsidence of 1,627 mm is less than the maximum predicted value of 1,900 mm. The ratio of the maximum measured to maximum predicted vertical subsidence is 0.86.

The maximum measured tilt of 31 mm/m is less than the maximum predicted value of 35 mm/m. The maximum tensile strain is less than predicted and maximum compressive strain is greater than predicted. The greater than predicted compressive strain occurred between survey marks TAG S147 and S148 during mining of LW407.

The greater than predicted compressive strain is not significant at higher values of strain and shallow mining conditions. The greater than predicted compressive strain has not resulted in exceedance of performance measures or Trigger Action Response Plan (TARP) triggers.

It is considered that the ground movements measured along the S Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

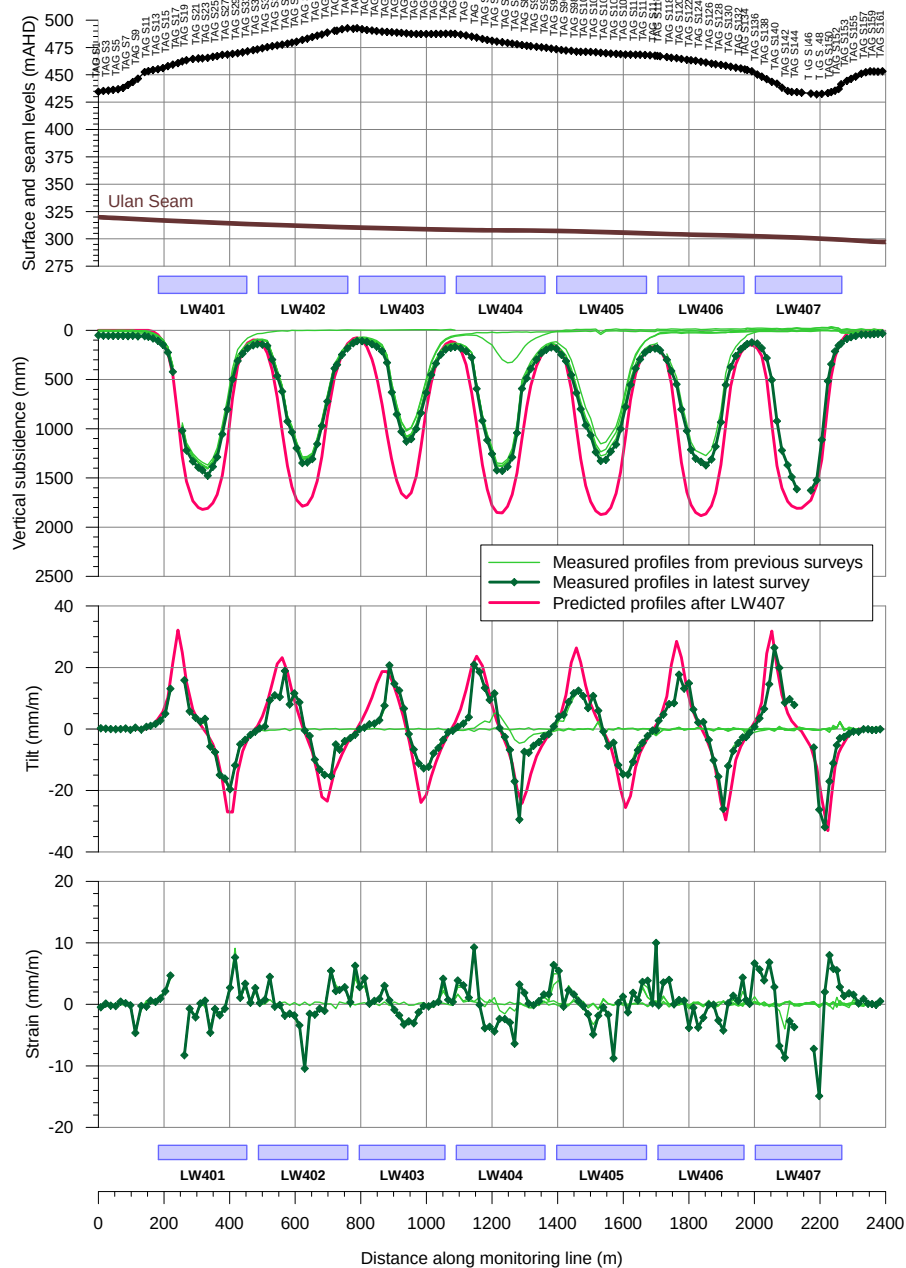


Fig. 2.5 Measured and predicted vertical subsidence, tilt and strain along the S Line

2.2.6. R Line

The R Line is a 3D subsidence monitoring line that follows the Ulan Road to the west of LW401-408 (Drawing No. MSEC1511-01). The survey dates for the R Line are provided in Table 2.11. The survey monitoring results represent the extraction of LW401-407.

Table 2.11 Survey dates for R Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (20 to 29 June 2022)	Post-mining surveys
	(1 to 2 February 2023)
	(11 to 12 October 2023)
	(28 to 29 February 2024)
	(8 to 13 August 2024)
	(18 to 19 December 2024)
	(7 to 8 August 2025)
	(12 to 13 March 2026)

The profiles of measured vertical subsidence, tilt and strain along the R Line due to LW401-407 are shown in Fig. 2.6. Only low-level vertical subsidence within the level of survey accuracy was measured along the R Line. It is noted that several survey marks have been disturbed or damaged due to the vehicles along Ulan Road.

A summary of the maximum measured and maximum predicted subsidence parameters for the R Line is provided in Table 2.12.

Table 2.12 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for the R Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	14	1.2	0.9	0.9
Predicted	< 20	< 0.5	< 0.5*	< 0.5*

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured subsidence of 14 mm is less than the quoted surveying accuracy for absolute height of ± 30 mm.

The measured maximum tilt and strains are higher than predicted but the majority of the measurements are generally in the order of survey tolerance of ± 0.5 mm/m consistent with the predicted tilt and strain.

As noted above, several marks have been disturbed or damaged due to vehicles along Ulan Road. The greater than predicted tilt and strain are considered to be related to the disturbance of survey marks. The measured tilt and strains greater than predicted have not resulted in exceedance of performance measures or TARP triggers.

The vectors of horizontal movement for the R Line are shown in Drawing No. MSEC1511-05. The maximum horizontal movement is 15 mm, which is less than the quoted accuracy of ± 20 mm. The orientations of the vectors therefore may not provide a true indication of the direction of absolute horizontal movement.

It is considered that the ground movements measured along the R Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

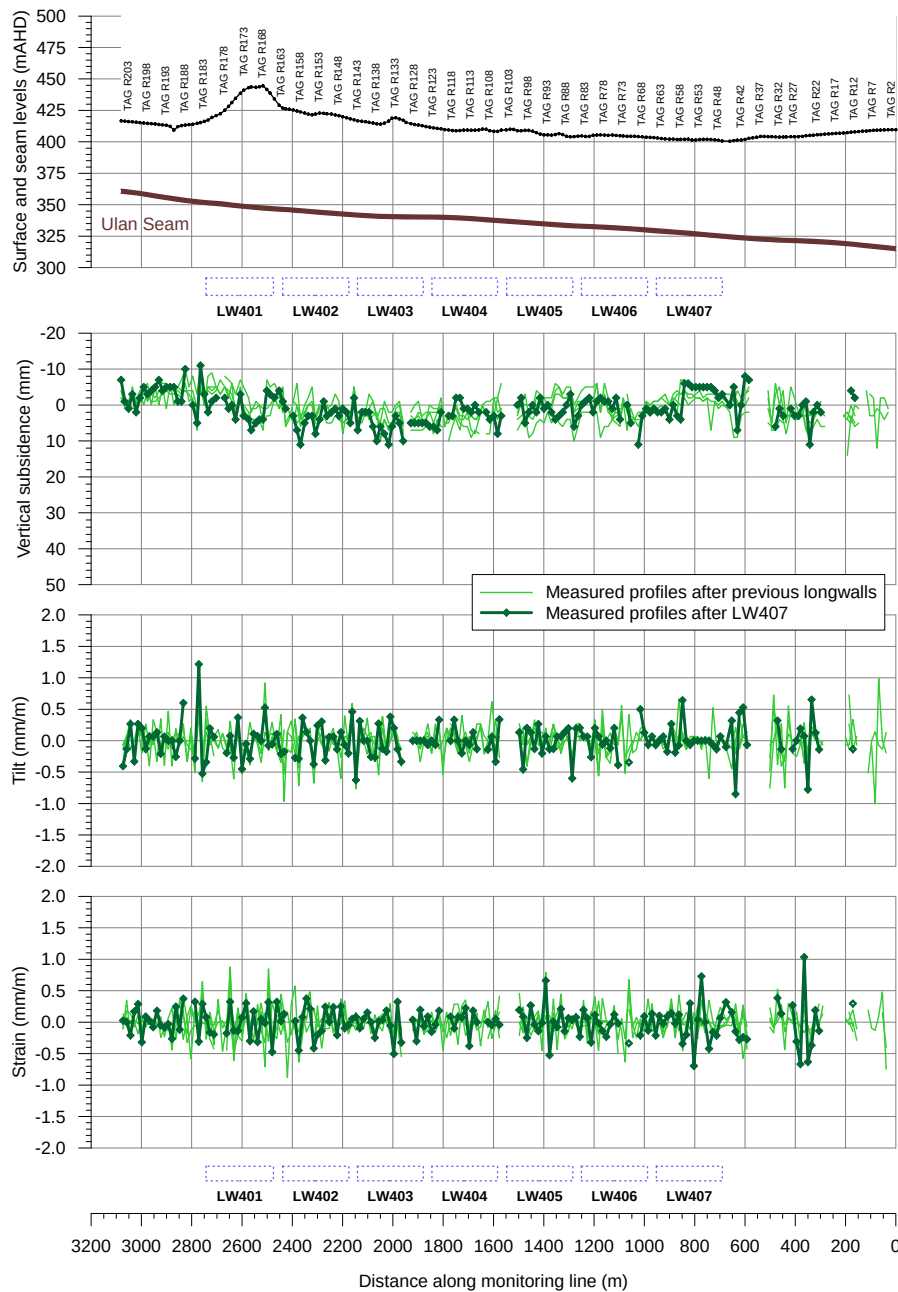


Fig. 2.6 Measured vertical subsidence, tilt and strain along the R Line

2.2.7. ARTC2 Line

The ARTC2 Line is a 3D ground monitoring line that follows the Sandy Hollow – Gulgong Railway Line located to the south of the UG4 longwalls (Drawing No. MSEC1511-01). The survey dates for the ARTC2 Line are provided in Table 2.13. At the latest survey, the LW403 face position was at Chainage 1,211 m. The latest survey results therefore represent the extraction of LW401-402 and part of LW403.

Table 2.13 Survey dates for ARTC2 Line

Mining phase commitments	Post-mining phase commitments
Baseline survey (12 July 2022)	Post-mining survey (17 September 2023)

The profiles of measured vertical subsidence, tilt and strain along the ARTC2 Line are shown in Fig. 2.7. Only low-level vertical subsidence within the level of survey accuracy was measured along the ARTC2 Line. The maximum subsidence was less than 5 mm.

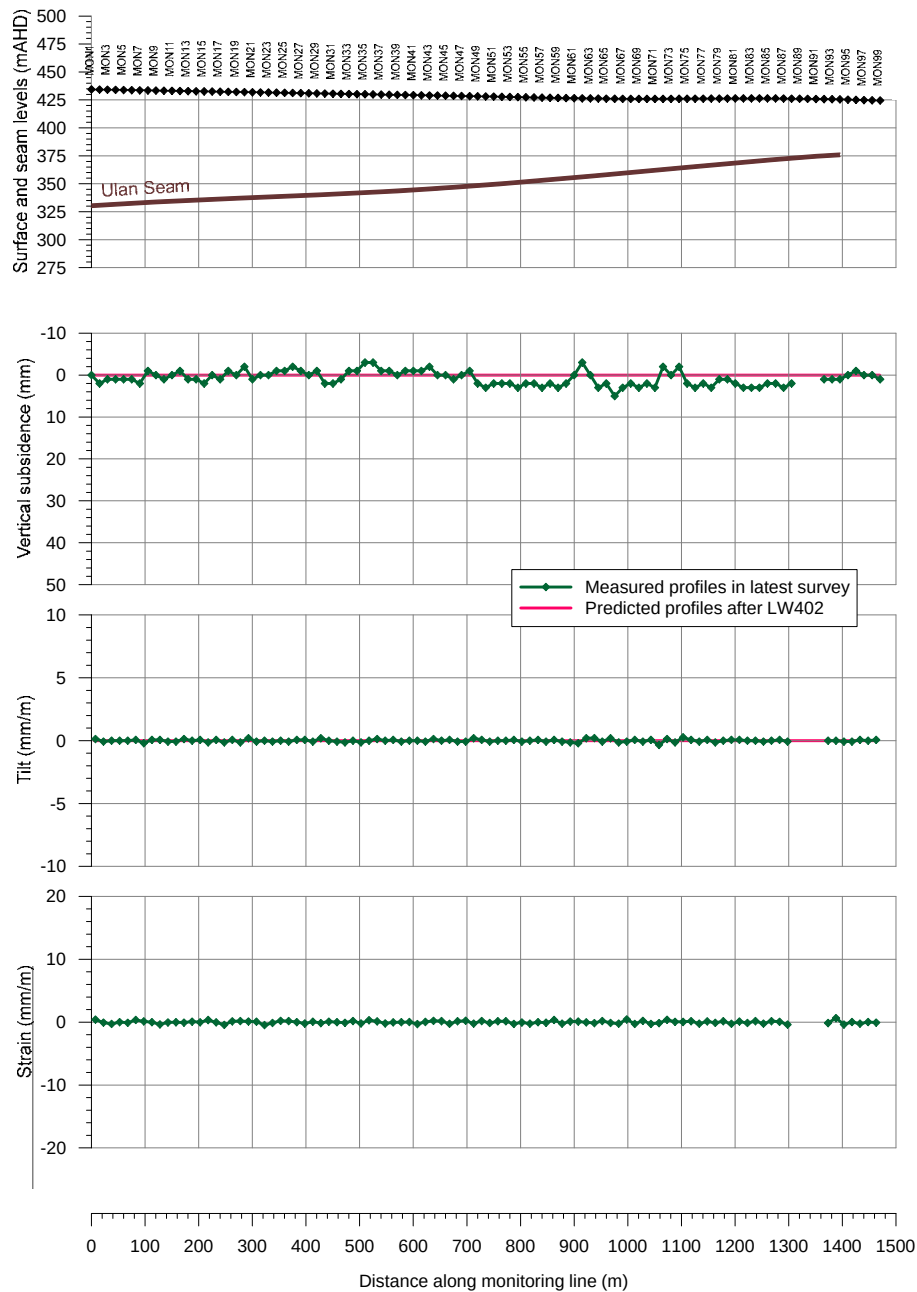


Fig. 2.7 Measured vertical subsidence, tilt and strain along the ARTC2 Line

A summary of the maximum measured and maximum predicted subsidence parameters for the ARTC Line is provided in Table 2.14.

Table 2.14 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for the ARTC Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
Measured	5	0.3	0.6	0.5
Predicted	< 20	< 0.5	< 0.5	< 0.5

Note: * denotes that the values represent the conventional strains based on the predicted curvatures multiplied by a factor of 10.

The maximum measured subsidence and tilt were less than predicted. The measured maximum strains were slightly greater than predicted but were within the normal range of accuracy. The majority of strains were negligible and less than the order of survey tolerance of ± 0.5 mm/m.

The vectors of horizontal movement for the ARTC2 Line are shown in Drawing No. MSEC1511-05. The maximum horizontal movement is 10 mm, which is less than the quoted accuracy of ± 20 mm. The orientations of the vectors therefore may not provide a true indication of the direction of absolute horizontal movement. The measured horizontal movements have not resulted in exceedance of performance measures or TARP triggers.

It is considered that the ground movements measured along the ARTC2 Line are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.2.8. Power Poles

The Essential Energy 66 kV / 22kV line and power poles monitoring comprises reflectorless survey of selected marks identified at the bases and tops of the power poles along the Essential Energy 66 kV / 22kV line. The powerline is located to the west and south west of LW401. A total of six poles, CE 15458 to CE 15464, were monitored during the extraction of LW403. The pole numbers are shown in Drawing No. MSEC1511-03

The survey dates for power poles are provided in Table 2.15. At the latest survey, the LW403 face was approximately 1.4 km from the nearest pole and is unlikely to have resulted in observed subsidence movements. The latest survey, therefore represents the movements due to the extraction of LW401-402.

Table 2.15 Survey dates for power poles

Mining phase commitments	Post-mining phase commitments
Baseline survey (16 July 2022)	Post-mining surveys (3 February 2023) (17 November 2023)

The measured vertical subsidence, pole tilt and changes in distance between power poles for the Essential Energy 66 kV/22kV line due to LW401-402 are shown in Table 2.16 and Table 2.17. The measured vertical subsidence and changes in distance between power poles are based on the survey marks at the bases of each of the power poles. The measured tilts represent the changes in the existing tilts of the power poles based on the differential horizontal movements of the survey marks at the tops and bases of each of the power poles. Two tilt values are presented for several poles due to the use of two reference marks at the tops of those power poles. The observed horizontal movement at the tops of the power poles is also presented in Table 2.16 and is based on the height between survey marks at the bases and tops of the power poles. With survey marks located above the pole ground level and at the cross arm at the top of the power poles, the horizontal movements are approximate only.

Table 2.16 Maximum measured vertical subsidence, tilt and horizontal movement for the power poles

Pole ID	Approximate Distance to LW401 (m)	Total subsidence after LW402 (mm)	Change in pole tilt after LW402 (mm/m)	Observed horizontal movement at top of pole (mm)
15464	400	-6	2.2	15
15463	440	10	-0.6 1.4	-5 12
15461	510	10	-0.5 1.8	-4 15
15460	680	8	-1.0	-10
15459	860	-3	-0.4 1.0	-3 8
15458	1030	-6	1.6 2.1	13 17

Note: dual values of power pole tilt are calculated from two separate reference marks used at the tops of those power poles.

**Table 2.17 Maximum measured change in bay length
between power poles**

Pole Bay ID	Distance between poles (m)	Total change in bay length after LW402 (mm)
15464 to 15463	326	-9
15463 to 15461	110	6
15461 to 15460	185	-4
15460 to 15459	186	3
15459 to 15458	183	11

Only low-level vertical subsidence of 10 mm or less was measured at the other power poles. The measured values are less than the reported surveying accuracy for absolute height of ± 30 mm.

The measured changes in pole tilt range from -1.0 mm/m to 2.2 mm/m, which is less than the estimated accuracy of ± 5 mm/m based on the reported accuracy of horizontal movement of ± 20 mm/m. The approximate observed horizontal movements at the tops of the power poles varies from -10 mm to 17 mm, which is less than the estimated accuracy of ± 35 mm based on the reported accuracy of horizontal movement of ± 20 mm/m.

The measured changes in bay length between the power poles vary from -9 mm to 11 mm are within the reported accuracy of ± 20 mm for each survey mark, or ± 40 mm between two survey marks.

The horizontal movements for the power poles with the exception of CE 15460 are 11 mm or less, which is within the reported accuracy of ± 30 mm for horizontal movement. The horizontal movement at CE 15460 is 42 mm. It is noted in the survey data that this power pole is leaning due to extreme wet weather. Given this power pole is 680 m from the nearest longwall, and the horizontal movement at closer power poles is 2 mm to 8 mm, it is considered that the movement at CE 15460 is not related to mine subsidence movements.

It is considered that the ground movements measured at the power poles are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.2.9. Telstra Telecommunications Tower

The Telstra tower is located approximately 400 m to the west of LW401 and is close to power pole CE 15464. The maximum measured vertical subsidence of -2 mm (i.e. uplift) is less than the surveying accuracy for absolute height of ± 30 mm. The maximum differential vertical and horizontal movements between the two marks located at the surrounding tower compound block wall is approximately 2 mm. The differential vertical and horizontal movements between the two marks around the substation are less than the expected order of survey tolerance for relative height and position of ± 3 mm.

The horizontal movements for the Telstra Tower are 6 mm or less, which is within the reported accuracy of ± 30 mm for horizontal movement.

It is considered that the ground movements measured at the Telstra Tower are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.3. Site S1MC280

Monitoring of Aboriginal Heritage Site S1MC280 was carried out during the extraction of LW402 and LW403. Ground monitoring lines included the X Line (early warning site monitoring) and Y Line (adjacent to S1MC280).

The X and Y Lines are short 3D ground monitoring lines positioned above the longwall pillar between LW402 and LW403 with orientations along, across and diagonal to the pillar. The monitoring lines were installed prior to the extraction of LW402 and therefore represent the extraction of LW402-403.

The profiles of measured and predicted vertical subsidence, tilt and strain along the X Line and Y Line due to the extraction of LW402-403 are shown in Fig. 2.8 and Fig. 2.9.

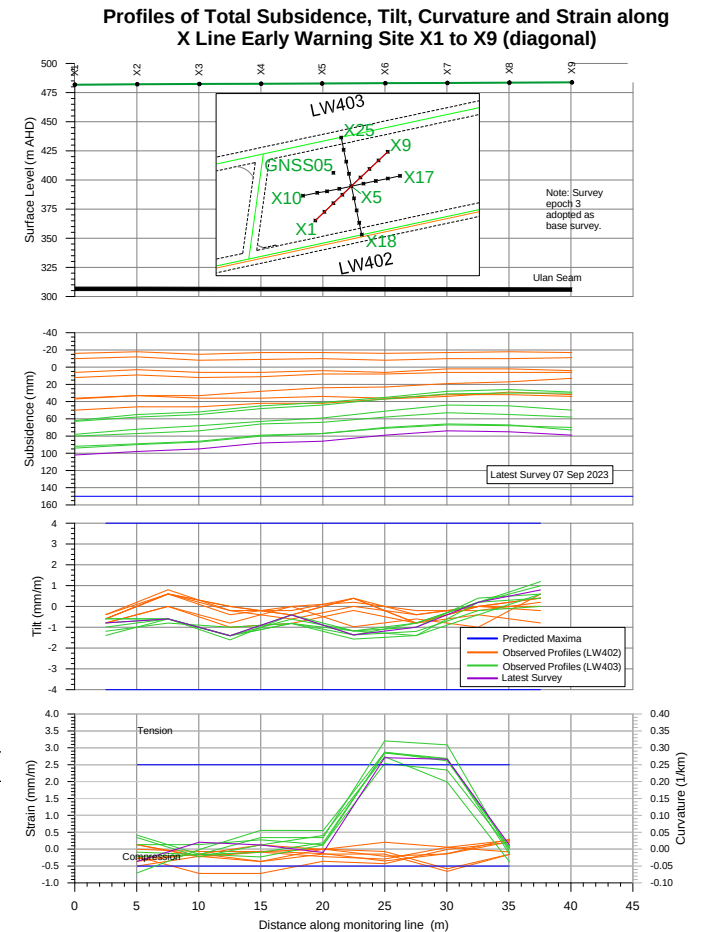
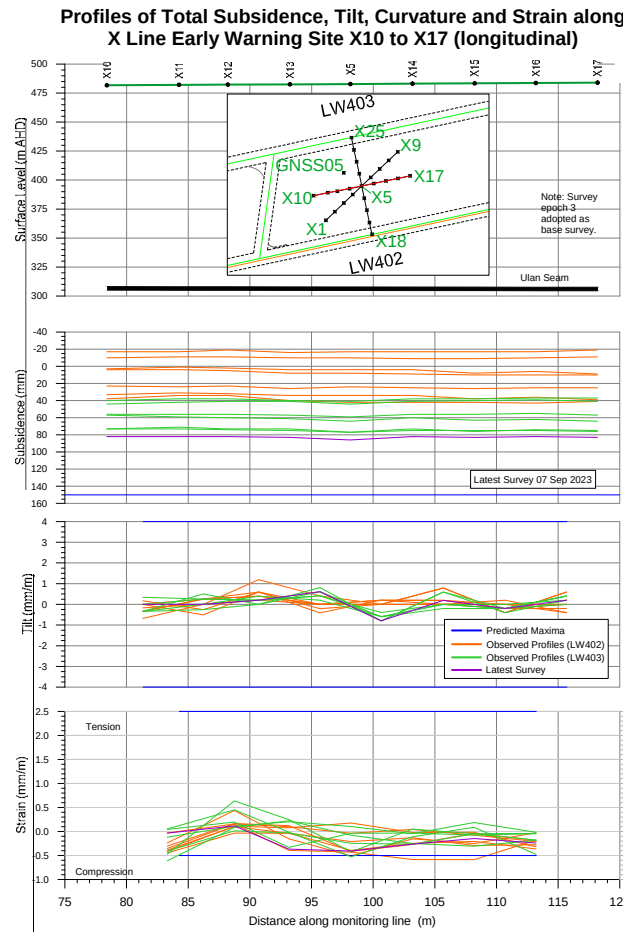
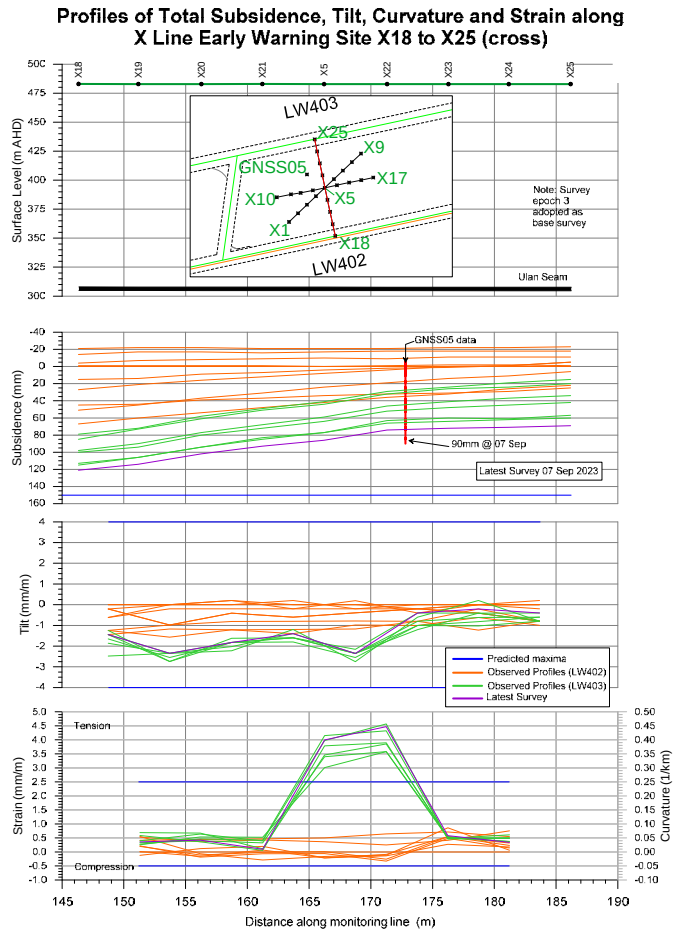


Fig. 2.8 Measured and predicted vertical subsidence, tilt and strain along the X Line

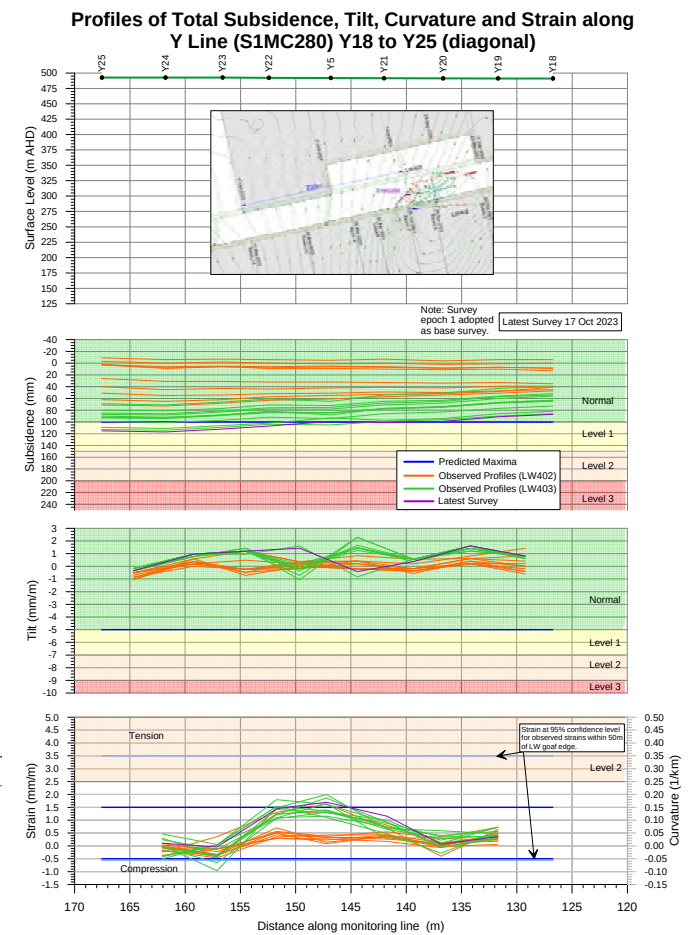
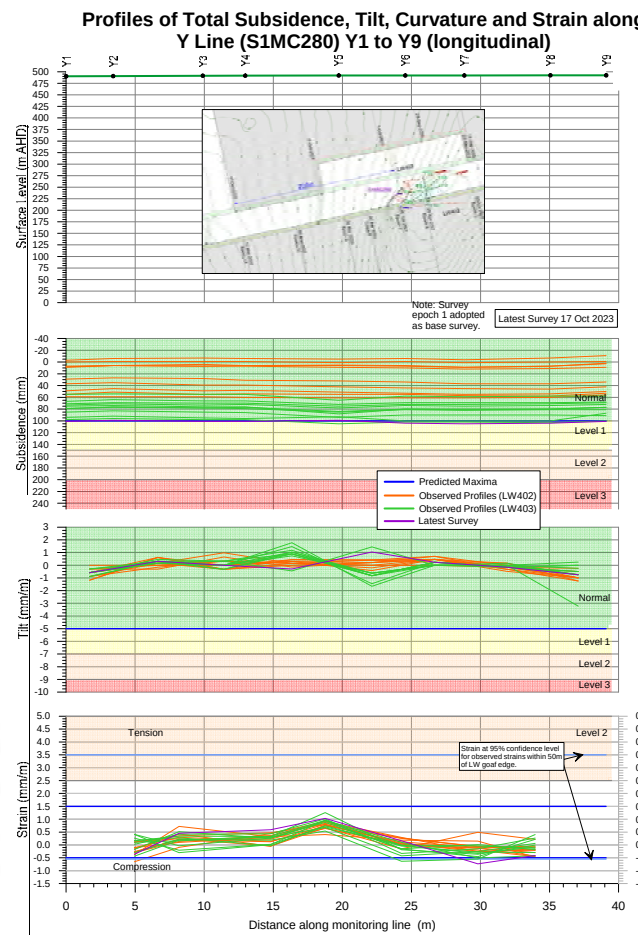
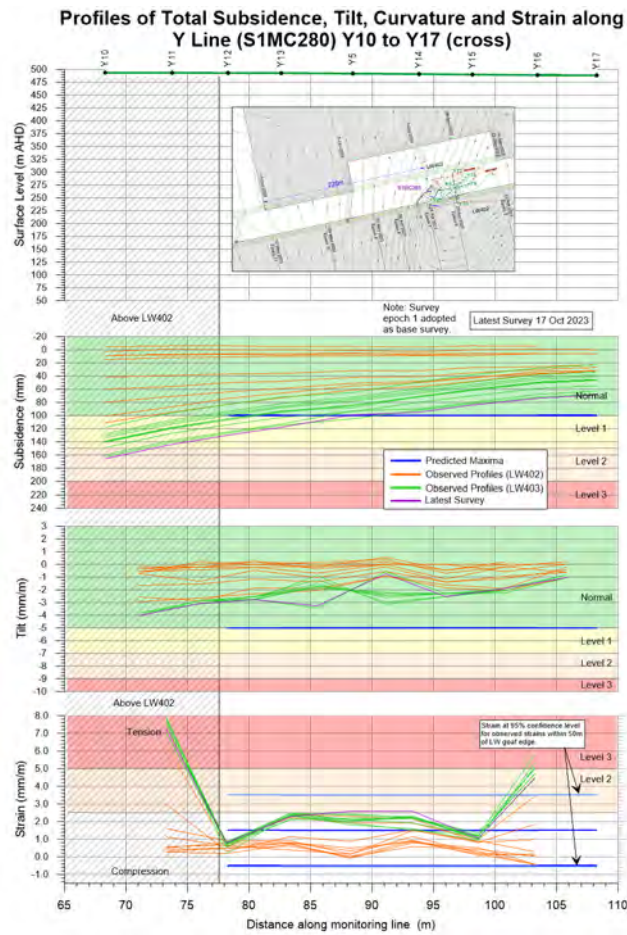


Fig. 2.9 Measured and predicted vertical subsidence, tilt and strain along the Y Line

A summary of the maximum measured and maximum predicted subsidence parameters for the X Line and Y Line is provided in Table 2.18.

Table 2.18 Comparison of maximum measured and maximum predicted vertical subsidence, tilt and strain for X Line and Y Line

Type	Maximum vertical subsidence (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
X Line - Measured	120	2.8	4.5	0.6
X Line – Predicted	150	4	2.5	0.5
Y Line – Measured (above chain pillar)	130	3.5	6	1.0
Y Line - Predicted	100	5	1.5	0.5

The maximum measured vertical subsidence and tilt along the X Line is less than predicted. The maximum compressive strain is similar to predicted and maximum tensile strain is greater than predicted. The maximum measured tilt along the Y Line is less than predicted. The maximum measured vertical subsidence and strains are greater than predicted.

With the exception of the measured vertical subsidence along the Y Line close to the LW402 goaf, the measured vertical subsidence and tilt are generally consistent with predictions. The greater than predicted compressive strain occurs at isolated locations and intermediate epochs and is likely due to survey accuracy. The compressive strains are generally less than predicted. The greater than predicted tensile strains are associated with longitudinal cracks that developed adjacent to the extracted longwalls. Elsewhere, the tensile strains are less than predicted.

It is considered that the ground movements measured along the X and Y Lines are reasonably consistent with the predictions.

2.4. GNSS monitoring

A total of 33 GNSS monitoring units are located across UG4 as shown in Drawing MSEC1511-01. Of the 33 units, 19 of the units are located throughout the UG4 mining area (i.e. LW401-408 and LW409-414) and 14 of the units are located to the north, near The Drip and Goulburn River Gorge.

A summary of the observed movements at each of the GNSS monitoring locations is provided the following section.

2.4.1. GNSS units

The 3D ground movements including changes in easting, changes in northing, vertical subsidence, climate data and loci plot are shown in Appendix B for GNSS units near and to the north of LW407. Observations from the graphs in Appendix B are provided below.

MCO01, MCO02, MCO03 and MCO05 (Fig. A.01, A.02, A.03, A.05)

GNSS Sites MCO01, MCO02, and MCO03 were mined beneath by LW401, LW403, and LW405. Observed maximum vertical subsidence at each site was less than predicted. Following development of maximum vertical subsidence and horizontal movement, minor ongoing movements can be observed with extraction of subsequent longwalls. Maximum horizontal movement of 466 mm was observed at MCO01. MCO05 is located above the chain pillar between LW402 and LW403 and experienced minor horizontal movement and maximum vertical subsidence of 120 mm.

MCO04 (Fig. A.04)

GNSS Site MCO04 is located 47 m to the north of LW407 and at LW408 tailgate. The graph shows horizontal movement of 133 mm to the south, towards the extracted longwalls. The site actively subsided during LW407 with 28 mm vertical subsidence at the latest survey.

MCO06 (Fig. A.06)

GNSS Site MCO06 is located 434 m to the north of LW407. The site is located to the southwest of CL3 and is on the southwest side of Drainage Line 2. The graph shows horizontal movement of 41 mm predominantly to the south, towards the extracted longwalls. The vertical subsidence is negative (uplift) but is predominantly within the range of accuracy for the GNSS unit and does not indicate developing vertical subsidence.

MCO07 (Fig. A.07)

GNSS Site MCO07 is located 523 m to the north of LW407. The site is near a local topographical high point. The graph shows horizontal movement of 34 mm to the south east, towards the extracted longwalls. The vertical subsidence is negative (uplift) with a maximum uplift of -17 mm. The uplift has reduced to -8 mm in the latest survey data.

MCO08 (Fig. A.08)

GNSS Site MCO08 is located 1,456 m to the north of LW407. The graph shows horizontal movement of 11 mm to the south east, towards the extracted longwalls. The vertical subsidence is within the range of accuracy for the GNSS unit and does not indicate developing vertical subsidence.

MCO09 (Fig. A.09)

GNSS Site MCO09 is located 2,050 m to the north of LW407. The graph shows horizontal movement of 7 mm to the east. It is possible the minor easterly movement is associated with the close proximity to the MCO surface pipeline corridor which is shown below Drawing MSEC1511-03. The vertical subsidence is predominantly within the range of accuracy for the GNSS unit. Elevated magnitude of uplift was observed during 2025 however the subsidence returned to zero indicating the movement may be associated with accuracy, possibly due to increased solar activity.

MCO10 to MCO16 (Fig. A.10 to Fig. A.16)

GNSS Sites MCO10 to MCO16 are located near the finishing ends of LW403 to LW405 and were installed to monitor ground movements within and adjacent to Dronvisa Quarry. Following development of maximum vertical subsidence and horizontal movement, minor ongoing movements can be observed with extraction of subsequent longwalls. Maximum horizontal movement of 586 mm was observed at MCO12. MCO13, MCO14 and MCO15 are located above solid coal adjacent to the ends of the longwalls and observed only minor vertical subsidence and horizontal movement.

MCO17 (Fig. A.17)

GNSS Site MCO17 is located at CL7, 455 m from LW407 and 160 m from the nearest LW406. The graph shows horizontal movement of 100 mm to the north east direction. The vertical subsidence is within the range of accuracy for the GNSS unit and shows no developing vertical subsidence.

MCO18 (Fig. A.18)

GNSS Site MCO18 is located 576 m to the north east of LW407. The site is at the top of CL3. The graph shows horizontal movement of 17 mm to the south, towards the extracted longwalls. The vertical subsidence is predominantly negative (uplift) but within the range of accuracy for the GNSS unit and does not indicate developing vertical subsidence.

MCO19 (Fig. A.19)

GNSS Site MCO19 is located 584 m to the north east of LW407. The site is above and to the east of CL3. The graph shows horizontal movement of 8 mm to the south, towards the extracted longwalls. The vertical subsidence is negative (uplift) with a maximum uplift of -18 mm. The uplift has reduced to -10 mm in the latest survey data.

MCO20 (Fig. A.20)

GNSS Site MCO20 is located 2,769 m to the north of LW407. The graph shows horizontal movement of 4 mm which is within the accuracy of the GNSS unit. The vertical subsidence is predominantly negative (uplift) but is within the range of accuracy for the GNSS unit. The survey data does not indicate developing horizontal movement or vertical subsidence.

MCO21 (Fig. A.21)

GNSS Site MCO21 is located 2,816 m to the north of LW407. The graph shows horizontal movement of 2 mm which is within the accuracy of the GNSS unit. The vertical subsidence is predominantly negative (uplift) but is within the range of accuracy for the GNSS unit. The survey data does not indicate developing horizontal movement or vertical subsidence.

MCO22 (Fig. A.22)

GNSS Site MCO22 is located 2,822 m to the north of LW407. The graph shows horizontal movement of 7 mm which is within the accuracy of the GNSS unit. The vertical subsidence is negligible and is within the range of accuracy for the GNSS unit. The survey data does not indicate developing horizontal movement or vertical subsidence.

MCO23 (Fig. A.23)

GNSS Site MCO23 is located 2,620 m to the north of LW407. The graph shows horizontal movement of 1 mm which is within the accuracy of the GNSS unit. The vertical subsidence is negligible and is within the range of accuracy for the GNSS unit. The survey data does not indicate developing horizontal movement or vertical subsidence.

MCO24 (Fig. A.24)

GNSS Site MCO24 is located 2,583 m to the north of LW407. The graph shows horizontal movement of 0 mm which is within the accuracy of the GNSS unit. The vertical subsidence is negligible and is within the range of accuracy for the GNSS unit. The survey data does not indicate developing horizontal movement or vertical subsidence.

NPWS_G01 to G09 (Fig. A.25)

GNSS Sites NPWS_G01 to NPWS_G09 are located 2,606 m to 3,079 m to the north of LW407. Two units are located to the west of The Drip and six units are located along the Goulburn River Gorge cliffs. A single unit is located at the top of The Drip. The graph shows horizontal movement varying predominantly within normal accuracy of the GNSS units with a maximum of 12 mm. The vertical subsidence varies from approximately -14 mm to 16 mm, with isolated spikes likely due to short term environmental effects. The variation follows a seasonal pattern with some lag compared to the climate data. The survey data does not indicate developing horizontal movement or vertical subsidence. Some deviation can be observed in NPWS_G06. It is possible that local features at the installation location may be contributing to the increased movements at this location.

A summary of the maximum predicted and observed total subsidence at the GNSS locations following the completion of LW407 is presented in Table 2.19 and Table 2.20.

Table 2.19 Summary of predicted and observed total subsidence for UG4 GNSS Units

GNSS ID	Location	Installation date	Latest survey date	Maximum total subsidence after LW407 (mm)	
				Predicted	Observed
MCO01	Above LW401	6 Sep 2022 during LW401	20 Apr 2024 during LW404	1900	1476
MCO02	Above LW403		10 Feb 2026 during LW407	1850	1052
MCO03	Above LW405		12 Mar 2026 after LW407	1900	1234
MCO04	Above LW408 tailgate	12 Nov 2022 during LW401	4 May during LW406	375	28
MCO05	Above LW402 maingate pillar	17 Dec 2022 prior to LW402		150	120
MCO06	434 m from LW407 (CL3)	04 Jan 2023 prior to LW402		< 20	-5
MCO07	523 m from LW408 71 m from LW409	21 Apr 2023 during LW402	12 Mar 2026 after LW407	< 20	-17
MCO08	Above LW412			< 20	0
MCO09	Above LW413			< 20	-20
MCO10	Above LW405 tailgate (Dronvisa Quarry)	29 Jul 2023 prior to LW403	29 Dec 2025 during LW407	375	70
MCO11	Above LW405 (Dronvisa Quarry)		12 Mar 2026 after LW407	1075	289
MCO12	Above LW405 (Dronvisa Quarry)			1875	1550
MCO13	27 m from LW403 (Dronvisa Quarry)			< 20	1
MCO14	25 m from LW403 (Dronvisa Quarry)		16 Jan 2026 during LW407	50	0
MCO15	43 m from LW403 (Dronvisa Quarry)			< 20	-13
MCO16	Above LW403 (Dronvisa Quarry)		12 Mar 2026 after LW407	1650	1108
MCO17	160 m from LW406 (CL7)			< 20	0
MCO18	576 m from LW407 (CL3) 37 m from LW413	4 Sep 2024 during LW405		< 20	-4
MCO19	584 m from LW407 (CL3) 40 m from LW414			< 20	-18
MCO20	335 m from LW413 2,769 m from LW407		12 Mar 2026 after LW407	< 20	-7
MCO21	475 m from LW413 2,816 m from LW407	Jul 2025 prior to LW407		< 20	-5
MCO22	405 m from LW413 2,822 m from LW407			< 20	4
MCO23	165 m from LW413 2,620 m from LW407			< 20	3
MCO24	355 m from LW413 2,583 m from LW407	Aug 2025 during LW407		< 20	8

Table 2.20 Summary of predicted and observed total subsidence for GNSS Units near The Drip and Goulburn River Gorge

GNSS ID	Location (2,606 m to 3,079 m from LW407)	Installation date and predicted total subsidence	Latest survey date	Observed total subsidence after LW407 (mm)
NPWS_G01	560m from LW413	21 Nov 2023 during LW403	12 Mar 2026 after LW407	-7
NPWS_G02	470m from LW413			0
NPWS_G03	Goulburn River Gorge 615m from LW413			-9
NPWS_G04	Goulburn River Gorge 700m from LW413			-7
NPWS_G05	Goulburn River Gorge 605m from LW413	Predicted vertical subsidence is less than typical survey accuracy of 20mm		-5
NPWS_G06	Goulburn River Gorge 670m from LW413			9
NPWS_G07	Goulburn River Gorge 545m from LW414			-5
NPWS_G08	Goulburn River Gorge 595m from LW414			1
NPWS_G09	Above The Drip 740m from LW413			-6

The observed subsidence at the GNSS units is less than predicted. It is considered that the vertical subsidence measured at the GNSS units are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan.

2.5. Horizontal Movement

The observed vectors of total horizontal movement are presented in Drawing No. MSEC1511-05. The maximum observed total horizontal movement above the extracted longwalls is 588 mm at MCO12 located above LW404. The vectors show horizontal ground movements outside the longwall panels reduce with increasing distance from the longwalls. The observed maximum horizontal movements are consistent with the predictions provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. The report notes... "The maximum predicted conventional horizontal movement is, therefore, greater than 600 mm, i.e. 60 mm/m multiplied by a factor of 10. This prediction is considered to be conservative, with the actual horizontal movements expected to be generally less than 400 mm."

2.6. Far-field Horizontal Movement

The assessment of far-field horizontal movements at the MCC is based on a database of observed far-field horizontal movements due to incremental longwall extraction from the NSW coalfields including Ulan Coal Mine and MCC. The database of observed incremental far-field horizontal movements versus distance from the extracted longwalls is shown in Fig. 2.10. The observed far-field horizontal movements due to the extracted longwalls within UG4 have been highlighted in this figure. The database represents large variations in depth of cover from less than 50 m to greater than 600 m. In order to improve the data presentation for MCC where depth of cover is relatively shallow, the data has been plotted as shown in Fig. 2.11 against the distances from the nearest edge of the incremental panel divided by the depth of cover.

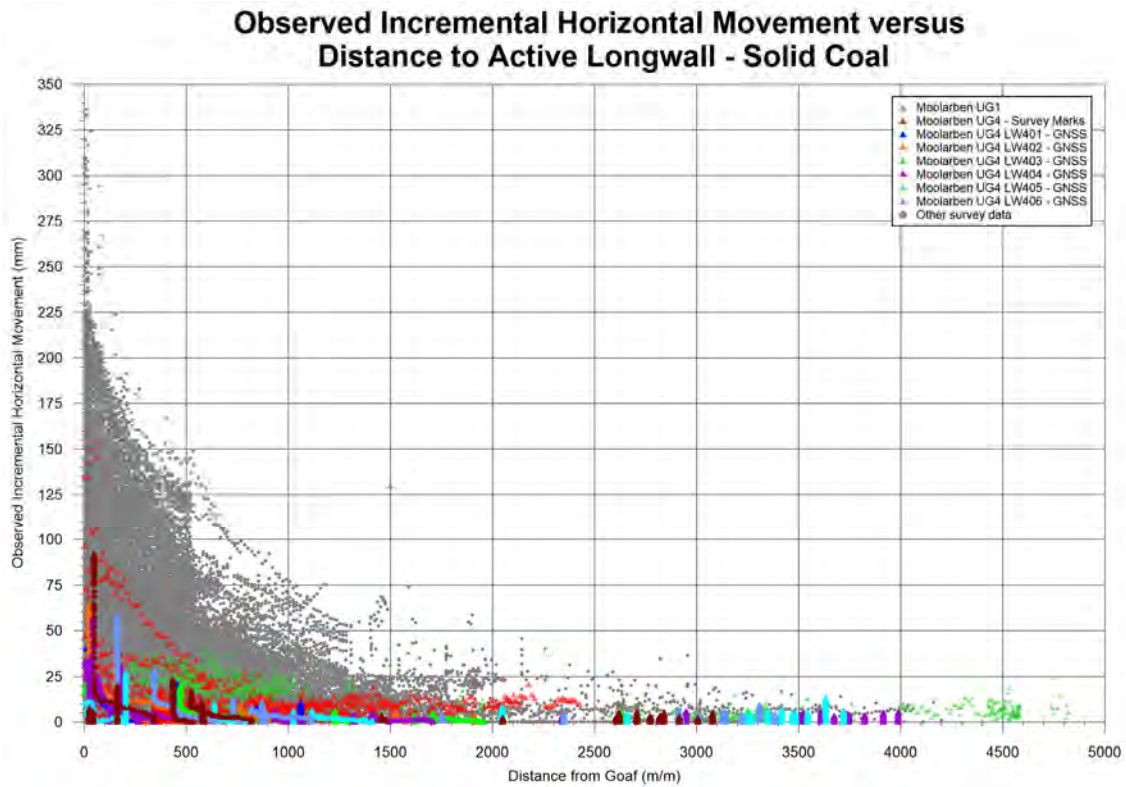


Fig. 2.10 Observed incremental horizontal movement versus distance to active longwall – solid coal

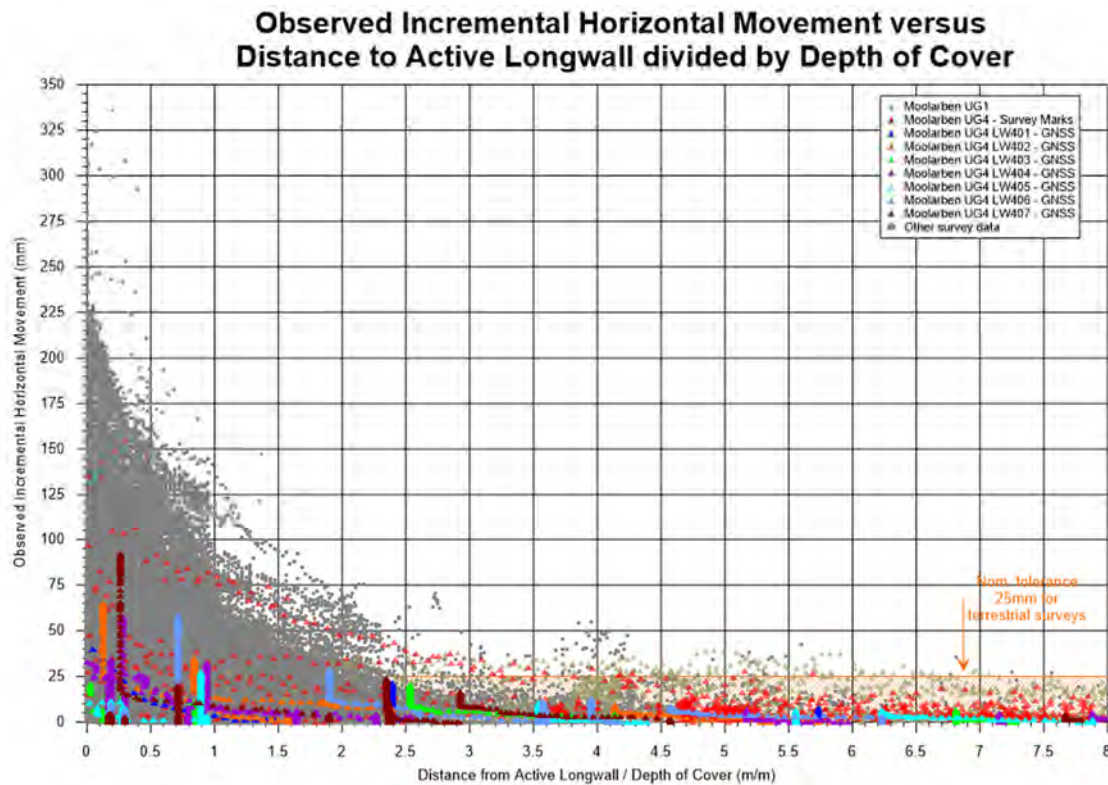


Fig. 2.11 Observed incremental horizontal movement versus distance to active longwall divided by depth of cover

It can be seen in Fig. 2.11 that MCC survey data is generally within the range of data from other regions in NSW. The majority of the GNSS monitoring data points indicates horizontal movements significantly less than the upper limits of the observed data.

The observed GNSS monitoring data from MCC provides a more accurate representation of potential horizontal movements within and surrounding the UG4 area for future longwall extraction. Monitoring of movements at The Drip, Corner Gorge and Goulburn River is based on an array of GNSS monitoring units within UG4 that have been established since the extraction of LW401. A plot of the GNSS monitoring data as **total** horizontal movement versus distance from extracted longwalls is presented in Fig. 2.12.

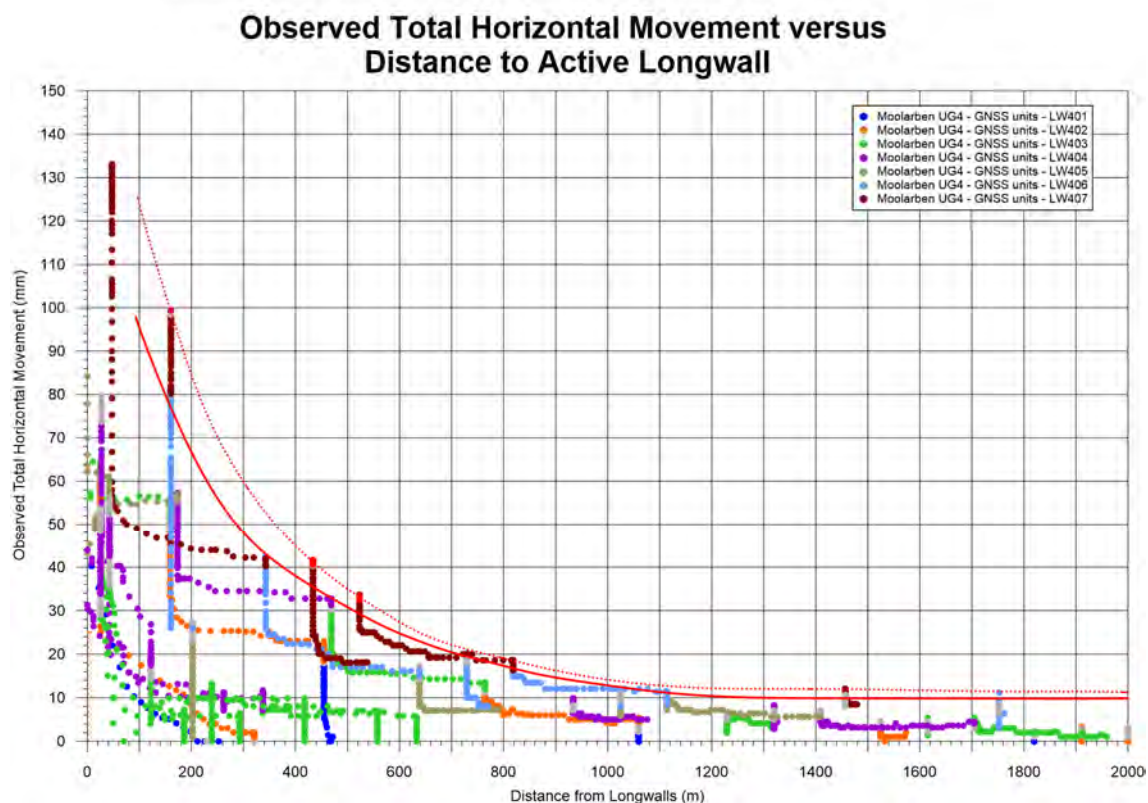


Fig. 2.12 Observed total horizontal movement versus distance to active longwall – UG4 GNSS

The accumulated total horizontal movement data in Fig. 2.12 shows the observed total far-field horizontal movement data ahead of the advancing UG4 longwalls. A red dashed upper bound line shown in Fig. 2.12 identifies the maximum observed total far-field horizontal movements for UG4. A red solid upper bound line shown in Fig. 2.12 represents a previous update to the data conducted in June 2025. It can be seen that the maxima have increased slightly from June 2025 to March 2026, which is expected at low magnitudes of movement and the accumulation of data.

At the minimum distances to The Drip (645 m) and Goulburn River Gorge (450 m) for the recently approved LW409-414, the maximum observed far-field horizontal movements are 25 mm and 40 mm respectively. These values compare with 22 mm and 35 mm for the data updated in June 2025.

At distances of 2,606 m to 3,079 m from LW407, the GNSS units located at The Drip and Goulburn River Gorge are not expected to experience mine subsidence related ground movements from the current UG4 longwall extraction. The observed movements at The Drip and Goulburn River Gorge are therefore considered to represent background variation from seasonal and atmospheric changes and equipment tolerance.

The loci plot of horizontal movement from Fig. A.25 is reproduced in greater detail below in Fig. 2.13. Radii of 8 mm and 10 mm are included in the figure. The distribution of changes in easting, northing and height from Fig. A.25 is shown below in Fig. 2.14.

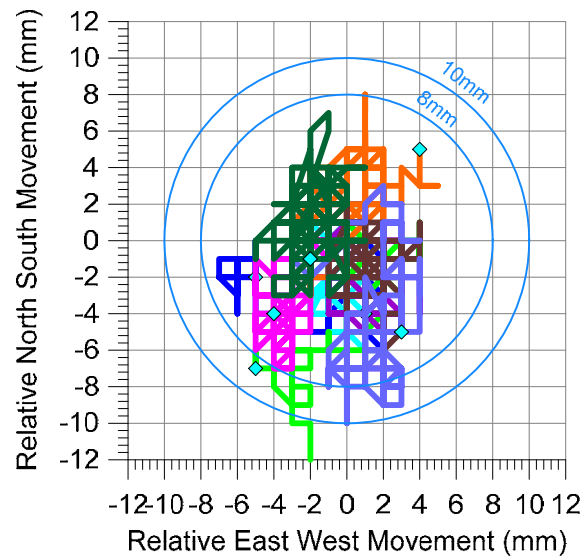


Fig. 2.13 Observed loci of horizontal movement – NPWS_G01 to G09

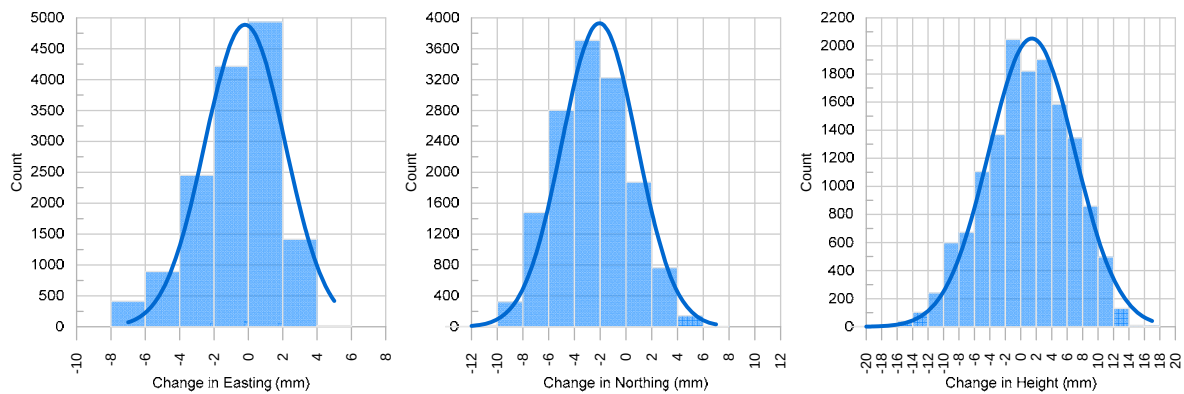


Fig. 2.14 Distribution of changes in vertical and horizontal movement – NPWS_G01 to G09

It can be seen in Fig. 2.13 that the majority of the horizontal movement data is within an 8 mm radius with horizontal movement up to 12mm. There appears to be a minor shift in a southwest direction, which is approximately 2 mm based on the change in northing distribution. While the shift to the south is towards the extracted longwalls, it is not certain that the shift is due to longwall extraction since other factors related to the environment or equipment could influence the baseline position. The average changes in easting and height are close to zero. Based on the above data, a baseline variation in horizontal movement of ± 10 mm is considered to be appropriate for The Drip and Goulburn River Gorge.

2.7. Opening and Closure movements

2.7.1. CL3

GNSS units MCO06, MCO18 and MCO19 were established at CL3 to provide data on vertical and horizontal movements and also differential movements. The differential movements between the three GNSS units at CL3 are shown in Fig. 2.15. The distance to these GNSS units of 434 to 584 m from LW407 represent similar distances to The Drip and Goulburn River Gorge from LW412 to LW414.

Total Opening and Closure at CL3 - GNSS Site MCO06 MCO17 MCO18

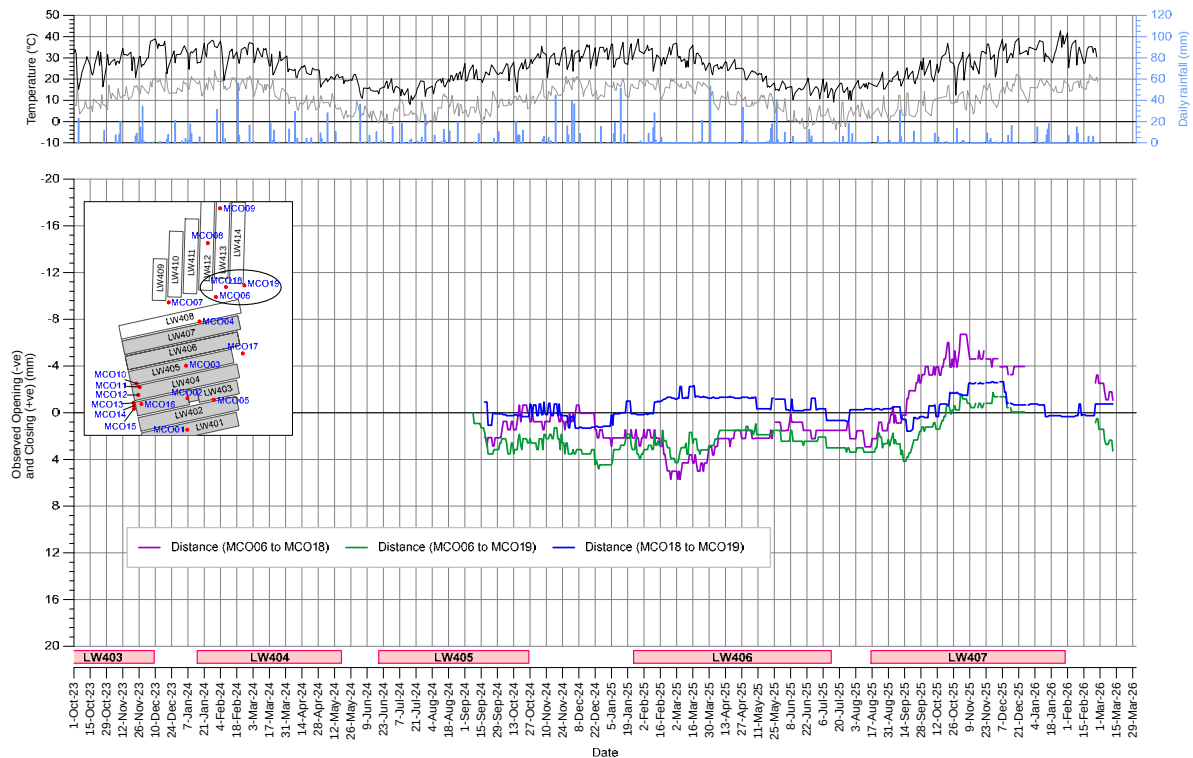


Fig. 2.15 Total observed opening and closure movements at CL3

The data presented in Fig. 2.15 represents the observed differential movements between the GNSS units since LW405, following the installation of MCO18 and MCO19. The observed differential movements showed minor development of opening during the extraction of LW407, with a maximum of -7 mm between MCO06 and MCO18. This magnitude of differential movement is small and within the limits of accuracy of the GNSS units. Given horizontal movements were observed at these GNSS units, it is considered that the observed minor opening is accurately represented. On this basis, no changes to predictions are required.

2.7.2. The Drip and Corner Gorge

A total of nine GNSS units is installed along the Goulburn River at The Drip and Goulburn River Gorge. The observed opening and closing movements between these units are presented below in Fig. 2.16 for opening/closing movements across the alignment of the Goulburn River, and in Fig. 2.17 for opening/closing movements along the alignments of the cliff lines.

The units NPWS_G01 to NPWS_G09 are located 2,606 m to 3,079 m from LW407 and at these distances, the vertical and horizontal movements are considered to represent baseline data without influence from the extraction of the current longwalls.

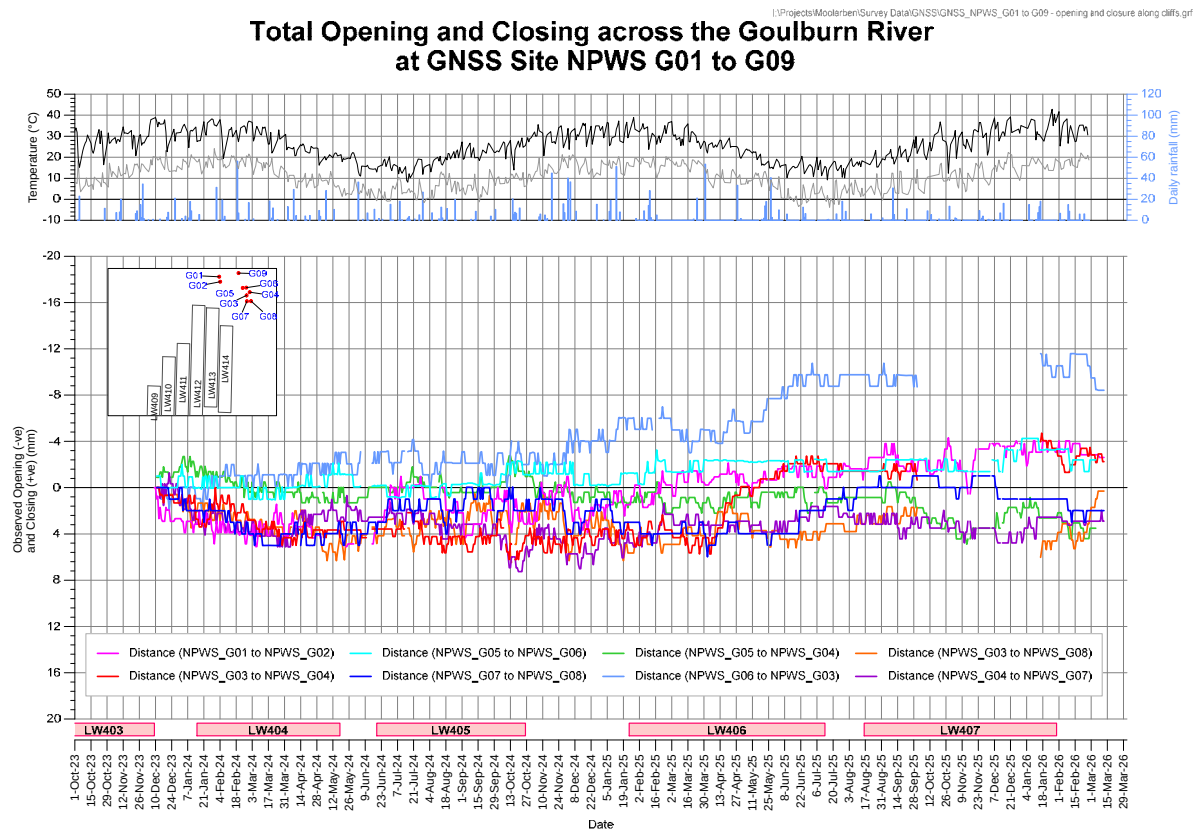


Fig. 2.16 Total observed opening and closure across the Goulburn River near The Drip and Corner Gorge

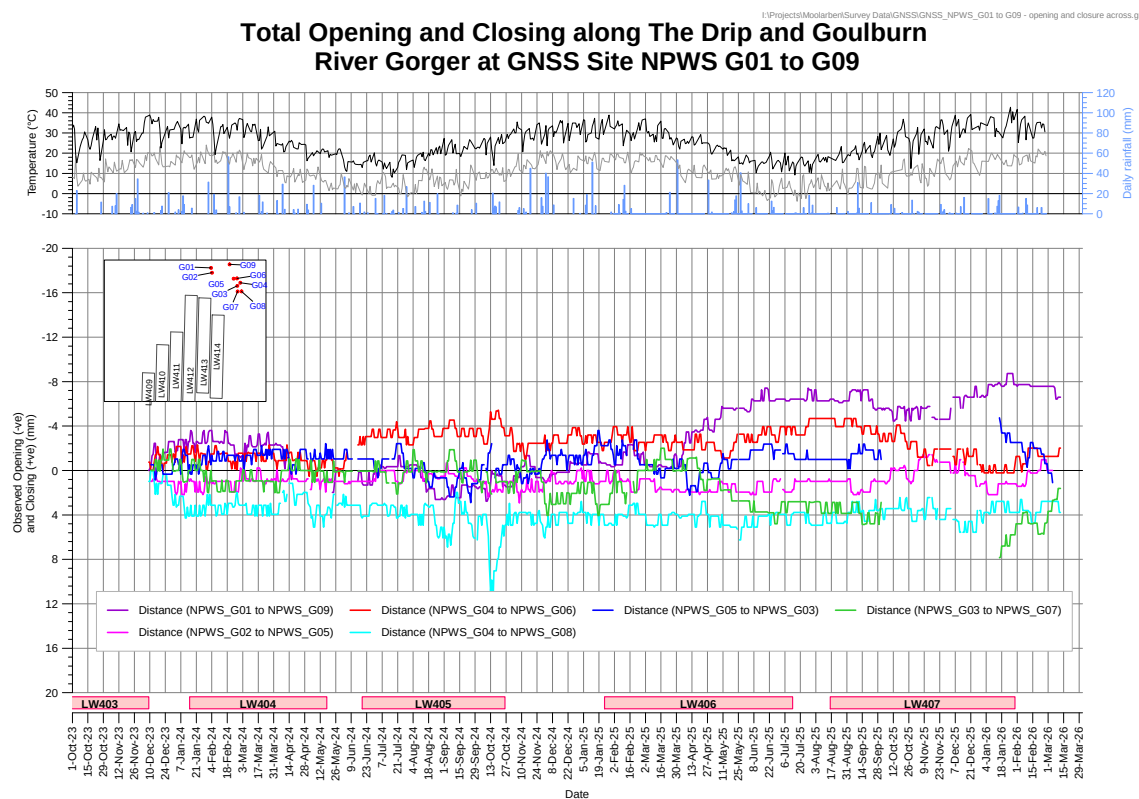


Fig. 2.17 Total observed opening and closure along cliffs at The Drip and Corner Gorge

With the exception of NPWS_G06 to NPWS_G03, the observed opening and closing movements across the Goulburn River vary from 7 mm to -4 mm, with the data predominantly within the limits of accuracy of the GNSS units. An opening movement of -11 mm was observed between NPWS_G06 to NPWS_G03 during the extraction of LW407. Given no similar movements were observed across the Goulburn River between the other GNSS units at Goulburn River Gorge, it is considered that this data is not representative of the overall opening/closing movements observed. A repair was carried out to NPWS_G03; therefore, accuracy of the data prior to the repair may have been impaired.

The observed opening and closing movements along the alignments of The Drip and Goulburn River Gorge Goulburn River vary from 12 mm to -9 mm, with the data predominantly within the limits of accuracy of the GNSS units. The maximum observed closure of 12 mm is shown as a spike in the data of NPWS_G04 to NPWS_G08 and is likely do to a short term loss of accuracy. The maximum opening of -9 mm occurs between NPWS_G01 to NPWS_G09. Given no similar movements were observed between the other GNSS units, it is considered that this data is not representative of the overall opening/closing movements observed. A repair was carried out to NPWS_G09; therefore, accuracy of the data prior to the repair may have been impaired. On this basis, no changes to predictions are required.

3.0 COMPARISON OF OBSERVED AND ASSESSED PHYSICAL IMPACTS

A summary of the natural, heritage and built features located near LW401-407 is provided in Section 1.3 and shown in Drawings No. MSEC1511-02 and 03. The assessed (i.e. predicted) impacts for these features due to the extraction of LW401-408 were provided in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. More detailed assessments for some natural and heritage features were provided in other consultants' reports associated with the LW401-408 Extraction Plan.

3.1. Comparison of observed and assessed physical impacts for the natural and heritage features

Comparisons between the MSEC assessments and the observed impacts for the key natural and heritage features due to the extraction of LW401-407 are provided in Table 3.1. The observed impacts are based on those recorded by the MCO field investigations and assessed by other specialist consultants. The comparisons provided below should be read in conjunction with the reports by the other consultants.

Table 3.1 Summary of the assessed and observed physical impacts for the natural and heritage features due to the extraction of LW401-407

Natural and heritage feature	MSEC assessed impacts*	Observed impacts
Drainage lines	Increased ponding could develop upstream of where the drainage lines cross the longwall edges	Minor cracking reported for Bora Creek and Drainage Line 1. Impact consistent with predictions.
	Fracturing and dilation of the bedrock	
	Diversion of surface water flows into the dilated strata beneath the stream beds	
Goulburn River	Adverse impacts unlikely to occur	No observed impacts due to the extraction of LW401-407.
The Drip and Goulburn River Gorge	Adverse impacts unlikely to occur	No mining-related impacts observed due to the extraction of LW401-407. Observed rock fall March 2024 assessed as natural separation.
CL3	Adverse impacts unlikely to occur	Negligible mining-related impacts observed due to the extraction of LW401-407.
Minor Cliffs	Fracturing, rockfalls and slabbing	No observed impacts to minor cliffs (including CL7 and minor cliffs in Goulburn River National Park within 400 m of longwalls) due to the extraction of LW401-407.
Threatened Ecological Community	Increased ponding could develop directly above mining	No mining-related impacts recorded due to the extraction of LW401-407.
	Surface cracking directly above mining	No mining-related impacts recorded due to the extraction of LW401-407.
Aboriginal Heritage Site 280	Revised subsidence likelihood reduced to moderate	No observed impacts due to the extraction of LW401-407. Management plan successfully implemented for Aboriginal Heritage Site 280 for the extraction of LW402-403.

Note: * MSEC assessed impacts are based on Report MSEC1165, which supported the LW401-408 Extraction Plan.

It is considered that the observed physical impacts at the natural and heritage features due to the mining of LW401-407 are consistent with those assessed in Report MSEC1165, which supported the LW401-408 Extraction Plan.

Further assessment undertaken by other specialist consultants are described in the relevant reports accompanying the LW401-407 End of Panel Report.

3.2. Comparison of observed and assessed physical impacts for the built features

Comparisons between the MSEC assessments and the observed physical impacts for the built features due to the extraction of LW401-407 are provided in Table 3.2. The observed impacts are based on those recorded by the MCO field investigations.

Table 3.2 Summary of the assessed and observed physical impacts for the built features due to the extraction of LW401-407

Built feature	MSEC assessed impacts*	Observed impacts
Sandy Hollow – Gulgong Railway Line	No adverse impacts anticipated	The Sandy Hollow – Gulgong Railway Line is located outside the LW401-408 Study Area. No observed or reported defects, deformation or displacement of joints in culverts due to the extraction of LW401-407.
Wollar-Wellington 330 kV transmission line		In consultation with TransGrid, no BFMP was required due to no predicted impacts of the Wollar-Wellington 330kV transmission line. No management measures have been developed.
Essential Energy 66 kV/22 kV line and power poles		The Essential Energy 66 kV/22 kV line and power poles are located outside the LW401-408 Study Area. No observed or reported impacts due to the extraction of LW401-407.
Telecommunications tower and telecommunications cables		The telecommunication cable, optical fibre cable and tower are located outside the LW401-408 Study Area. No observed or reported impacts due to the extraction of LW401-407.
Ulan Road and bridges		Ulan Road and bridges are located outside the LW401-408 Study Area. No observed or reported impacts due to the extraction of LW401-407.
Millers Dam Compound and associated infrastructure		The UCMPL Millers Dam Compound and associated infrastructure are located outside the LW401-408 Study Area. No observed or reported impacts due to the extraction of LW401-407.
Dronvisa Quarry		Dronvisa Quarry is located above the finishing end of LW403, 404 and 405. Impact consistent with predictions.

Note: * MSEC assessed impacts are based on Report MSEC1165, which supported the LW401-408 Extraction Plan.

It is considered that the observed physical impacts at built features above the longwalls are less than those assessed in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. The observed impacts have been managed in accordance with the Built Features Management Plans.

3.3. Performance measures

The subsidence impact performance measures outlined in Table 14 and Table 15 in Schedule 3 of the MCP Stage 1 Approval (05_0117) are provided below in Table 3.3, as well as subsidence impact performance indicators developed to ensure that the performance measures are achieved as predicted in the LW401-408 Extraction Plan.

Discussions on the reported impacts have also been provided for each of these performance measures.

Table 3.3 Summary of the subsidence impact performance measures and indicators for the natural, heritage and built features due to the extraction of LW401-407

Subsidence Impact Performance Measure (Stage 1 Project Approval [05_0117])		Subsidence Impact Performance Indicator	Indicators Exceeded?	Performance Measures Exceeded?
Natural and Heritage Features				
The Drip and Goulburn River Gorge	Nil impact or environmental consequences	No specific subsidence performance indicator developed for the Drip and Corner Gorge; however, relevant criteria are included in future Extraction Plan and will apply to future assessments where relevant	N/A – baseline monitoring only.	No
Goulburn River and the bed of the Goulburn River	Negligible impact or environmental consequences. Remain outside the zone of recorded subsidence damage for longwall mining	Unpredicted impacts on Goulburn River (cracking and or noticeable changes in erosion or pools) during LW401-408.	No	No
Cliff Line 3	Minimise subsidence damage	CL3 impacts due to LW401-408 are less than 1.9 m vertical conventional subsidence and 60 mm/m conventional tilt.	No	No
Minor cliffs in Goulburn River National Park within 400m of Longwall	N/A	Negligible impact due to longwall mining for Minor Cliffs in Goulburn River National Park.	No	N/A
Aboriginal Heritage Site 280	Reduce the likelihood of subsidence damage to moderate.	Revised subsidence likelihood reduced to moderate.	No	No
Key Public Infrastructure				
Gulgong-Sandy Hollow Railway Line	Always safe and serviceable. Damage that does not affect safety or serviceability must be fully repairable, and must be fully repaired	- No defects or deformation of the rail track and associated infrastructure due to UG4 mining; and - No visual displacement at joints or cracks in culverts due to UG4 mining.	No	No
Wollar-Wellington 330kV Transmission Line		No performance indicators were developed for the transmission line.	N/A – no predicted impacts from LW401-407	No
Other Infrastructure				
Roads:				
Ulan Road		No joint displacement or cracking or other defects of the drainage structure (e.g. pipes/culverts) in excess of 5 mm (when compared against baseline condition) due to UG4 mining.	No	No
Ulan Road Bridge over the Sandy-Hollow Railway Line	Safe, serviceable and repairable unless the owner agrees otherwise in writing.	No performance indicators were developed for the Ulan Road Bridge over the Sandy-Hollow Railway Line and the Ulan Road Bridge over the Goulburn River.	N/A – no predicted impacts from LW401-407	No
Ulan Road Bridge over the Goulburn River				

Subsidence Impact Performance Measure (Stage 1 Project Approval [05_0117])	Subsidence Impact Performance Indicator	Indicators Exceeded?	Performance Measures Exceeded?
Other built features and improvements, including fences:			
Telstra optical fibre telecommunication cable Telstra copper telecommunication cable Telstra telecommunication tower	Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.	- Negligible transmission loss from mine subsidence impacts; - Negligible impacts on structural integrity of the cable lines from mine subsidence; and - Negligible impacts on structural integrity of the communications tower from mine subsidence.	No No
Essential Energy 66 kV/22 kV line and power poles	Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.	The structural integrity of the powerline (power poles and transmission lines) is maintained.	No No
UCMPL Millers Dam Compound and associated infrastructure, Bridge, Bore and Monitoring Piezometers	Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.	Subsidence monitoring indicates subsidence is consistent with approved impacts.	No No
Dronvisa Quarry	Serviceability should be maintained wherever practicable. Loss of serviceability must be fully compensated. Damage must be fully repairable, and must be fully repaired or else replaced or fully compensated.	Subsidence monitoring indicates subsidence is consistent with approved impacts.	No No
Public Safety			
Public Safety	Negligible additional risk.	No more than negligible additional risk to public safety.	No No

4.0 SUMMARY AND RECOMMENDATIONS

During the extraction of LW401-407, subsidence movements were monitored using monitoring lines K to N, R, and S, and an array of GNSS monitoring units. Specific natural, heritage and built features monitored included the Ulan-Wollar Rail line, Essential Energy 66 kV/22 kV line and power poles, a Telstra telecommunications tower, cliffs and drainage lines and Aboriginal Heritage site S1MC280.

The ground movements measured during LW401-407 were similar to or less than those predicted in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. It is therefore not considered necessary to re-calibrate the prediction method based on the currently available monitoring data.

It is considered that based on the monitoring completed, the impacts on the natural, heritage and built features are similar to those assessed in Report No. MSEC1165, which supported the LW401-408 Extraction Plan. These impacts have been managed in accordance with the LW401-408 Extraction Plan. Further assessment undertaken by other specialist consultants are described in the relevant reports accompanying the LW401-407 End of Panel Report.

The far-field horizontal movement data from GNSS monitoring units has been used to develop a database of total horizontal movement specific to UG4. The database has gathered total horizontal movement data from the extraction of LW401-407. As can be seen from this report, the GNSS monitoring data shows far-field horizontal movements are within the range of incremental movements from the database of MCO monitoring and monitoring from other collieries. While the developing database of total far-field horizontal movements shows a slight increase in the maxima, which may increase further with the cumulation of GNSS data, no physical impacts have been identified due to the extraction of LW401-407. MCO have installed a further five GNSS monitoring units between LW409-414 to provide additional far-field monitoring data. With the accumulation of total GNSS monitoring data, further analysis could be carried out including statistical analysis of baseline values for each GNSS unit and analysis of far-field horizontal movement data such as location dependent influences (e.g. side vs end locations). To date, baseline horizontal movements at The Drip and Corner Gorge are consistent with predictions.

No changes to the subsidence monitoring program and TARPs provided in the LW409-414 Extraction Plan are proposed in consideration of the review of subsidence monitoring and performance measures/indicators for LW401-407.

APPENDIX A. DRAWINGS



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Tel +61 2 9413 3777
www.minesubsidence.com



MOOLARBEN COAL PROJECT

UG4 MONITORING REVIEW

LW407 END OF PANEL

GENERAL LAYOUT & MONITORING

DATE: 13 Aug 2026	SCALE: as shown	DRAWING No: MSEC1511-01	Rev No A
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LEGEND

- Monitoring Locations
- Cliffs
- Minor Cliffs
- Watercourse

0m 500m 1000m
SCALE

GOULBURN RIVER STATE
CONSERVATION

GOULBURN RIVER
NATIONAL PARK

The Drip
CL5

Goulburn River
Gorge

GOULBURN RIVER
NATIONAL PARK

BORA CREEK

GOULBURN
RIVER

ARTC2 Line

Power Poles

SANDY HOLLOW GULFONG RAILWAY

UG4

Y Line SIM280Y

X Line

L Line

M Line

K Line

N Line

S Line

R Line

CL1

CL2

CL3

CL4

CL6

CL7

CL8

LW401

LW402

LW403

LW404

LW405

LW406

LW407

LW408

MCO01

MCO02

MCO03

MCO04

MCO05

MCO06

MCO07

MCO08

MCO09

MCO10

MCO11

MCO12

MCO13

MCO14

MCO15

MCO16

MCO17

MCO18

MCO19

NPWS_G01

NPWS_G02

NPWS_G03

NPWS_G04

NPWS_G05

NPWS_G06

NPWS_G07

NPWS_G08

NPWS_G09

Start LW401 - 12 Jun 2018

Finish LW401 - 12 Jun 2018

Start LW402 - 15 Jan 2022

Finish LW402 - 15 Jan 2022

Start LW403 - 31 Jul 2023

Finish LW403 - 31 Jul 2023

Start LW404 - 15 Jan 2024

Finish LW404 - 15 Jan 2024

Start LW405 - 9 Jun 2024

Finish LW405 - 9 Jun 2024

Start LW406 - 15 Jan 2025

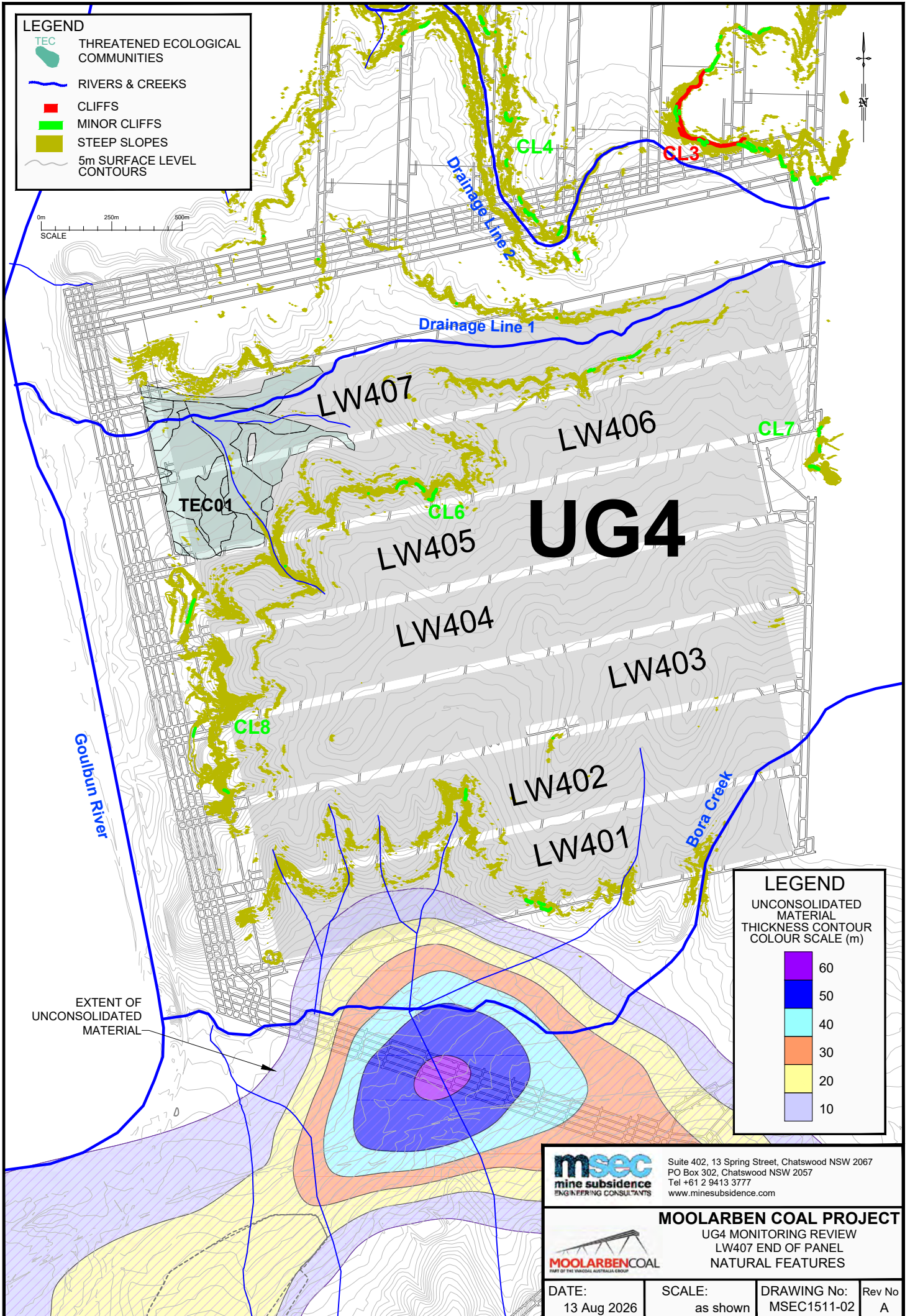
Finish LW406 - 15 Jan 2025

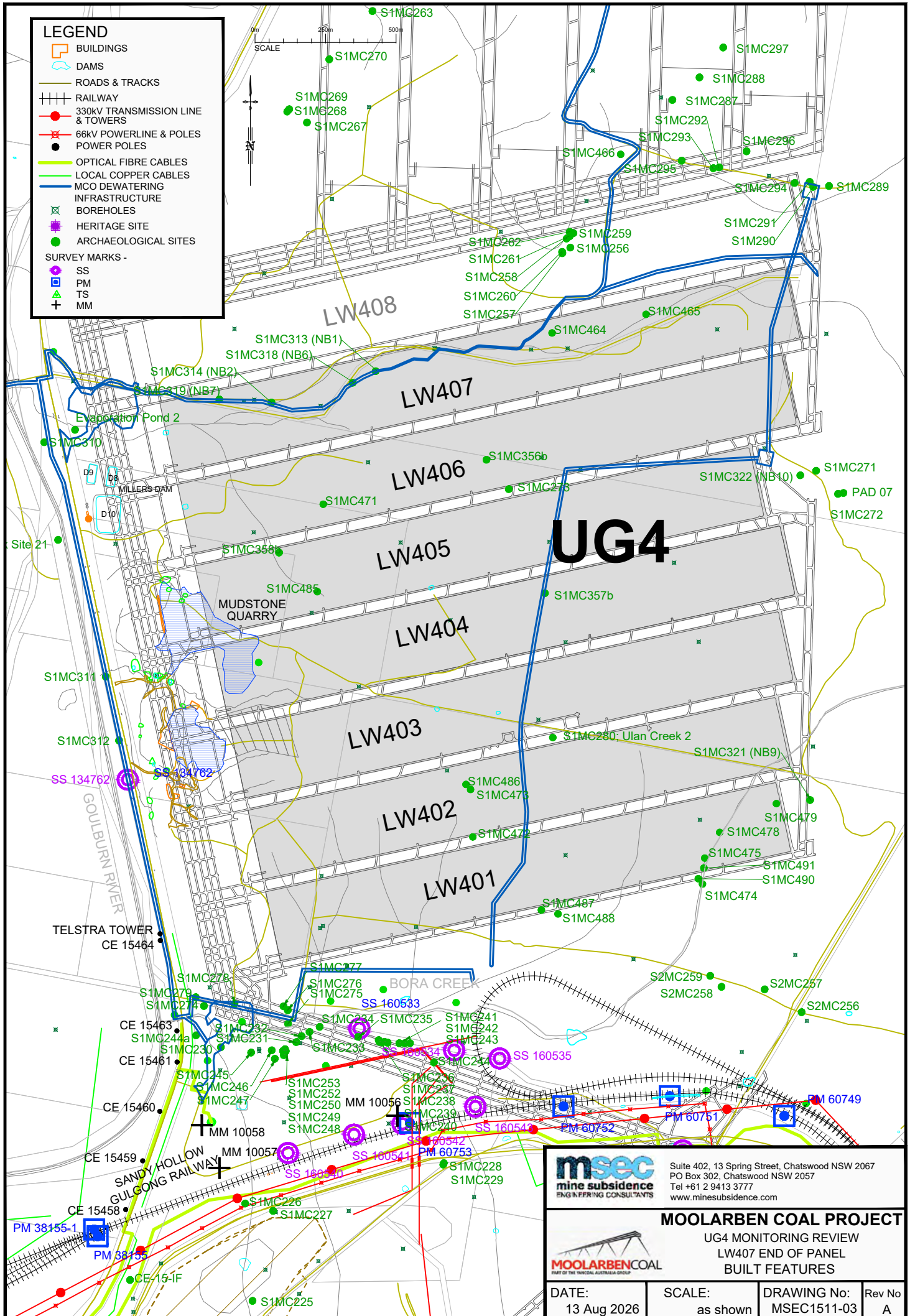
Start LW407 - 15 Jan 2026

Finish LW407 - 15 Jan 2026

Start LW408 - 30 Jan 2026

Finish LW408 - 30 Jan 2026







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MOOLARBEN COAL PROJECT
UG4 MONITORING REVIEW
LW407 END OF PANEL
PREDICTED TOTAL SUBSIDENCE
AFTER LW407 AT 31 DEC 2025

DATE:
13 Aug 2026

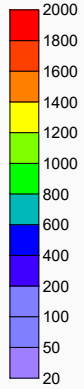
SCALE:
as shown

DRAWING No:
MSEC1511-04

Rev No
A

NOTE:
The value of the Subsidence Contours, from the outside to the inside of the panels, are 20mm, 50mm, 100mm, 200mm and so forth, in 200mm increments.
The maximum subsidence is shown in brackets - ie. 1890

LEGEND
SUBSIDENCE CONTOUR
COLOUR SCALE (mm)



0m 250m 500m
SCALE



UG4

LW408

LW407

LW406

LW405

LW404

LW403

LW402

LW401

(1800)

(1890)

(1900)

(1890)

(1890)

(1890)

(1850)

GOULBURN
RIVER

BORA CREEK

SANDY HOLLOW
GULGONG RAILWAY



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MOOLARBEN COAL PROJECT
UG4 MONITORING REVIEW
LW407 END OF PANEL
VECTORS OF TOTAL HORIZONTAL
MOVEMENTS

DATE:
13 Aug 2026

SCALE:
as shown

DRAWING No:
MSEC1511-05

Rev No
A

VECTOR & MAGNITUDE OF OBSERVED
HORIZONTAL MOVEMENT (mm)



GNSS



SURVEY PEGS



0m 250m 500m
SCALE

Location Goulburn River Gorge & The Drip

UG4

See inset map for location of
Galston River Gorge & The Drip

LW408

LW407

LW406

LW405

LW404

LW403

LW402

LW401

Dams

R Line

GOLBURN RIVER

M Line

K Line

BORA CREEK

SANDY HOLLOW
GULGONG RAILWAY

ARTC2 Line

Y Lne (SIM280)

X Lne (EWS)

0m 250m 500m
SCALE

APPENDIX B. GNSS FIGURES

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO01

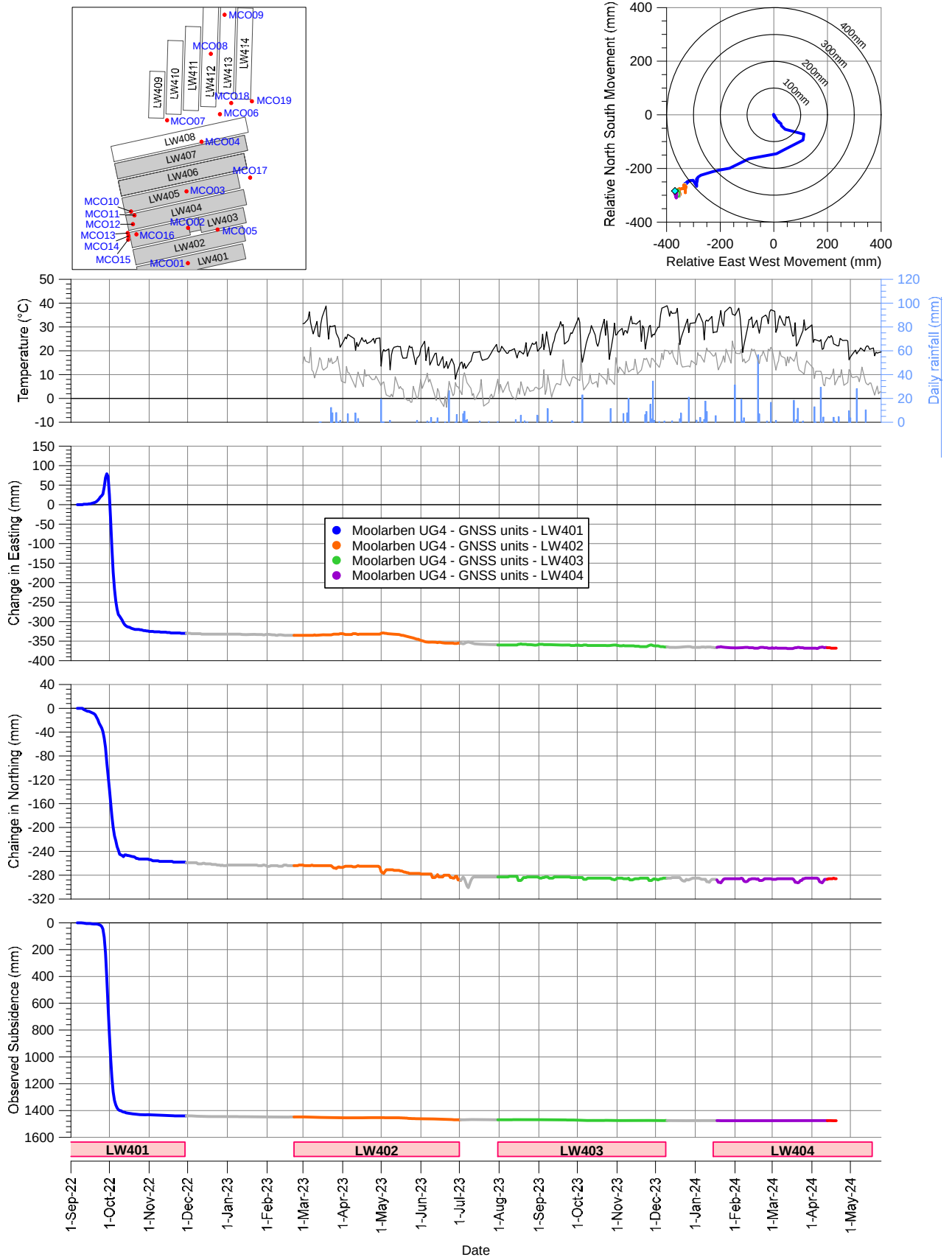


Fig. A.1 Total horizontal movement and vertical subsidence at GNSS Site MCO01

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO02

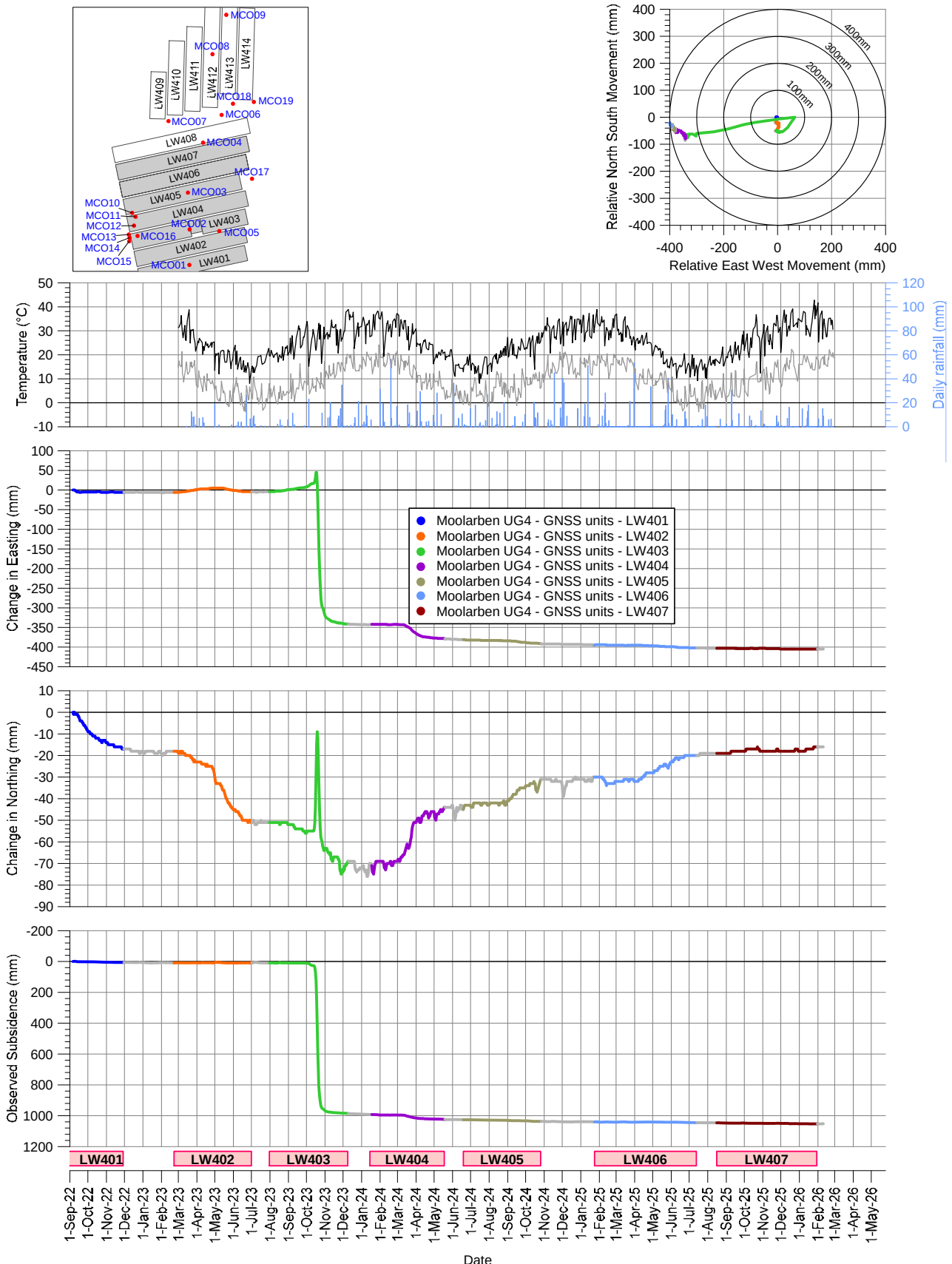


Fig. A.2 Total horizontal movement and vertical subsidence at GNSS Site MCO02

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO03

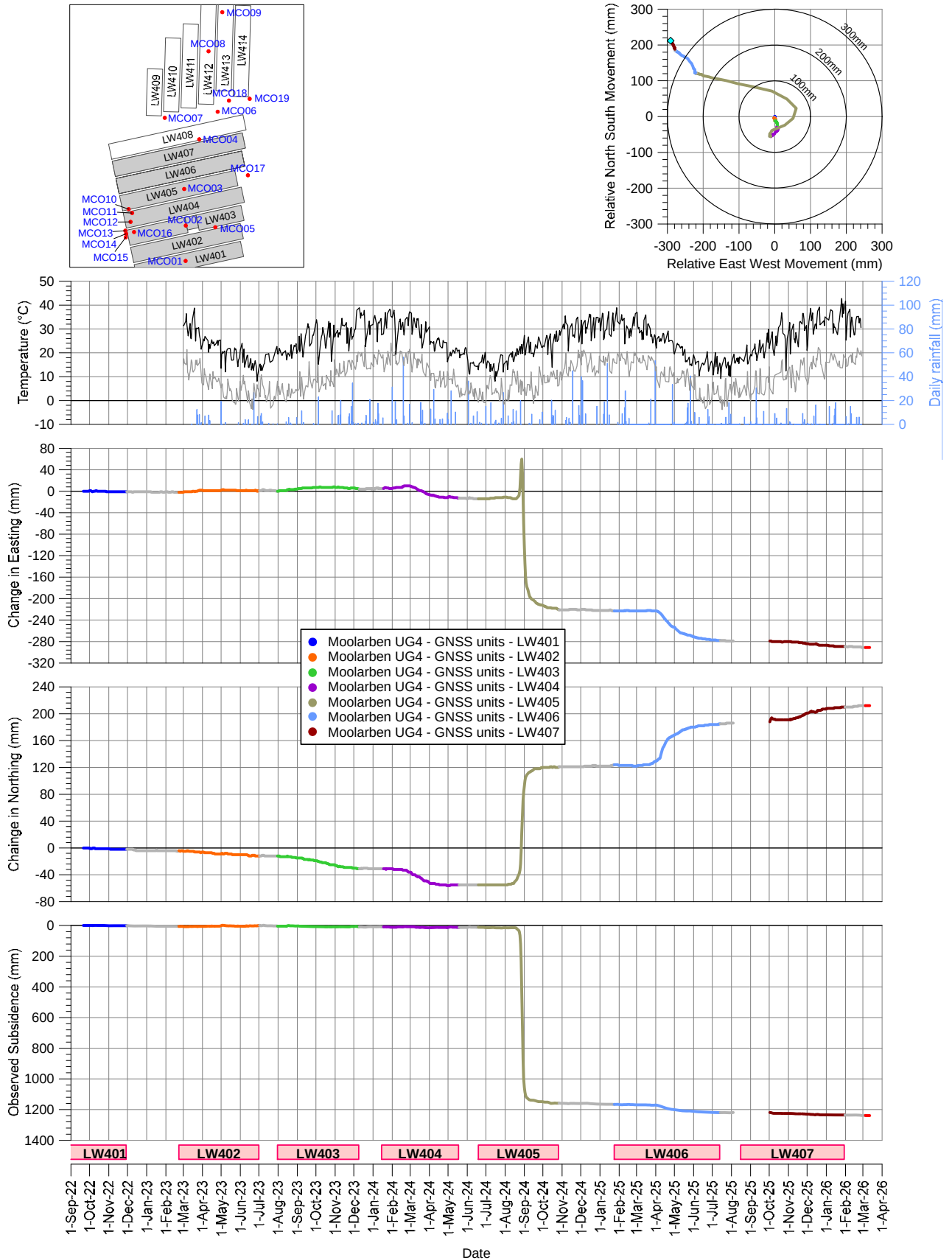


Fig. A.3 Total horizontal movement and vertical subsidence at GNSS Site MCO03

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO04

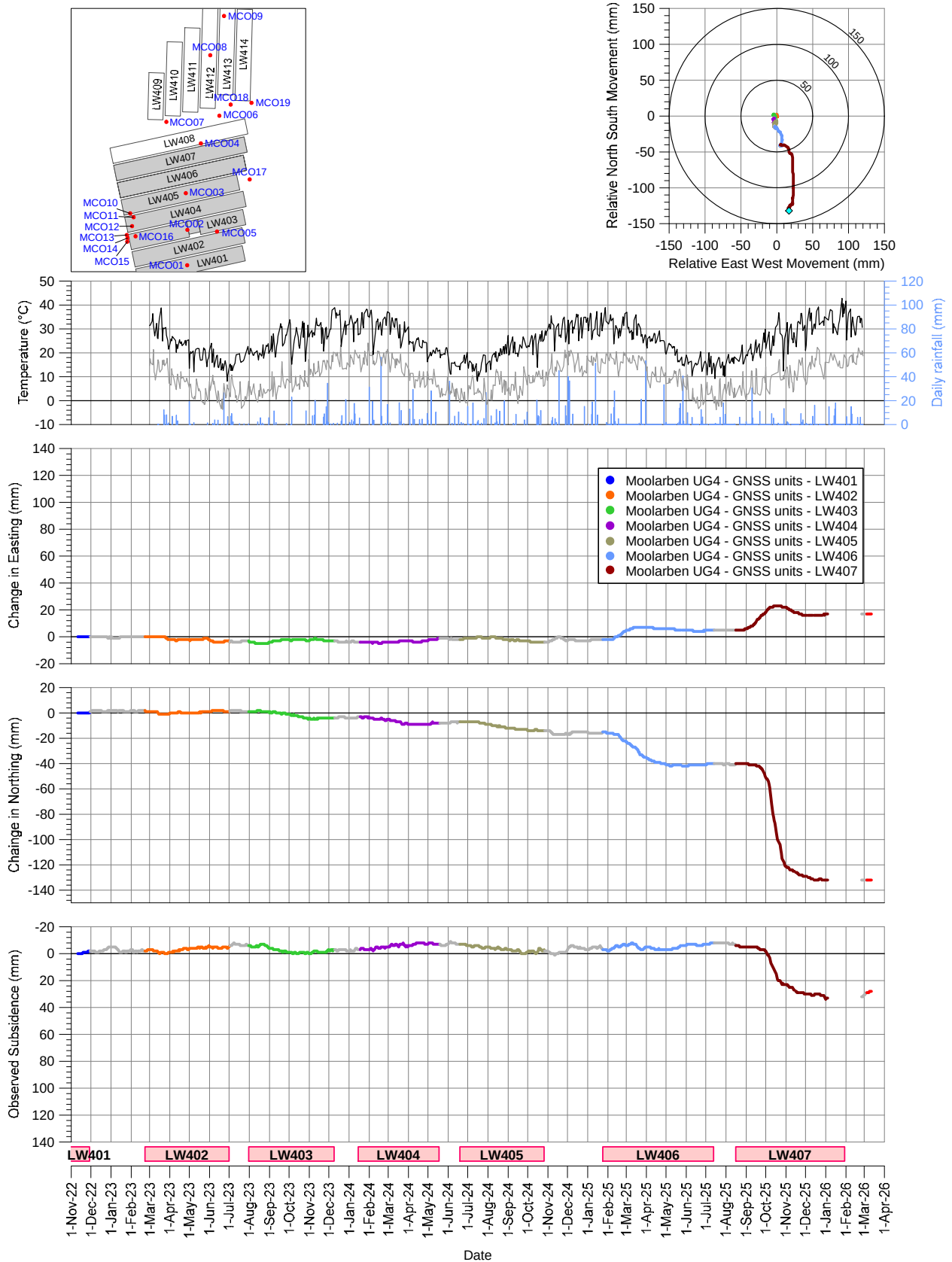


Fig. A.4 Total horizontal movement and vertical subsidence at GNSS Site MCO04

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO05

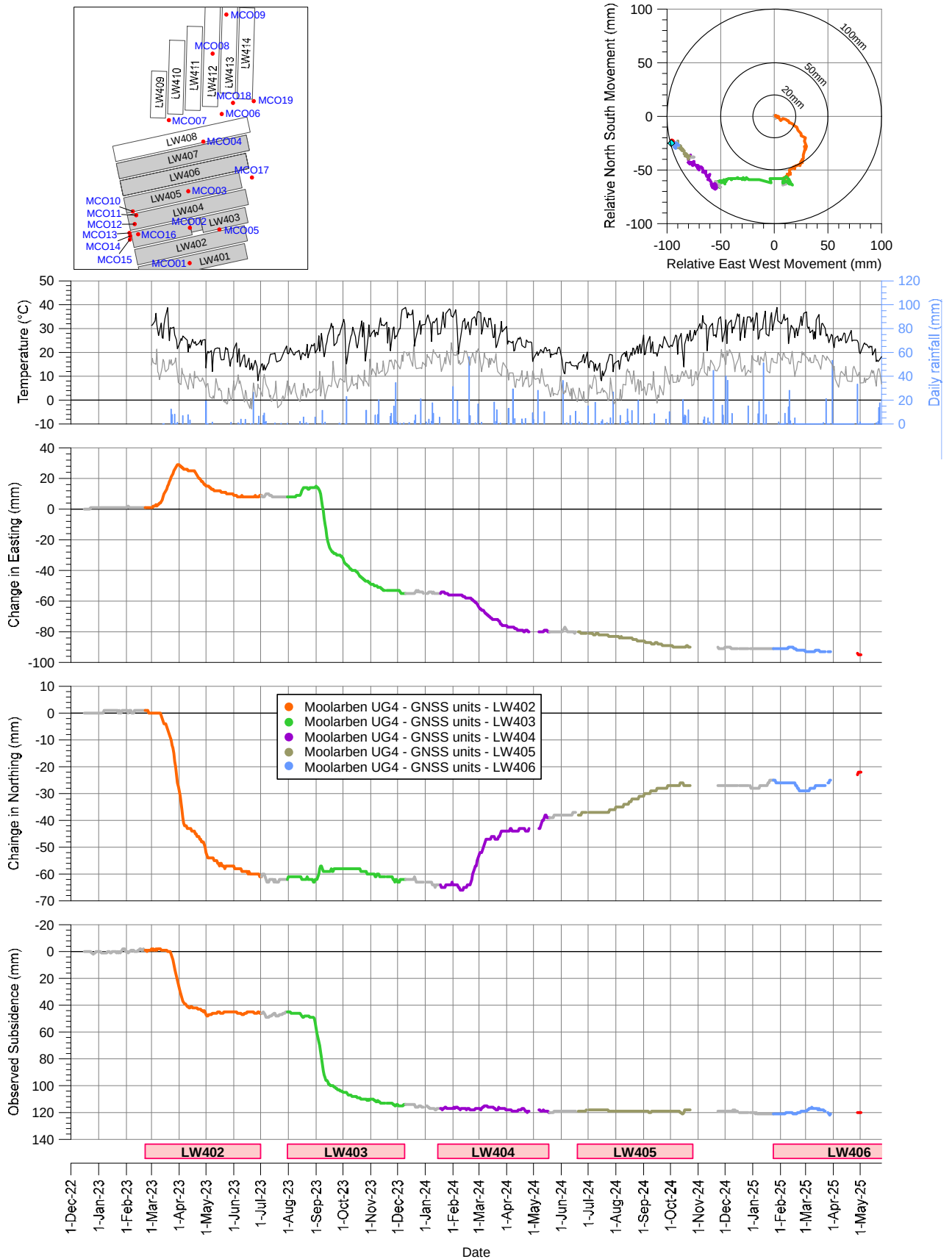


Fig. A.5 Total horizontal movement and vertical subsidence at GNSS Site MCO05

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO06

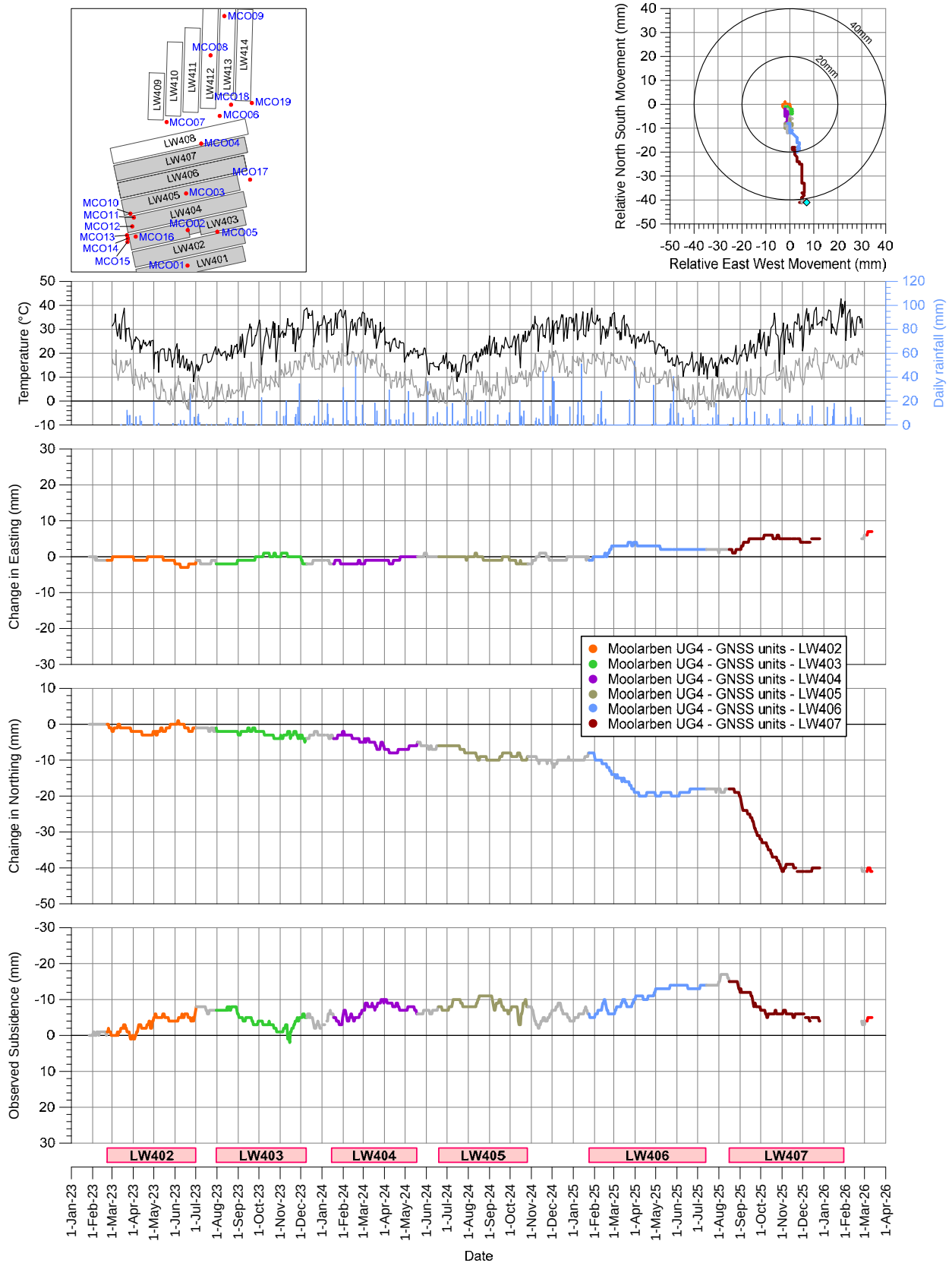


Fig. A.6 Total horizontal movement and vertical subsidence at GNSS Site MCO06

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO07

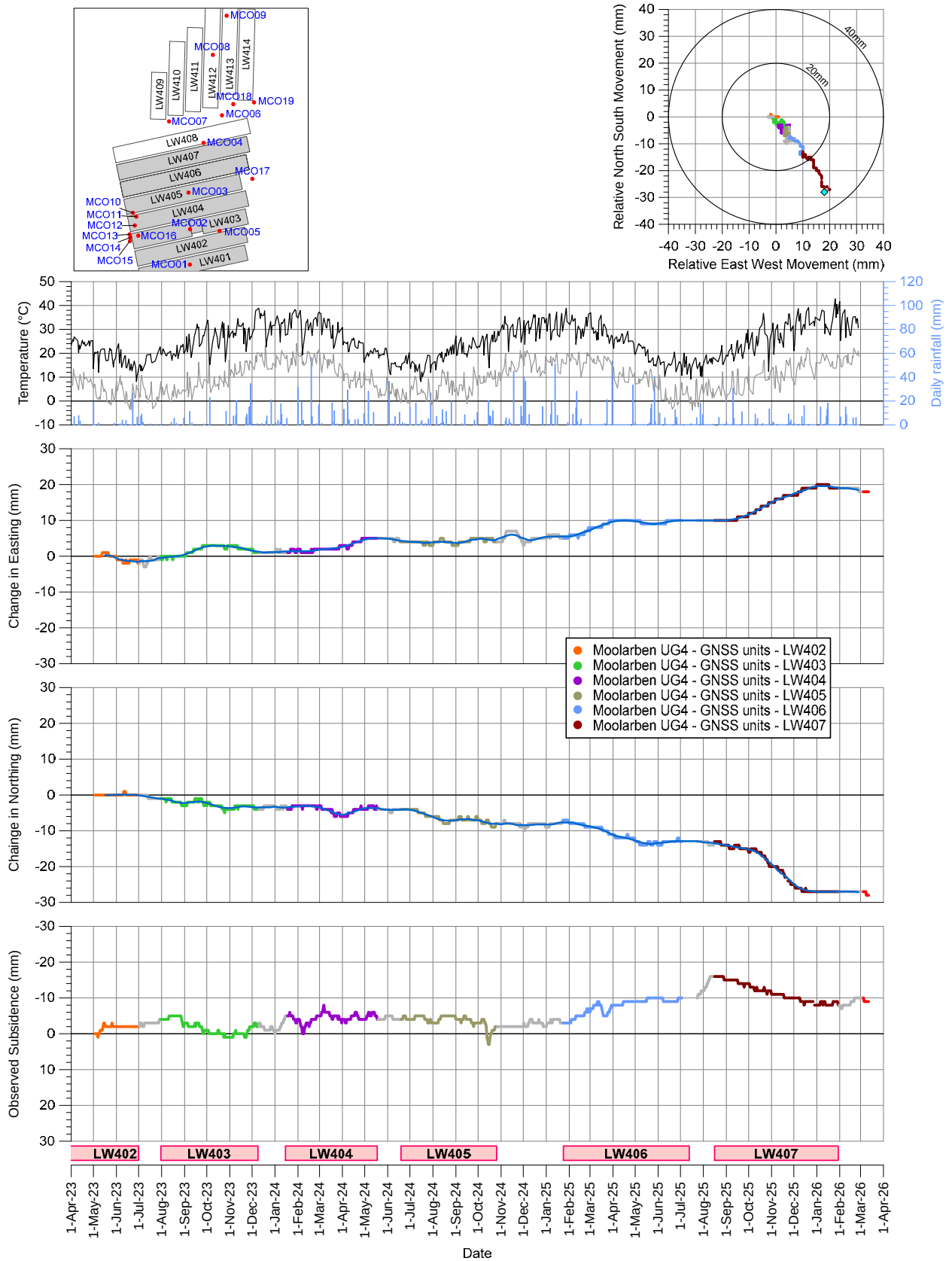


Fig. A.7 Total horizontal movement and vertical subsidence at GNSS Site MCO07

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO08

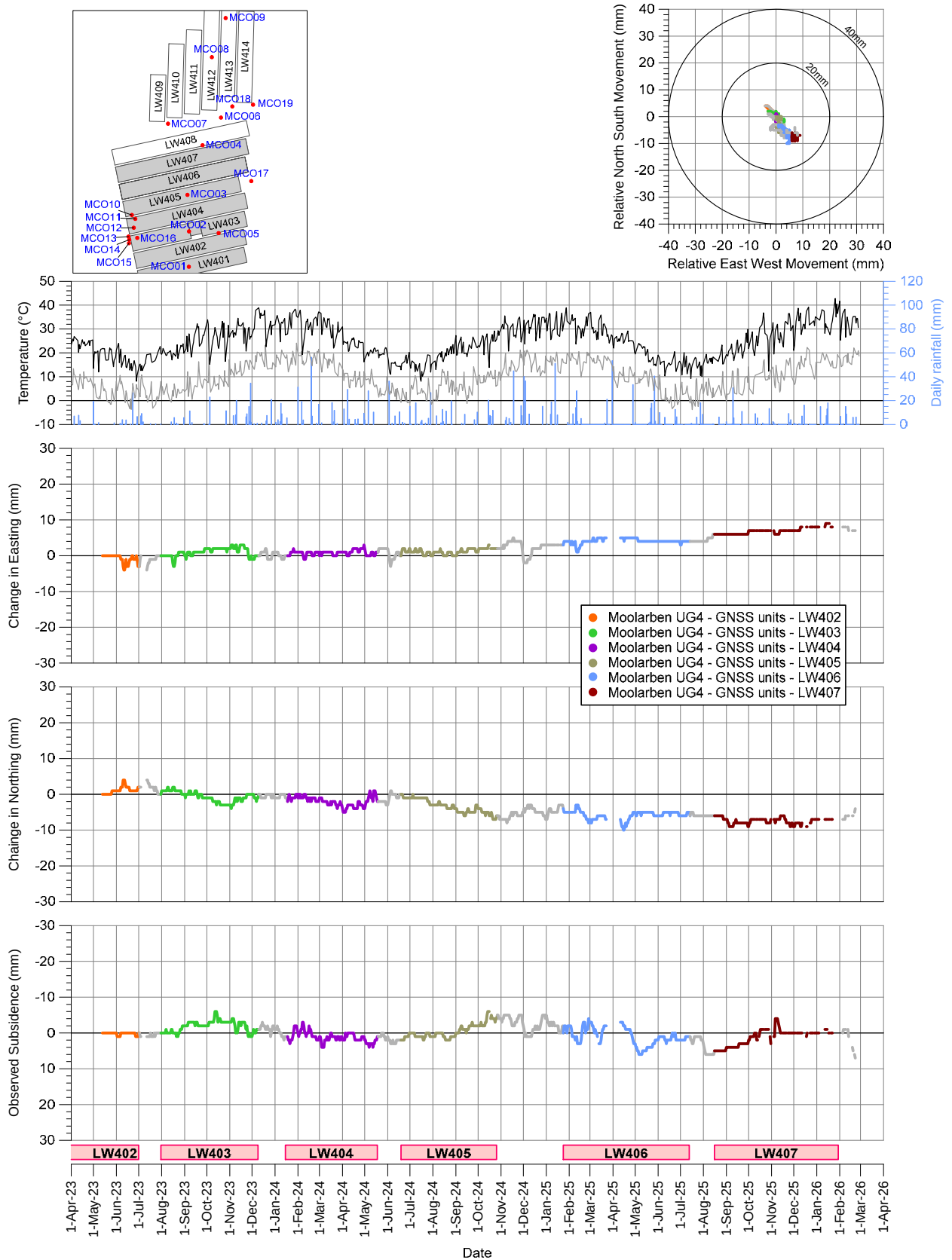


Fig. A.8 Total horizontal movement and vertical subsidence at GNSS Site MCO08

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO09

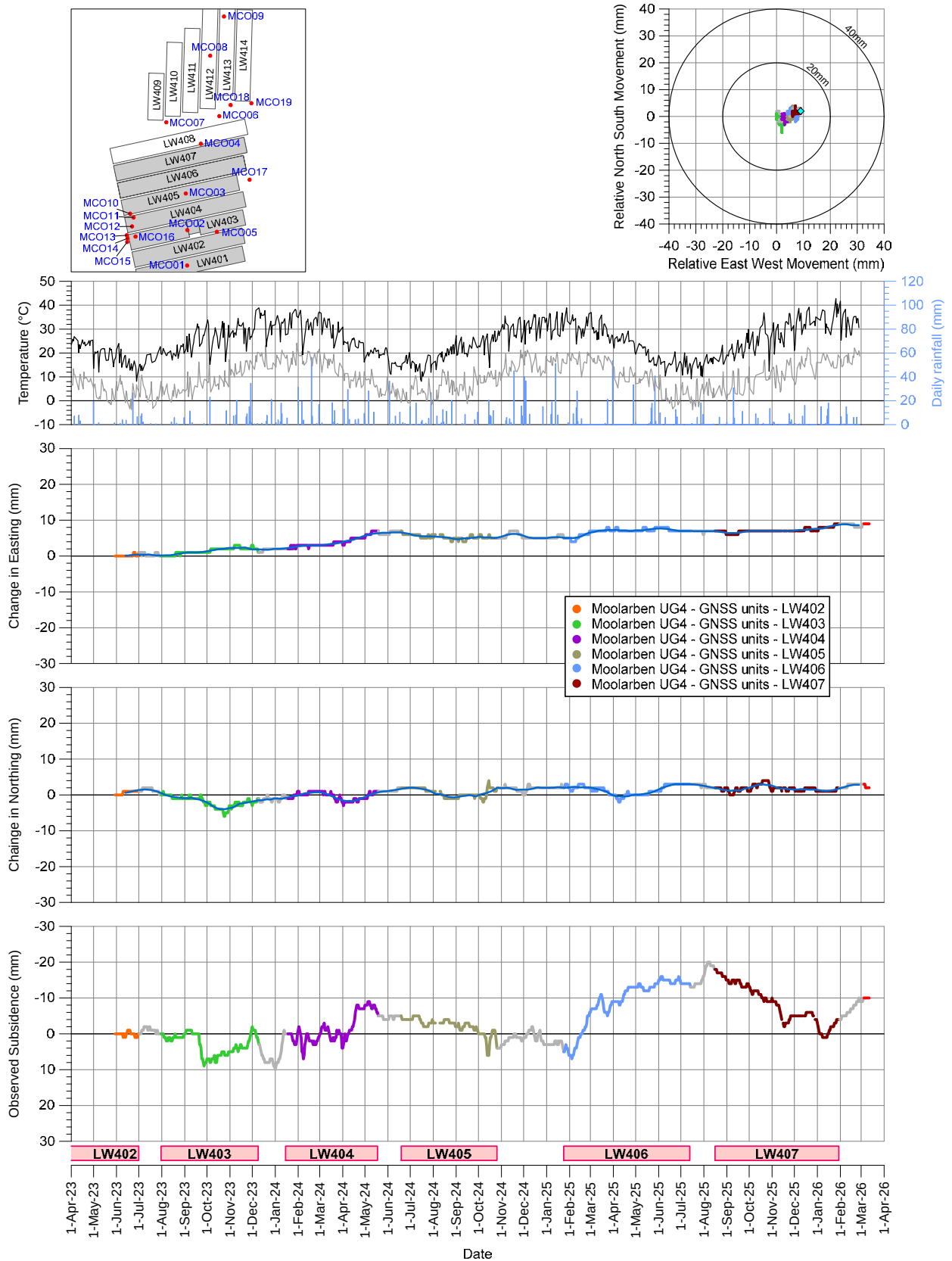


Fig. A.9 Total horizontal movement and vertical subsidence at GNSS Site MCO09

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO10

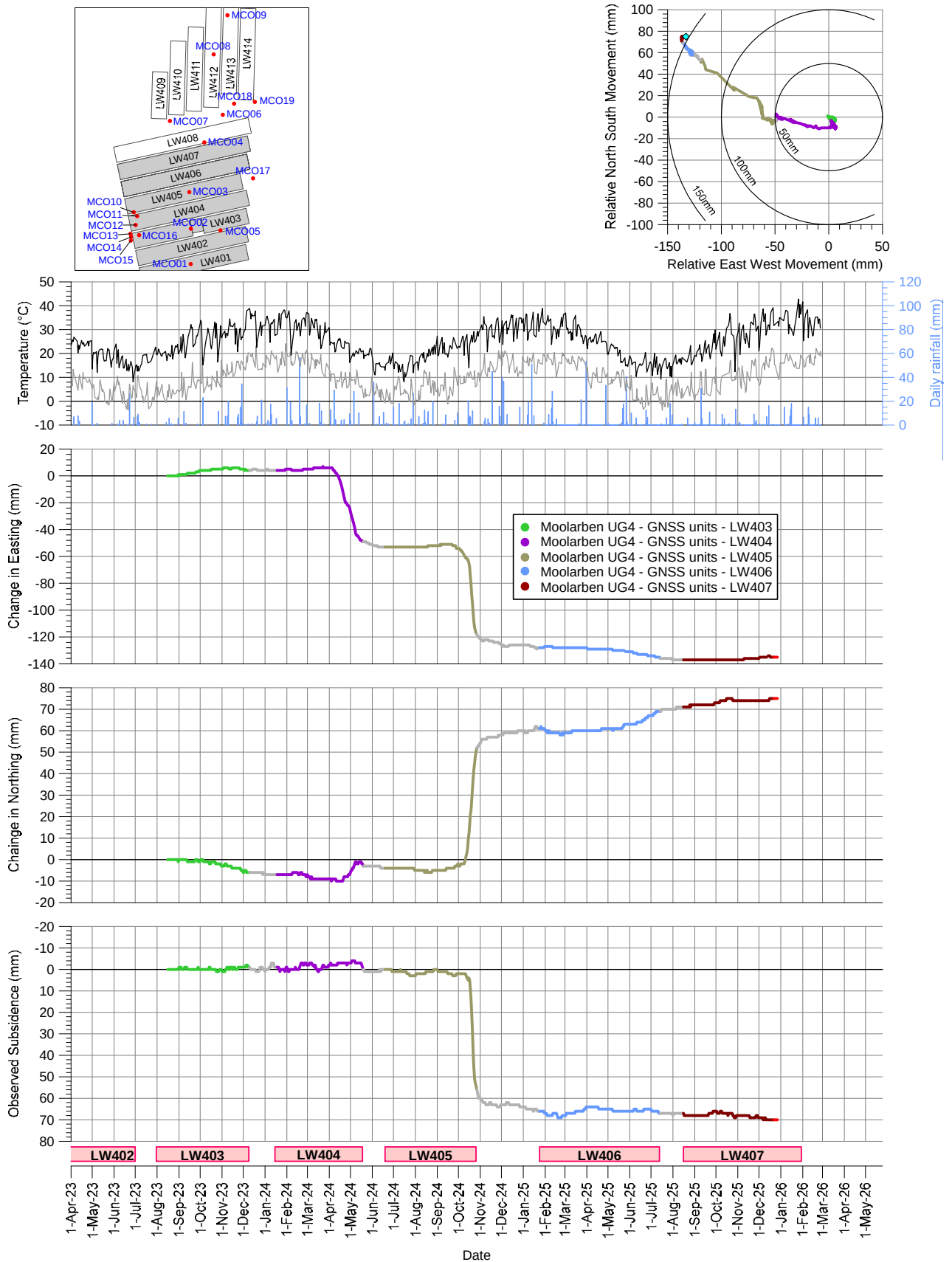


Fig. A.10 Total horizontal movement and vertical subsidence at GNSS Site MCO10

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO11

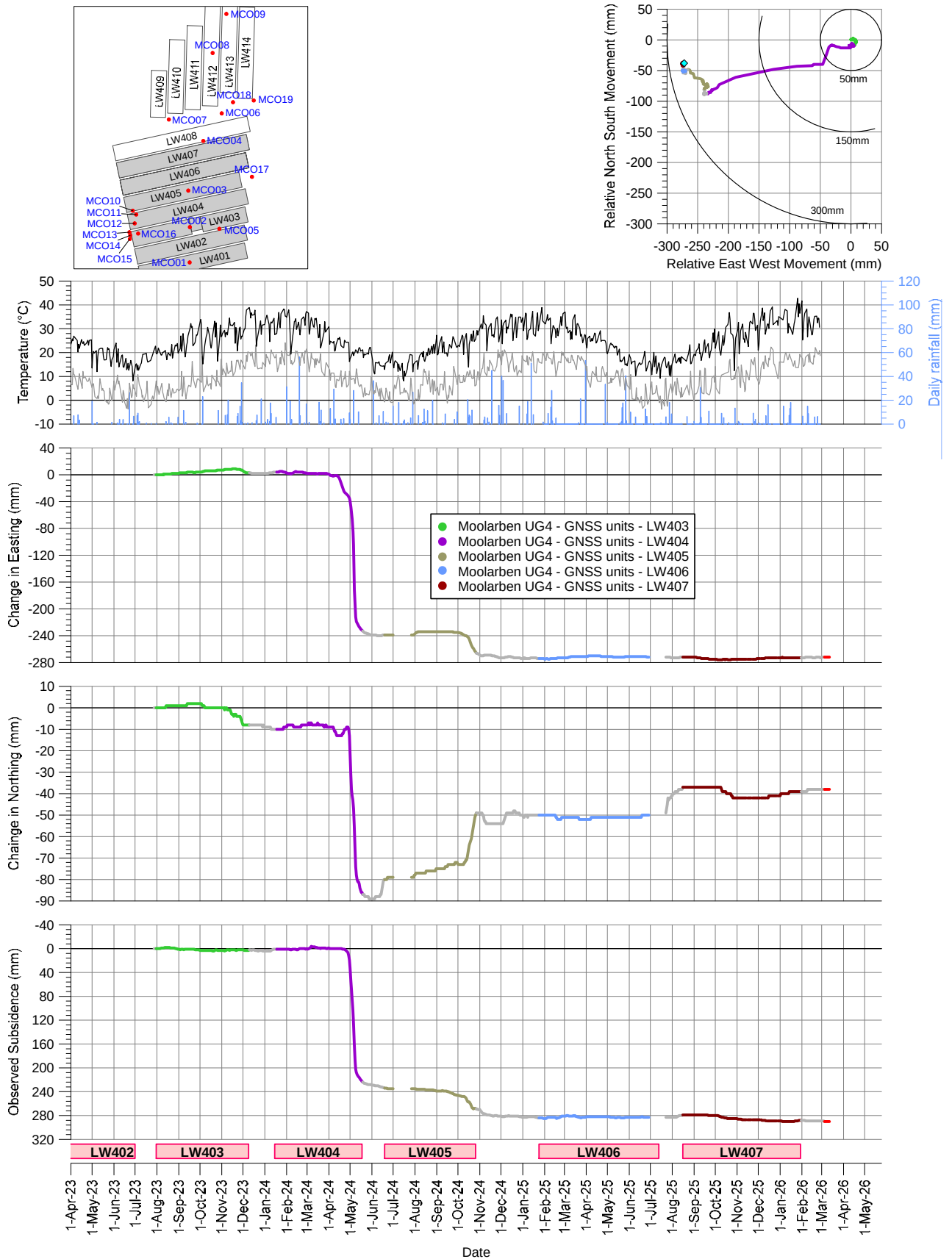


Fig. A.11 Total horizontal movement and vertical subsidence at GNSS Site MCO11

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO12

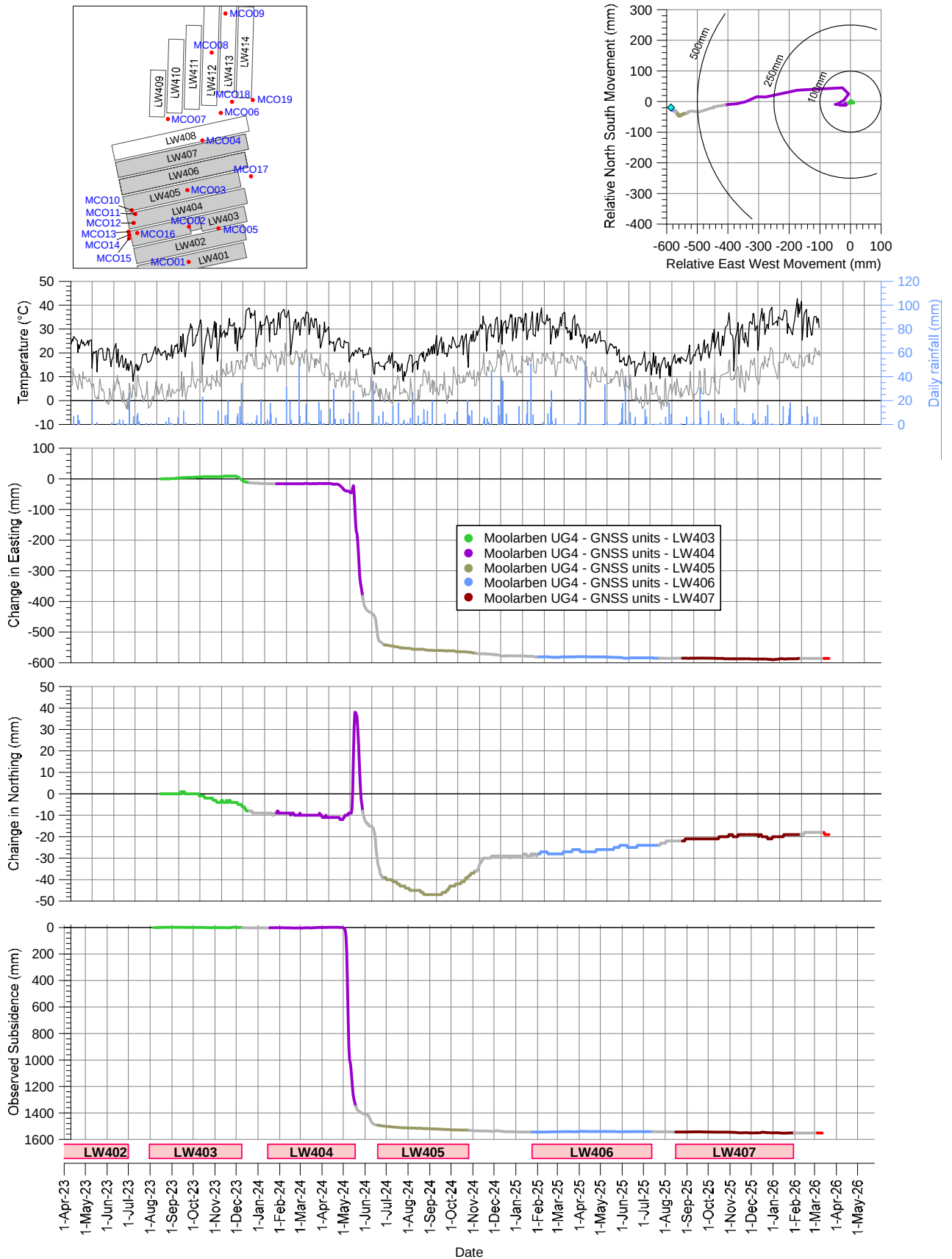


Fig. A.12 Total horizontal movement and vertical subsidence at GNSS Site MCO12

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO13

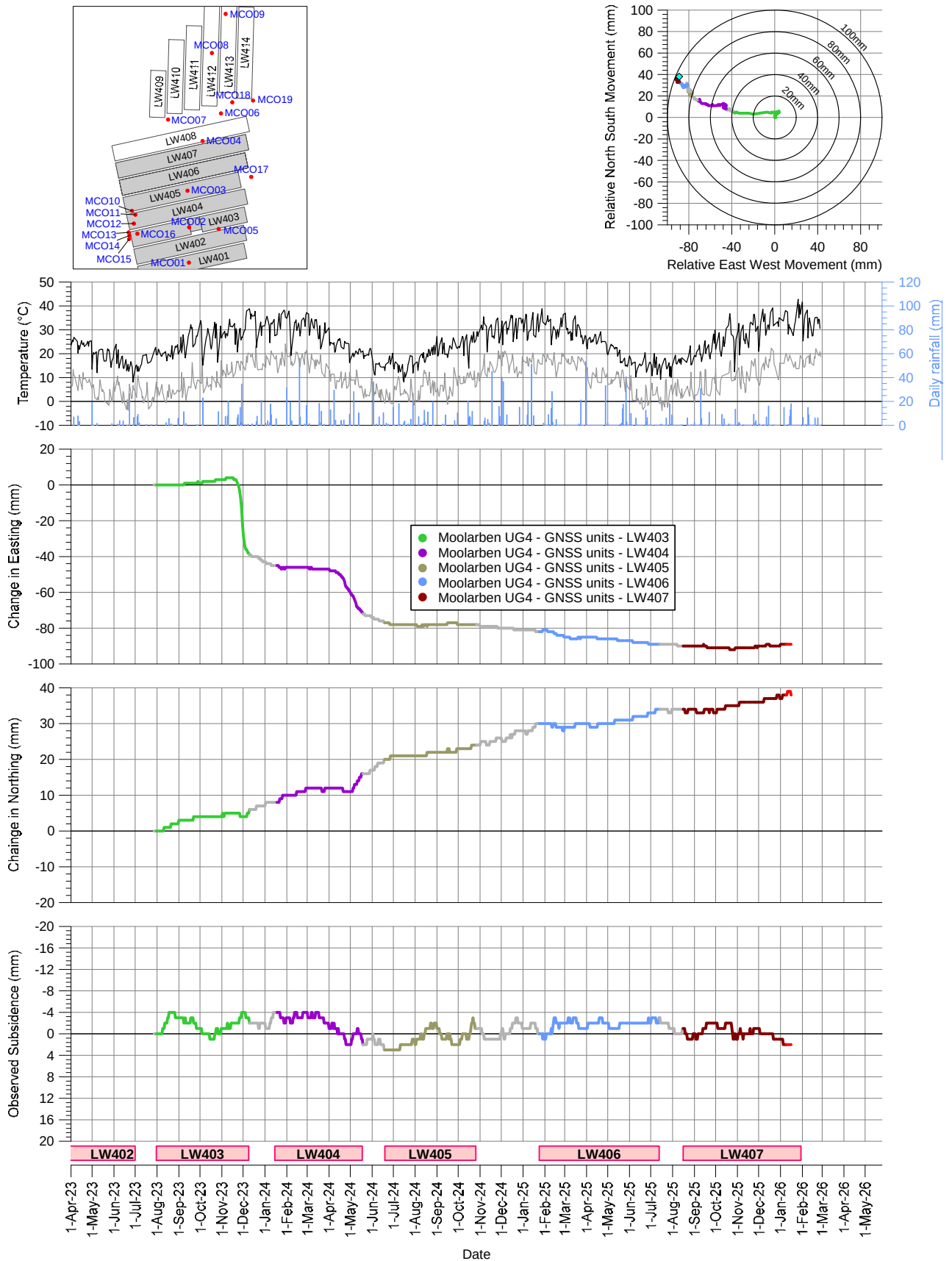


Fig. A.13 Total horizontal movement and vertical subsidence at GNSS Site MCO13

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO14

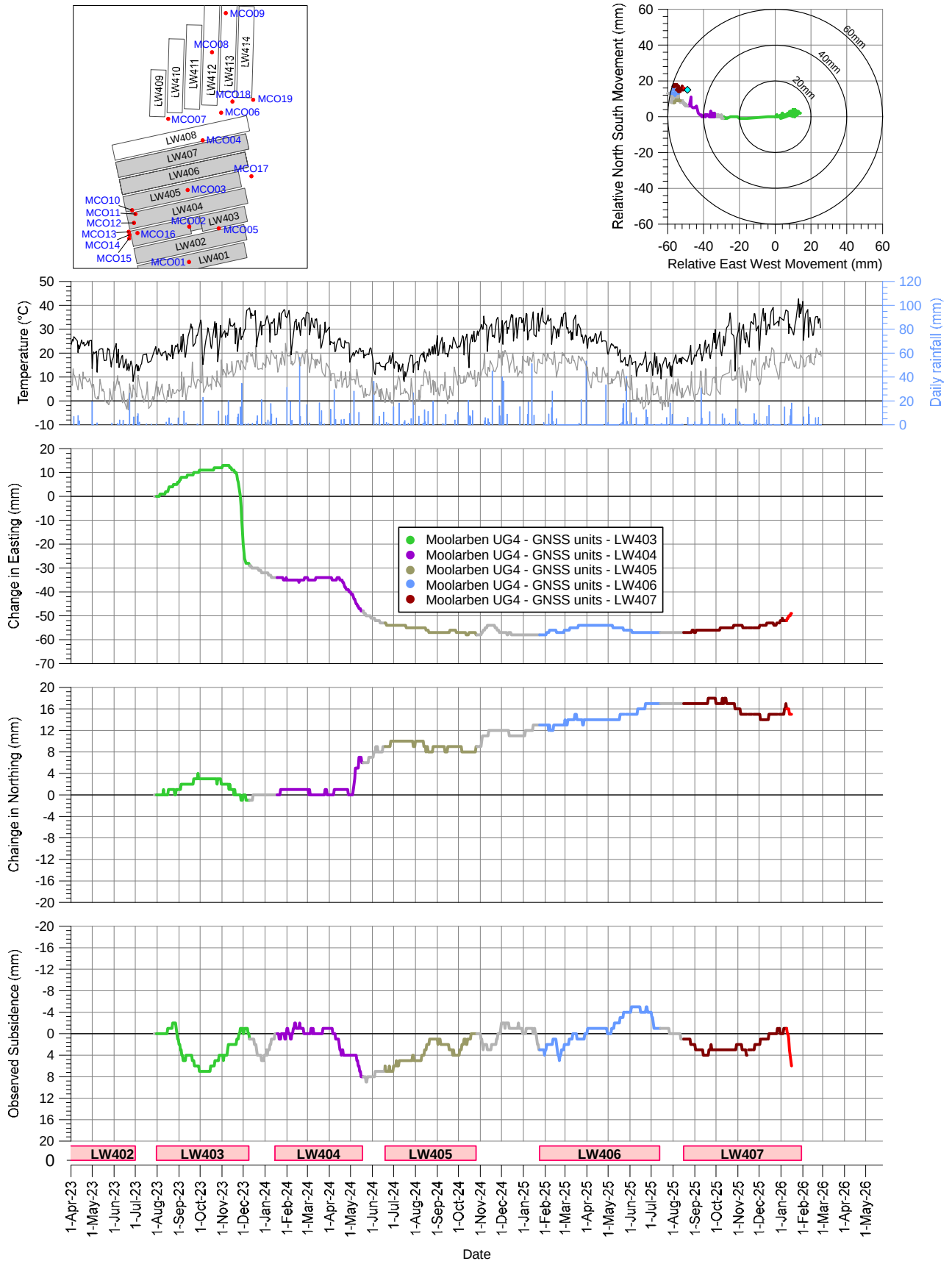


Fig. A.14 Total horizontal movement and vertical subsidence at GNSS Site MCO14

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO15

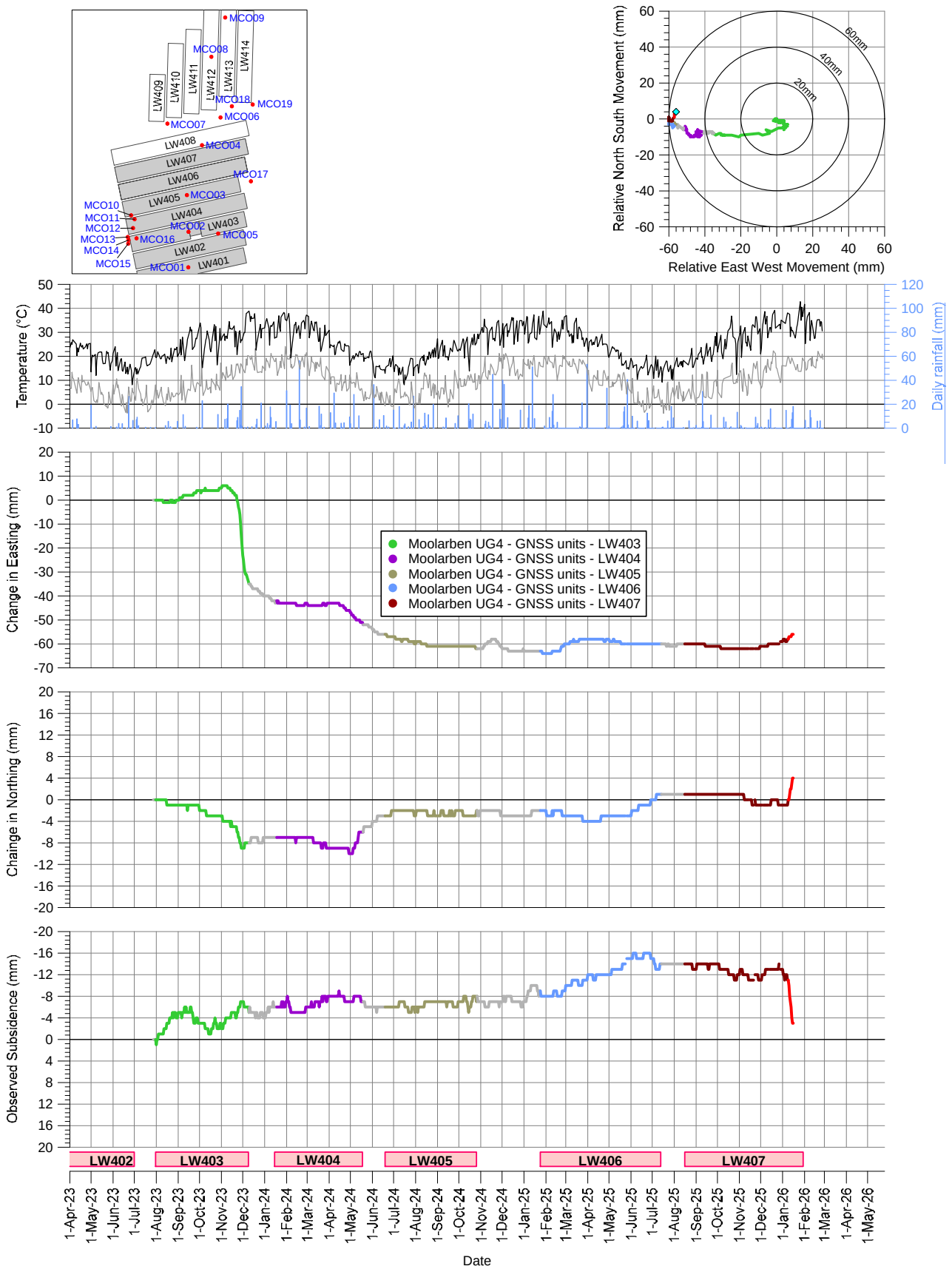


Fig. A.15 Total horizontal movement and vertical subsidence at GNSS Site MCO15

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO16

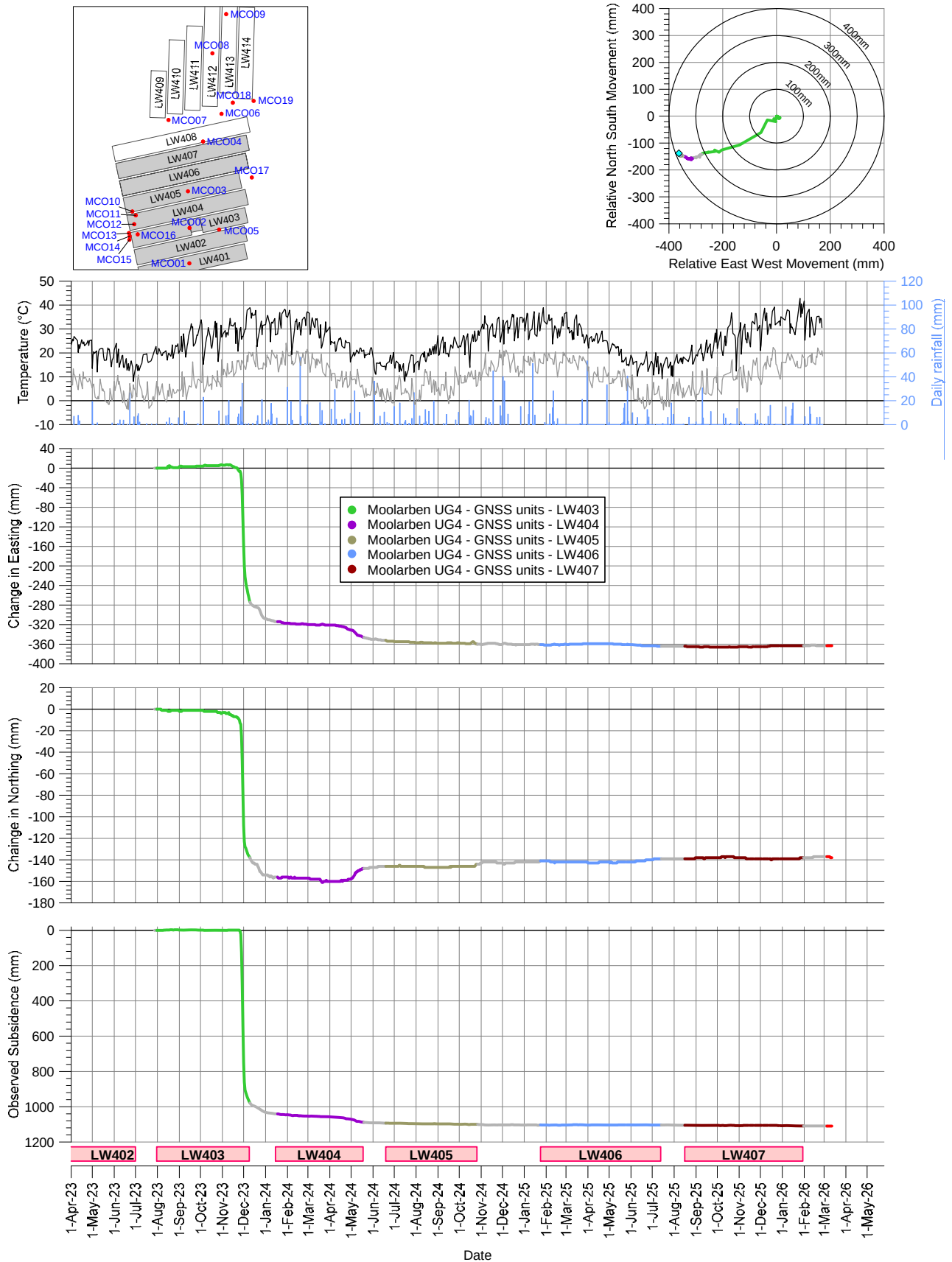


Fig. A.16 Total horizontal movement and vertical subsidence at GNSS Site MCO16

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO17

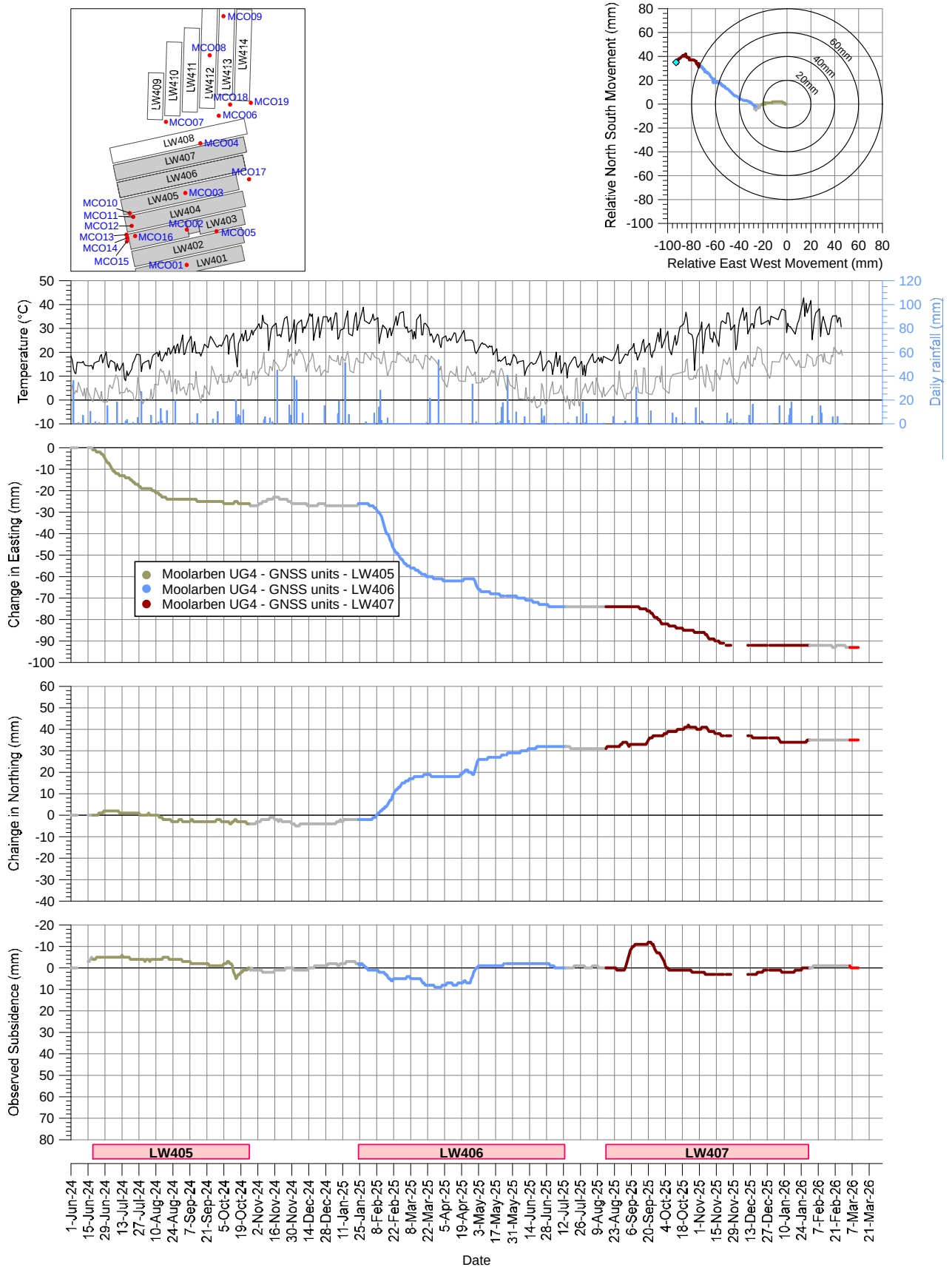


Fig. A.17 Total horizontal movement and vertical subsidence at GNSS Site MCO17

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO18

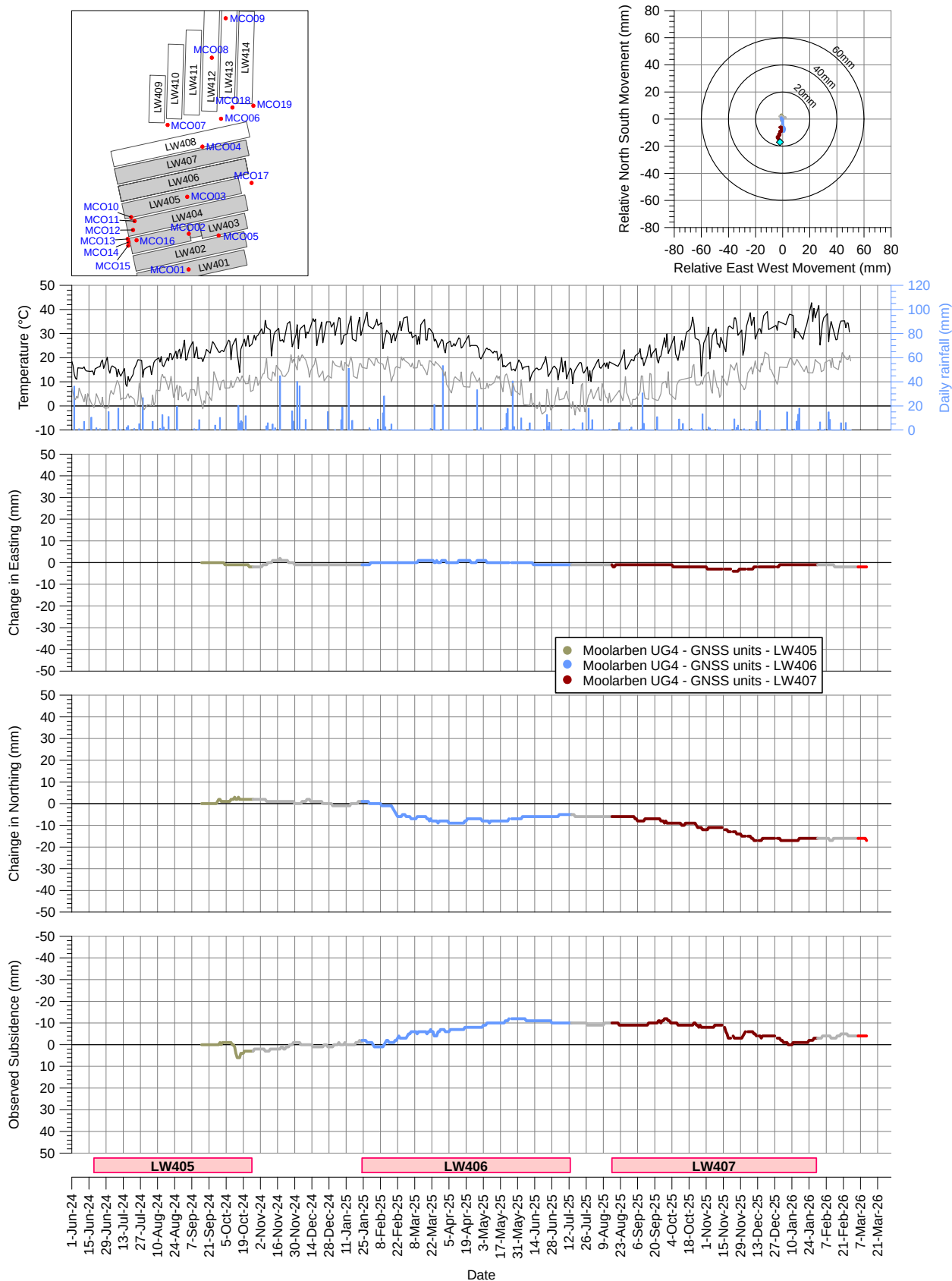


Fig. A.18 Total horizontal movement and vertical subsidence at GNSS Site MCO18

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO19

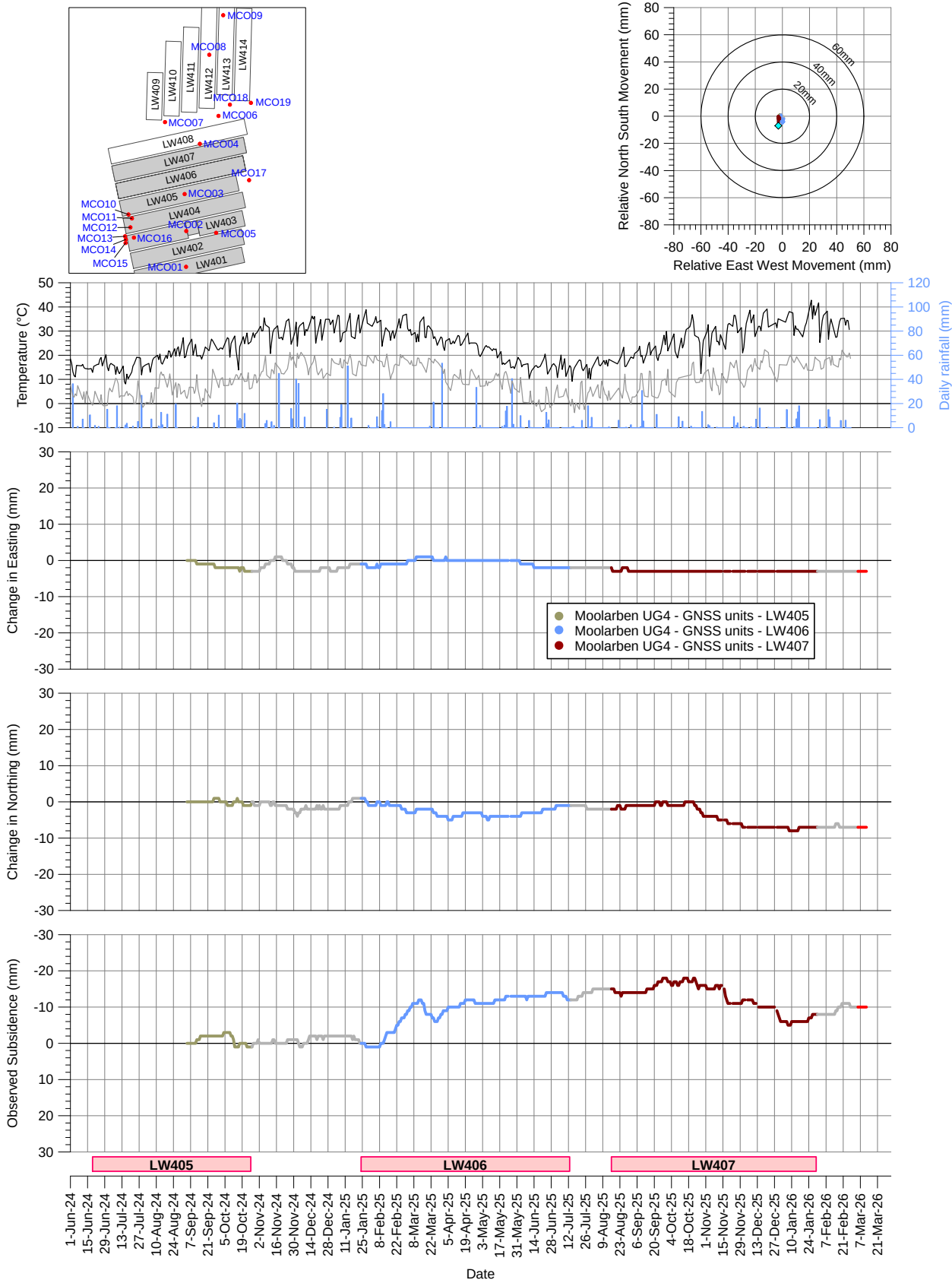


Fig. A.19 Total horizontal movement and vertical subsidence at GNSS Site MCO19

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO20

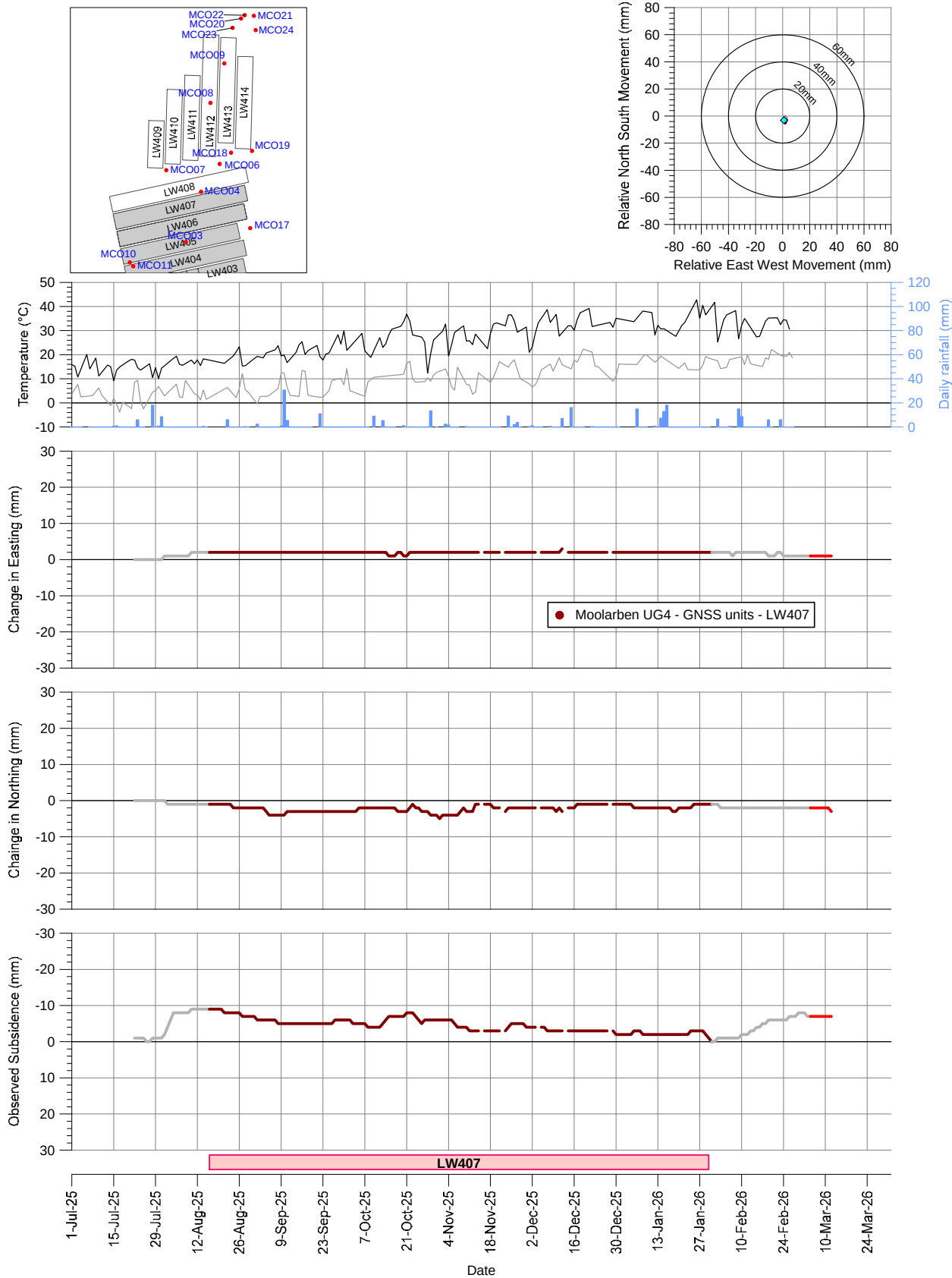


Fig. A.20 Total horizontal movement and vertical subsidence at GNSS Site MCO20

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO21

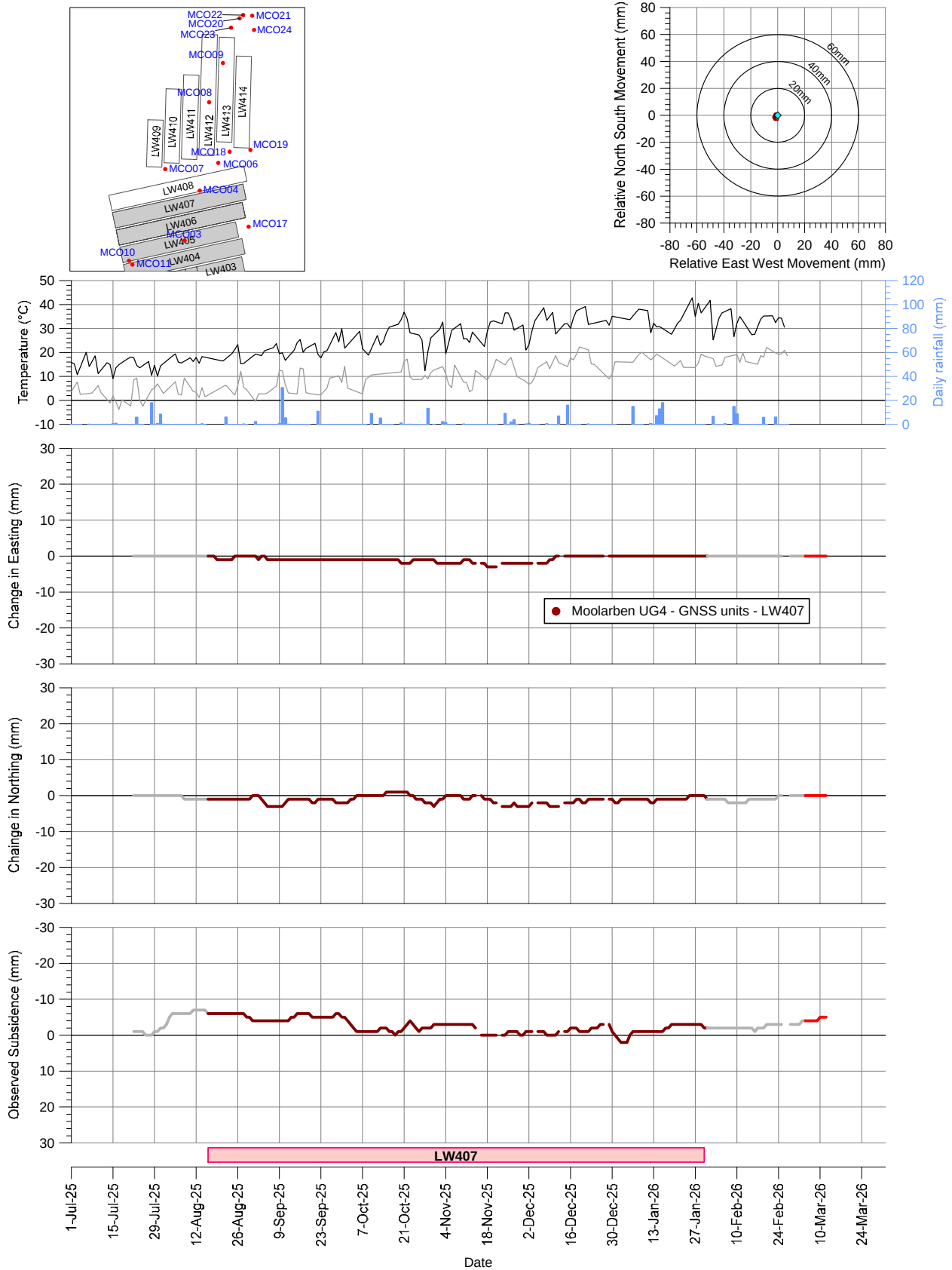


Fig. A.21 Total horizontal movement and vertical subsidence at GNSS Site MCO21

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO22

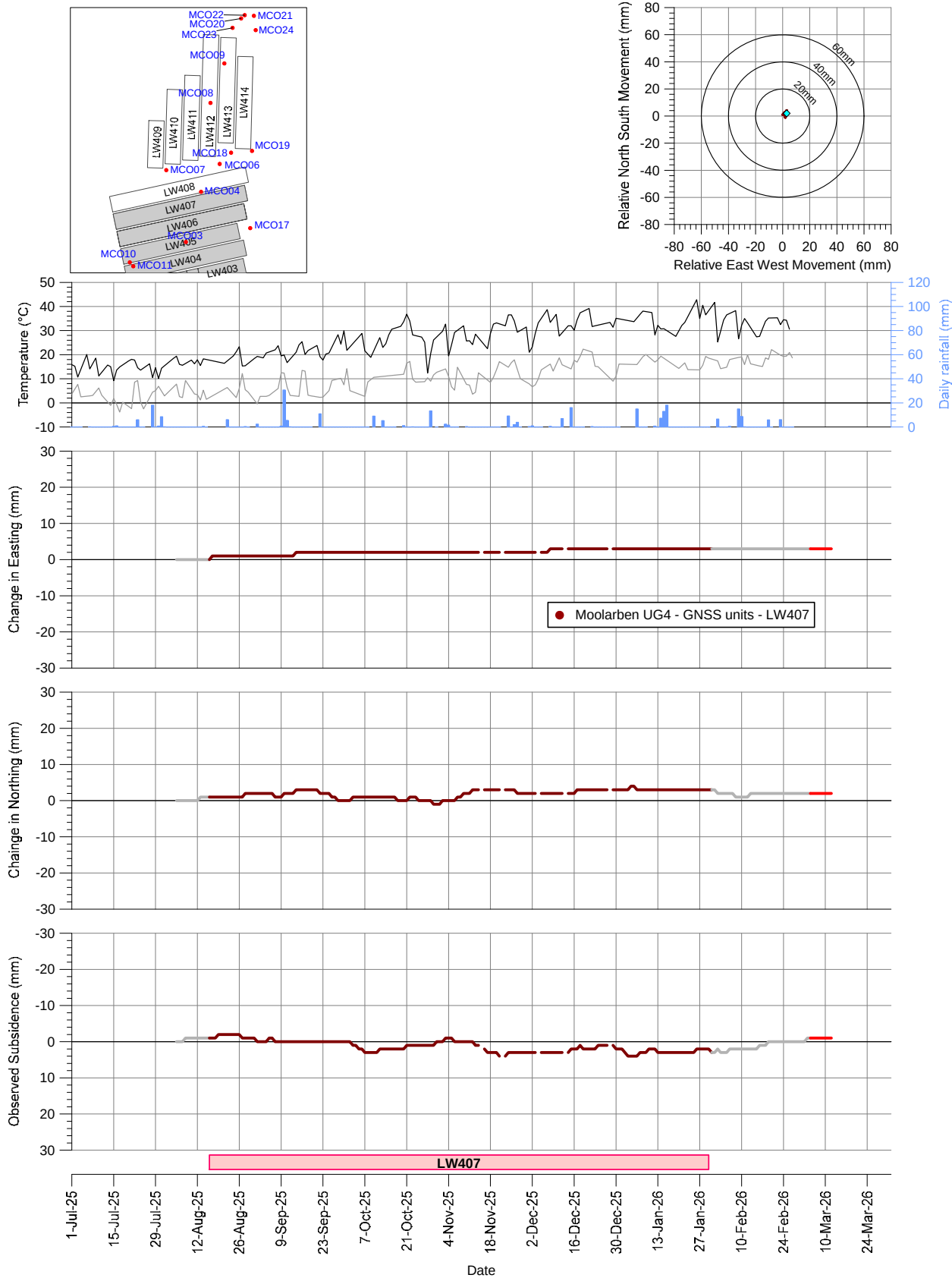


Fig. A.22 Total horizontal movement and vertical subsidence at GNSS Site MCO22

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO23

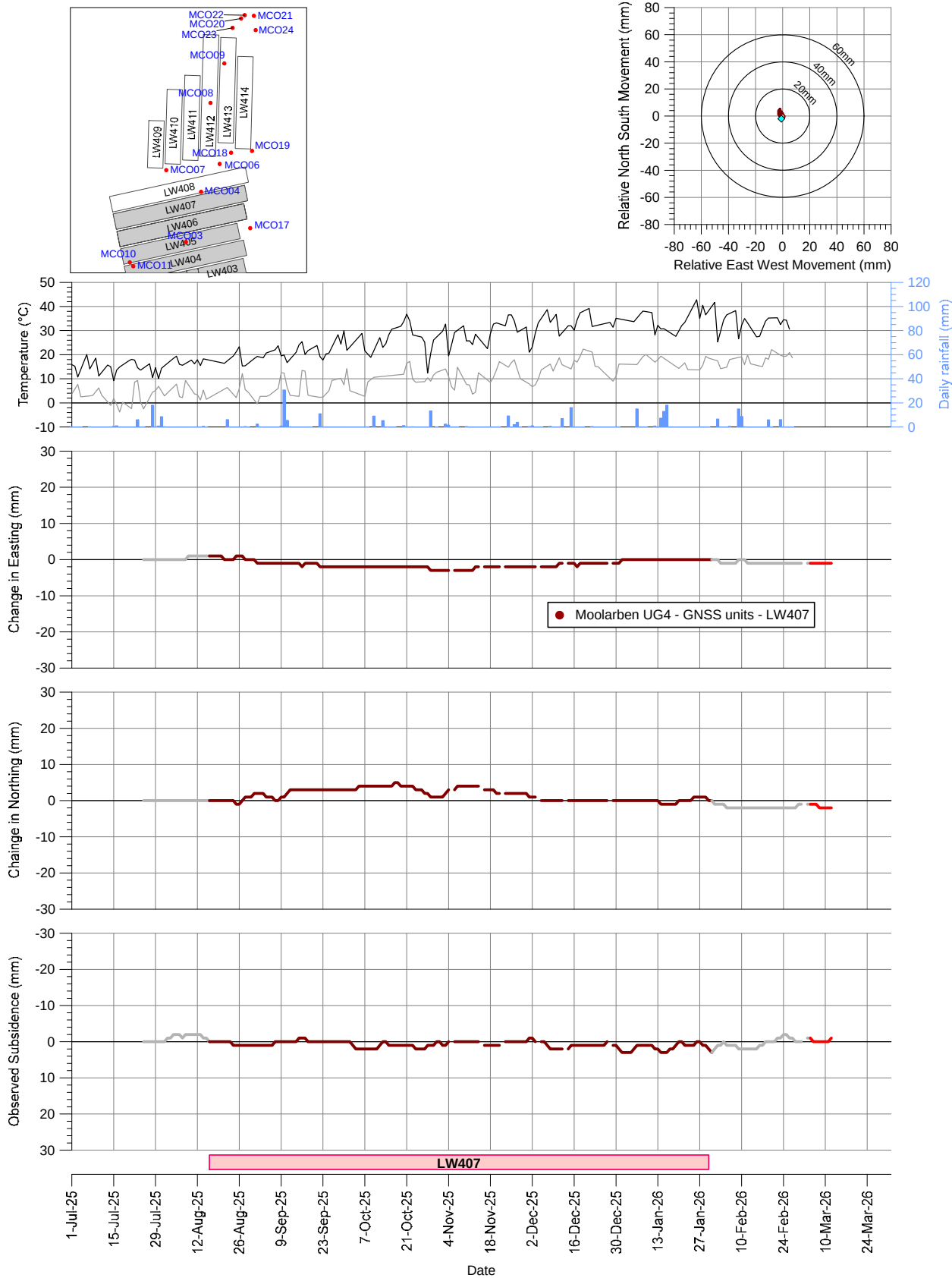


Fig. A.23 Total horizontal movement and vertical subsidence at GNSS Site MCO23

Total Horizontal Movement and Vertical Subsidence at GNSS Site MCO24

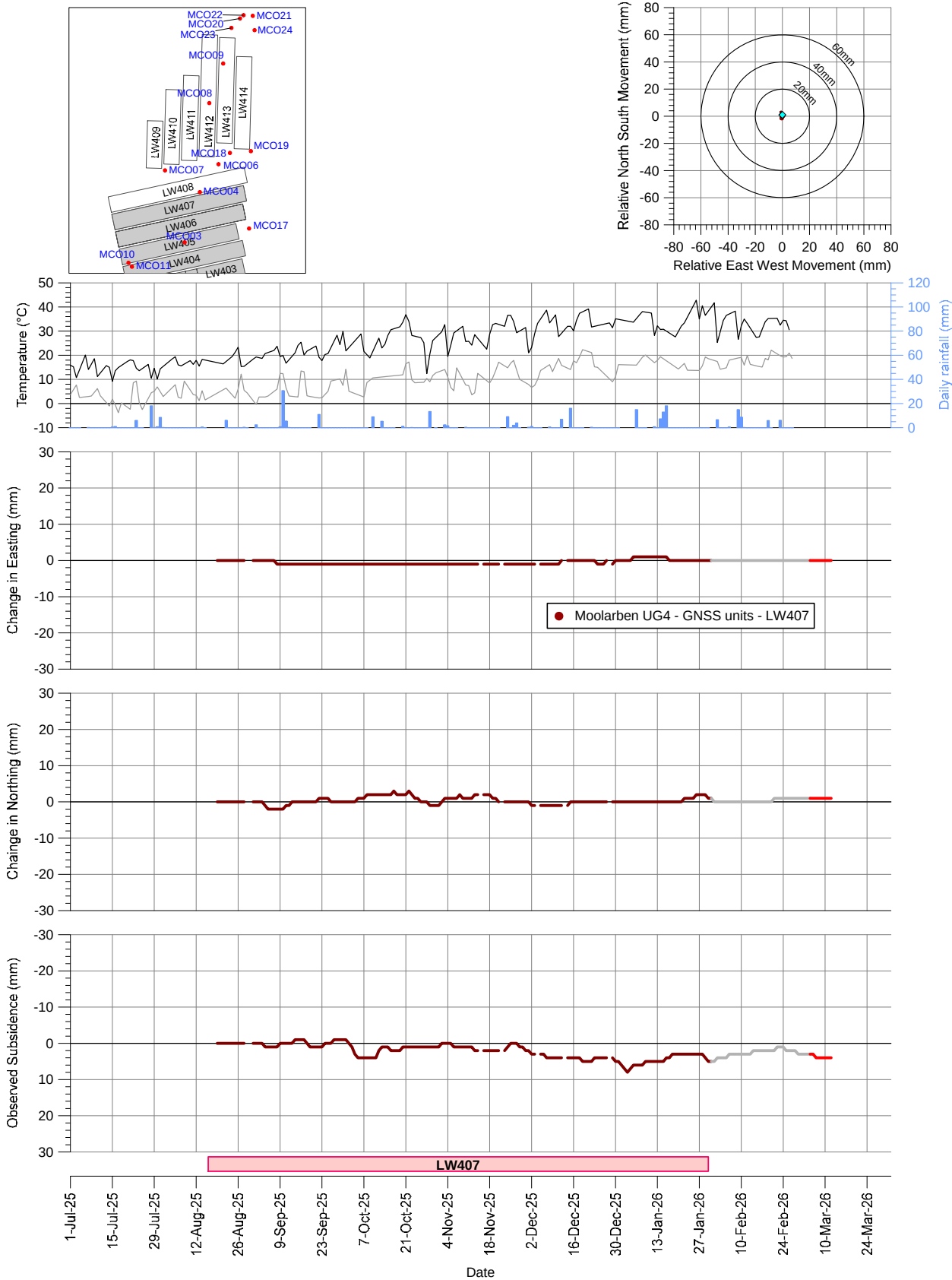


Fig. A.24 Total horizontal movement and vertical subsidence at GNSS Site MCO24

Total Horizontal Movement and Vertical Subsidence at GNSS Site NPWS G01 to G09

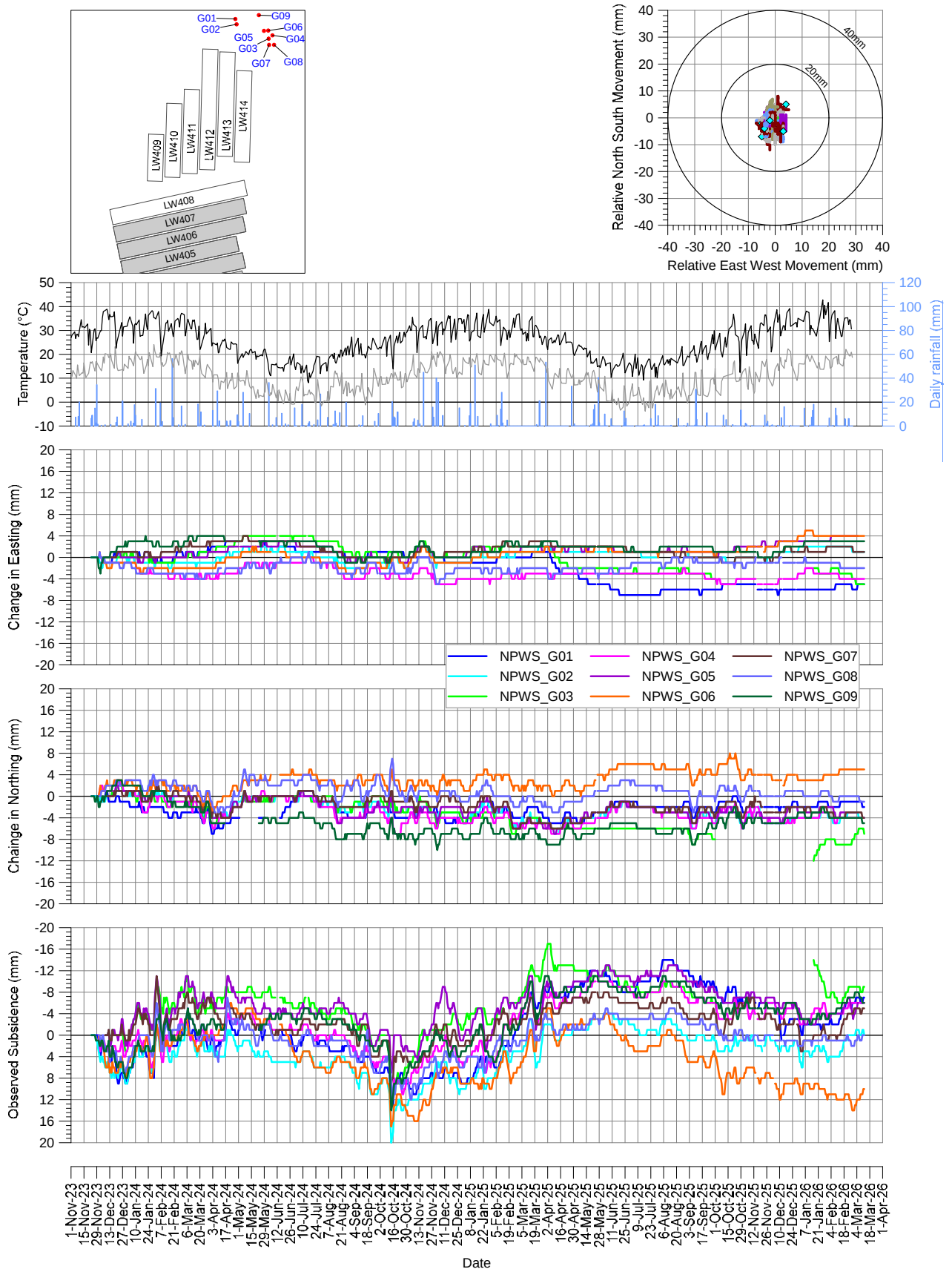


Fig. A.25 Total horizontal movement and vertical subsidence at GNSS Site NPWS G01 to G09

APPENDIX B

MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT – GROUNDWATER REPORT (AGE, 2026)



Australasian
Groundwater
& Environmental
Consultants

Report on

UG4 LW401 to LW407 End of Panel Report - Groundwater Review

Prepared for
Moolarben Coal Operations Pty Ltd



Project No. MOO5018.001
August 2026

ageconsultants.com.au

ABN 64 080 238 642

Document details and history



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UG4 LW401 to LW407 End of Panel Report – Groundwater Review

1 Introduction

The Moolarben Coal Complex is an open cut and underground coal mine located approximately 40 kilometres (km) northeast of Mudgee, New South Wales (NSW) (Figure 1.1). The Moolarben Coal Complex is operated by Moolarben Coal Operations Pty Ltd (MCO) on behalf of the Moolarben Joint Venture. MCO is a wholly owned subsidiary of Yancoal Australia Limited.

The Moolarben Coal Complex comprises four approved open cut mining areas (OC1 to OC4), three approved underground mining areas (UG1, UG2 and UG4) and other mining related infrastructure (including coal processing and transport facilities) (Figure 1.2).

Mining operations at the Moolarben Coal Complex are currently approved until 31 December 2038 in accordance with Project Approval (05_0117) (Moolarben Coal Project Stage 1) (as modified) and Project Approval (08_0135) (Moolarben Coal Project Stage 2) (as modified), granted under the NSW *Environmental Planning and Assessment Act 1979*.

The UG4 Longwall (LW) 401 to LW408 is a component of the Moolarben Coal Project Stage 1 Approval (05_0117) (Figure 1.3). Secondary extraction of LW401 commenced in July 2022 and LW407 was completed in January 2026. The subsequent longwall, LW408, is currently being mined and is indicatively scheduled for completion during August 2026.

1.1 Purpose and scope

In response to the UG4 LW401-403 End of Panel Report (EoPR) submitted in January 2024 (MCO, 2024), the NSW Department of Planning, Housing and Infrastructure (DPHI) requested MCO also provide an EoPR after the extraction of LW407 (and before the completion of LW408) including:

- an assessment of subsidence predictions and actual impacts;
- data and trends for all underlying groundwater systems, and an assessment of impacts to the Triassic sandstone aquifer and its environmental and cultural assets adjacent to and downstream of the UG4 area;
- surface water data and trends for the Goulburn River adjacent to and downstream of the UG4 area; and
- an assessment of cultural heritage impacts.

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) has been commissioned by MCO to report on any observed groundwater system impacts resulting from extraction of panels LW401 to LW407.

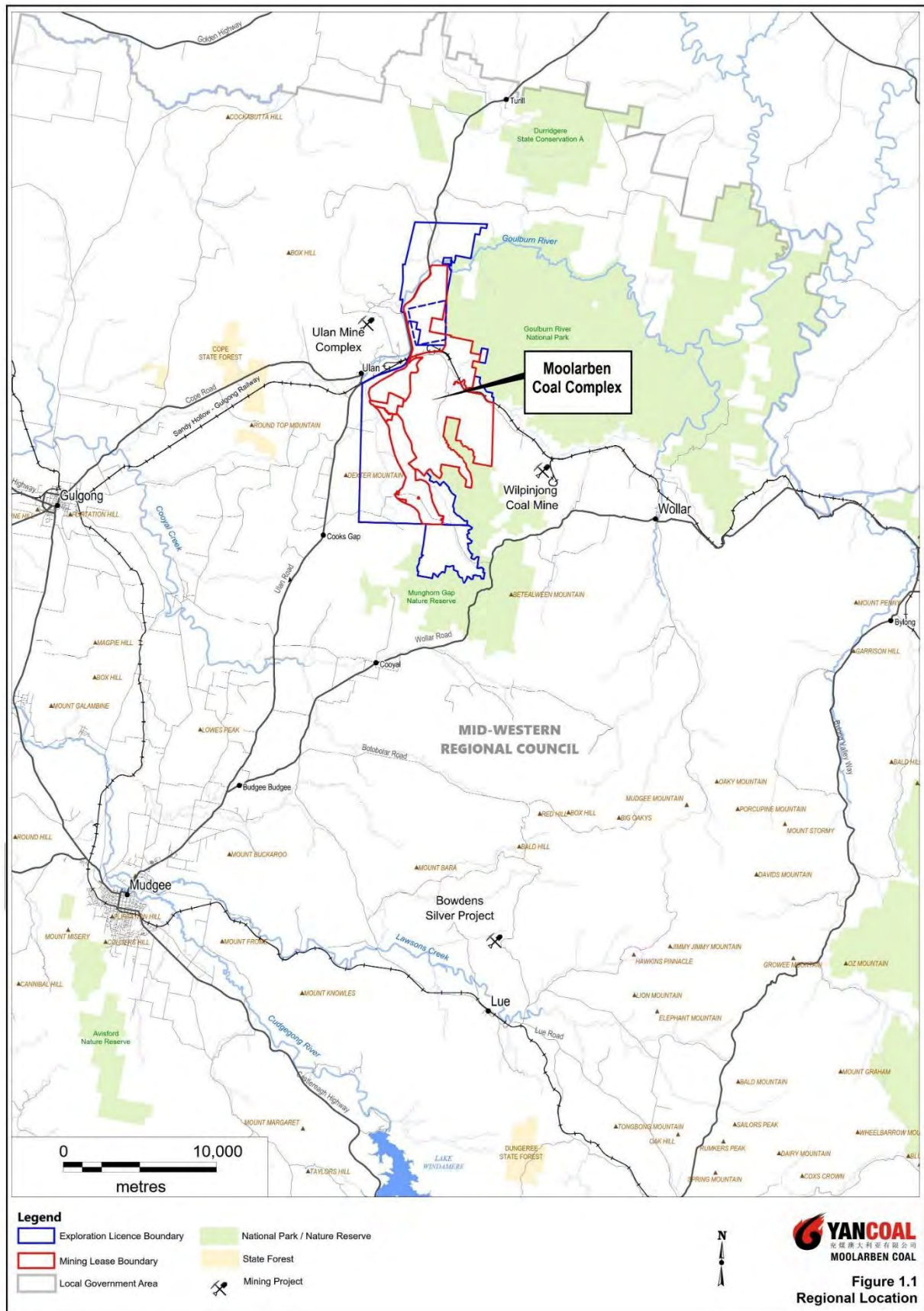


Figure 1.1 Regional location

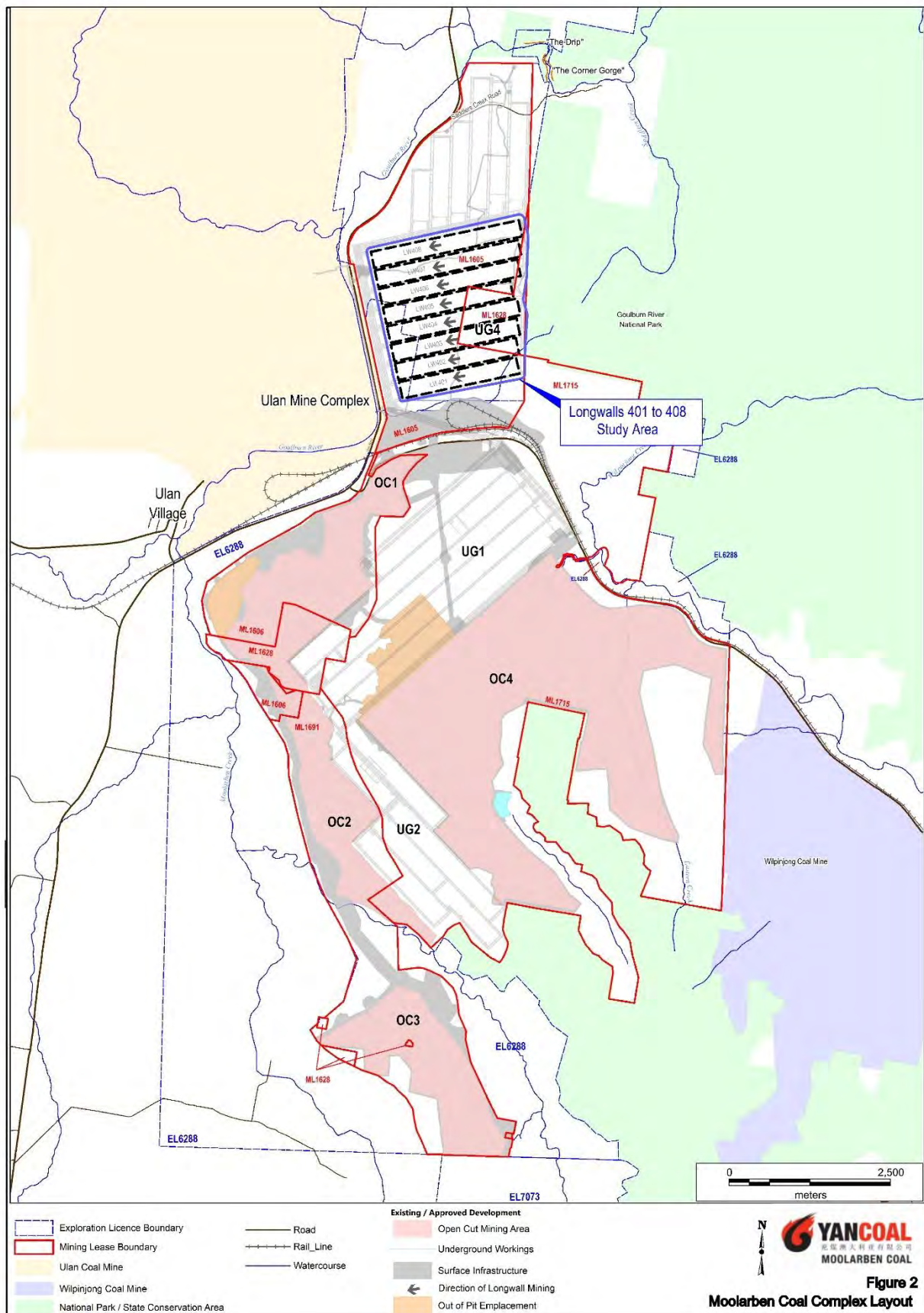


Figure 1.2 Moolarben Coal Complex layout

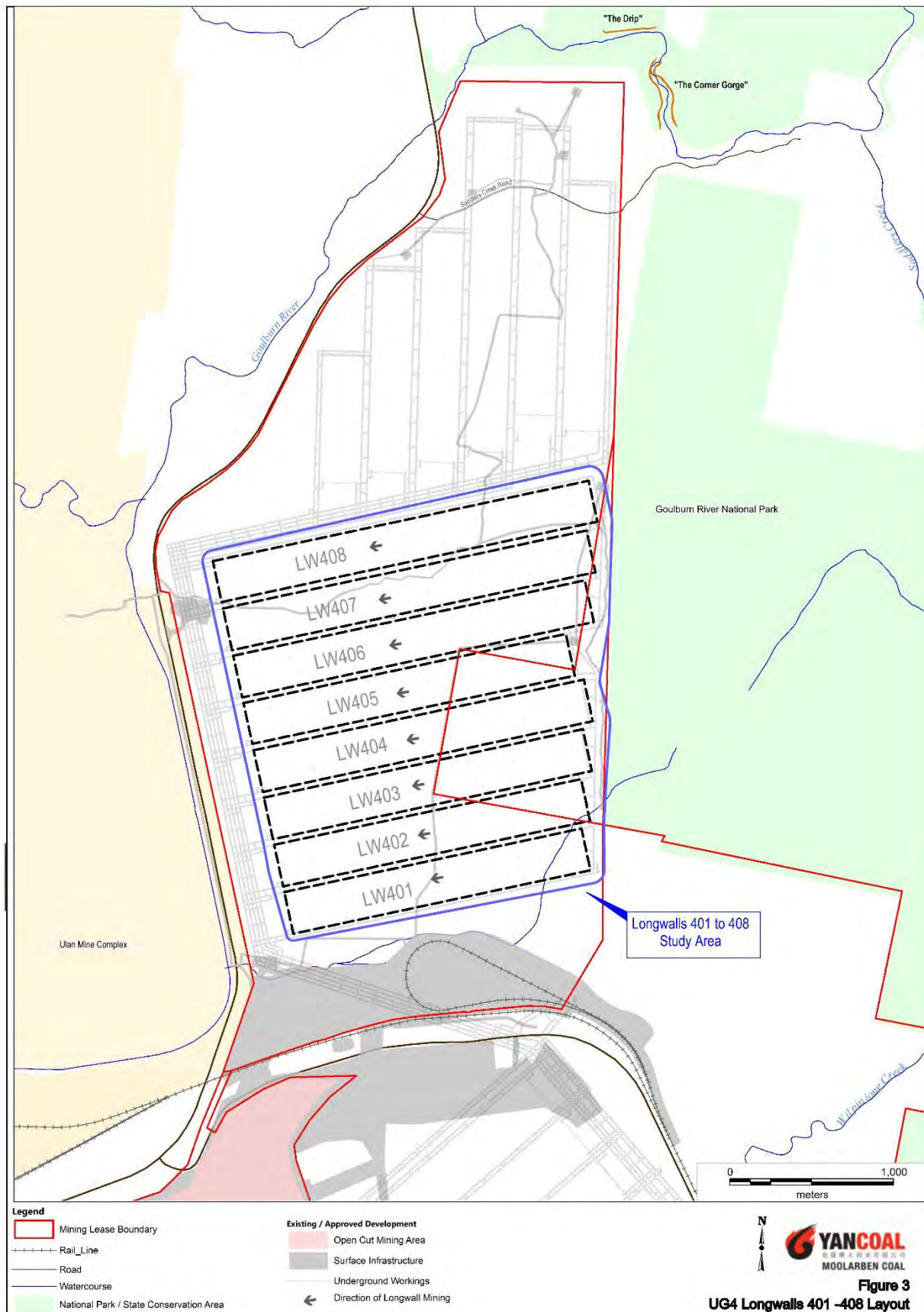


Figure 1.3 UG4 Longwalls 401-408 layout

This report is structured as follows:

- Section 1 – overview of the Project area, scope of the report and UG4 LW401 to LW407 mine progression.
- Section 2 – overview of the groundwater monitoring network in the UG4 area, investigation trigger levels and other groundwater users.
- Section 3 – assessment of observed impacts to the Triassic Sandstone groundwater levels and its environmental/cultural assets adjacent to and downstream of the UG4 area from mining of LW401 to LW407 (i.e. Goulburn River and The Drip), and comparison with the approved level of groundwater impacts and subsidence impact performance measures in Project Approval (05_0117).
- Section 4 – conclusions, providing review of Trigger Action Response Plans (TARPs) based on the monitoring data.
- Appendix A – details for the UG4 groundwater monitoring network.
- Appendix B – water level hydrographs for the UG4 groundwater monitoring network.
- Appendix C – water quality for the UG4 groundwater monitoring network.

1.2 UG4 LW401 to LW407 mine progression

Longwall mining at UG4 occurs in the Ulan Seam, which has been historically mined to the south and west of the UG4 area at both the Moolarben Coal Complex and Ulan Coal Mine Complex.

LW401 to LW407 were mined progressively from east to west, extending from the southernmost panel (LW401) to the northernmost panel (LW407) (Figure 1.3).

Within the mining area, the seam floor generally dips from the southwest towards the northeast. The thickness of the Ulan Seam D-Working Section within the longwall extents varies between 2.8 metres (m) and 3.2 m, with a nominal mining height of 3.0 m.

The secondary extraction schedule for LW401 to LW407 is summarised in Table 1.1. Mining of LW408 commenced in February 2026.

Table 1.1 UG4 LW401 to LW407 secondary extraction schedule

Longwall	Start date	Completion date
LW401	July 2022	November 2022
LW402	February 2023	July 2023
LW403	July 2023	December 2023
LW404	January 2024	May 2024
LW405	June 2024	October 2024
LW406	January 2025	July 2025
LW407	August 2025	January 2026

2 Groundwater monitoring

This section describes the groundwater monitoring program implemented for LW401 to LW407, including the monitoring network, relevant performance measures and groundwater investigation trigger levels in accordance with approved management plans and regulatory requirements.

This study reviewed groundwater monitoring data from June 2022 to January 2026, representing the period from before the commencement of UG4 LW401 operations to the completion of LW407 operations.

2.1 Groundwater monitoring network

MCO operates in accordance with the approved Complex-wide Groundwater Management Plan (MCO, 2026) and the approved UG4 LW401 to LW408 Water Management Plan (MCO, 2023), which were prepared to address the current statutory obligations contained in the conditions of the Project Approval (05_0117) (as modified) and Project Approval (08_0135) (as modified). The UG4 LW401 to LW408 Water Management Plan was prepared using baseline data from previous groundwater assessments within and surrounding the Moolarben Coal Complex, supported by a groundwater monitoring record extending back to 2005.

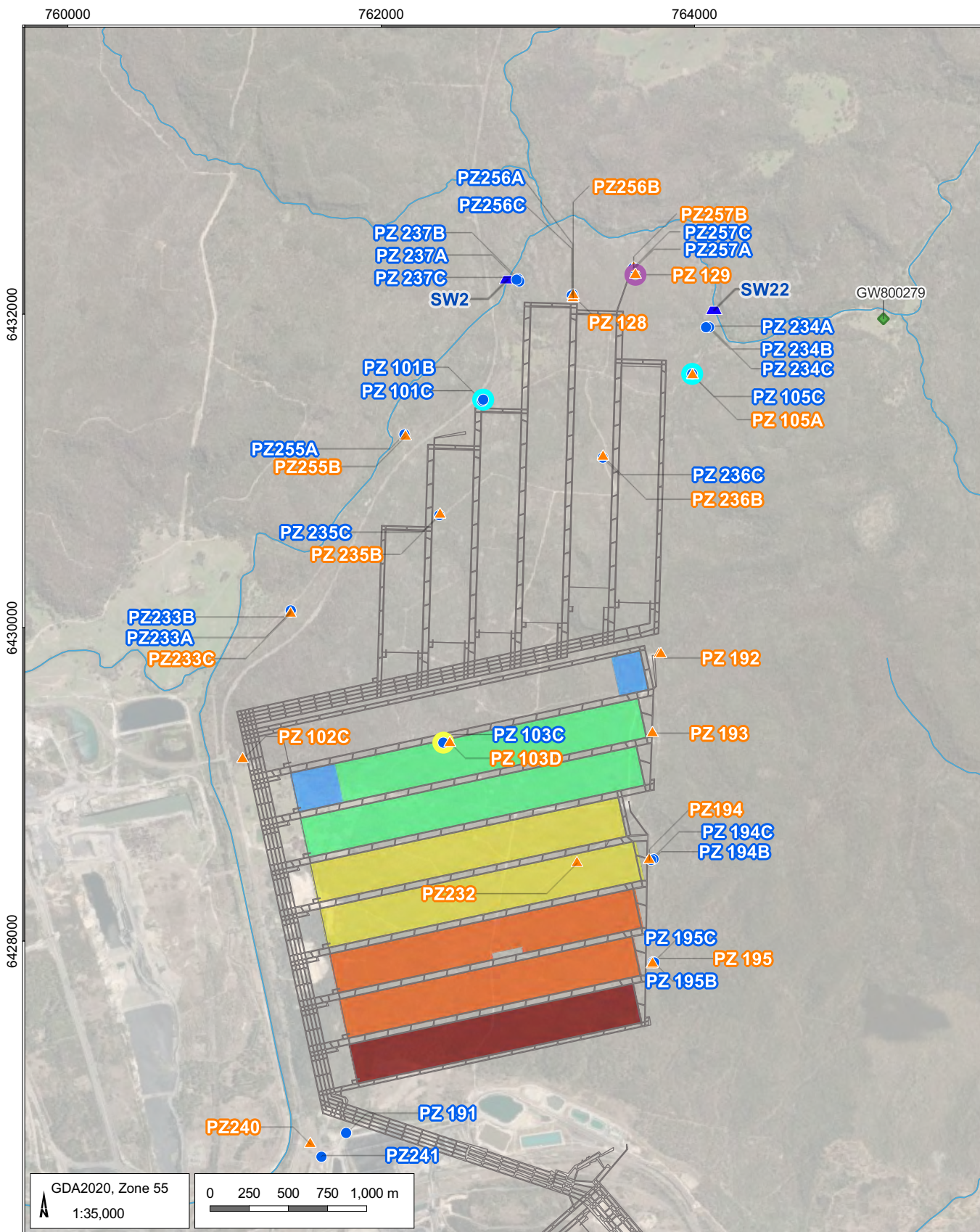
Figure 2.1 shows the MCO groundwater monitoring network in the UG4 area and Appendix A presents construction and monitoring program details for each monitoring site. Table 2.1 summarises the additional monitoring sites which have been installed since the commencement of secondary extraction in UG4.

Table 2.1 Groundwater monitoring sites installed since commencement of secondary extraction in UG4

Piezometer	Type	Lithology screened	Date of installation	Location relative to LW401-407
PZ194B	Standpipe	Triassic	July 2022	Commencing end of LW404
PZ194C	Standpipe	Permian	July 2022	
PZ195B	Standpipe	Triassic	July 2022	Commencing end of LW402
PZ195C	Standpipe	Permian	June 2022	
PZ232	Nested VWP	Triassic and Permian	June 2022	Above LW404
PZ235B	Nested VWP	Permian OB and Ulan Seam	November 2022	Approx. 1.1 km from LW401-407
PZ235C	Standpipe	Triassic	September 2023	
PZ236B	Nested VWP	Permian and Ulan Seam	October 2022	Approx. 1.3 km from LW401-407
PZ236C	Standpipe	Base of Triassic	July 2024	
PZ234A	Standpipe	Triassic	November 2023	Adjacent to Goulburn River monitoring location SW22 to monitor groundwater/surface water interaction
PZ234B	Standpipe	Lower Triassic / Upper Permian	November 2023	
PZ234C	Standpipe	Permian	November 2023	

Piezometer	Type	Lithology screened	Date of installation	Location relative to LW401-407
PZ237A	Standpipe	Triassic	December 2023	Adjacent to Goulburn River monitoring location SW2 to monitor groundwater/surface water interaction
PZ237B	Standpipe	Lower Triassic / Upper Permian	December 2023	
PZ237C	Standpipe	Permian	December 2023	
PZ240	VWP	Ulan Seam	July 2024	South of LW401-407 near PZ191 to confirm extent of paleochannel
PZ241	Standpipe	Palaeochannel	July 2024	South of LW401-407 near PZ191 to confirm extent of paleochannel
PZ256B	Nested VWP	Triassic, Permian and Ulan Seam	August 2025	Replacement of site 'PZ128', north of LW409-414
PZ256A	Standpipe	Triassic	August 2025	
PZ256C	Standpipe	Permian	August 2025	
PZ257B	Nested VWP	Triassic, Permian, Ulan Seam OB and Ulan Seam	July 2025	Replacement of site 'PZ129', north of LW409-414.
PZ257A	Standpipe	Triassic	August 2025	
PZ257C	Standpipe	Permian	August 2025	
PZ233A (PZ-A SP1)	Standpipe	River level	August 2025	Approx 0.7 km north of LW401-407 and approx. 0.6 km west of LW409-414
PZ233B (PZ-A SP2)	Standpipe	Permian	August 2025	
PZ233C (PZ-A VWP)	Nested VWP	Moolarben Seam, Permian, Ulan Seam OB and Ulan Seam	August 2025	

Note: VWP = vibrating wire piezometer, OB = Overburden.



LEGEND

- UG4 Mine Plan
- Drainage
- ◆ Registered private bore
- ▲ Flow Gauging Station

Groundwater Monitoring Site

- Standpipe
- ▲ VWP

Trigger site

- Groundwater levels and groundwater quality
- Groundwater levels
- Groundwater quality

Mine progression (Year)

- 2022
- 2023
- 2024
- 2025
- 2026

Moolarben Mine - End of Panel Reporting - UG4
LW401 to LW407 (MOO5018.002)

UG4 groundwater monitoring network



AGE

DATE
13/08/2026

FIGURE No:
2.1

2.2 Trigger action response plan

2.2.1 Performance measures

Project Approval (05_0117) requires MCO to ensure that the project does not cause any exceedance of the subsidence performance measures for natural and heritage features outlined in Table 14 of Condition 73, Schedule 3 and to comply with the water management performance measures outlined in Table 11 of Condition 32, Schedule 3.

Performance measures relevant to groundwater are summarised in Table 2.2.

Table 2.2 Performance measures

Feature	Performance Measure
Water Management	
The Drip	Nil impact on the water supply to The Drip.
Subsidence	
The Drip and Goulburn River Gorge	Nil impact or environmental consequences.
Goulburn River and the bed of the Goulburn River	Negligible impact or environmental consequences. Remain outside the zone of recorded subsidence damage for longwall mining.

2.2.2 Investigation trigger levels

MCO has established water level and quality investigation threshold values that, when exceeded, trigger review of water level and water quality data to determine potential causes and inform consideration of response actions, if required. The trigger level thresholds for groundwater levels and water quality relevant to LW401 to LW407 are provided in the UG4 LW401 to LW408 Water Management Plan (MCO, 2023). Investigation trigger values are part of a TARP that are designed to identify the potential for performance criteria/indicators to be exceeded. Investigation triggers are not confirmation of an exceedance.

Groundwater levels within the Permian coal measures strata are extensively affected by past mining and will continue to undergo further depressurisation due to ongoing mining at the Ulan Coal Mine Complex, Moolarben Coal Complex and the Wilpinjong Coal Mine. Accordingly, investigation trigger levels have not been set for the majority of monitoring piezometers within the Permian and Ulan Seams.

Table 2.3 and Table 2.4 present the water quality and water level trigger levels for groundwater bores relevant to LW401 to LW407, respectively.

Table 2.3 Groundwater quality investigation triggers (salinity and pH)

Piezometer	Lithology Screened	Screened Depth (mbgl)	Historical lab EC (5 th to 95 th percentile) (µS/cm)	EC Trigger value (µS/cm)	pH Trigger value (5 th to 95 th percentile)
PZ101C	Lower Triassic	30	610 - 810	810	6.1 – 7.7
PZ103C	Lower Triassic	30	310 - 448	448	5.2 – 6.8
PZ105C	Lower Triassic ¹	28	198 - 319	319	5.3 – 7.4

Note: 1: Screened interval for PZ105C also includes a small portion of underlying Permian.

Table 2.4 Groundwater level investigation triggers

Piezometer	Lithology Screened	Screened Depth (mbgl)	Minimum Observed Level (mAHD)	Investigation Trigger Level (mAHD)
PZ101C	Lower Triassic	30	380.0	378.0
PZ105C	Lower Triassic ¹	28	373.7	371.7
PZ129	Triassic	35 (VWP)	388.0	386.0

Notes: 1: Screened interval for PZ105C also includes a small portion of underlying Permian.

mAHD = metres Australian Height Datum.

mbgl = metres below ground level.

VWP = vibrating wire piezometer.

3 Assessment of observed and predicted groundwater impacts

This section presents an assessment of groundwater level impacts in the Triassic Sandstone aquifer caused by mining of UG4 LW401 to LW407, with consideration of adjacent and downstream natural and heritage features, and comparison against the approved level of groundwater impact, including the subsidence and water management performance measures in Project Approval (05_0117).

3.1 Mine inflow

Measuring groundwater inflows to mining operations is complex. Unlike groundwater level measurements, inflow estimates are affected by rainfall, evaporation, water reuse, seepage losses and the addition of other water sources. These factors make it difficult to accurately quantify groundwater inflows to the mining operations.

Table 3.1 presents a comparison between estimated groundwater inflows with model predictions since the commencement of UG4 first workings (i.e. in October 2020) to the completion of secondary extraction of LW407 (i.e. January 2026).

Estimated inflows exceeded the combined UG4 and UG1 model predictions during July 2020 - June 2023 which is attributed to above-average rainfall conditions experienced during this period.

During July 2023 - June 2024 and July 2024 - June 2025, estimated inflows were lower than the combined model predictions. The model predictions were based on the mining schedule available at the time of approval. Consequently, differences in the timing of predicted and estimated inflows may partly reflect differences between the planned and actual progression of mining.

MCO obtains and holds volumetric water licenses to account for groundwater inflows and surface water take associated with the development and operation of the Moolarben Coal Complex in accordance with the requirements of the *Water Management Act 2000* and the *Water Act 1912*.

Table 3.1 Comparison of estimated and predicted inflows between July 2022 and January 2026

Review period	Estimated actual groundwater inflows (UG1 and UG4) (ML)	Model predicted groundwater inflows (ML)*	
		UG4 only	UG4 + UG1
July 2020 – June 2021	2,834	296	2,015
July 2021 – June 2022	3,338	692	2,472
July 2022 – June 2023	4,453	2,813	3,041
July 2023 – June 2024	2,714	3,471	3,710
July 2024 – June 2025	2,247	3,626	3,861
July 2025 – January 2026	948	776	920
Total	16,534	11,674	16,019

Note: * Moolarben Coal Complex groundwater model 2023 (AGE, 2023).

3.2 Groundwater levels

Observed groundwater levels in the UG4 area are presented in hydrographs in Appendix B, together with the Cumulative Rainfall Departure (CRD). This section focusses on the assessment of UG4 LW401-407 mining related impacts on the regional groundwater table in the Triassic sandstone as none of the receptors (i.e. Goulburn River, The Drip, private bore) rely on deeper aquifer systems held in the Permian units.

Figure 3.1 shows the estimated observed groundwater drawdowns in the Triassic sandstone regional groundwater table related to UG4 LW401 to LW407 operations at each monitoring point as of the end of January 2026. Water table drawdown was calculated for each monitoring point by subtracting the latest standing water level (SWL) from the SWL at the time groundwater level trends deviate from climatic trends. PZ192 VWP 68m was left out from the assessment, as discussed in the UG4 LW401 to LW408 Extraction Plan (AGE, 2023), the response at this site is likely related to issues in the construction of this VWP.

As shown in Figure 3.1 and Appendix B, observed water table drawdowns at the Triassic UG4 monitoring points suggest that UG4 LW401 to LW407 related drawdown has only been observed in the Triassic Sandstone water table at monitoring points located nearby the active mine footprint. In particular, the following monitoring results are noted:

- PZ195B and PZ194B (located adjacent to the commencing ends of LW402 and LW404 respectively) – mining-related drawdown observed at these two bores. Monitoring point PZ195B is dry.
- PZ103C (located directly above LW407) – negligible mining-related drawdown observed until 5 days before longwall extraction directly beneath the bore location in November 2025. Groundwater levels recorded at PZ103C since December 2025 are likely related to stagnant water below the screened interval at the bottom of the bore, and do not represent the aquifer conditions. As such, the bore can be considered dry.
- PZ235C and PZ236C (located above the UG4 LW409 to LW414 footprint) – no mining-related drawdown has been observed.
- The gently declining trend observed at PZ234A (adjacent to SW22) is not related to the UG4 mining activities but rather a higher responsiveness of the aquifer to climate conditions at this location. This is supported by the following lines of evidence:
 - absence of observed impacts on the Triassic Sandstone water table at monitoring bore PZ236C, which is located closer to the active mine footprint; and
 - a similar trend observed at the nearby Triassic monitoring bore PZ105C, where the long-term groundwater level time series is aligned with the CRD.

Figure 3.2 shows a comparison between estimated saturated thickness in the Triassic sandstone in June 2022 and in January 2026 (i.e. completion of LW407). Table 3.2 provides a comparison between predicted drawdown and observed drawdown at monitoring bores as of end of LW407 (i.e. January 2026).

Localised drawdown around the LW401 to LW407 mining areas aligns with model predictions, which predict drainage of the Triassic immediately above and adjacent to the goaf, but do not predict extensive drawdown away from the goaf in the Triassic strata. In the Ulan Seam and Permian more laterally extensive drawdown away from the goaf area is observed, which also aligns with model predictions.

No exceedances of the investigation trigger values developed as part of the UG4 LW401 to LW408 Water Management Plan (MCO, 2023) were recorded during extraction of LW401 to LW407. Table 3.3 summarises the outcomes of review of the groundwater level TARP for each trigger investigation bore during mining of LW401 to LW407.

Table 3.2 Comparison between observed and predicted drawdown at Triassic sandstone monitoring bores due to UG4 LW401 to LW07 operations

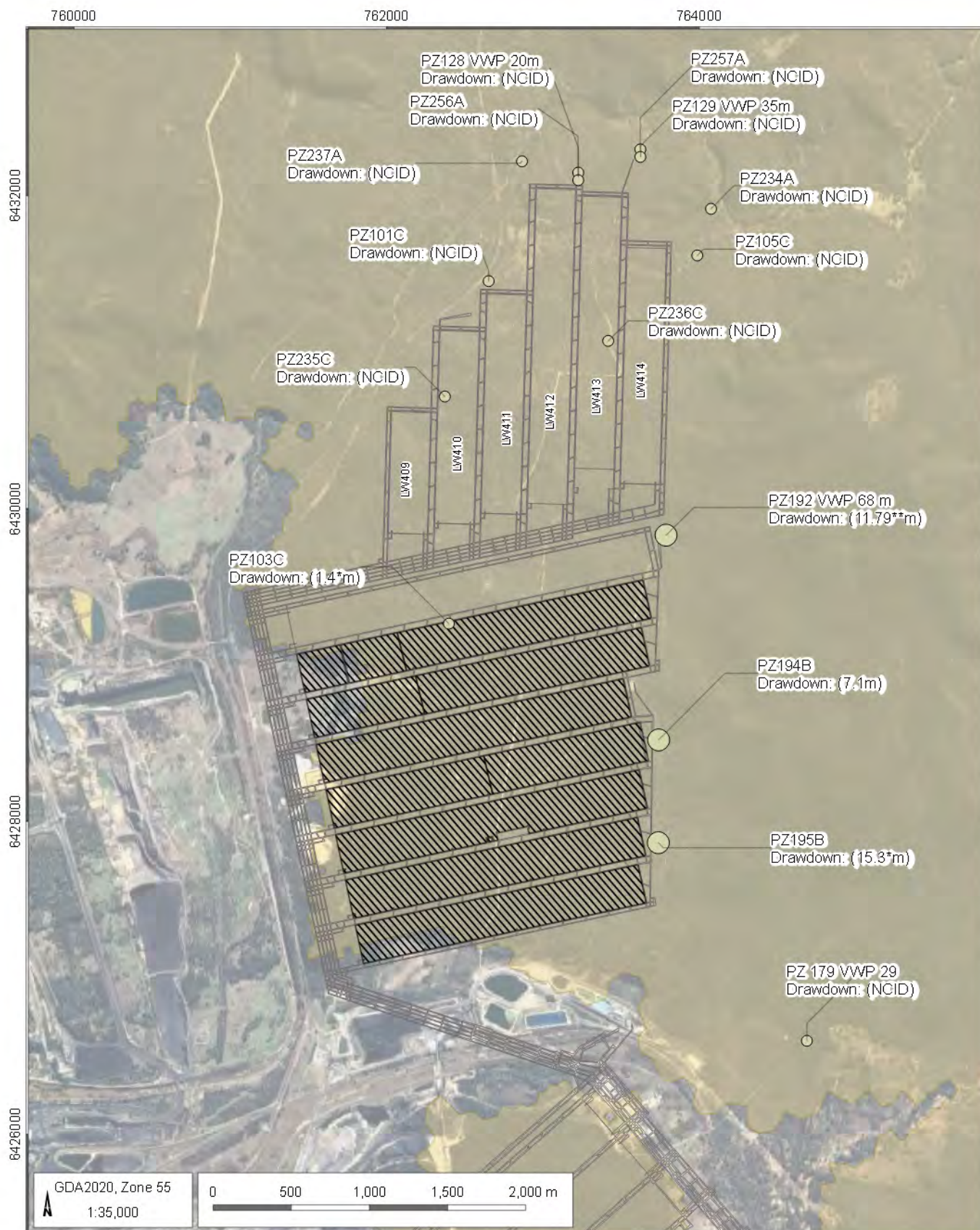
Monitoring bore	Observed mining-related drawdown as of end of LW407 (i.e. January 2026)	Predicted drawdown as of end of LW407 (AGE, 2023)*
PZ101C	No clearly identifiable drawdown	< 0.01 m
PZ103C	1.4** m	29.3 m
PZ105C	No clearly identifiable drawdown	< 0.01 m
PZ128 VWP 20 m	No clearly identifiable drawdown	< 0.01 m
PZ129 VWP 35 m	No clearly identifiable drawdown	< 0.01 m
PZ194B	7.1 m	32.4 m
PZ195B	15.3** m	27.1 m
PZ234A	No clearly identifiable drawdown	< 0.01 m
PZ235C	No clearly identifiable drawdown	< 0.01 m
PZ236C	No clearly identifiable drawdown	< 0.01 m
PZ237A	No clearly identifiable drawdown	< 0.01 m
PZ256A	No clearly identifiable drawdown	< 0.01 m
PZ257A	No clearly identifiable drawdown	< 0.01 m

Notes: * UG4 LW401-408 Extraction Plan Revised Groundwater Technical Report (AGE, 2023).

** dry bore.

Table 3.3 Groundwater level TARP review

Piezometer	Investigation trigger level (mAHD)	Minimum observed level as of end of LW407 (mAHD)	Any recorded investigation trigger exceedances?
PZ101C	378.0	379.2	No
PZ105C	371.7	373.5	No
PZ129 VWP 35 m	386.0	389.9	No



LEGEND

- Drainage
- UG Mine plan
- Modelled Triassic Extent
- UG4 Mined LW as of January 2026

Estimated drawdown (m)

- 0 to 2 m
- 2 to 5 m
- 5 to 20 m

NCID: No Clearly Identifiable Drawdown as of January 2026
 * Indicates a dry bore
 ** Indicates Lower Confidence Estimate

Moolarben Mine - End of Panel Reporting -
 UG4 LW401 to LW407 (MOO5018.002)

**Observed mining-related drawdown
 due to UG4 operations as of end of
 LW407**

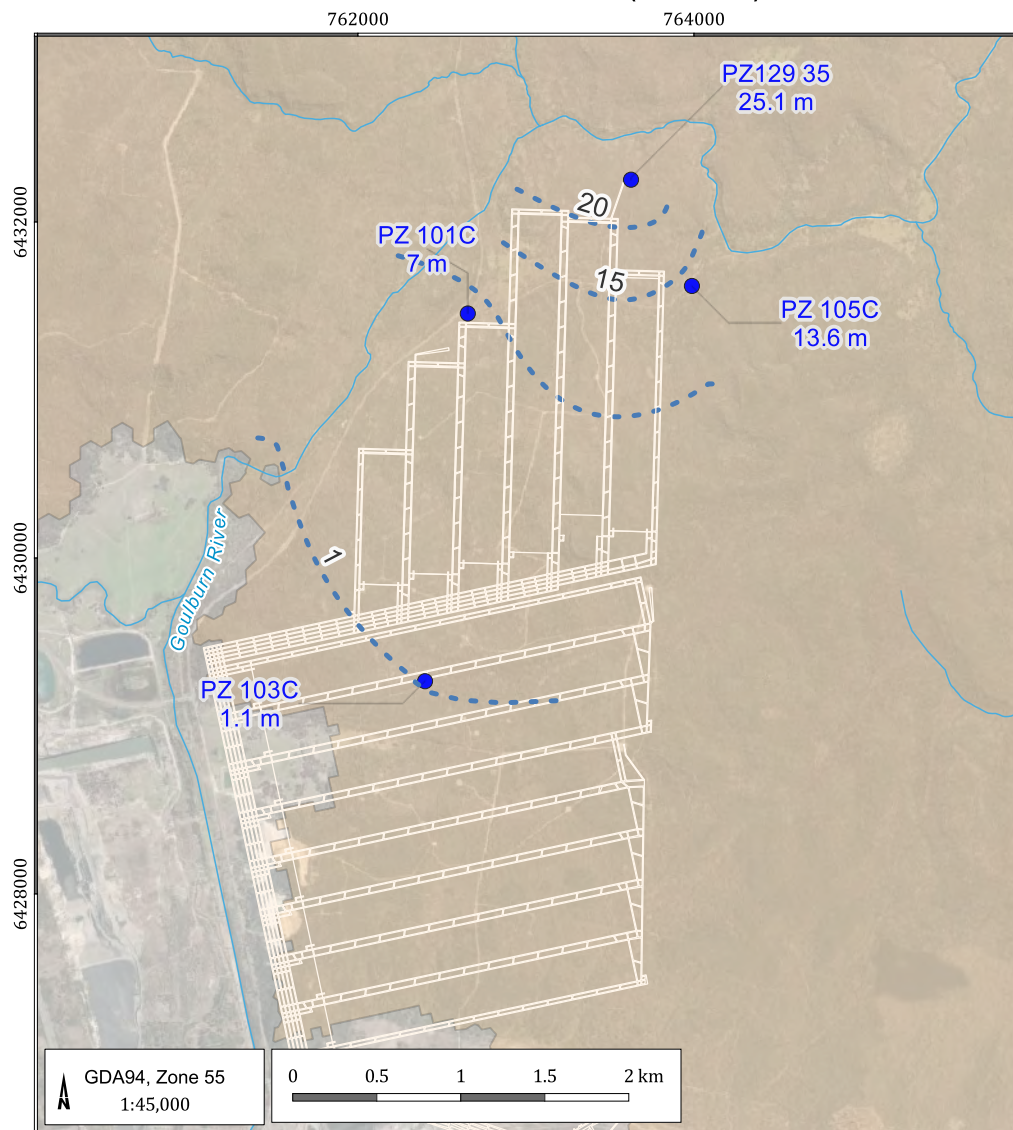


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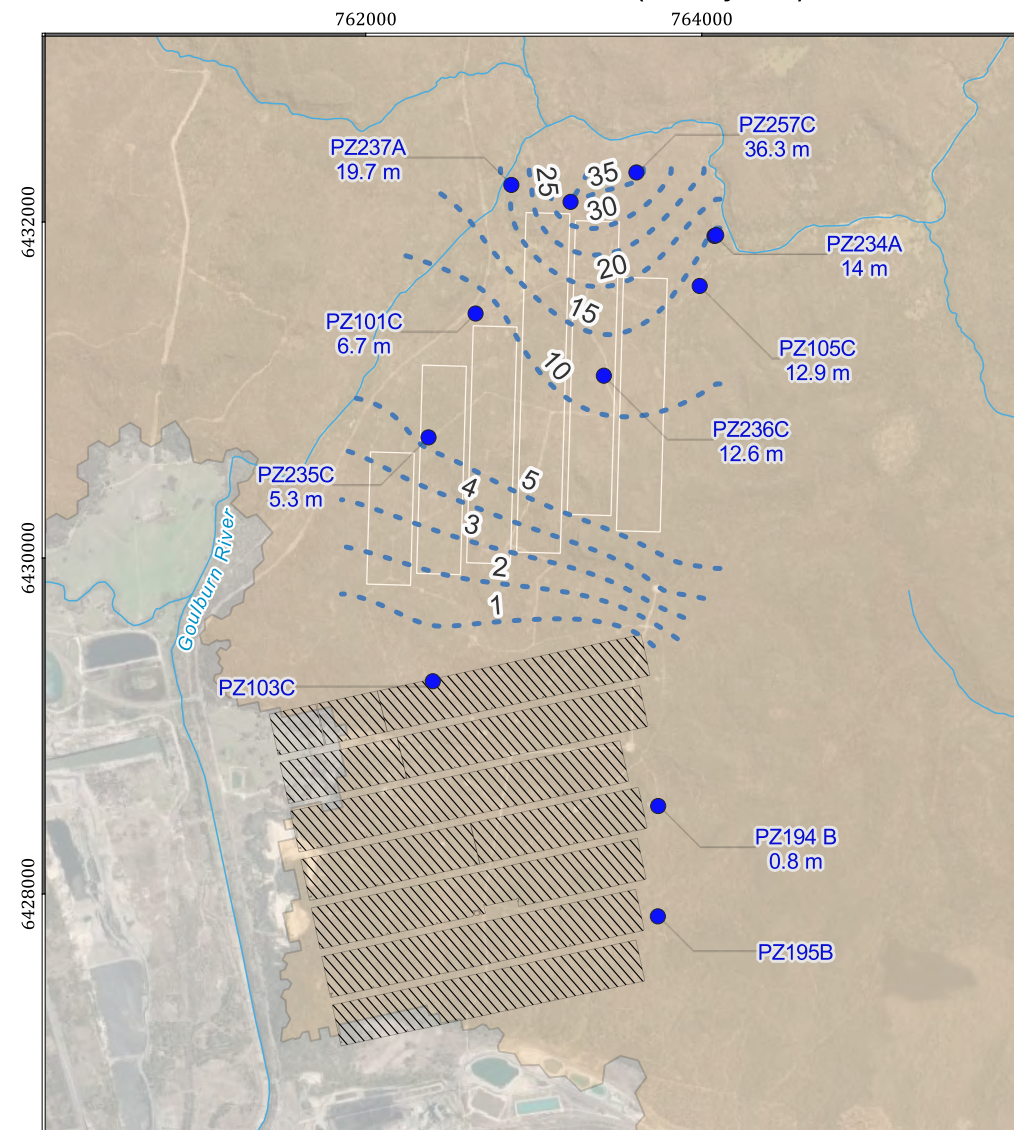
Estimated saturated thickness – Triassic formation (June 2022)



LEGEND

- Drainage
- Triassic Extent
- UG4 Mined LW

Estimated saturated thickness – Triassic formation (January 2026)



Moolarben Mine - End of Panel Reporting - UG4
LW401 to LW407 (MOO5018.002)

**Estimated saturated thickness –
Triassic formation (June 2022 and
January 2026)**

DATE
13/08/2026

FIGURE No:
3.2

3.3 Groundwater quality

Groundwater quality monitoring is undertaken in accordance with the complex-wide Groundwater Management Plan (MCO, 2026) and UG4 LW401 to LW408 Water Management Plan (MCO, 2023). Monitored parameters include physical parameters, major cations and anions, dissolved metals and nutrients.

Site-specific investigation triggers for acidity (pH) and electrical conductivity (EC) have been developed for three Triassic sandstone monitoring bores relevant to UG4 LW401 to LW408 mining area, namely PZ101C, PZ103C and PZ105C, based on baseline conditions (pre-July 2022) (Section 2.2.2). Laboratory EC and field pH time series at these three monitoring bores since 2020 compared with the investigation trigger values are provided in Appendix C.

The monitoring results highlight that groundwater quality conditions have not been affected by UG4 LW401 to LW407, with both the values and the trends post July 2022 showing similar results to the baseline conditions.

Groundwater quality observations did not exceed trigger investigation levels due to extraction of LW401 to LW407 and the TARP for groundwater quality was not triggered. Table 3.4 summarises the outcomes of review of the groundwater quality TARP for each trigger investigation bore during mining of LW401 to LW407.

Table 3.4 Groundwater quality TARP review

Piezometer	Monitoring parameter	Investigation trigger exceedances
PZ101C	Quality	No
PZ103C	Quality	No
PZ105C	Quality	No

3.4 Groundwater and surface water interaction

As mentioned in Section 2.1, MCO installed two additional gauging stations, namely SW2 and SW22, and two shallow standpipe monitoring bores, namely PZ237A and PZ234A, to compare surface / groundwater levels at two locations along the Goulburn River (Figure 2.1).

Figure 3.3 and Figure 3.4 show the water level data collected at each pair of surface water / groundwater monitoring points. The collected data indicates that:

- At the SW2-PZ237A pair, which is located approx. 230 m northwest of LW412 (i.e. upstream of The Drip), the Goulburn River is gaining, and the relationship between groundwater and surface water has been stable since their installation in November 2023. The observed gradient between groundwater and surface water has varied between 0.04 percent (%) and 0.07%.
- At the SW22-PZ234A pair, which is located approx. 490 m northeast of LW414 (i.e. downstream of The Drip), the Goulburn River is losing. However, it is important to consider that gauging station SW22 is located about 100 m upstream of groundwater monitoring bore PZ234A, which causes some uncertainty in the assessment of groundwater – surface water relationship at this location. The observed gradient between groundwater and surface water has varied between -0.01% and -0.1%.

The declining groundwater level trend observed at PZ234A is not related to the UG4 mining activities but rather a higher responsiveness of the aquifer to climate conditions at this location due to drier periods below rainfall averages. This is supported by the absence of observed impacts at monitoring bore PZ236C, which is located closer to the active mine footprint and a similar declining trend observed at the nearby monitoring bore PZ105C, where the long-term groundwater level time series is aligned with the CRD (Section 3.2).

The surface water levels along the Goulburn River are likely less affected by climate conditions due to the water released upstream by both the Moolarben Coal Complex and the Ulan Coal Complex.

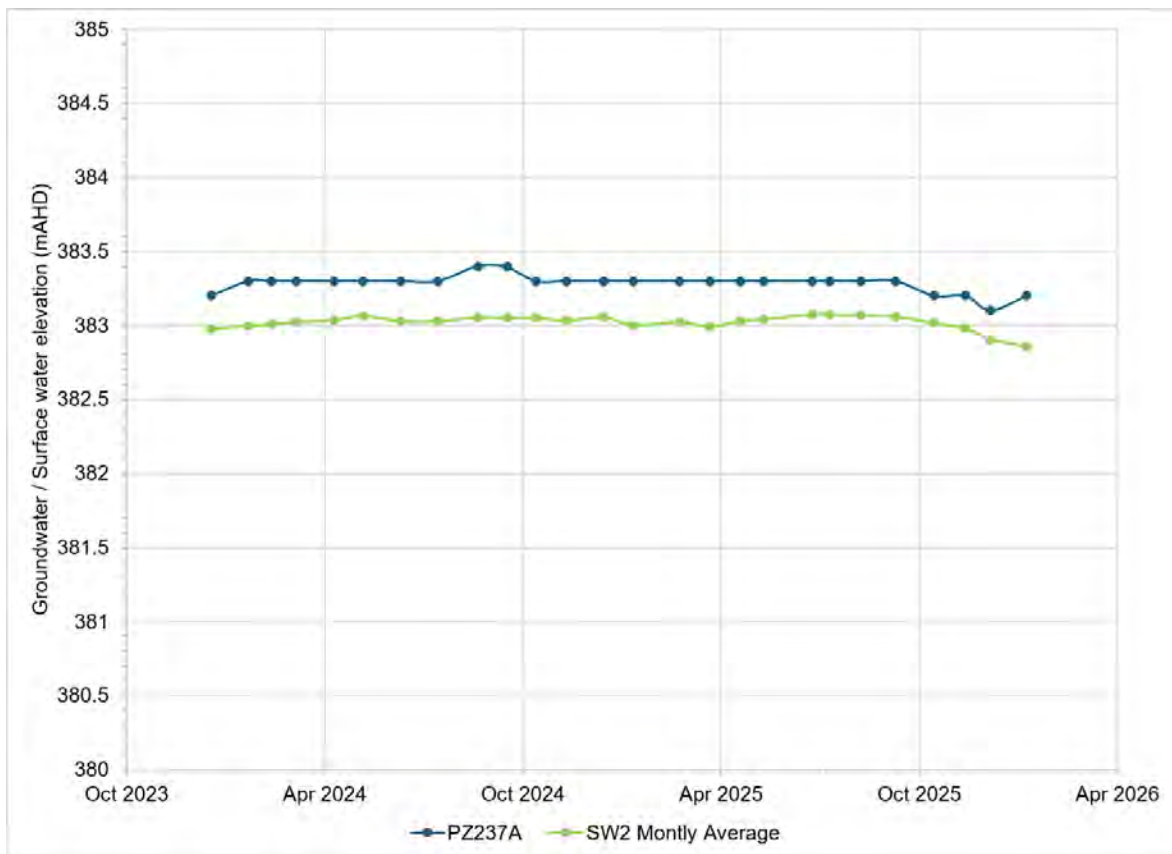


Figure 3.3 PZ237A / SW2 water level comparison

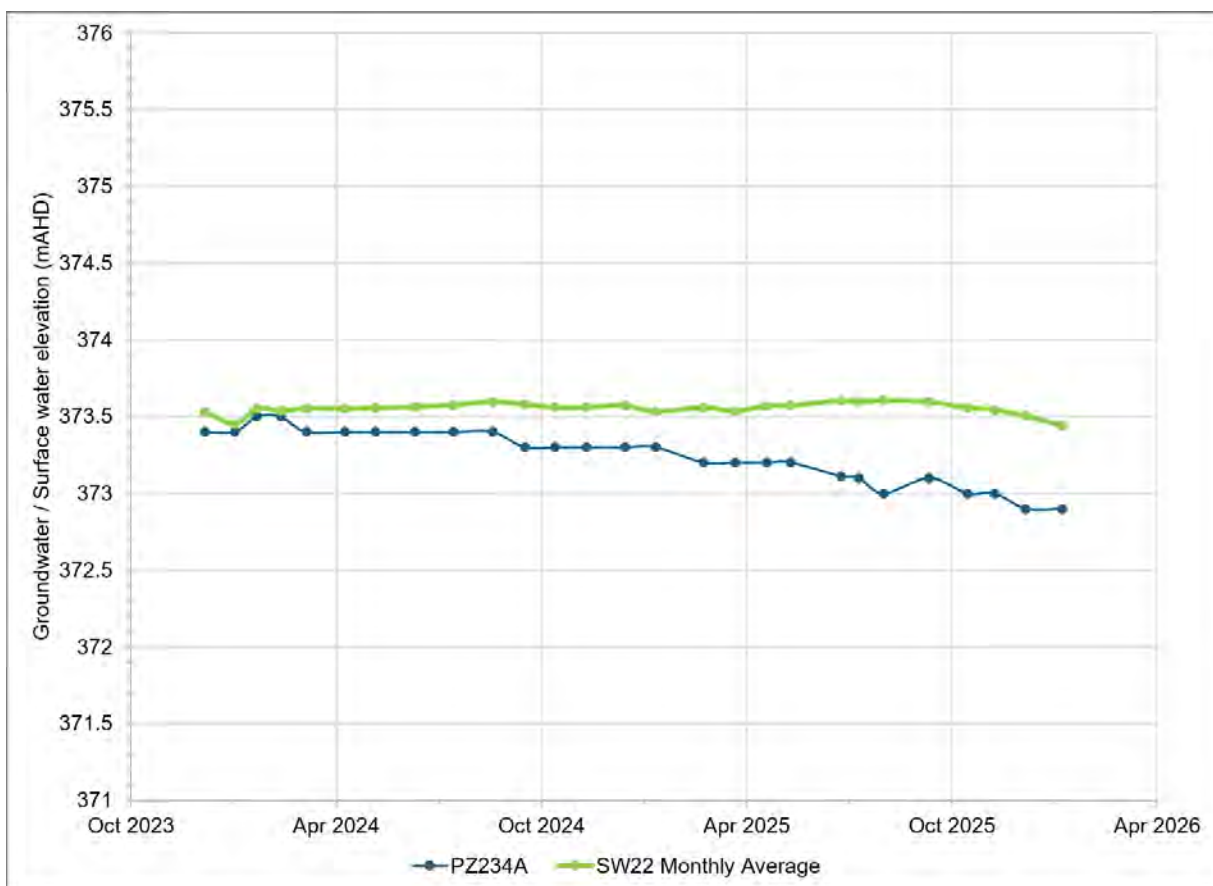


Figure 3.4 PZ234A / SW22 water level comparison

3.5 Private bores

There is one private bore (GW800279) in the vicinity of LW401 to LW407, located approximately 2.9 km northeast of the eastern corner of LW407. The bore is a relatively shallow bore (24 m) developed in Triassic sandstone and connected to the river alluvium (Figure 2.1). The location and baseline condition of this bore from 2020 is summarised in Table 3.5.

No cumulative groundwater drawdown is predicted at this bore whilst mining LW401 to LW408 and the predicted drawdown is less than the 2 m minimal impact consideration specified under the NSW Aquifer Interference Policy (AIP) for privately-owned groundwater bores. Groundwater level investigation triggers are based on the greater of the predicted groundwater drawdown, or 2 m drawdown below the minimum observed water level, and therefore, the groundwater level investigation trigger for the private bore is 2 m.

Table 3.5 Baseline condition of privately owned bores

Work ID	Licence no.	Easting	Northing	Bore type	Hydrogeological unit	Water Level (mAHD)	EC (µS/cm)	pH
GW800279	80BL236762	765208	6431971	Domestic	Triassic Narrabeen Group	371 (2020)	730	6.00

Notes: EC = electrical conductivity.
µS/cm = microSiemens per centimetre.
m AHD = metres Australian Height Datum.

There was an approximate 0.8 m decline in groundwater level at this bore between 2020 and 2025 (AGE, 2026). However, as discussed in Section 3.2, UG4 LW401 to LW407 related groundwater drawdown has only been observed in the Triassic Sandstone water table at monitoring points located adjacent to the active mine footprint. As such, it is unlikely that the observed drawdown at this bore is related to the UG4 LW401 to LW407 operations.

Accordingly, there were no trigger investigation events of the TARP due to extraction of LW401 to LW407, and no compensatory water supply was required or provided during the period. Therefore, UG4 LW401 to LW407 mining activities have had negligible impact on private bores.

3.6 Potential impacts to The Drip

The Drip is a cliff face water feature located more than 2.5 km north of LW408 and occurs directly adjacent to the northern side of the Goulburn River (Figure 1.3) with local cultural and community significance.

Previous studies (AGE, 2019; AGE, 2022) have conceptualised that The Drip is formed by an isolated localised groundwater system that is sustained by rainfall recharge to the Triassic Quartzose Sandstone units that overly the Illawarra Coal Measures. Groundwater seepage from The Drip occurs at an elevation of approximately 387 mAHD, compared to the Goulburn River water level at The Drip of approximately 380 mAHD.

There is no evidence indicating that The Drip is being impacted by Moolarben Coal Complex operations. No drawdown has been observed at the Triassic monitoring bores closest to The Drip during mining of LW401 to LW407 (i.e. PZ128 and PZ129 until decommissioning or replacement bores PZ256A and PZ257A once installed in August 2025) (Figure 3.1).

4 Conclusion

Observed groundwater level and quality monitoring data indicates that UG4 LW401 to LW407 mining operations have had negligible impacts on the Triassic sandstone aquifer, both in terms of quantity and quality. Also, observed groundwater level monitoring data indicates that UG4 LW401 to LW407 mining operations have had nil impacts to The Drip, as no drawdown has been observed at the Triassic monitoring bores closest to The Drip during mining of LW401 to LW407 (Figure 3.1).

Localised drawdown around the LW401 to LW407 mining areas aligns with model predictions, which predict drainage of the Triassic immediately above and adjacent to the goaf, but do not predict extensive lateral drawdown away from the goaf in the Triassic strata. In the Ulan Seam and Permian more laterally extensive drawdown away from the goaf area is observed, which also aligns with model predictions.

No exceedances of the investigation trigger values developed as part of the UG4 LW401 to LW408 Water Management Plan (MCO, 2023) have been recorded during extraction of LW401 to LW407. Table 4.1 summarises the outcomes of review of the groundwater level and quality TARPs during mining of LW401 to LW407.

Table 4.1 Groundwater TARP review

Piezometer	Monitoring Parameter	Investigation trigger exceedances	Recommended action and response
PZ101C	Level	No	No action, continue to monitor.
	Quality	No	No action, continue to monitor.
PZ103C	Quality	No	No action (remove from management plan as it was undermined during LW407 operations).
PZ105C	Level	No	No action, continue to monitor.
	Quality	No	No action, continue to monitor.
PZ129 VWP 35 m	Level	No	No action, bore has been decommissioned and replaced.

UG4 LW401 to LW407 mining activities have had negligible impact on private bores and did not exceed trigger investigation levels of the TARP due to extraction of LW401 to LW407. As such, no compensatory water supply was required or provided during the period.

There is no evidence indicating that The Drip is being impacted by Moolarben Coal Complex operations. No drawdown has been observed at the Triassic monitoring bores closest to The Drip during mining of LW401 to LW407.

As there were no groundwater investigation trigger events under the UG4 LW401 to LW408 Water Management Plan (MCO, 2023), there were no exceedances of the relevant water management and subsidence performance measures outlined in Condition 32 and Condition 73, Schedule 3 of Project Approval (05_0117) during UG4 LW401 to LW407 operations.

The following changes to the monitoring network and TARPs are considerate appropriate, based on the mine progression, the monitoring data review and the location of sensitive receptors in the UG4 area:

- removal of monitoring bore PZ103C from the trigger site list and the management plans, as it was undermined during UG4 LW07 operations;
- removal of monitoring sites PZ192 and PZ193 from the management plans due to their reliability; and
- removal of monitoring sites PZ191, PZ194, PZ195, PZ240 and PZ241 from the management plans due to their location in relation to future mine operations and sensitive receptors in the UG4 area.

5 References

Australasian Groundwater and Environmental Consultants, (2019) *“Ulan Coal Mine Complex – Review of Conditions at The Drip”*.

Australasian Groundwater and Environmental Consultants (2022) *“Ulan Coal Mines Modification 6 (MOD6) Groundwater Impact Assessment”*.

Australasian Groundwater and Environmental Consultants (2023) *“UG4 LW401-408 Extraction Plan Revised Groundwater Technical Report”*.

Australasian Groundwater and Environmental Consultants (2026) *“Ulan Coal Mine Annual Groundwater Review 2025”*.

Moolarben Coal Operations Pty Ltd (2023) *“Moolarben Coal Complex UG4 Longwall 401 to 408 Water Management Plan”*.

Moolarben Coal Operations Pty Ltd (2024) *“UG4 LW401-403 End of Panel Report”*.

Moolarben Coal Operations Pty Ltd (2026) *“Moolarben Coal Complex Groundwater Management Plan”*.

Appendix A

UG4 Groundwater Monitoring Network Details

Table A 1 UG4 groundwater monitoring network details

Name	Survey Easting	Survey Northing	Elevation (mAHD)	Type	Depth (mbgl)	Lithology Screened	Screened Interval (mngl)	Stick up (TOC) (m)	TOC (mAHD)	Base of screen/VWP sensor (mAHD)	Water Level Monitoring Frequency	Water Quality Monitoring Frequency
PZ101B	762647	6431447	403.28	Standpipe	60	Permian OB	54 - 60	0.6	403.2	342.5	Manual monthly	6-monthly
PZ101C	762652	6431455	402.59	Standpipe	30	Lower Triassic	24 - 30	0.6	403.2	342.5	Manual monthly	6-monthly
PZ102A*	761118	6429150	408.5	Standpipe	125	Marrangaro	116 – 125	-	408.5	-	Manual monthly	6-monthly
PZ102B*	761117	6429147	408.2	Standpipe	86	Ulan Seam	80 - 86	-	408.2	-	Manual monthly	6-monthly
PZ102C VWP	761115	6429160	408.6	VWP	28	Permian OB	28	-	-	-	Datalogger recorded monthly	N/A
PZ102C VWP	761115	6429160	408.6	VWP	64	Permian OB	64	-	-	-		
PZ103A*	762410	6429261	425.1	Standpipe	128	Ulan Seam	118 - 127	-	425.2	-	Manual monthly	6-monthly
PZ103B*	762397	6429264	424.8	Standpipe	87	Permian	81 - 87	-	425	-	Manual monthly	6-monthly
PZ103C	762398	6429266	424.73	Standpipe	30	Lower Triassic	24 - 30	0.2	425	395	Manual monthly	6-monthly
PZ103D VWP 31 m	762439	6429263	425.26	VWP	31	Permian	31	-	-	394.2	Datalogger recorded monthly	N/A
PZ103D VWP 55 m	762439	6429263	425.26	VWP	55	Permian	55	-	-	370.2		
PZ103D VWP 85 m	762439	6429263	425.26	VWP	85	Permian	85	-	-	340.2		
PZ105C	763986	6431619	389	Standpipe	28	Lower Triassic	20 - 28	0.4	389	360.5	Manual monthly	6-monthly
PZ105A VWP 28 m	763988	6431611	388.93	VWP	28	Permian	28	-	-	360.9	Datalogger recorded monthly	N/A
PZ105A VWP 80 m	763988	6431611	388.93	VWP	80	Permian	80	-	-	308.9		
PZ105A VWP 118 m	763988	6431611	388.93	VWP	118	Ulan Seam	118	-	-	270.9		
PZ105A VWP 130 m	763988	6431611	388.93	VWP	130	Ulan Seam	130	-	-	258.9		
PZ128 VWP 20 m*	763227	6432121	409.52	VWP	20	Triassic	20	-	-	389.5	Datalogger recorded monthly	N/A
PZ128 VWP 36 m*	763227	6432121	409.52	VWP	36	Permian OB	36	-	-	373.5		
PZ128 VWP 55 m*	763227	6432121	409.52	VWP	55	Permian OB	55	-	-	354.5		
PZ129 VWP 35 m*	763624	6432252	417.95	VWP	35	Triassic	35	-	-	382.9	Datalogger recorded monthly	N/A
PZ129 VWP 53 m*	763624	6432252	417.95	VWP	53	Permian OB	53	-	-	364.9		
PZ129 VWP 74 m*	763624	6432252	417.95	VWP	74	Permian OB	74	-	-	343.9		
PZ191	761777	6426774	417.69	Standpipe	72	Ulan Seam	60 - 72	0.1	417.4	345.3	Manual monthly	6-monthly
PZ192 VWP 68 m	763787	6429831	453.52	VWP	68	Triassic	68	-	-	385.5	Datalogger recorded monthly	N/A
PZ192 VWP 166 m	763787	6429831	453.52	VWP	166	Ulan Seam Roof	166	-	-	287.5		
PZ192 VWP 178 m	763787	6429831	453.52	VWP	178	Ulan Seam Base	178	-	-	275.5		
PZ193 VWP 80 m	763733	6429326	461.40	VWP	80	Permian OB	80	-	-	381.4	Datalogger recorded monthly	N/A
PZ193 VWP 162 m	763733	6429326	461.40	VWP	162	Ulan Seam Roof	162	-	-	299.4		
PZ193 VWP 184 m	763733	6429326	461.40	VWP	184	Ulan Seam Base	184	-	-	277.4		

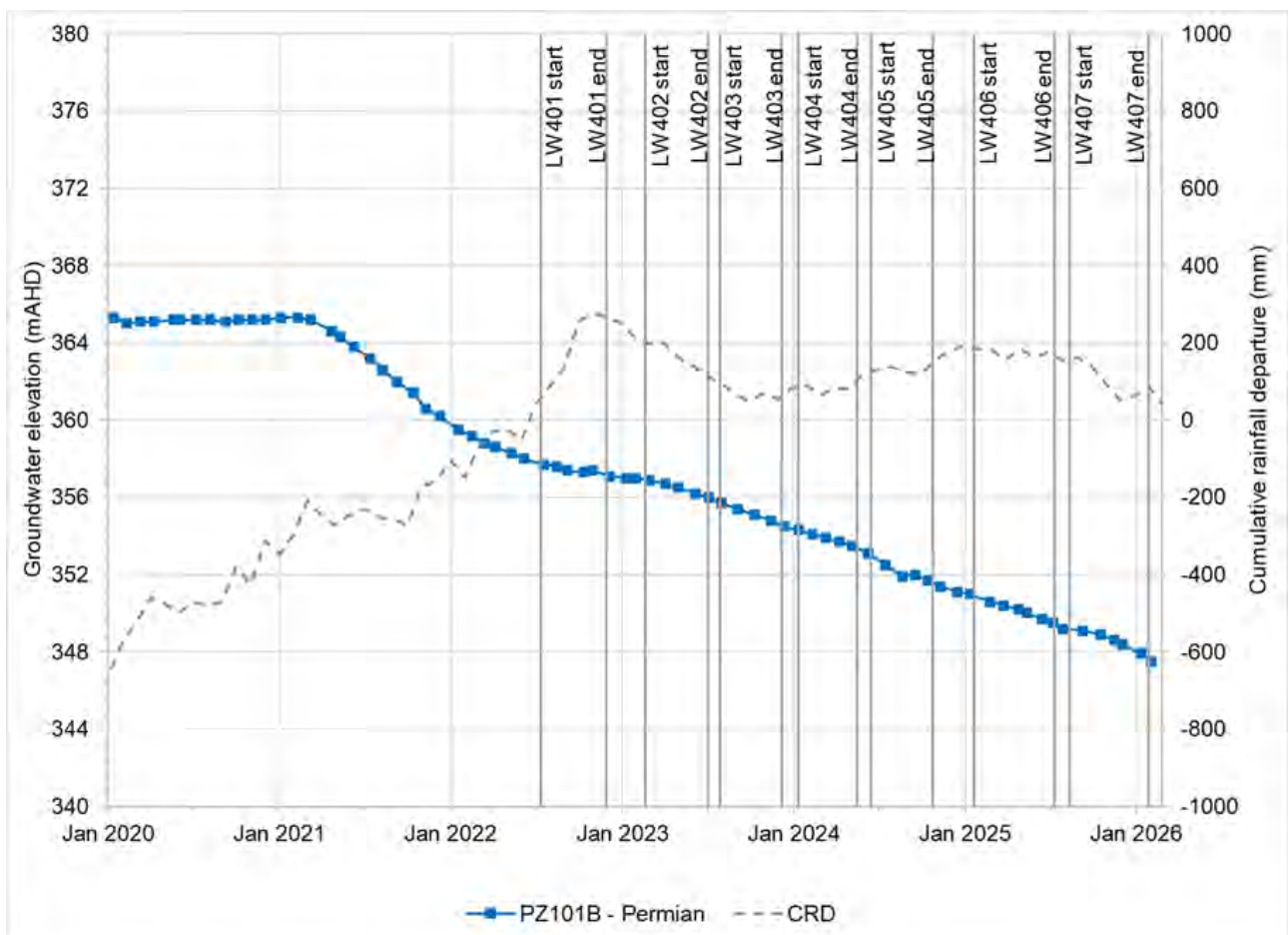
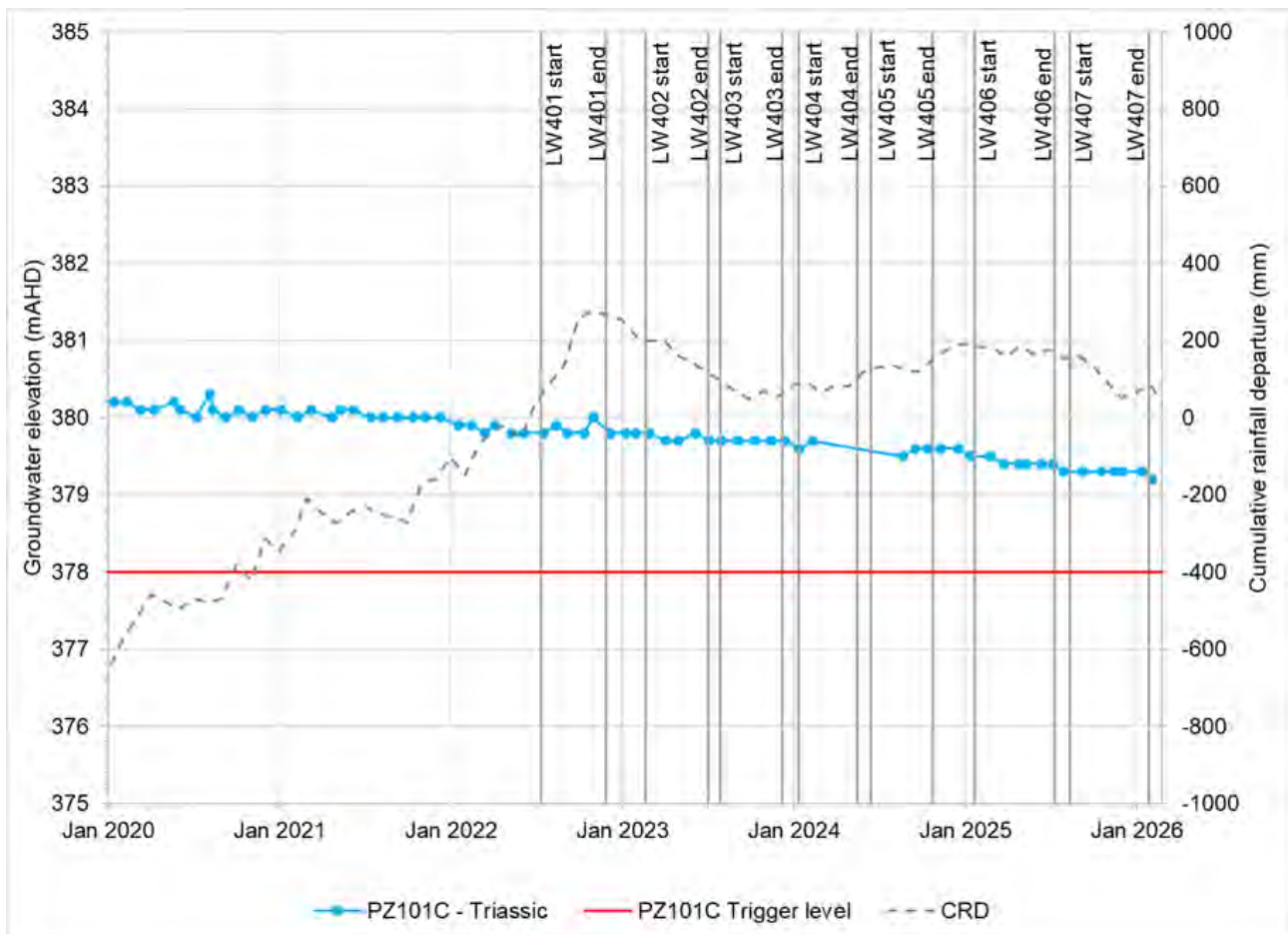
Name	Survey Easting	Survey Northing	Elevation (mAHD)	Type	Depth (mbgl)	Lithology Screened	Screened Interval (mngl)	Stick up (TOC) (m)	TOC (mAHD)	Base of screen/VWP sensor (mAHD)	Water Level Monitoring Frequency	Water Quality Monitoring Frequency
Piezometer PZ194B	763740	6428522	486.19	Standpipe	88	Triassic	85 - 88	0.67	486.8	398.1	Manual monthly	6-monthly
Piezometer PZ194C	763724	6428517	486.70	Standpipe	109	Permian	100 - 106	0.82	487.5	380.2	Manual monthly	6-monthly
Piezometer PZ194 VWP 78 m	763724	6428517	486.70	VWP	78	Triassic	78	-	-	408.7	Datalogger recorded monthly	N/A
Piezometer PZ194 VWP 173 m	763724	6428517	486.70	VWP	173	Ulan Seam	173	-	-	313.7		
Piezometer PZ194 VWP 196 m	763724	6428517	486.70	VWP	196	Ulan Seam	196	-	-	290.7		
Piezometer PZ195B	763738	6427865	471.43	Standpipe	66	Triassic	63-66	0.7	472.1	405.4	Manual monthly	6-monthly
Piezometer PZ195C	763716	6427847	470.72	Standpipe	91	Permian	81-87.8	0.6	471.3	382.9	Manual monthly	6-monthly
Piezometer PZ195 VWP 72 m	767876	6427832	471.40	VWP	180	Base of Triassic/Upper Permian	72	-	-	291.4	Datalogger recorded monthly	N/A
Piezometer PZ195 VWP 162 m	767876	6427832	471.40	VWP	180	Ulan Seam Roof	162	-	-	291.4		
Piezometer PZ195 VWP 175 m	767876	6427832	471.40	VWP	180	Ulan Seam Base	175	-	-	291.4		
Piezometer PZ232 VWP 45 m*	763251	6428497	484.6	VWP	195.2	Triassic	45	-	-	439.6	Datalogger recorded monthly	N/A
Piezometer PZ232 VWP 75 m*	763251	6428497	484.6	VWP	195.2	Triassic	75	-	-	409.6		
Piezometer PZ232 VWP 96 m*	763251	6428497	484.6	VWP	195.2	Permian	96	-	-	388.6		
Piezometer PZ232 VWP 132 m*	763251	6428497	484.6	VWP	195.2	Permian	132	-	-	352.6		
Piezometer PZ233A (PZ-A)	761423	6430099	403.03	Standpipe	18	River level	15 - 18	0.8	403.9	385.0	Manual monthly	6-monthly
Piezometer PZ233B (PZ-A)	761424	6430110	402.89	Standpipe	54	Permian	51 - 54	0.9	403.8	347.8	Manual monthly	6-monthly
Piezometer PZ233C VWP 20 m	761422	6430090	402.73	VWP	20	Moolarben Seam	20	-	-	382.7	Datalogger recorded monthly	N/A
Piezometer PZ233C VWP 52 m	761422	6430090	402.73	VWP	52	Permian	52	-	-	350.7		
Piezometer PZ233C VWP 75 m	761422	6430090	402.73	VWP	75	Ulan OB	75	-	-	327.7		
Piezometer PZ233C VWP 99 m	761422	6430090	402.73	VWP	99	Ulan Seam	99	-	-	303.7		
Piezometer PZ233C VWP 109 m	761422	6430090	402.73	VWP	109	Permian	109	-	-	293.7		
Piezometer PZ234A (PZ-E)	764075	6431917	384.94	Standpipe	18	Triassic	15 - 18	0.9	385.8	366.9	Manual monthly	6-monthly
Piezometer PZ234B (PZ-E)	764085	6431921	384.67	Standpipe	30	Lower Triassic/Upper Permian	27 - 30	0.8	385.4	354.6	Manual monthly	6-monthly
Piezometer PZ234C (PZ-E)	764095	6431918	384.07	Standpipe	78	Permian	69 - 75	0.8	384.9	309.0	Manual monthly	6-monthly
Piezometer PZ235A* (PZ-C)	762372	6430718	436.17	Standpipe	49	Triassic	44 - 49	0.1	436.1	-	-	-
Piezometer PZ235C (PZ-C)	762370	6430725	434.6	Standpipe	49	Triassic	46 - 49	0.7	435.1	385.3	Manual monthly	6-monthly
Piezometer PZ235B VWP 68 m	762377	6430721	434.86	VWP	68	Permian OB	68	-	-	366.8	Datalogger recorded monthly	N/A
Piezometer PZ235B VWP 96 m	762377	6430721	434.86	VWP	96	Permian OB	96	-	-	338.8		
Piezometer PZ235B VWP 147 m	762377	6430721	434.86	VWP	147	Ulan Seam	147	-	-	287.8		
Piezometer PZ236A* (PZ-D)	763416	6431085	437.5	Standpipe	60	Base of Triassic	54 - 60	0.9	437.5	376.6	Manual monthly	6-monthly

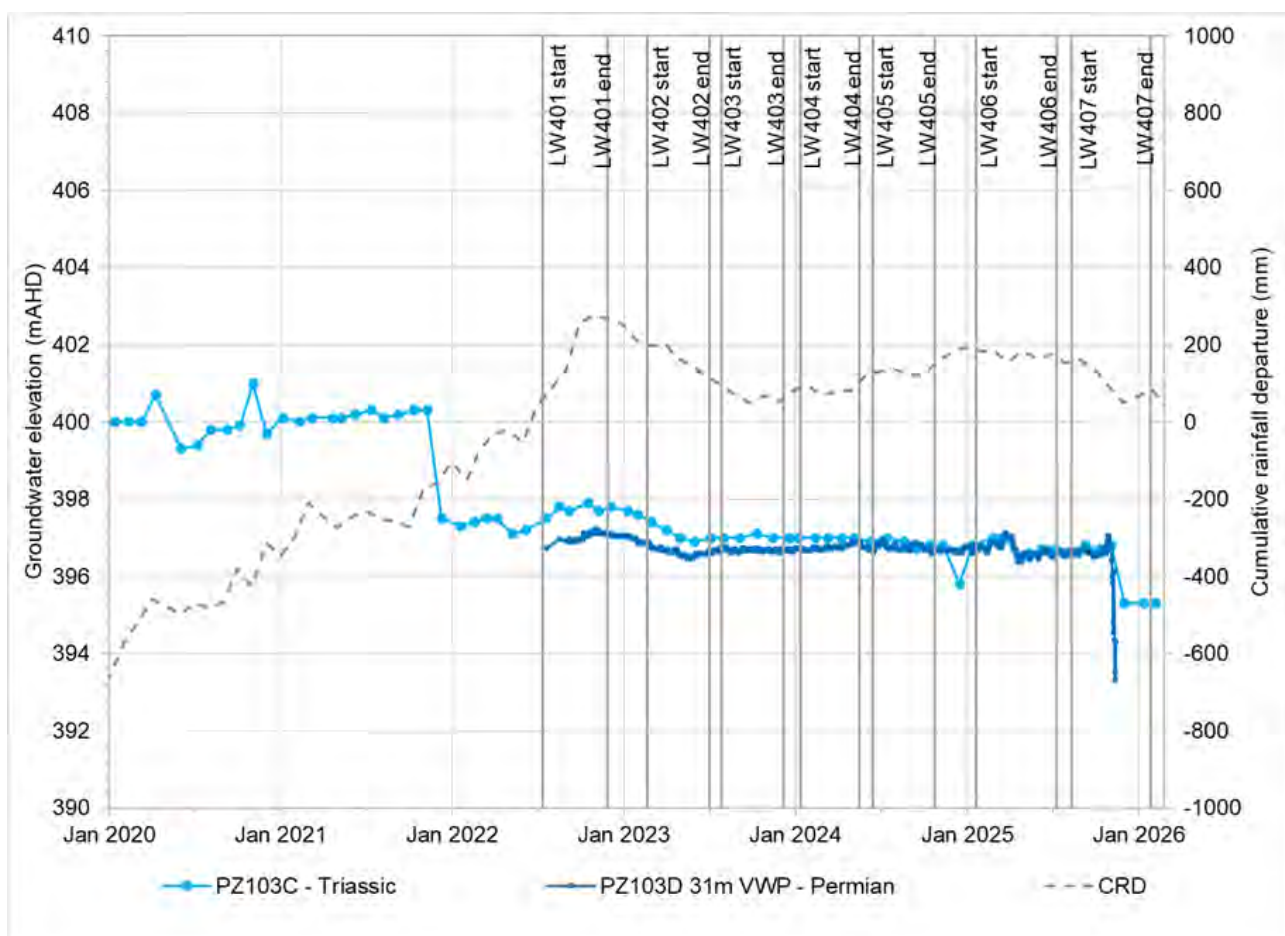
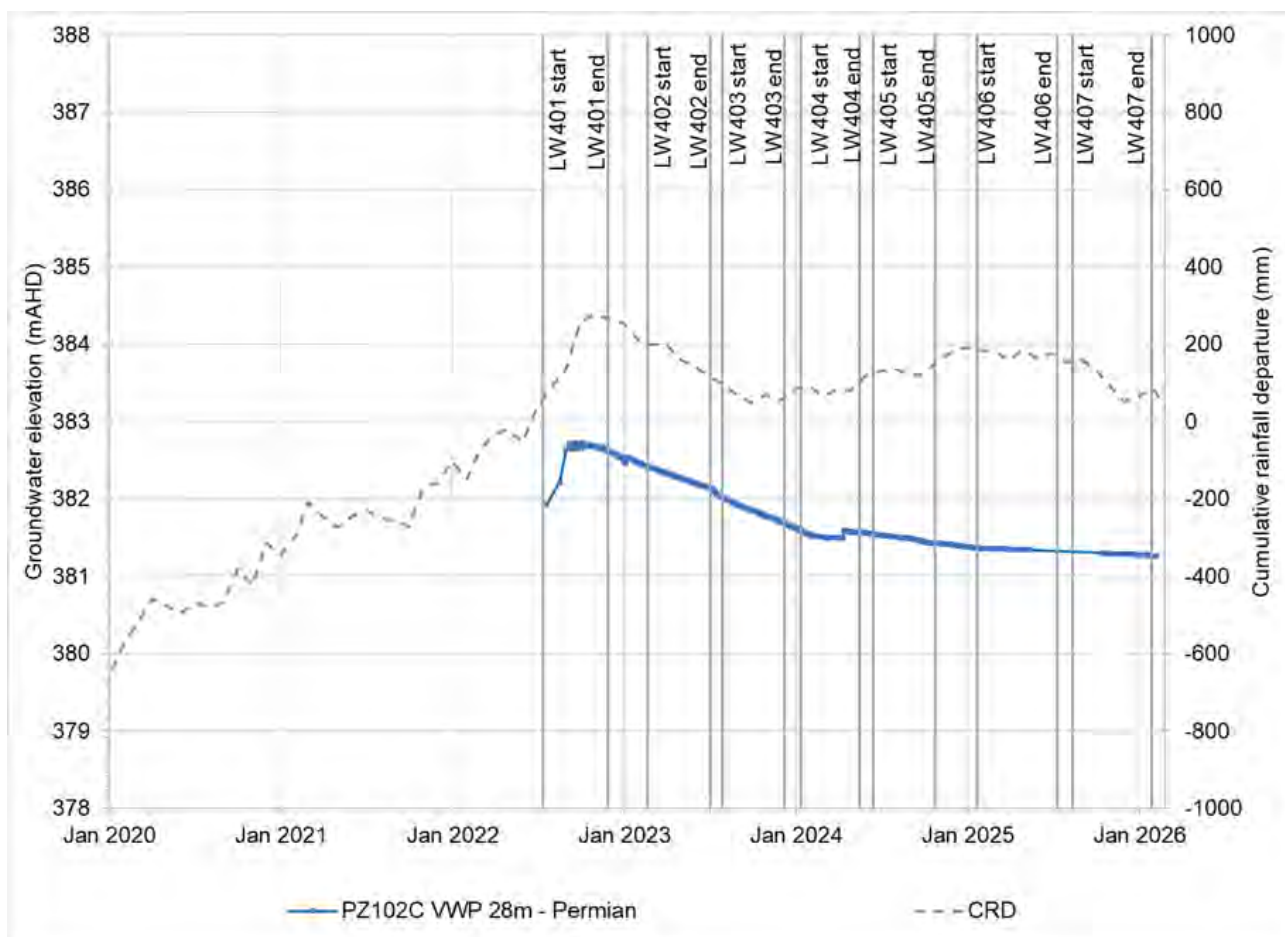
Name	Survey Easting	Survey Northing	Elevation (mAHD)	Type	Depth (mbgl)	Lithology Screened	Screened Interval (mngl)	Stick up (TOC) (m)	TOC (mAHD)	Base of screen/VWP sensor (mAHD)	Water Level Monitoring Frequency	Water Quality Monitoring Frequency
Piezometer PZ236C (PZ-D)	763417	6431073	437.5	Standpipe	58	Base of Triassic	55 - 58	0.7	-	378.7	Manual monthly	6-monthly
Piezometer PZ236B VWP 85 m	763418	6431091	436.70	VWP	85	Permian	85	-	-	351.7	Datalogger recorded monthly	N/A
Piezometer PZ236B VWP 110 m	763418	6431091	436.79	VWP	110	Permian	110	-	-	326.7		
Piezometer PZ236B VWP 157 m	763418	6431091	436.75	VWP	157	Ulan Seam	157	-	-	279.7		
Piezometer PZ237A (PZ-F)	762866	6432221	390.27	Standpipe	17	Triassic	14 - 17	1.0	391.2	373.2	Manual monthly	6-monthly
Piezometer PZ237B (PZ-F)	762876	6432225	390.66	Standpipe	30	Lower Triassic / Upper Permian	27 - 30	0.9	391.6	360.6	Manual monthly	6-monthly
Piezometer PZ237C (PZ-F)	762883	6432210	392.15	Standpipe	76	Permian	66 - 72	0.8	393.0	320.1	Manual monthly	6-monthly
Piezometer PZ240 VWP 59 m	761548	6426705	416.20	VWP	59	Ulan Seam	59	-	-	353.7	Datalogger recorded monthly	N/A
Piezometer PZ241	761619	6426622	417.81	Standpipe	22	Paleochannel	19-22	0.9	418.7	395.8	Manual monthly	6-monthly
Piezometer PZ256A	763224	6432128	409.35	Standpipe	40	Triassic	37 - 40	0.8	410.2	369.3	Manual monthly	6-monthly
Piezometer PZ256C	763218	6432120	409.61	Standpipe	71	Permian	67 - 71	0.8	410.4	338.6	Manual monthly	6-monthly
Piezometer PZ256B VWP 60 m	763226	6432103	409.03	VWP	60	Triassic	60	0.5	409.5	349.0	Datalogger recorded monthly	N/A
Piezometer PZ256B VWP 96 m	763226	6432103	409.03	VWP	96	Permian	96	0.5	409.5	313.0		
Piezometer PZ256B VWP 120m	763226	6432103	409.03	VWP	120	Ulan Seam	120	0.5	409.5	289.0		
Piezometer PZ256B VWP 145 m	763226	6432103	409.03	VWP	145	Ulan Seam	145	0.5	409.5	264.0		
Piezometer PZ256B VWP 155 m	763226	6432103	409.03	VWP	155	Permian	155	0.5	409.5	254.0		
Piezometer PZ257A	763621	6432295	419.14	Standpipe	61	Triassic	58-61	0.9	420.0	357.1	Manual monthly	6-monthly
Piezometer PZ257C	763610	6432295	419.47	Standpipe	84	Permian	81-84	0.8	420.3	335.4	Manual monthly	6-monthly
Piezometer PZ257B VWP 63 m	763613	6432297	419.50	VWP	63	Triassic	63	0.4	419.9	356.4	Datalogger recorded monthly	N/A
Piezometer PZ257B VWP 120 m	763613	6432297	419.50	VWP	120	Permian	120	0.4	419.9	299.4		
Piezometer PZ257B VWP 140 m	763613	6432297	419.50	VWP	140	Ulan Seam OB	140	0.4	419.9	279.4		
Piezometer PZ257B VWP 167 m	763613	6432297	419.50	VWP	167	Ulan Seam	167	0.4	419.9	252.4	Datalogger recorded monthly	N/A
Piezometer PZ257B VWP 175 m	763613	6432297	419.50	VWP	175	Permian	175	0.4	419.9	244.4		

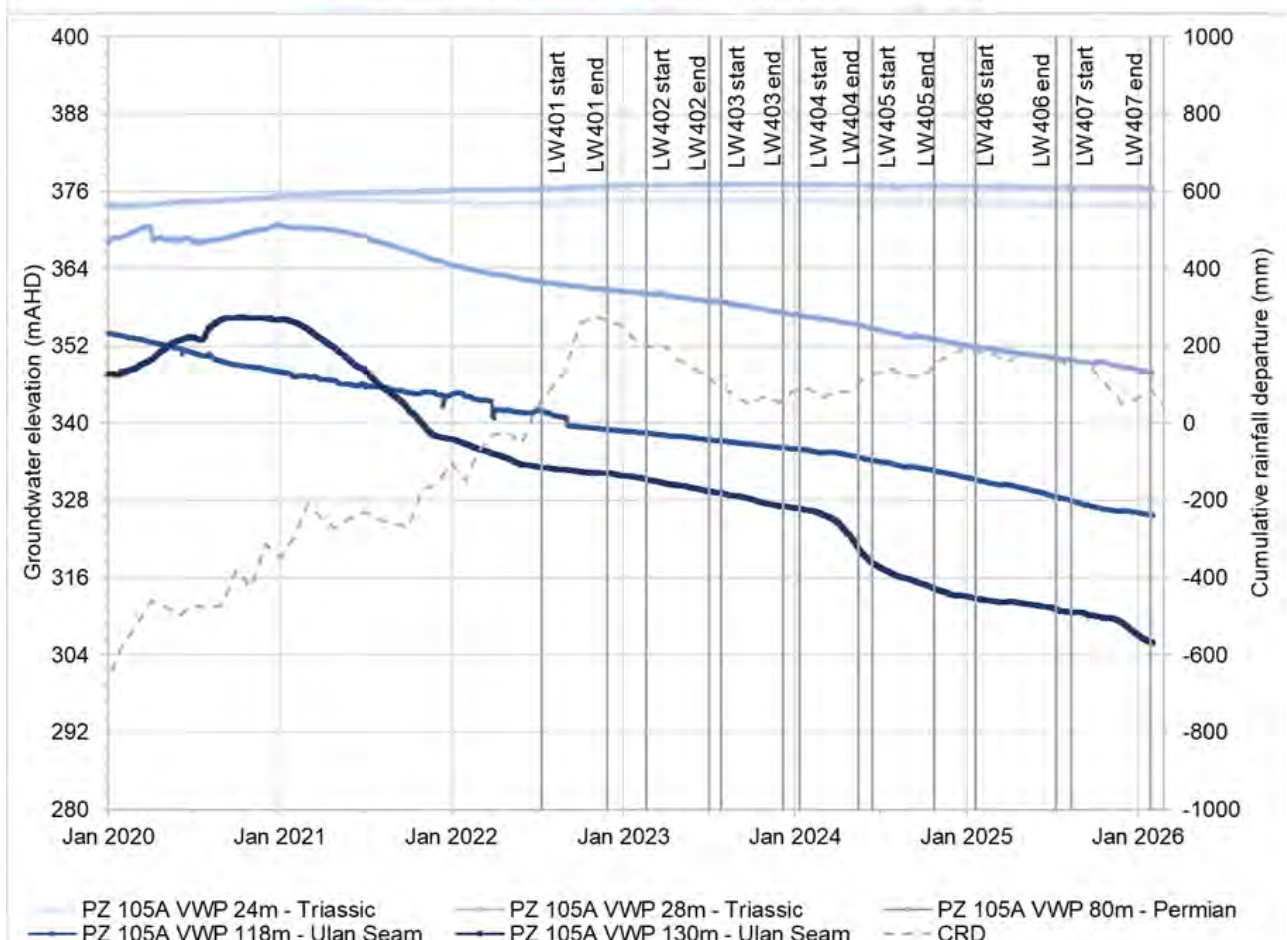
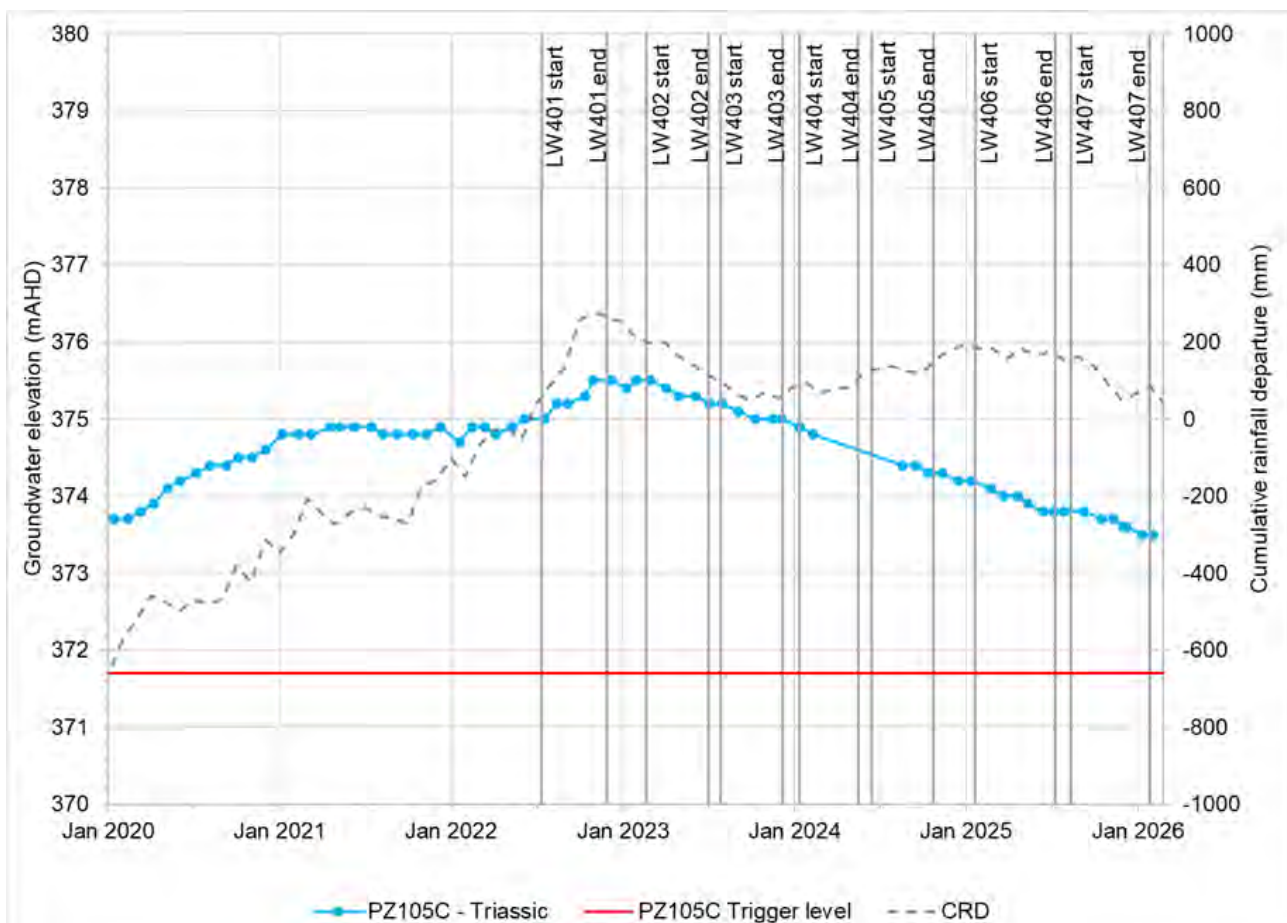
Note: * = decommissioned

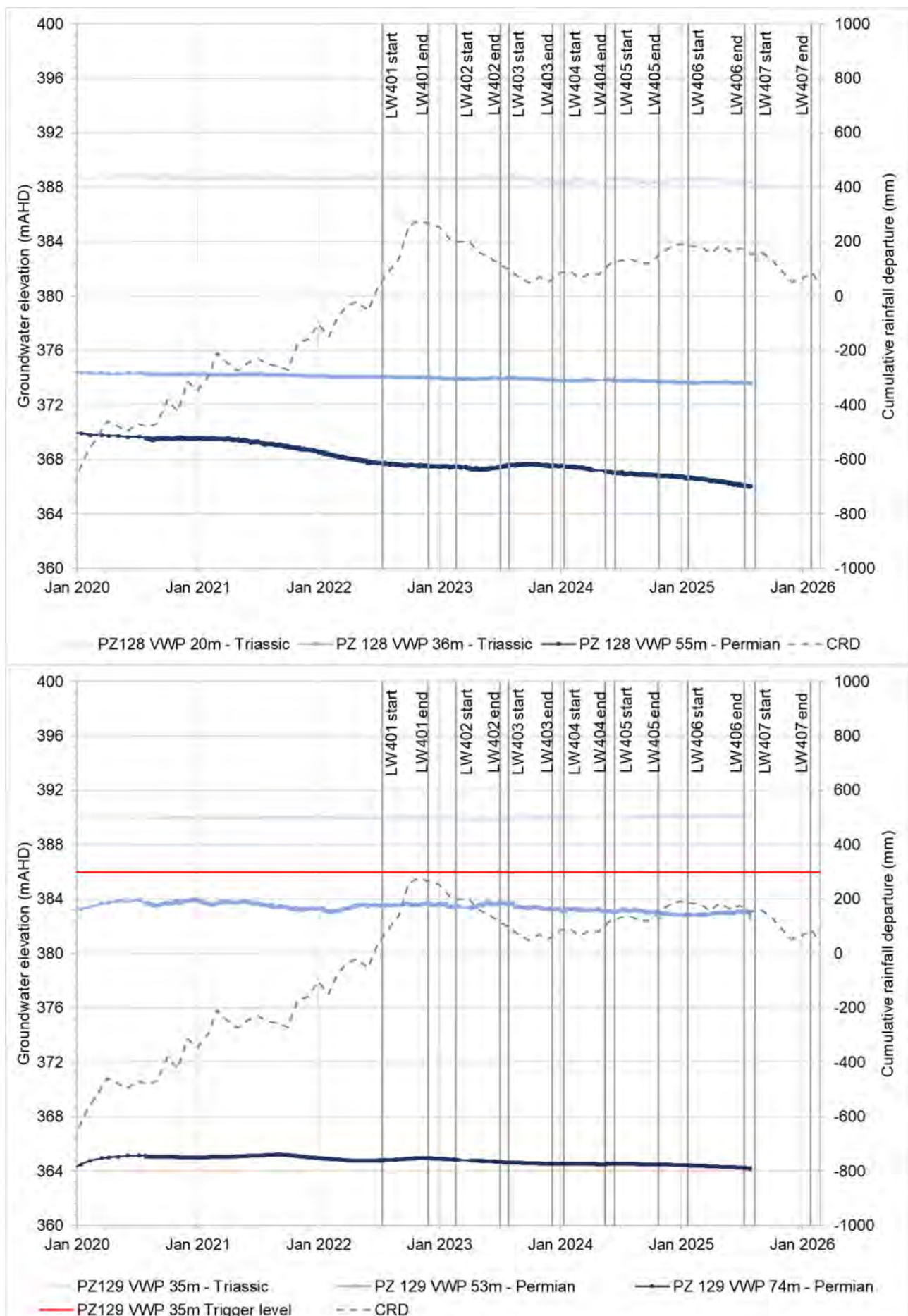
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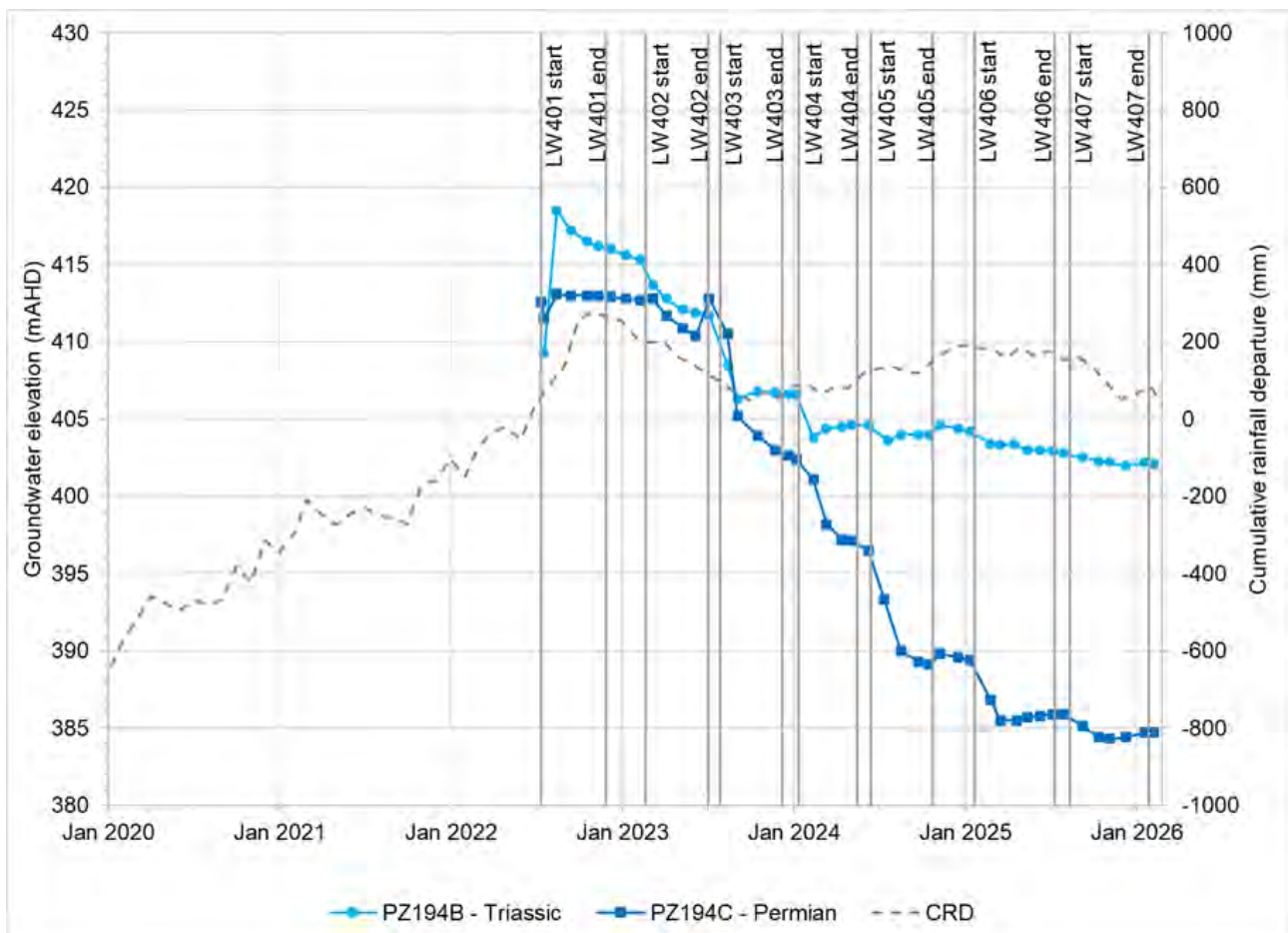
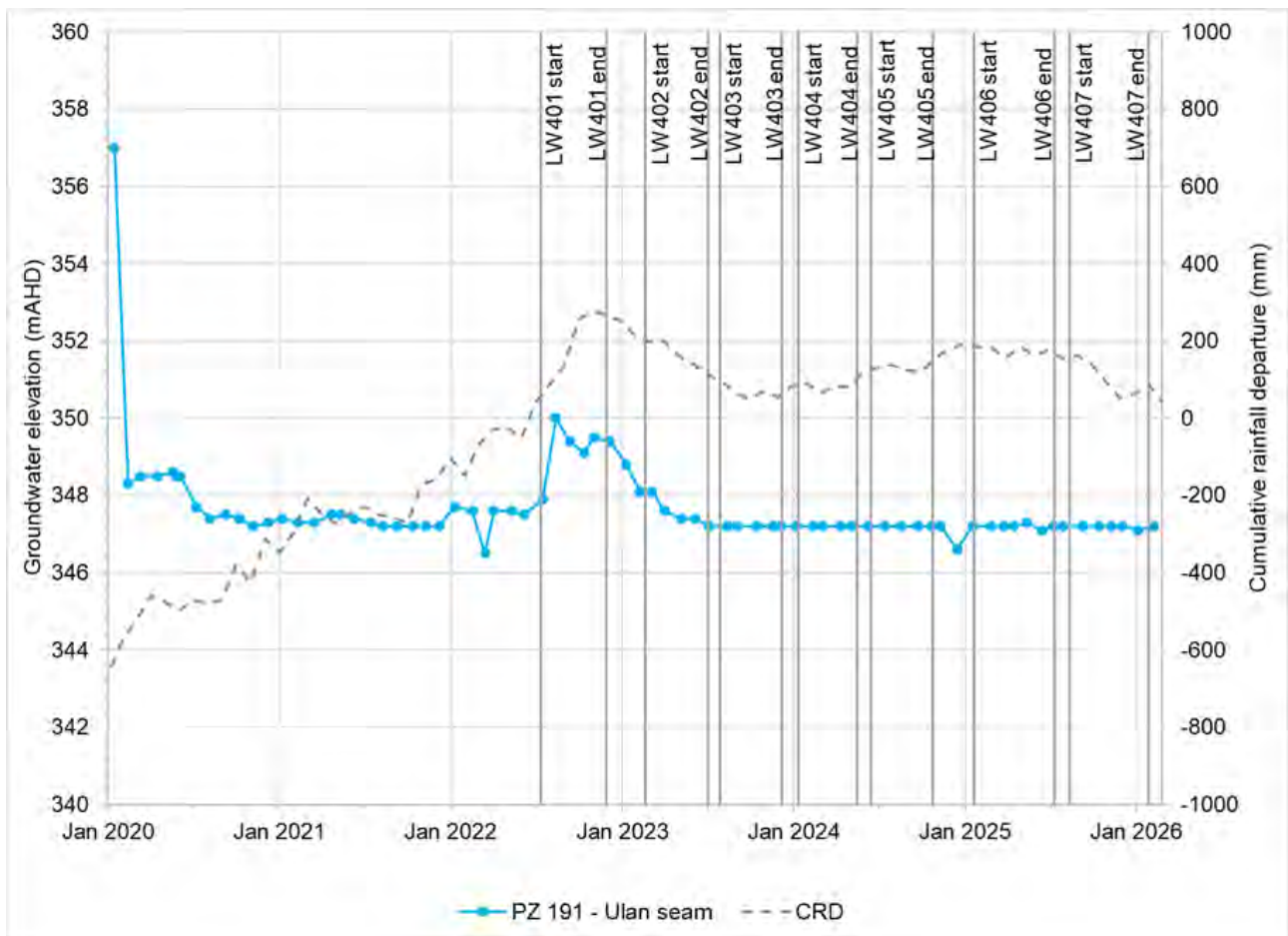
UG4 Groundwater Monitoring Network - Hydrographs

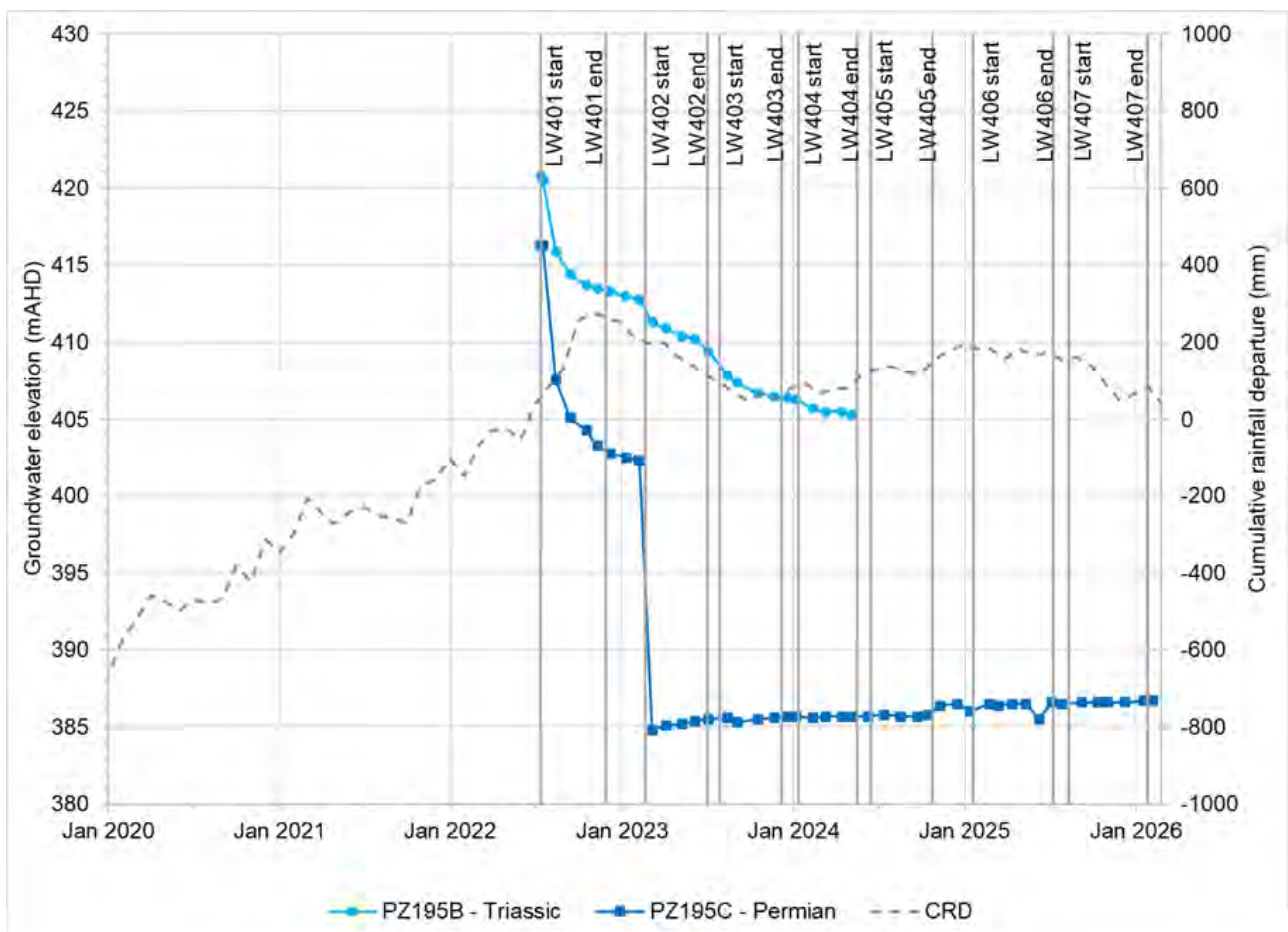
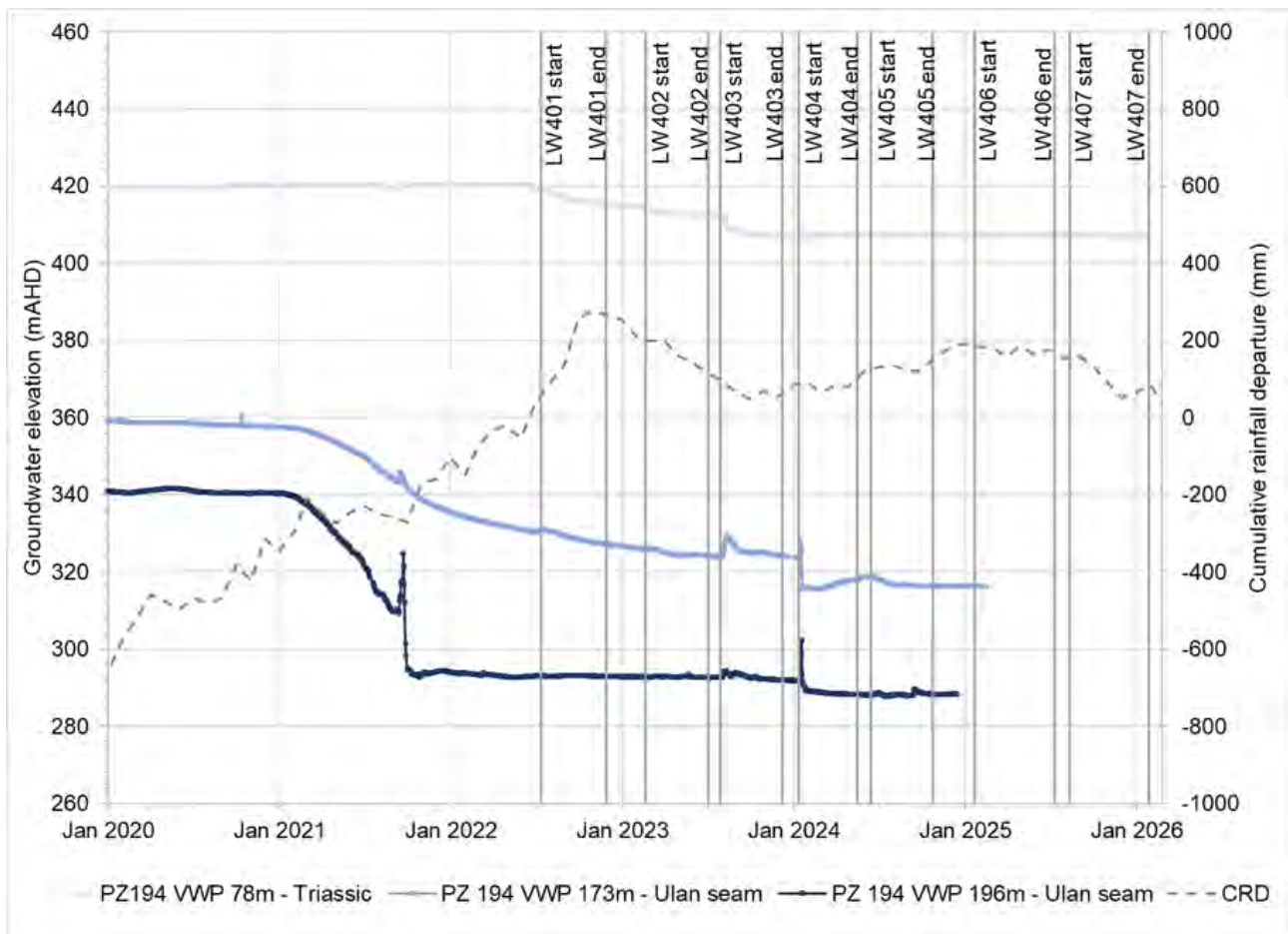


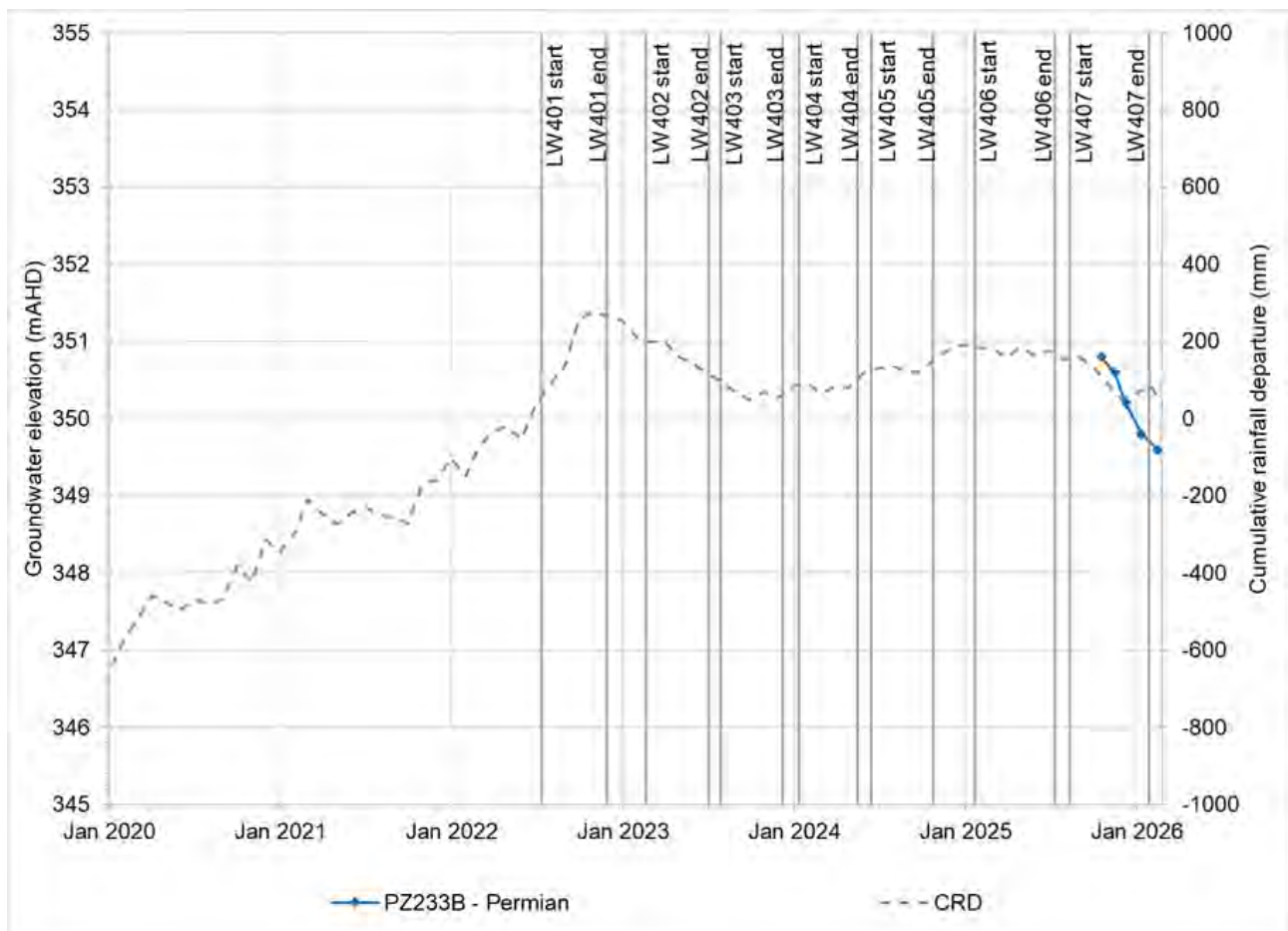
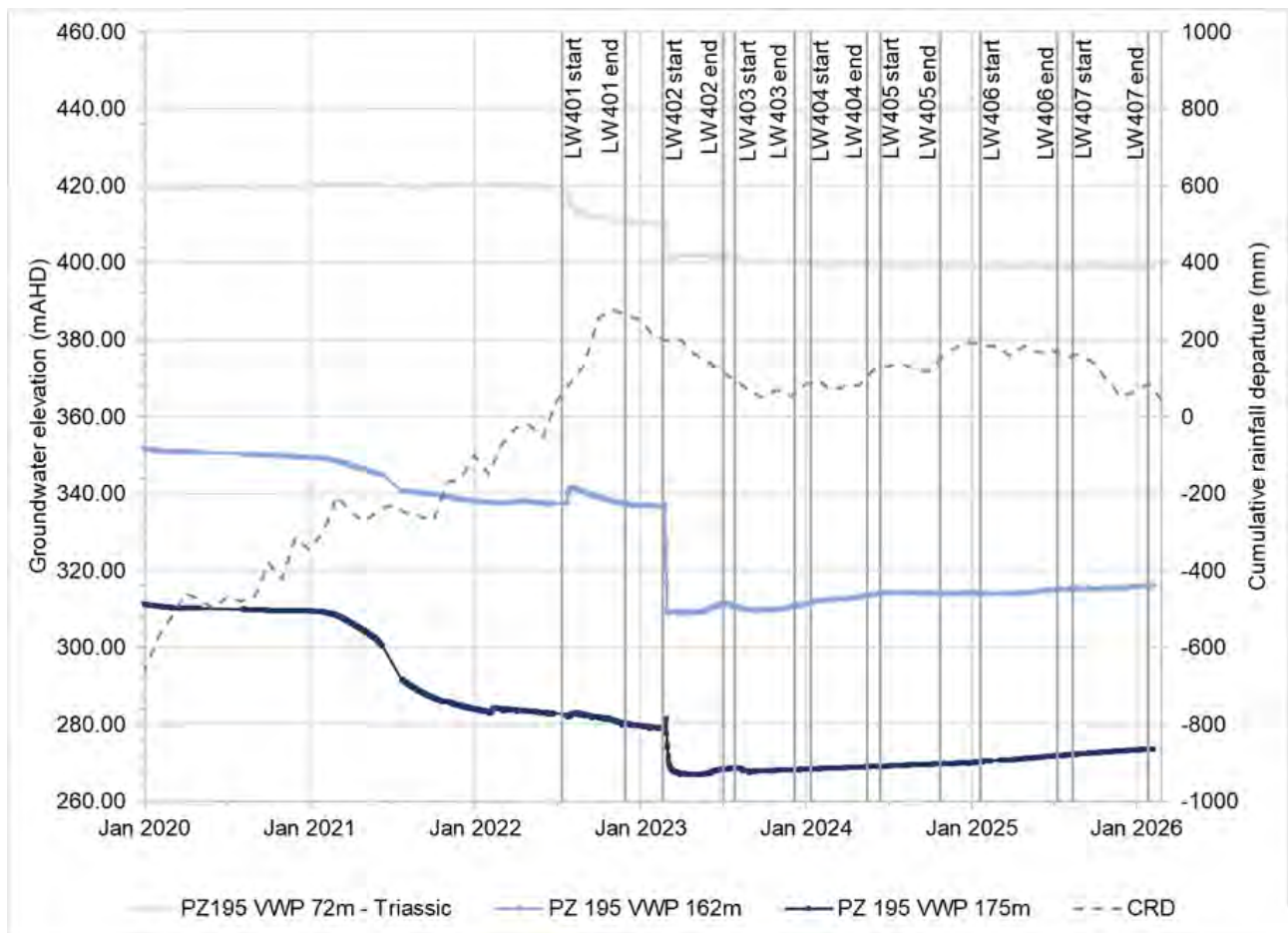


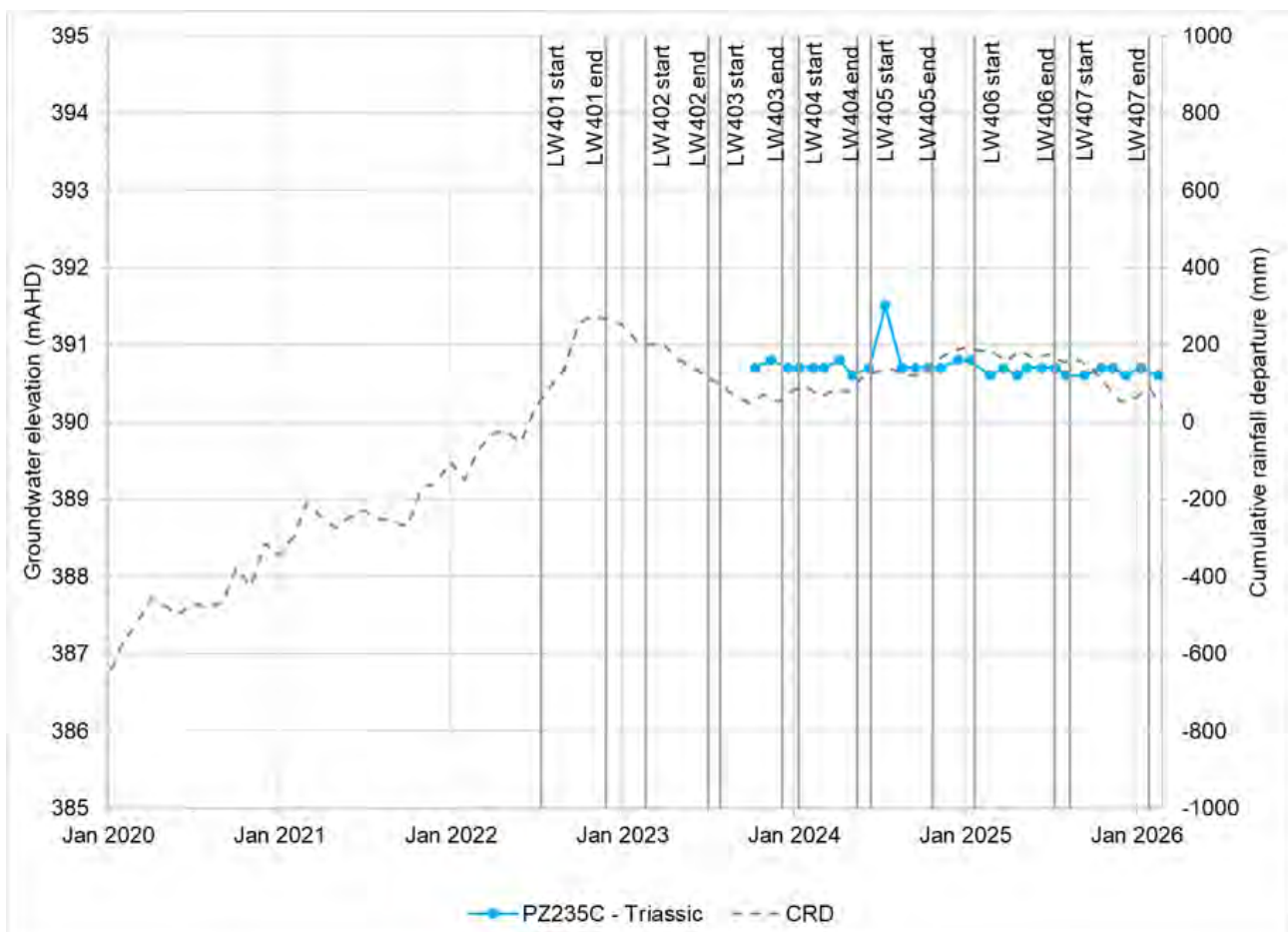
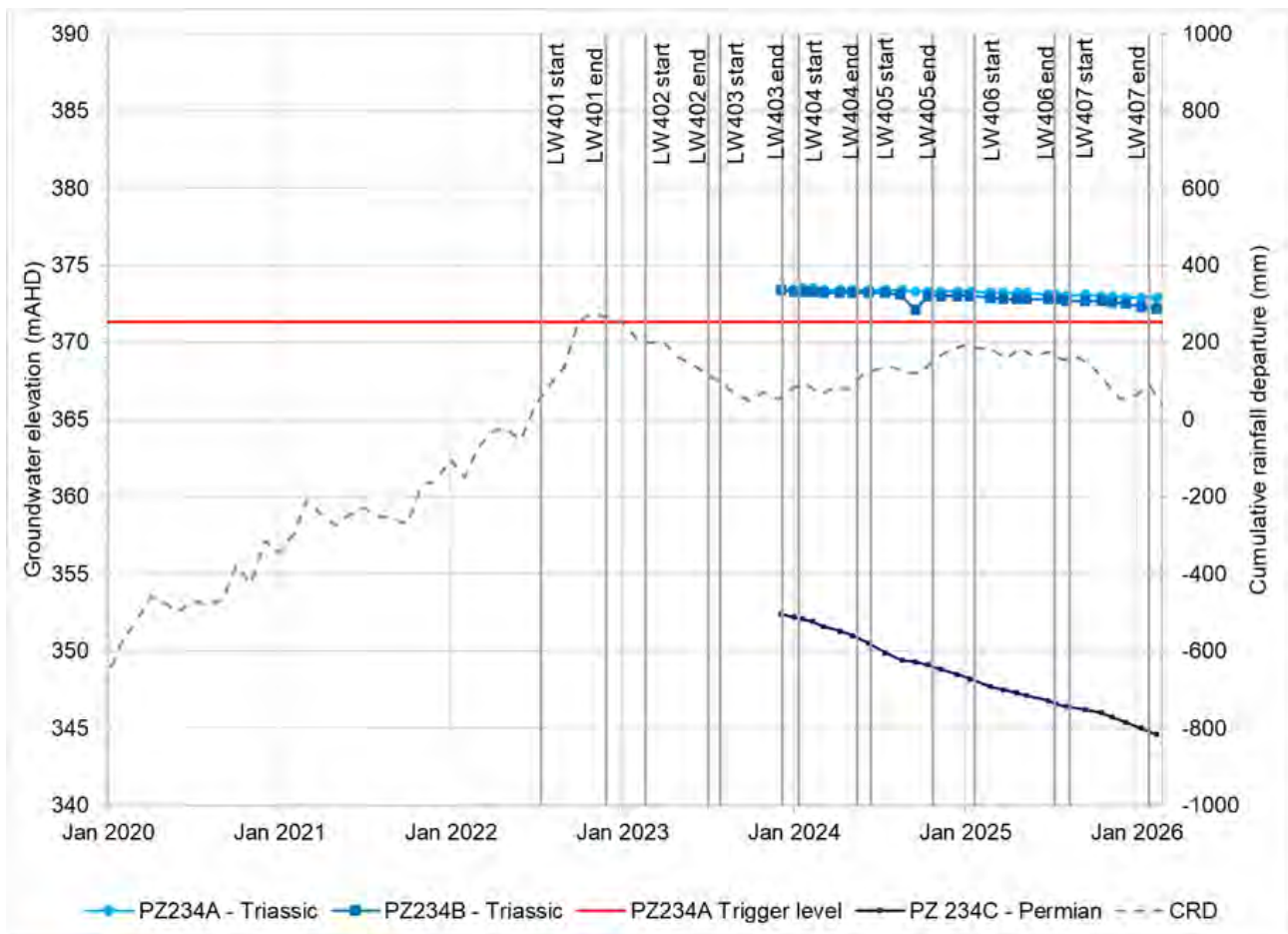


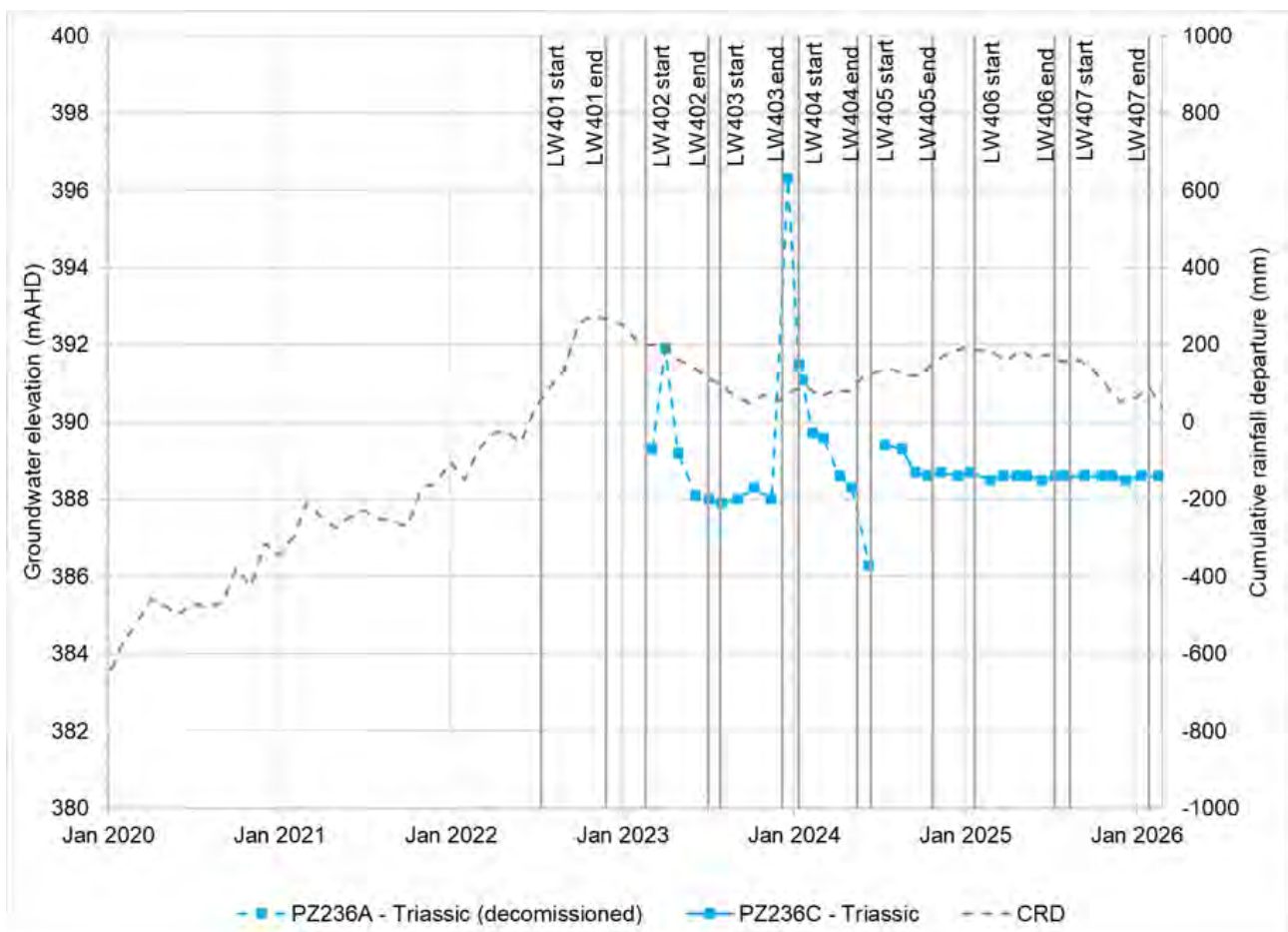
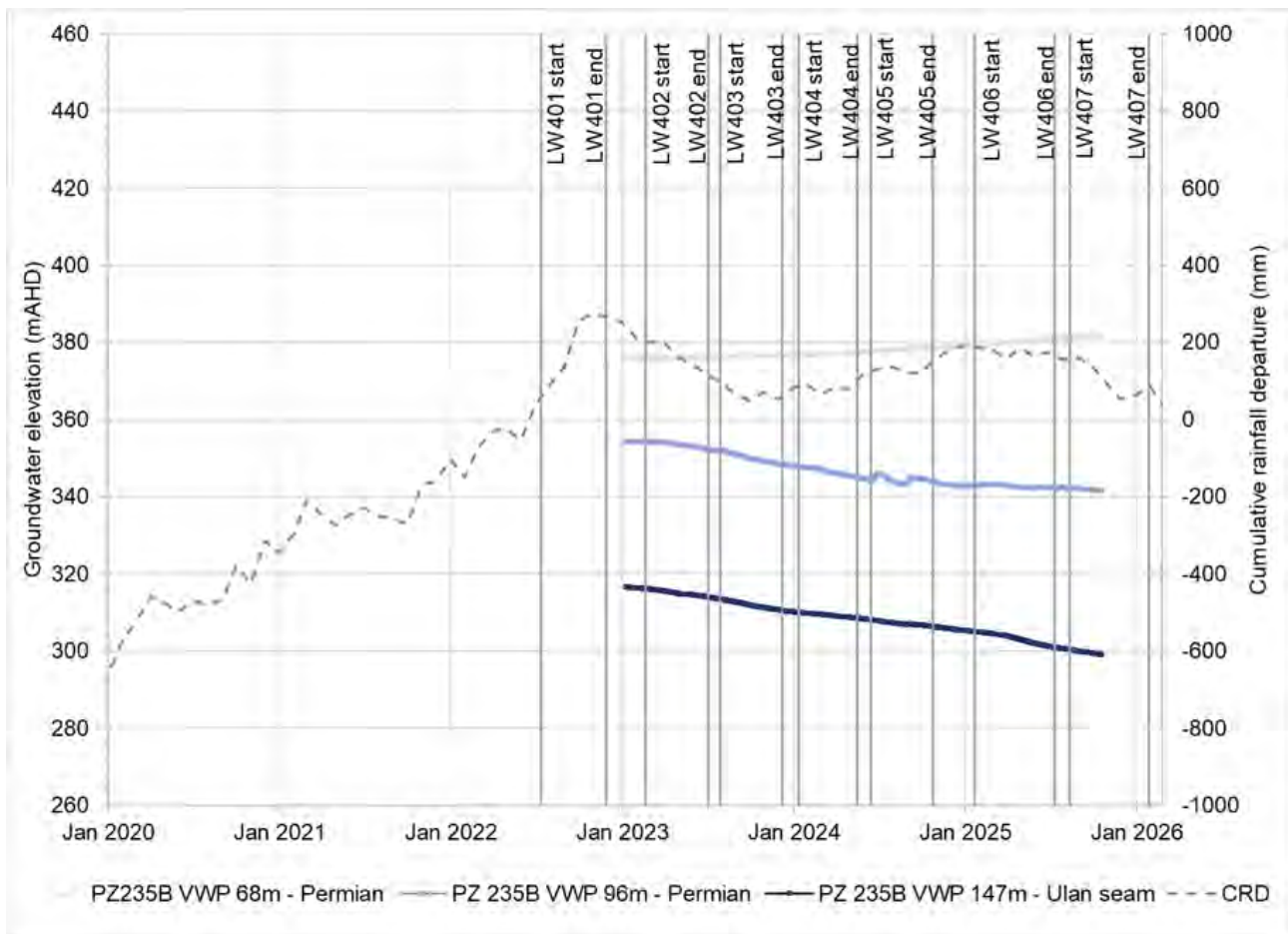


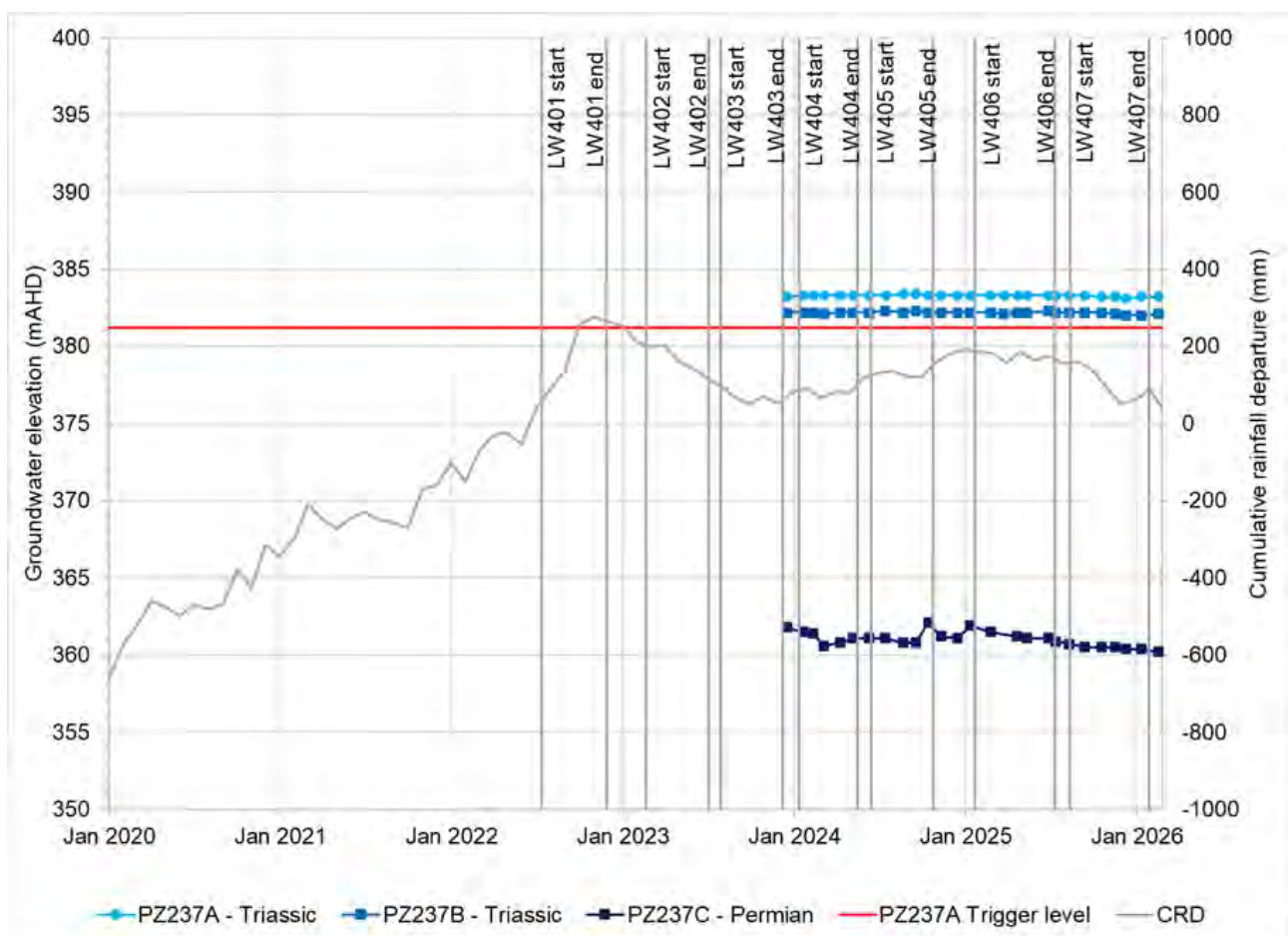
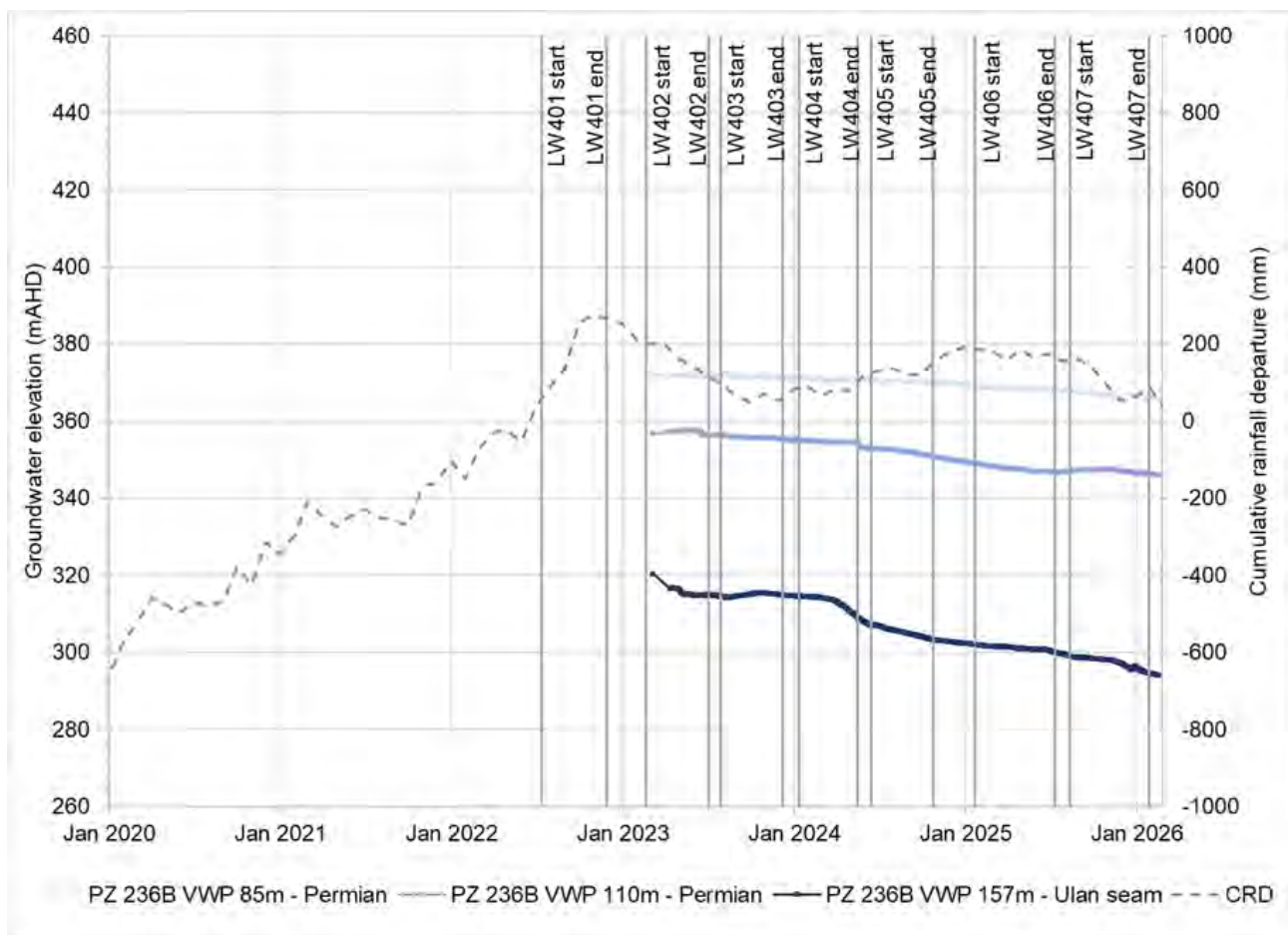


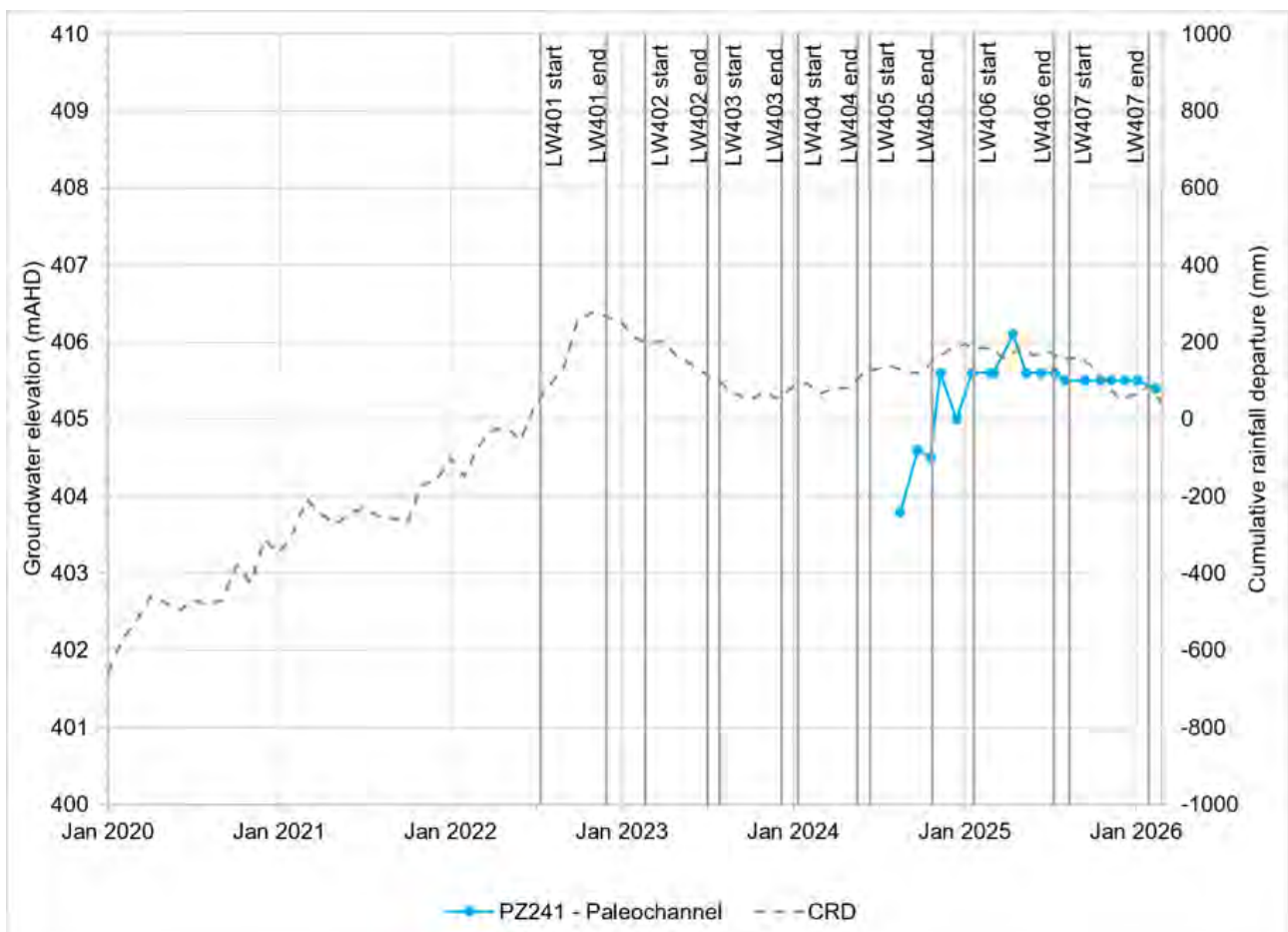
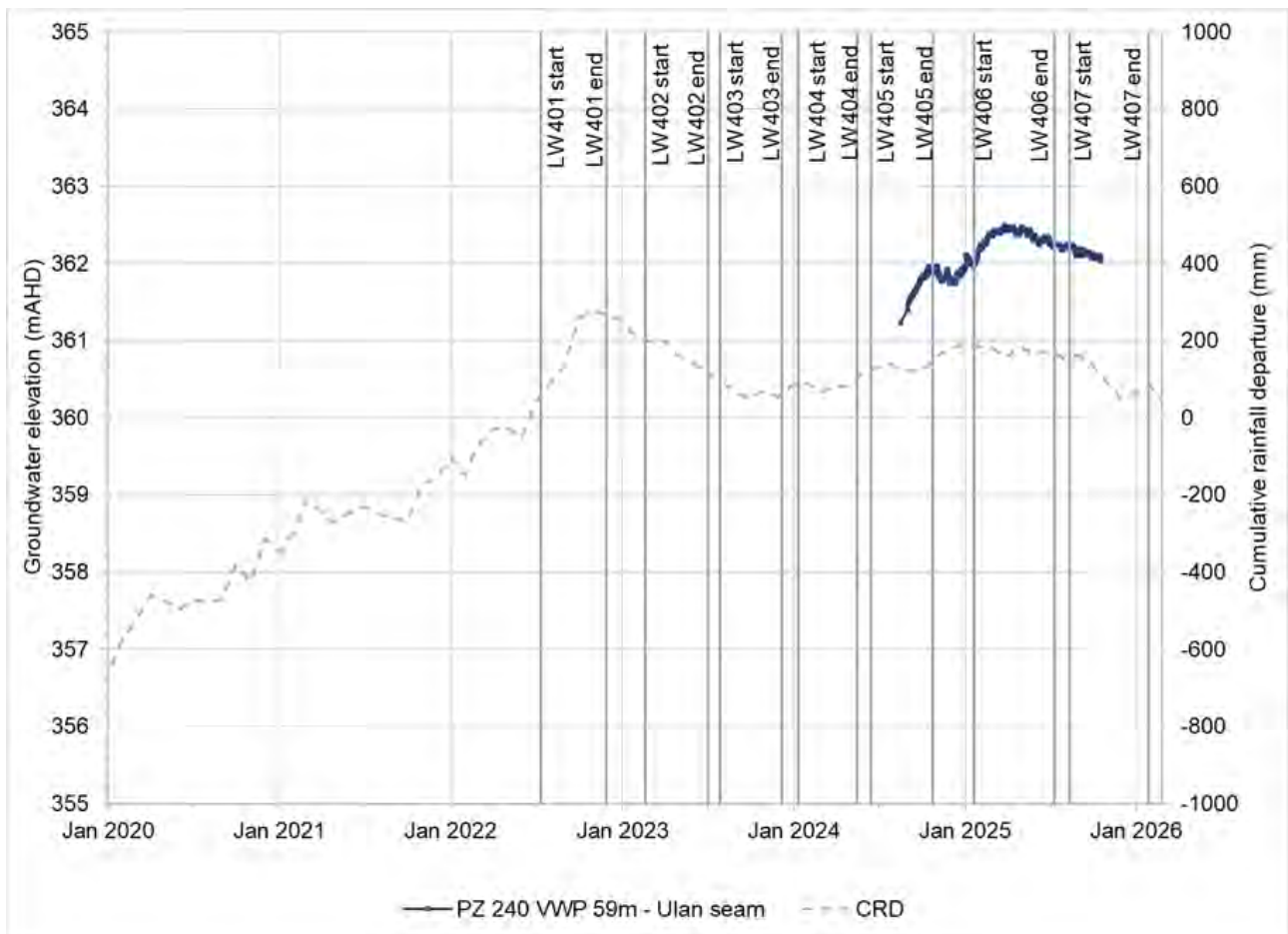


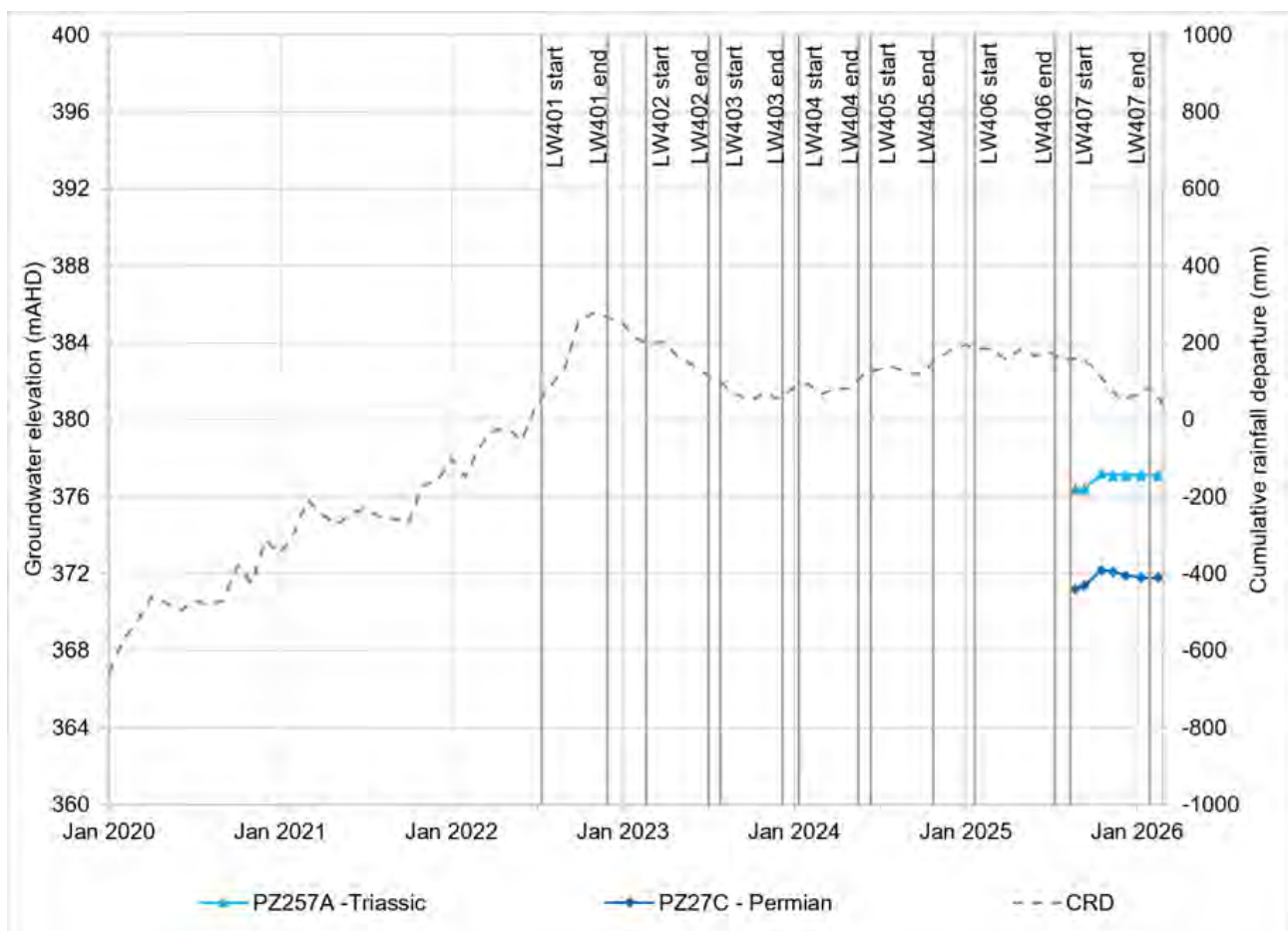
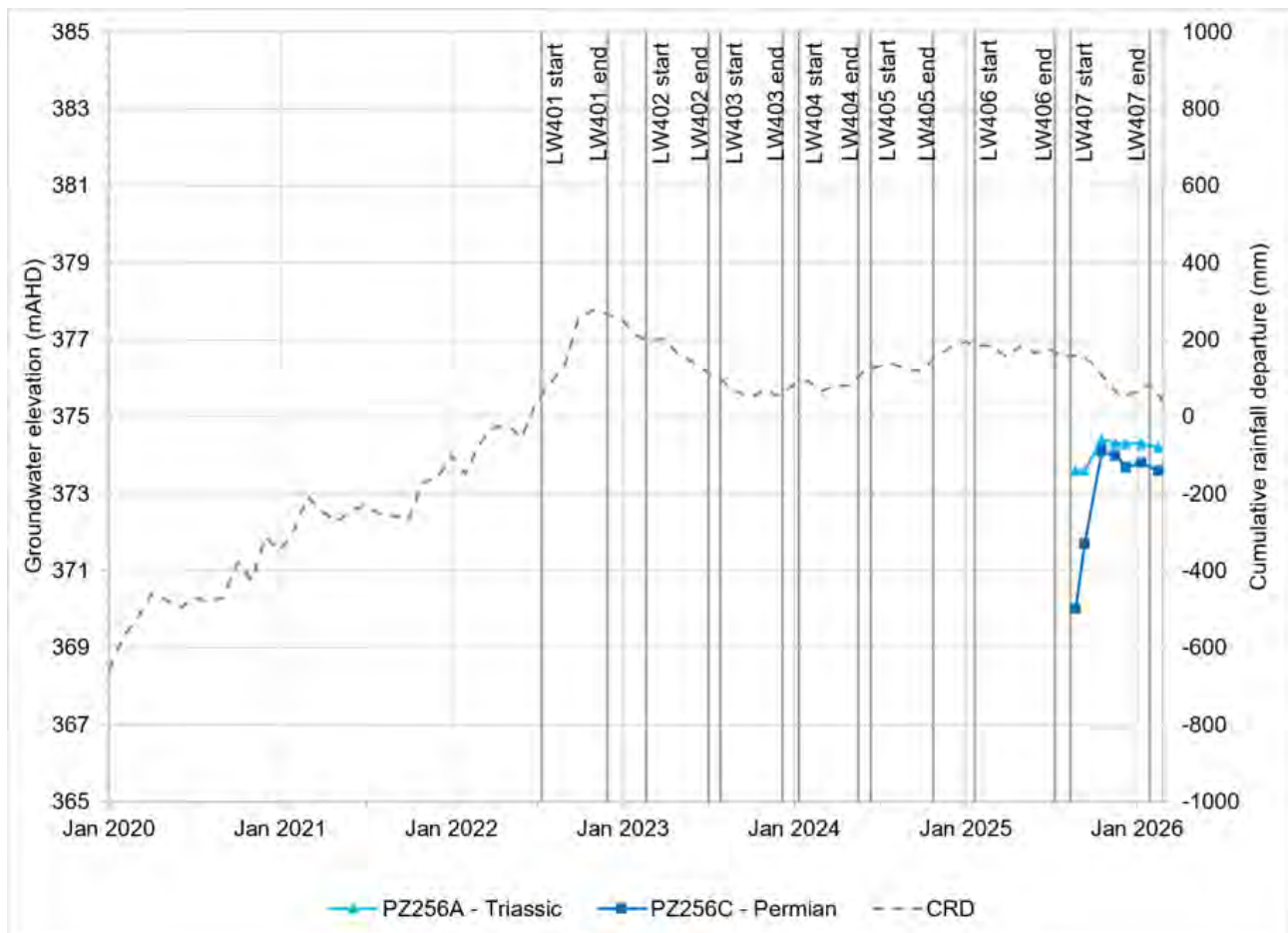






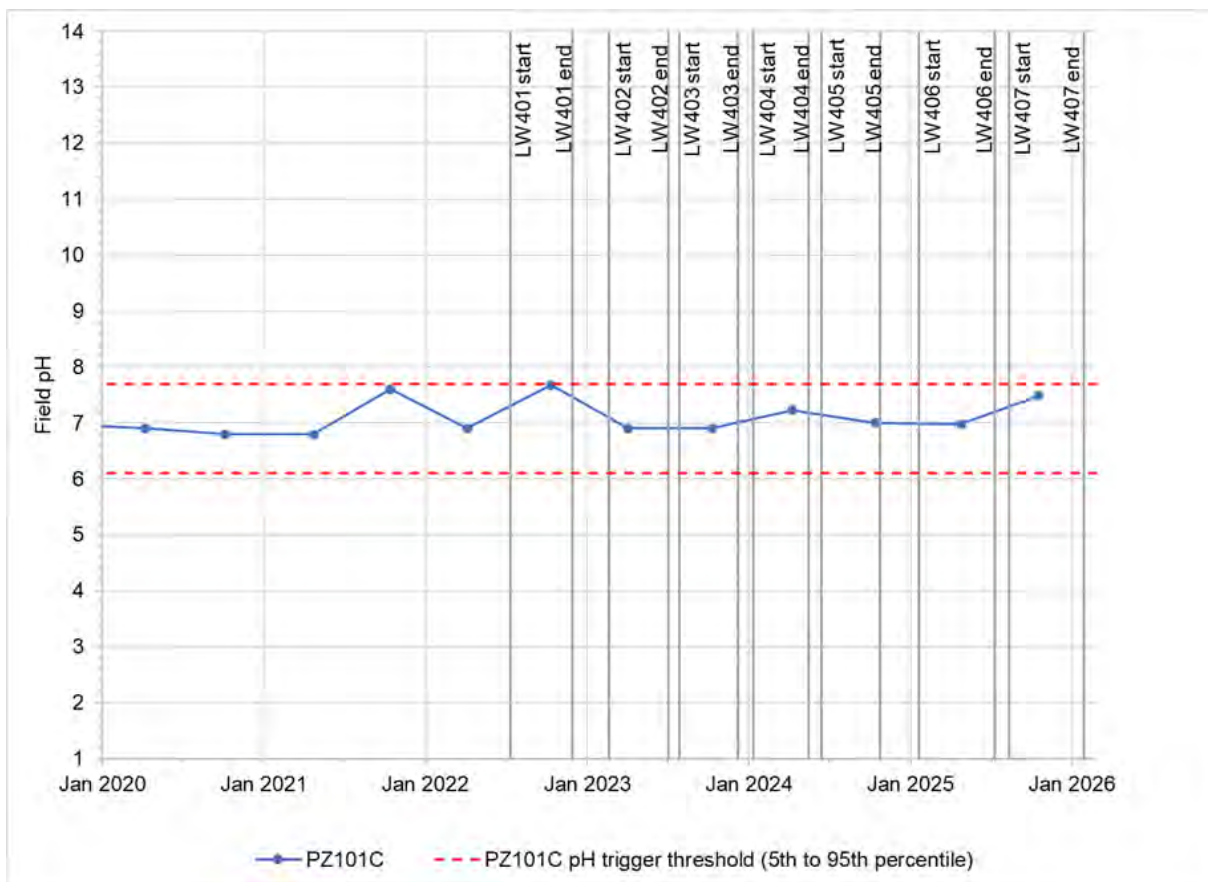
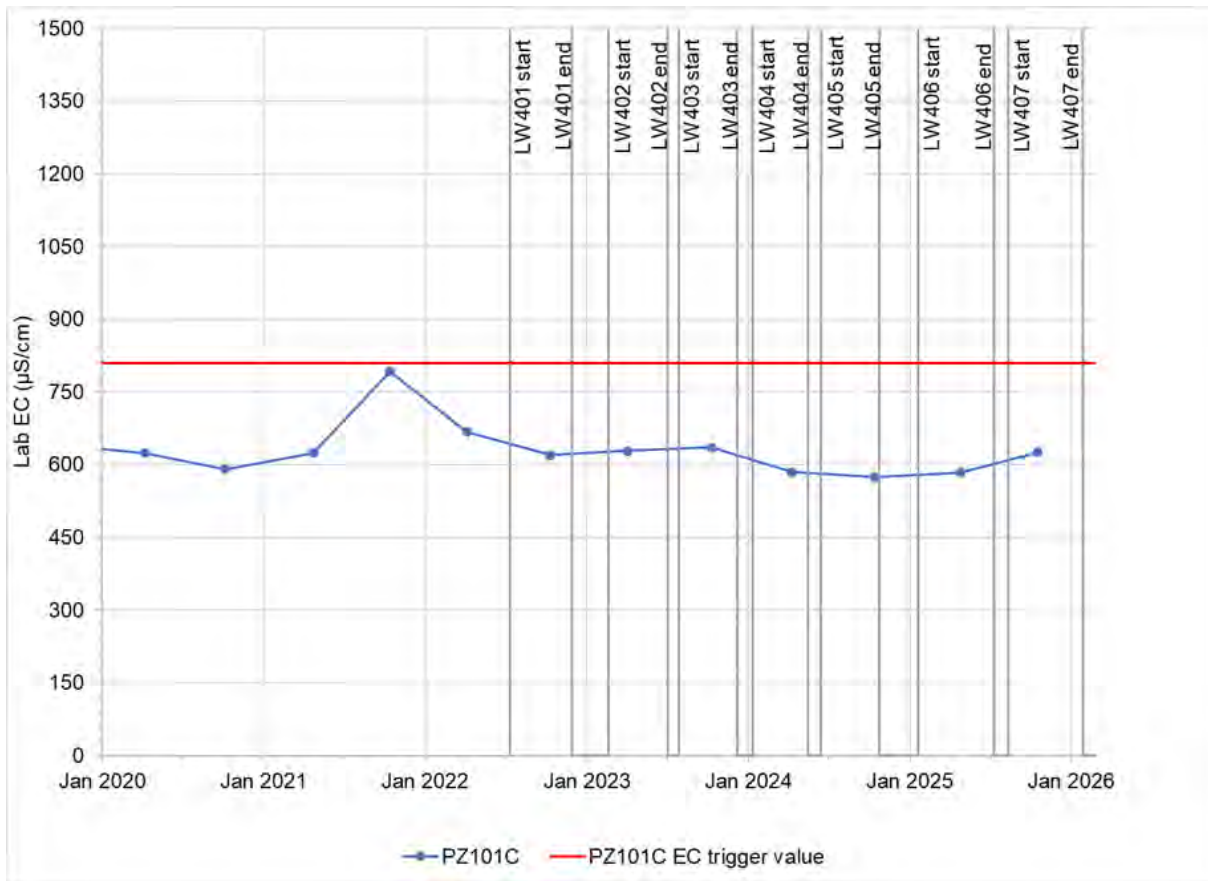


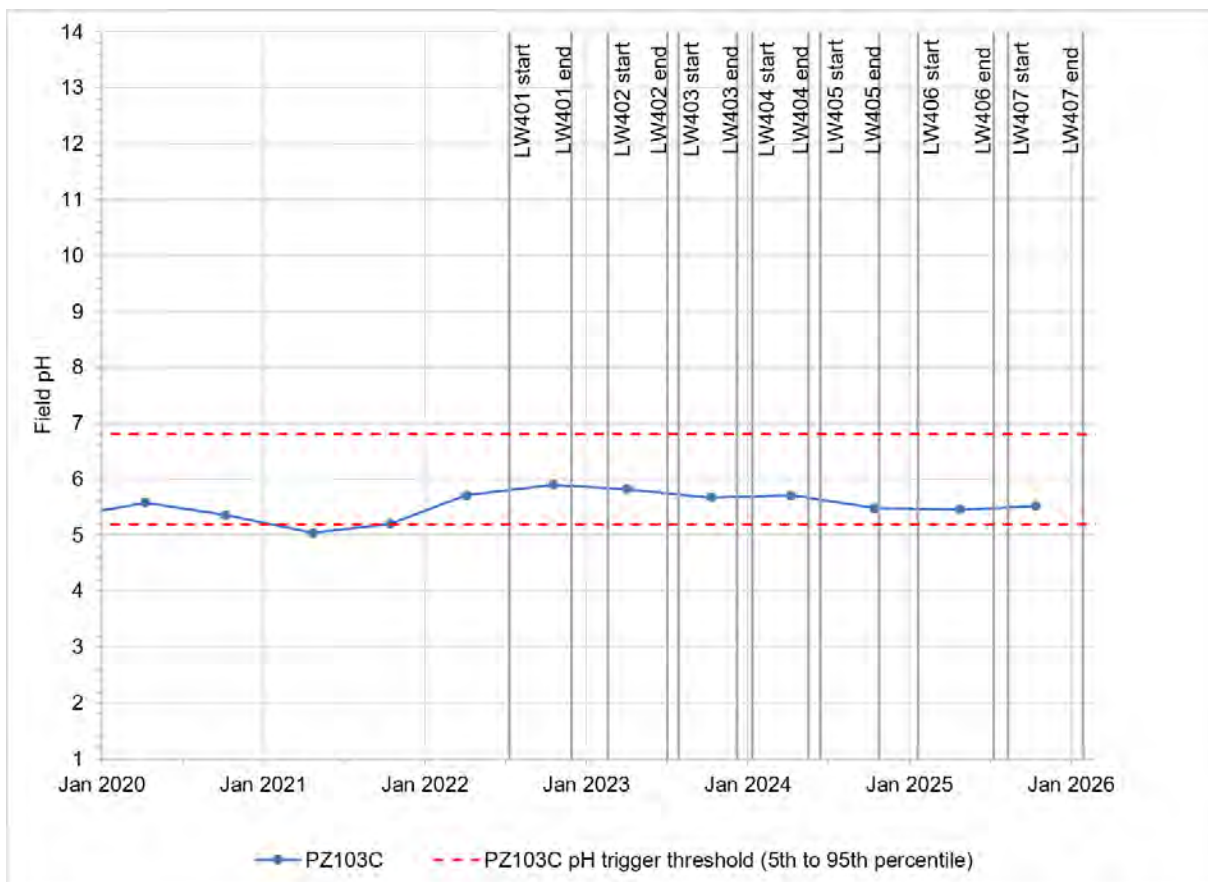
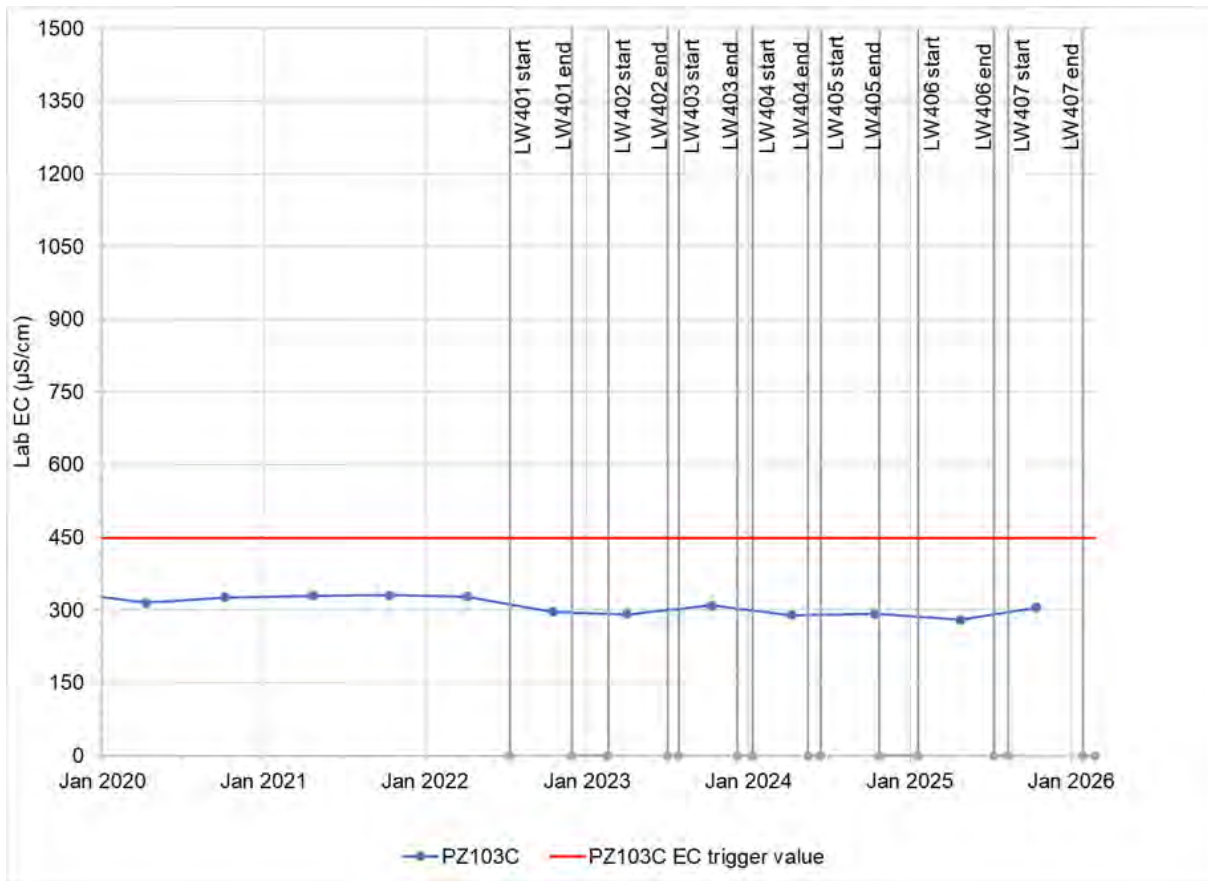


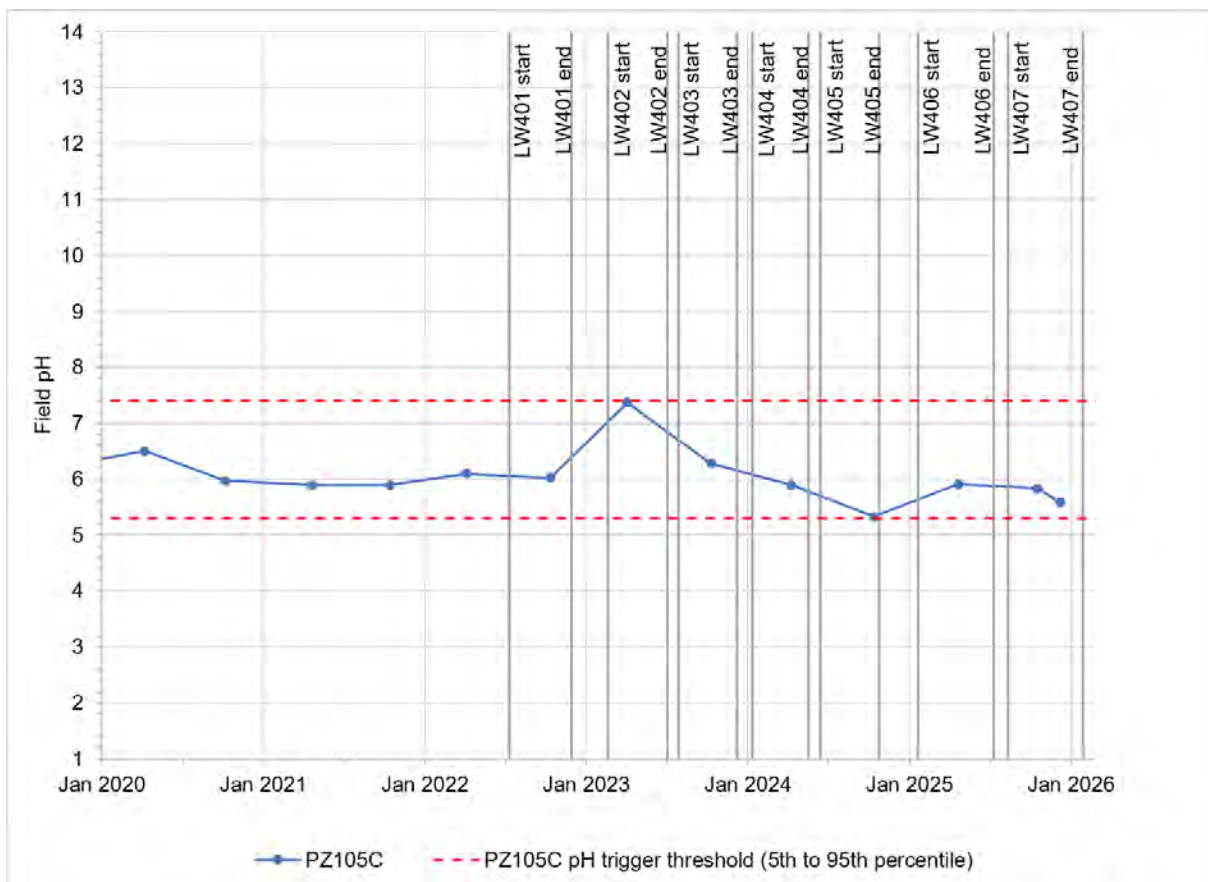
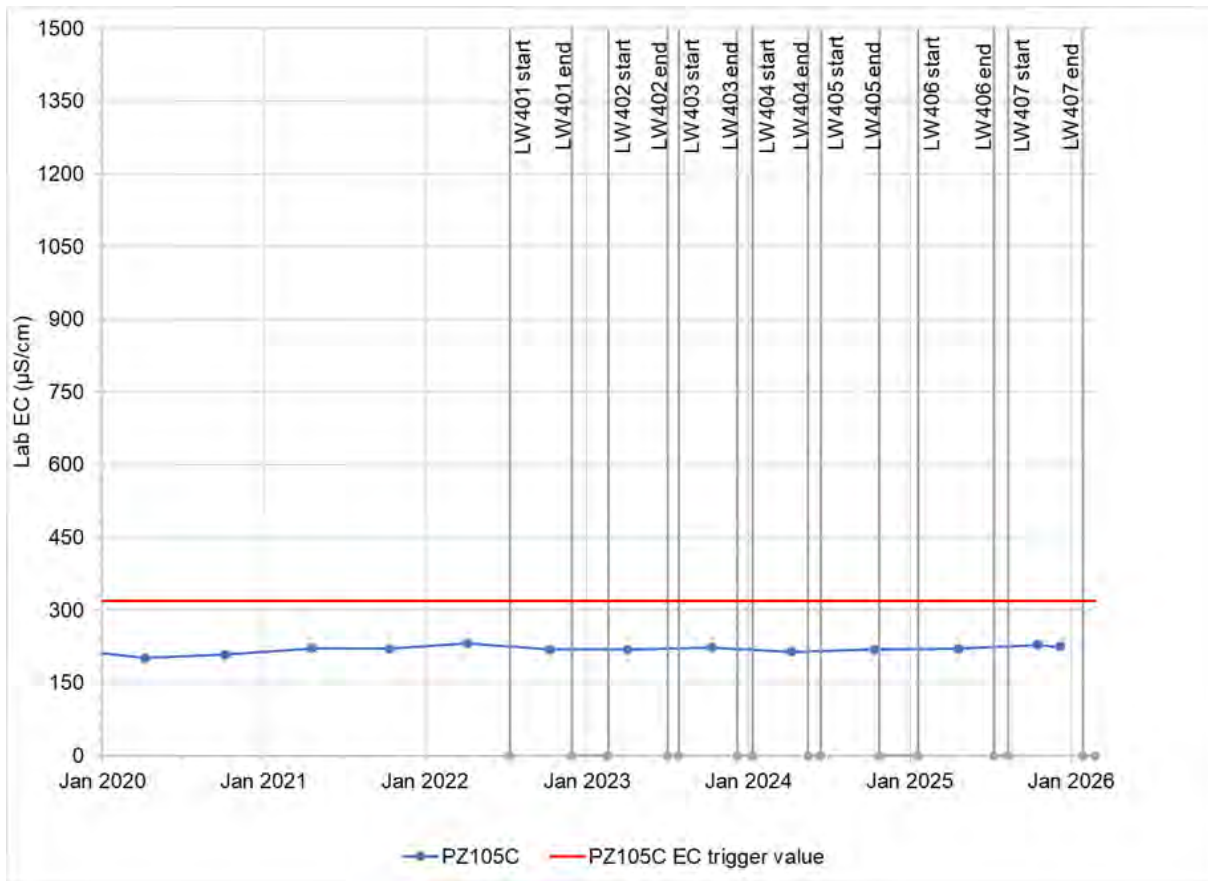


Appendix C

UG4 Groundwater Monitoring Network - Water Quality







APPENDIX C

MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT – SURFACE WATER REPORT (WRM, 2026)

21 August 2026

0926-57-B5

Ian Flood
Environment & Community Manager
Moolarben Coal Operations
c/- Resource Strategies

Re: Moolarben Coal Project: LW401-407 End-of-Panel Surface Water Report

Dear Ian,

1 INTRODUCTION

The UG4 Underground Mine (UG4) is a component of the approved Moolarben Coal Complex. Longwalls 401 to 407 (LW401-407) are the first seven longwalls extracted in the UG4 area. Secondary extraction of LW401 commenced in July 2022 and LW407 was completed in January 2026.

This report provides an assessment of observed surface water data compared to baseline data to identify impacts, if any, associated with the extraction of LW401-407 of Moolarben Coal Project Stage 1 under the approved UG4 LW401-408 Extraction Plan (Extraction Plan) (Moolarben Coal Operations [MCO], 2023a).

The following sections of the report provide:

- a description of the local drainage network and available surface water data.
- an assessment of observed impacts from mining of LW401-407, based on monitoring data, compared to predictions and subsidence impact performance measures in the Project Approval (05_0117).
- assessment of whether any Trigger Action Response Plans (TARPs) were triggered based on the observed monitoring data.
- comments on the suitability of the existing surface water monitoring program/TARPs and any recommended updates.

2 DRAINAGE NETWORK

The drainage network in the UG4 area is shown in Figure 2.1. The area overlying LW401-408 drains to the Goulburn River via Bora Creek, Drainage Line 1 (DL1) and other small ephemeral drainage lines.

2.1 SUBSIDENCE PREDICTIONS

The Subsidence Predictions and Impact Assessments for LW401-408 were prepared by Mine Subsidence Engineering Consultants (MSEC) in 2021. This assessment includes predicted subsidence effects for LW401-408 on natural features within the LW401-408 Study Area including drainage lines.

MSEC (2021) concluded that potential impacts to DL1, DL2 and Bora Creek within the Study Area include ponding, changes in grade, surface cracking, fracturing of the bedrock and erosion during subsequent rain events.

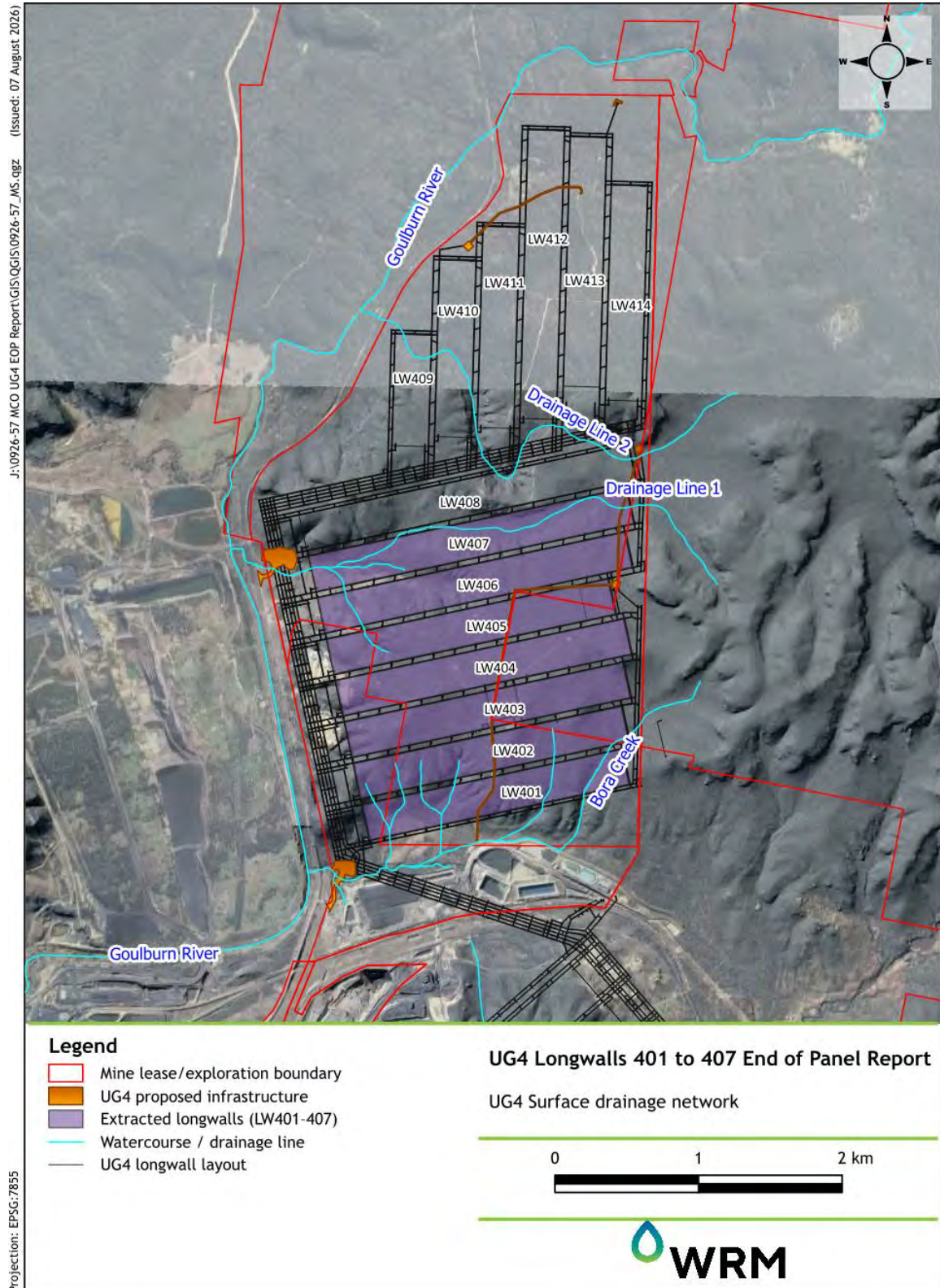


Figure 2.1 UG4 Surface drainage network

3 SURFACE WATER MONITORING

3.1 SURFACE WATER MONITORING PROGRAM

The Water Management Plan for UG4 LW401-408 (MCO, 2023b) includes the following subsidence monitoring requirements for Bora Creek, DL1 and Goulburn River:

- walkover visual inspection and photographic record of upper reaches of Bora Creek and DL1; and
- visual inspection at access points along the Goulburn River.

Details of the subsidence monitoring program for surface water features for LW401-408 are provided in Table 3.1.

Surface water monitoring for receiving watercourses is undertaken for flow and water quality in accordance with the UG4 LW401-408 Water Management Plan (see Table 3.2). Surface water monitoring sites are shown in Figure 3.1.

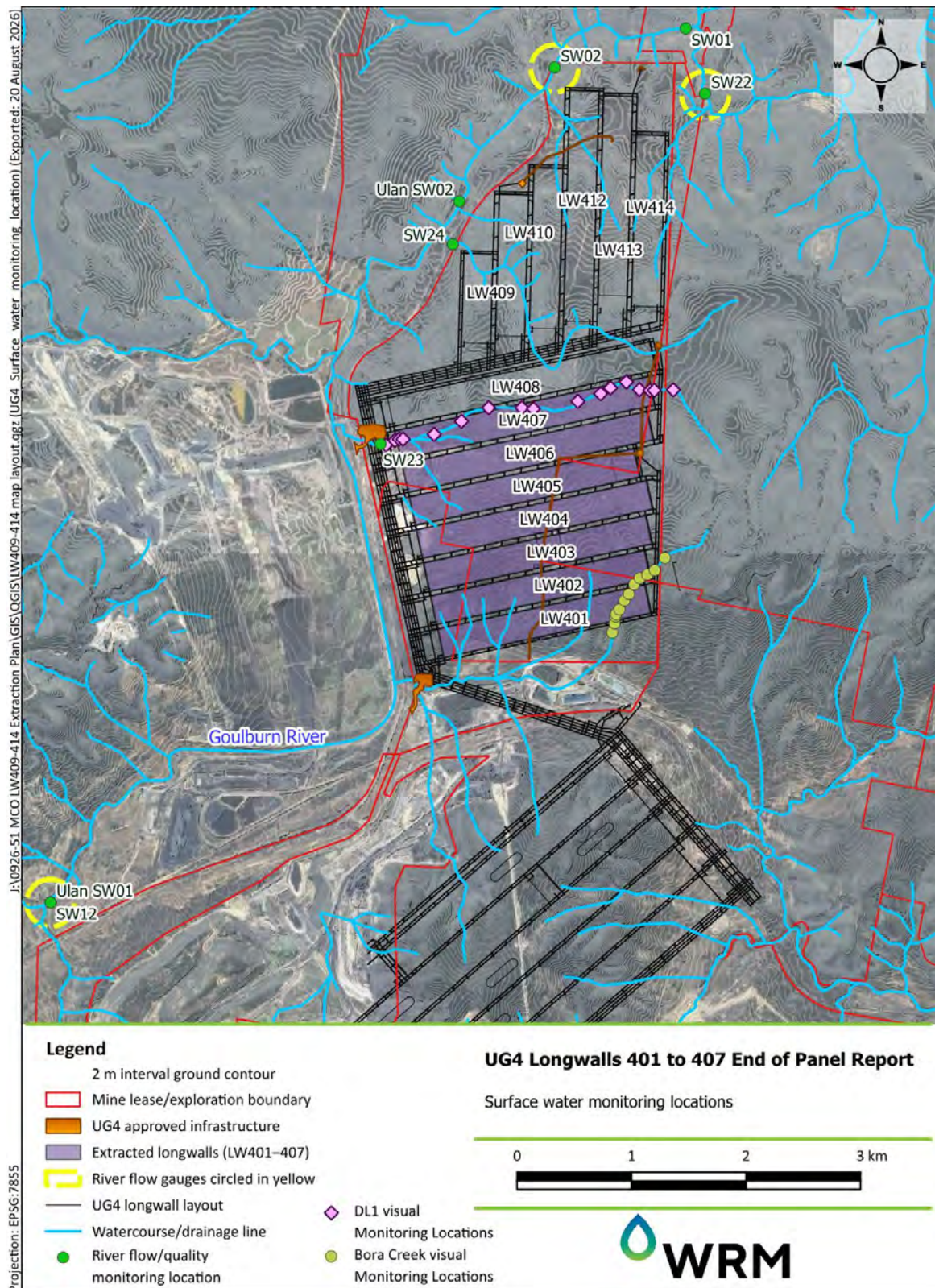
Table 3.1 Subsidence monitoring program for surface water features for LW401-408 (source: Table 12 [MCO, 2023b])

Monitoring Component	Parameter	Timing/Frequency	Responsibility
Pre-mining			
Goulburn River	Undertake a baseline inspection at access points along Goulburn River Diversion and Goulburn River adjacent to LW401 – 408 and downstream to Corner Gorge, noting the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking. Collect photographic record of channel condition.	Prior to completion of LW401	Environment and Community Manager
Visual inspection of upper reaches of Bora Creek and DL1 and DL2	Undertake a baseline inspection along the upper reaches of Bora Creek over LW401 and LW402 and drainage lines DL1 and DL2 above LW407 and LW408 respectively. Note the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking. Collect photographic record of channel condition along Bora Creek over LW401 and LW402 and drainage lines DL1 and DL2 above LW407 and LW408 respectively.	Prior to commencement of LW401 for Bora Creek Prior to commencement of LW406 for drainage line DL1. Prior to the commencement of LW408 for DL2 .	
During and Post Mining			
Goulburn River	Undertake periodic visual inspection and update photographic record of access points along the Goulburn River Diversion and Goulburn River adjacent to LW401 to LW408.	6 monthly until 1 year after completion of Longwall 408 extraction	Environment and Community Manager
Visual inspection of upper reaches of Bora Creek and DL1 and DL2	Undertake post mining inspection along the upper reaches of Bora Creek over LW401 and LW402 and drainage lines DL1 and DL2 above LW407 and LW408 respectively and update photographic record.	Within three months of undermining Bora Creek and drainage lines DL1 & DL2. An inspection every six months for one year after longwall undermines Bora Creek and drainage lines DL1 and DL2.	

Table 3.2 Surface water monitoring program for LW401-408 (source: Table 13 [MCO, 2023b])

Site	Frequency	Parameters	Site Justification
SW01	Monthly (if flowing)	Flow – Observation pH, EC, TSS, TDS, temperature, turbidity	Located downstream of LW401-408 mining operations and downstream of open cut and CHPP on Goulburn River
	Six monthly (in addition to above)	Al, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, DO, Total P and Total N	
	After rainfall event (>30mm in 24 hours)	Flow – Observation pH, EC, TSS, TDS, Zn, Fe	
SW02	Monthly (if flowing)	Flow – Observation pH, EC, TSS, TDS, temperature, turbidity	Located downstream of LW401-408 mining operations and downstream of open cut and CHPP on Goulburn River
	Six monthly (in addition to above)	Al, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, DO, Total P and Total N	
	After rainfall event (>30mm in 24 hours)	Flow – Observation pH, EC, TSS, TDS, Zn, Fe	
SW22*	Monthly (if flowing)	Flow – Measurement** pH, EC, TSS, TDS, temperature, turbidity	Located downstream of LW401-408 mining operations and downstream of open cut and CHPP on Goulburn River
	Six monthly (in addition to above)	Al, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, DO, Total P and Total N	
	After rainfall event (>30mm in 24 hours)	Flow – Observation pH, EC, TSS, TDS, Zn, Fe	
SW23*	Monthly (if flowing)	Flow – Observation pH, EC, TSS, TDS, temperature, turbidity	Located downstream of UG4 LW407 on drainage Line 1.
	Six monthly (in addition to above)	Al, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, DO, Total P and Total N	
	After rainfall event (>30mm in 24 hours)	Flow – Observation pH, EC, TSS, TDS, Zn, Fe	
SW24*	Monthly (if flowing)	Flow – Observation pH, EC, TSS, TDS, temperature, turbidity	
	Six monthly (in addition to above)	Al, Cu, Pb, Zn, Ni, Fe, Mn, As, Se, Cd, Cr, Li, Ba, Sr, DO, Total P and Total N	Located downstream of UG4 LW408 on drainage Line 2.
	After rainfall event (>30mm in 24 hours)	Flow – Observation pH, EC, TSS, TDS, Zn, Fe	

Note: SW01 and SW02 are also referred to as MCO SW01 and MCO SW02, respectively, in this report.



Note: SW01 and SW02 are also referred to as MCO SW01 and MCO SW02, respectively, in this report.

Figure 3.1 Surface water monitoring locations

3.2 AVAILABLE DATA

Available data relevant to UG4 LW401-408 surface water monitoring includes (see Figure 3.1):

- Site rainfall data
- Goulburn River flow – Ulan SW01, MCO SW02, MCO SW22;
- Goulburn River water quality – MCO SW01, MCO SW02, MCO SW22;
- DL1 water quality – SW23 (dry – no samples collected);
- DL2 water quality – SW24 (dry – no samples collected);
- Flow volume and water quality monitoring of clean water released from the water treatment plant;
- Stream health and channel stability in accordance with the complex-wide Surface Water Management Plan;
- Light Detection and Ranging (Lidar) topographic data from February 2021 (pre-mining), December 2024 (LW401-408) and December 2025 (LW404-408);
- Visual inspection reports for Bora Creek and Goulburn River:
 - pre-mining (Jun 2022).
 - Oct/Nov 2022.
 - Apr/May 2023.
 - Oct 2023.
 - Apr 2024.
 - Oct 2024 (Goulburn River only).
 - Apr 2025 (Goulburn River only).
- Visual inspection reports for DL1:
 - pre-mining (Jan 2025).
 - post-mining (March 2026).

4 ASSESSMENT OF OBSERVED AND PREDICTED IMPACTS TO SURFACE WATER FEATURES

4.1 BORA CREEK

4.1.1 Subsidence Effects

Bora Creek was directly undermined by LW401 to LW402 between July 2022 and March 2023. Figure 4.1 shows a comparison of Lidar ground levels for Bora Creek between February 2021 (i.e. pre-mining) and December 2024 (i.e. post-mining).

Figure 4.2 shows a longitudinal section of Bora Creek between the 2021 and 2024 Lidar, including subsidence predictions from MSEC (2021). The locations of monitoring points along Bora Creek are shown in Figure 4.1 and Figure 4.2. The extent and magnitude of subsidence is consistent with the predictions.

The Bora Creek visual monitoring report (MCO, 2024) shows:

- visual inspections from 12 monitoring sites show minor cracking at some locations, consistent with Extraction Plan predictions.
- potential headcut observed at BC105, however this area experienced reduction in grade due to subsidence (see Figure 4.2), therefore any change in erosion characteristics is due to natural variability and is not mining related.

An excerpt of visual inspection results at BC105 is provided in Attachment 1.

The monitoring results show negligible impact or environmental consequences due to extraction of LW401-407, consistent with Extraction Plan predictions for Bora Creek.

4.2 DRAINAGE LINE 1

4.2.1 Subsidence Effects

DL1 was directly undermined by LW407 between August 2025 and January 2026. Figure 4.1 shows a comparison of Lidar ground levels for DL1 between February 2021 (i.e. pre-mining) and December 2025 (i.e. during mining).

Figure 4.3 shows a longitudinal section of DL1 from the 2021 and 2025 Lidar, including subsidence predictions from MSEC (2021). The locations of monitoring points along DL1 are shown in Figure 4.1. The extent and magnitude of subsidence are consistent with the predictions, noting that mining of LW407 was partially complete at the time of the Lidar survey (therefore observed subsidence around DL01-05 has not yet been recorded).

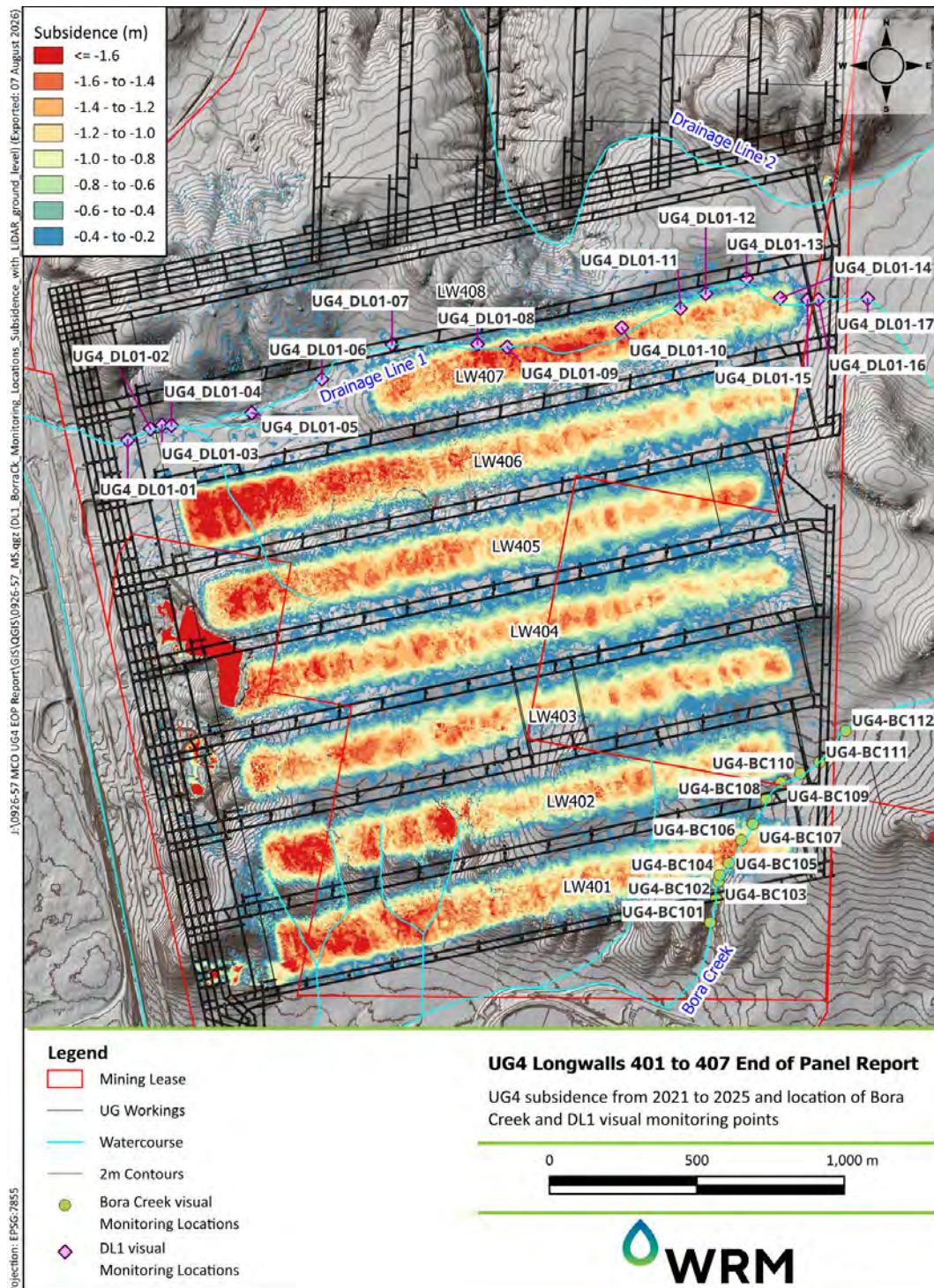


Figure 4.1 UG4 subsidence from 2021 to 2025 and location of Bora Creek and DL1 visual monitoring points

2021 LiDAR vs 2024 LiDAR along Bora Creek

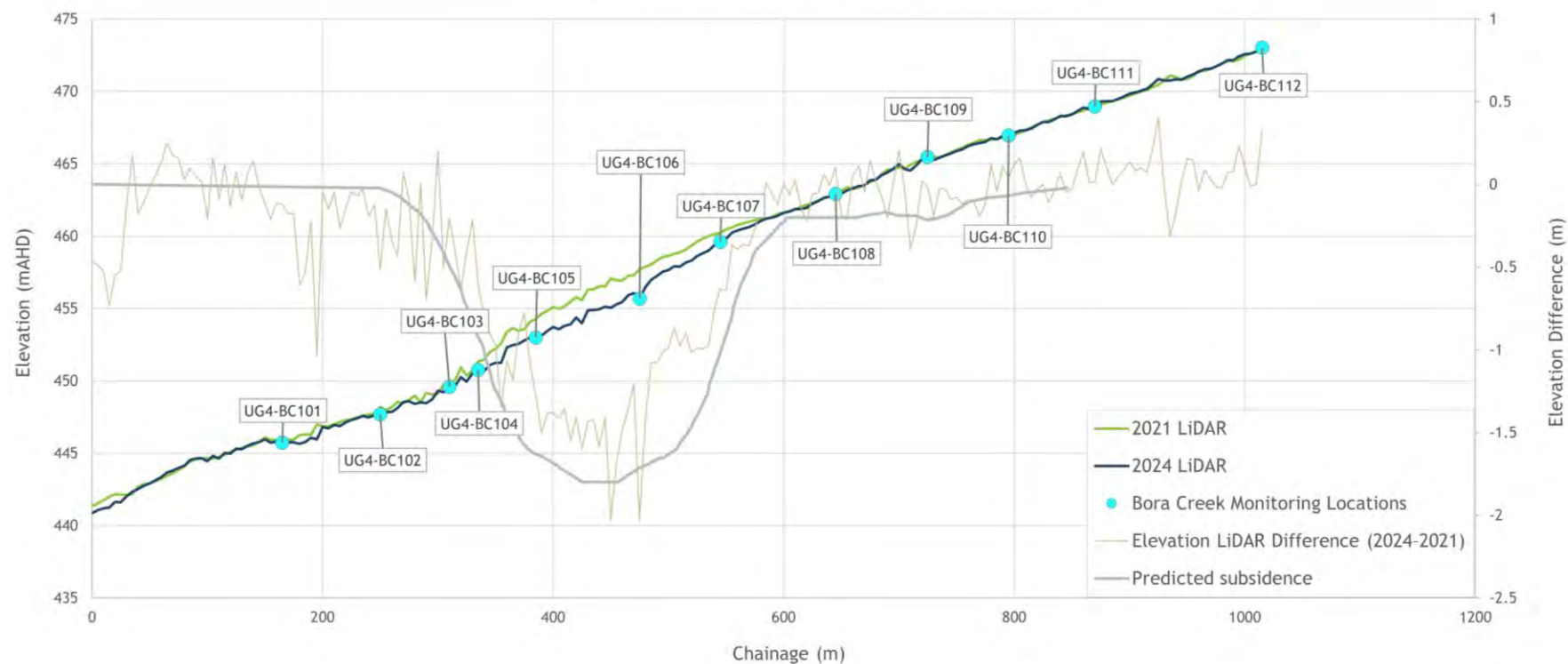


Figure 4.2 Bora Creek longitudinal section

Note: Elevation differences are derived from comparisons between Lidar-based ground surface datasets and may vary locally due to data processing and site conditions. Values should be interpreted as indicative, point-specific estimates.

2021 LiDAR vs 2025 LiDAR along Drainage Line 1

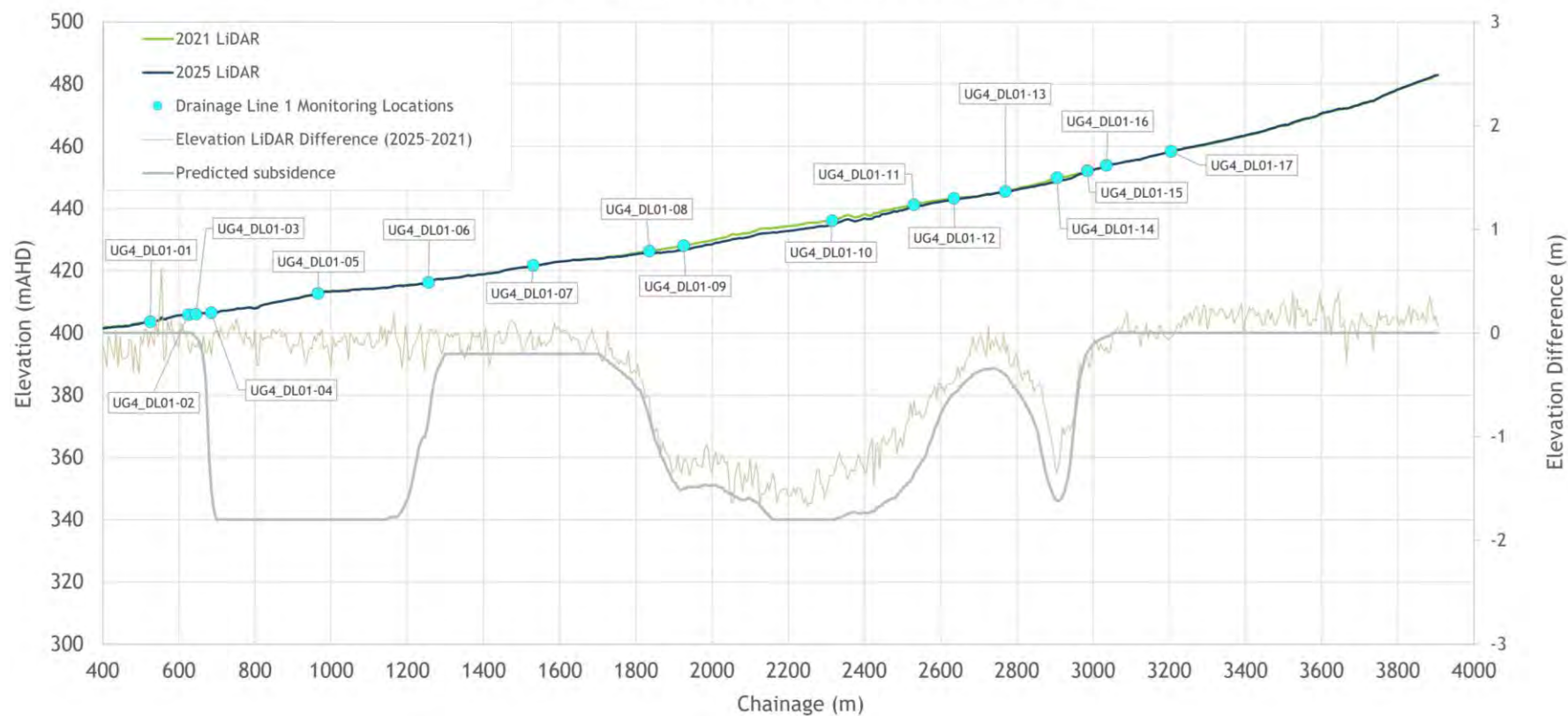


Figure 4.3 DL1 longitudinal section

Note: Elevation differences are derived from comparisons between Lidar-based ground surface datasets and may vary locally due to data processing and site conditions. Values should be interpreted as indicative, point-specific estimates.

The DL1 visual monitoring report from the inspection of 19 March 2026 (i.e. 2 months after completion of LW407 extraction) (MCO, 2026) shows:

- drainage line conditions were generally consistent with previous monitoring, considering drier seasonal conditions. Some surface cracking was observed at monitoring locations, along with other locations along DL1 between monitoring locations. Potential ponding areas upstream from DL01-03 were observed, albeit dry at the time.
- monitoring results are consistent with predicted impacts.

The visual inspection result at DL01-03 is provided in Attachment 1.

The monitoring results show negligible impact or environmental consequences due to extraction of LW401-407, consistent with Extraction Plan predictions for DL1.

4.2.2 Surface Water Quality

DL1 is an ephemeral watercourse which only flows for a short period during and immediately after significant rainfall. Consequently, it has not been possible to collect any surface water samples from DL1 over the extraction period (i.e. from SW23).

4.3 GOULBURN RIVER

4.3.1 Subsidence Effects

LW401-407 do not undermine the Goulburn River. The river channel is 425 metres (m) from the finishing end of LW406 at its nearest point, which is five to six times the depth of cover from LW401-408. MSEC (2021) did not predict any measurable subsidence impact to the Goulburn River.

Visual monitoring locations for the Goulburn River are shown in Figure 4.4.

Visual monitoring sites show results consistent with predicted impacts with no cracking or subsidence effects observed (MCO, 2025). Drop structure conditions were generally consistent with previous monitoring with no subsidence effects observed. The GR-13 drop structure monitoring location shows signs of continued erosion and settlement, which is consistent with pre-mining conditions (MCO, 2025).

4.3.2 Surface Water Flow

Flow in the Goulburn River is recorded at four locations shown in Figure 3.1. LW401-407 are located between monitoring sites Ulan SW01 and MCO SW02, and upstream of SW22.

The reach of the Goulburn River adjacent to LW401-407 receives catchment runoff, as well as treated water discharges from MCO and Ulan Mine, as shown in Figure 4.5.

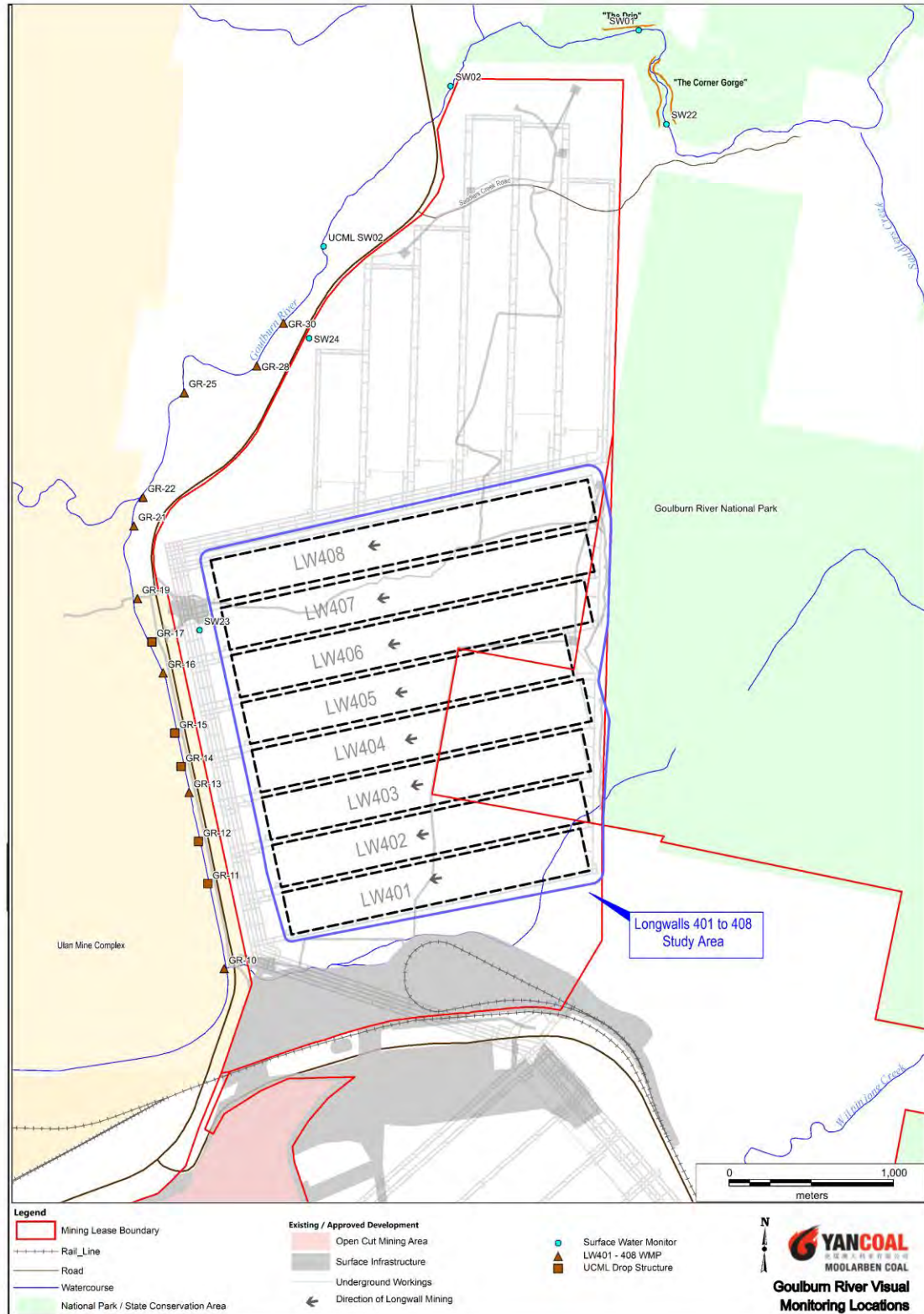


Figure 4.4 Goulburn River visual monitoring locations

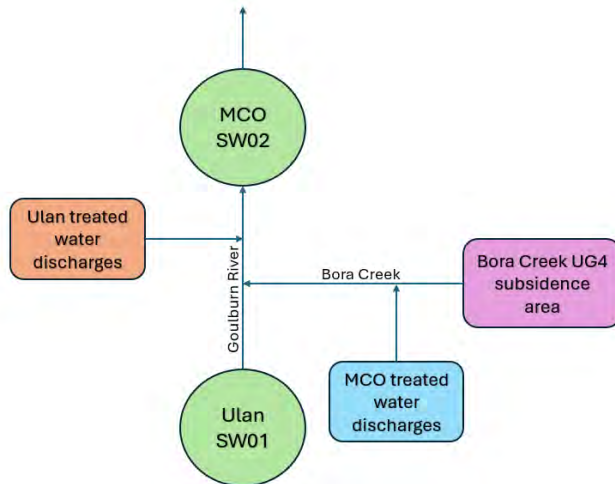


Figure 4.5 Schematic representation of Goulburn River inflows between Ulan SW01 and MCO SW02

The change in flow along the reach of the river between monitoring sites Ulan SW01 and MCO SW02 was assessed by comparing flow at MCO SW02 with the combined total flow from:

- Ulan SW01 + Ulan treated discharges + MCO treated discharges.

Table 4.2 shows total recorded flow at the various Goulburn River gauges for the period December 2023 to December 2025¹, as well as recorded treated water discharges from Ulan Mine and MCO. The data shows treated water discharges form a significant proportion of Goulburn River flow in the reach adjoining LW401-407. There is no loss of flow between the Ulan SW01 and MCO SW02 gauges.

Table 4.2 Total observed Goulburn River flow, December 2023 to December 2025

Location	Total (ML)
Ulan SW01	528
Estimated Ulan treated water discharge*	7,763
MCO treated water discharge	3,662
Total	11,953
MCO SW02	16,676
Change in flow between Ulan SW01 and MCO SW02	+ 4,724
MCO SW22	16,594

* Ulan Mine treated water discharge volumes are estimated from publicly available Ulan Mine Annual Review data.

Note: ML = megalitres

¹ MCO SW02 and SW22 were installed in November 2023. Ulan Mine treated water discharge volumes are estimated from publicly available Ulan Mine Annual Review data.

Figure 4.6 compares 7-day total flow from Ulan SW01 and treated water discharges from Ulan Mine and MCO (horizontal axis) with flow at the downstream MCO SW02 and SW22 gauges (vertical axis). If there was no gain or loss of flow along the reach between the Ulan SW01 and MCO SW02/SW22 gauges, then the points would plot along the diagonal equivalence line (noting that some variability would be expected due to limited accuracy of rating curves). Points would plot below the line if the reach was losing flow, and above the line if the reach was gaining flow.

The plotted points show that there is generally a gain in flow along this reach (i.e. adjacent to LW401-408), as would be expected with increasing catchment area and inflows from Bora Creek and DL1. Some points show a minor flow loss (less than 3 megalitres per day [ML/d]) consistent with normal seepage and evaporation loss under dry conditions.

MCO SW02 and MCO SW22 are located upstream and downstream respectively of The Drip. Allowing for the accuracy of stream flow recording (typically of the order of +/- 20 percent [%]) the data shows no loss of flow along the Goulburn River from upstream of UG4 to downstream of The Drip.

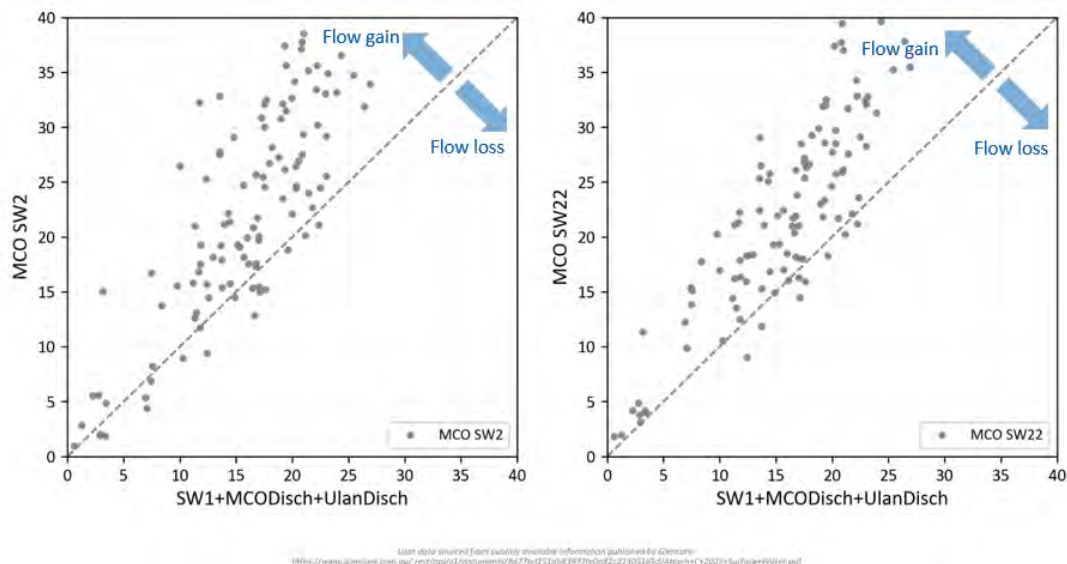


Figure 4.6 7-day average flow volume (ML/d) at Goulburn River gauges Ulan SW01 (+ treated water discharges from Ulan and MCO) and MCO SW02, MCO SW22, Dec 2023 to Dec 2025

4.3.3 Surface Water Quality

Table 4.1 shows a summary of surface water quality data for the Goulburn River from July 2022 to January 2026 (56 samples). Water quality in the Goulburn River is influenced by treated water discharges from MCO and Ulan Mine. The data shows minimal variation in water quality along the Goulburn River.

Table 4.1 Goulburn River water quality, mean of 56 samples from July 2022 to January 2026

Location	EC ($\mu\text{S}/\text{cm}$)	pH	Turbidity (NTU)
Trigger Investigation Values at SW01	900*	6.5 – 8.5**	25***
MCO SW01	615	7.8	24
MCO SW02	611	7.8	29
MCO SW22	620	7.9	26

* EC trigger levels reflect approved discharge limits at the Ulan Mine Complex (Ulan's discharge points are located upstream of SW01). ** Per 20th/80th %ile trigger values. *** Per ANZECC Guideline values.

Figure 4.4 shows a time series of recorded electrical conductivity (EC) and pH in the Goulburn River at MCO SW01 from monthly and event sampling, compared to the trigger investigation levels. Turbidity values are shown in Figure 4.5:

- All pH values are within the upper and lower trigger levels.
- The data shows one trigger event (two consecutive monthly values exceeding the trigger level) for EC in December 2022/January 2023 (Figure 4.7). Monitoring data from the upstream site, MCO SW12 (see Figure 3.1) shows EC values up to 1,270 $\mu\text{S}/\text{cm}$ in December 2022 and 1500 $\mu\text{S}/\text{cm}$ in January 2023. This indicates that the elevated EC values in December 2022/January 2023 were due to high EC from the upstream catchment and were not caused by extraction of LW401 to LW407.
- The data shows one trigger event (two consecutive monthly values exceeding the trigger level) in July/August 2022 (Figure 4.8). This corresponded to a period of high rainfall during the reporting period. Monitoring data from MCO SW12 (see Figure 3.1) show up to 163 NTU between July and August 2022. This indicates that the elevated turbidity values in 2022 were due to high turbidity from the upstream catchment and were not caused by extraction of LW401 to LW407.

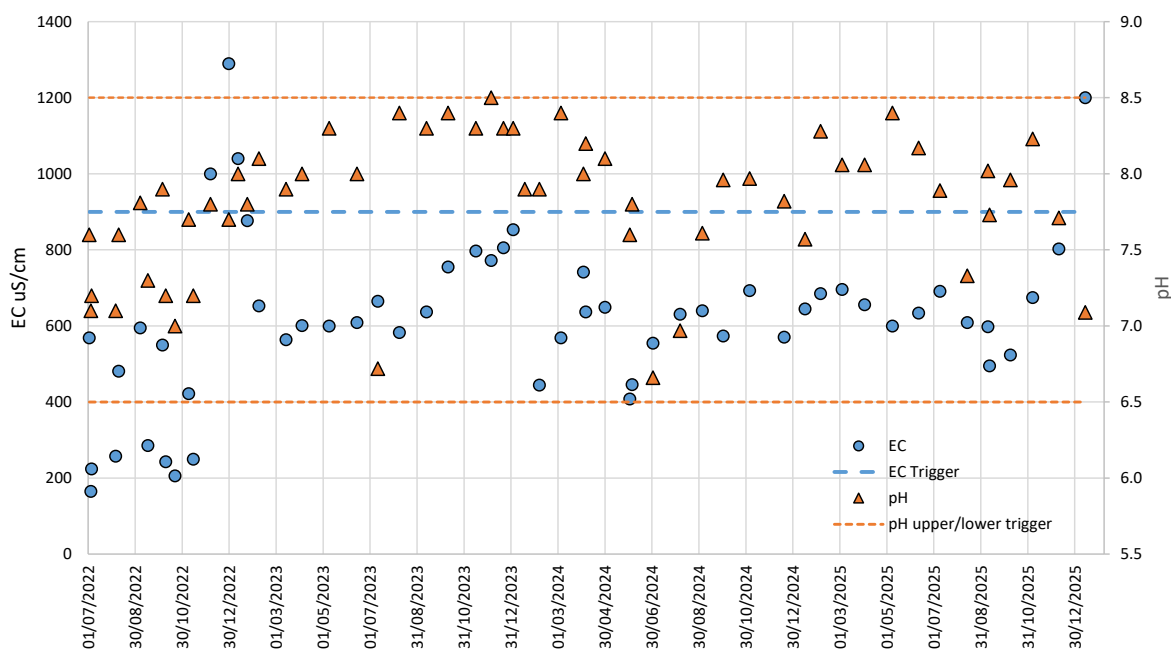


Figure 4.4 Goulburn River water quality, pH & EC – MCO SW01

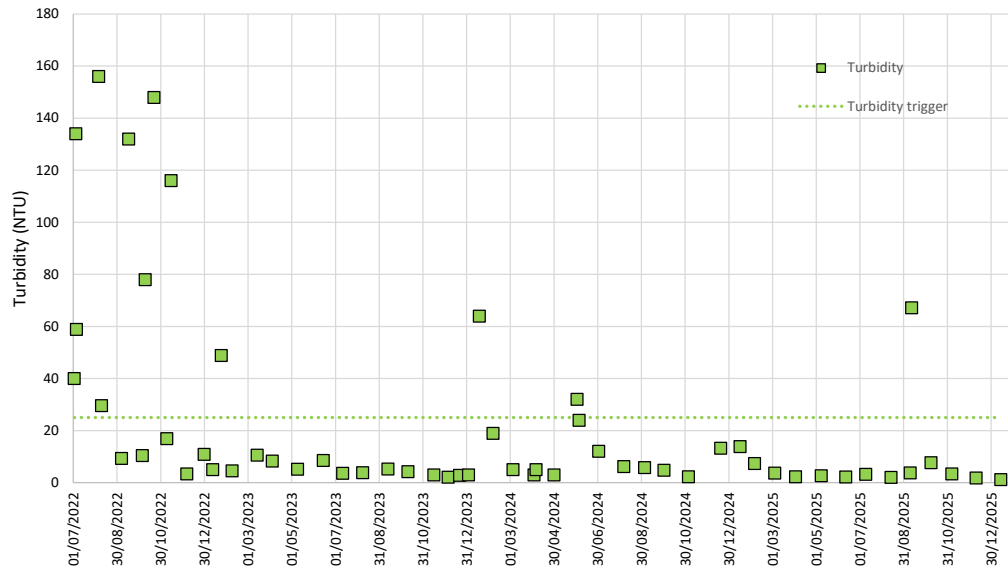


Figure 4.5 Goulburn River water quality, turbidity – MCO SW01

5 REVIEW OF RELEVANT PERFORMANCE MEASURES AND TARPS

The Stage 1 Project Approval conditions (05_0117) include the following subsidence impact performance measure related to surface water resources for LW401-408:

- Negligible impact or environmental consequences for the Goulburn River and the bed of the Goulburn River

Table 5.1 shows the performance criteria and trigger events from the UG4 LW401-408 Water Management Plan (MCO, 2023b) and the UG4 LW401-408 Surface Water Technical Report (WRM, 2021).

The available data shows no trigger events have occurred for Bora Creek, DL1 or DL2 due to mining-related impacts from extraction of LW401-407.

Investigation of the Goulburn River water quality trigger level exceedances shows that the exceedances were due to upstream water quality and were not adverse mining-related effects caused by extraction of LW401 to LW407.

Therefore, the performance criteria and performance measure are considered to have been met.

The results of the LW401-408 monitoring program show negligible impact or environmental consequences due to extraction of LW401-407, consistent with Extraction Plan predictions. On this basis, no changes to the surface water monitoring program, investigation triggers or TARPs provided in the LW409-414 Extraction Plan are proposed.

Table 5.1 Surface water trigger events

Feature	Performance criteria	Trigger event	Trigger exceeded?
Bora Creek	Unpredicted impacts on Bora Creek	Noticeable new areas of erosion or expansion of existing erosion. Initiation of headcut or noticeable upstream advance of existing headcut. Development of new pools or drainage of existing pools.	Not triggered
DL1 and DL2	Unpredicted impacts on DL1 and DL2	Two consecutive monthly surface water quality monitoring results exceed investigation triggers at SW23 or SW24 after commencement of LW406.	Not triggered
Goulburn River	Unpredicted impacts on Goulburn River	Visible cracking of bed or banks, or notable change in erosion or existing pools identified during monitoring inspections.	Not triggered
	No significant adverse mining related effects to downstream water quality (when compared to baseline and/or ANZECC limits).	Two consecutive monthly surface water quality monitoring results exceed investigation triggers at trigger monitoring location MCO SW01.	Triggered: - Dec 22/Jan 23 for EC - Jul-Aug 22 for Turbidity Investigation of upstream water quality data shows that exceedance of trigger values is due to upstream water quality and is not an adverse mining related effect

6 CONCLUSIONS AND RECOMMENDATIONS

Conclusions:

- Surface water monitoring results show negligible impact or environmental consequences due to extraction of LW401-407, consistent with Extraction Plan predictions.
- The available data shows no trigger events have occurred for Bora Creek, DL1 or DL2 due to mining-related impacts from extraction of LW401-407. Investigation of two Goulburn River water quality trigger level exceedances shows that the exceedances were due to upstream water quality and were not adverse mining-related effects caused by extraction of LW401 to LW407.
- The relevant surface water resources performance measure for LW401-408 (i.e. Negligible impact or environmental consequences for the Goulburn River and the bed of the Goulburn River) and other performance criteria for surface water features have been met.
- Based on the LW401-407 monitoring results, no changes to the surface water monitoring program provided in the LW409-414 Extraction Plan are required.

Recommendations:

- Visual inspections of Bora Creek are no longer required as it has been greater than 12 months since undermining and no subsidence effects were observed.
- Visual inspections for DL1 should continue until 12 months after undermining is completed (indicatively January 2027).
- Monitoring of SW23 (DL1) is no longer required as undermining of DL1 is complete and no samples have been collected at this site due to ephemeral flow.
- No other changes to the surface water monitoring program, trigger levels or TARPs are required for remainder of LW408.

7 REFERENCES

- MCO, 2023a *UG4 Longwalls 401 to 408 Extraction Plan, Version 2, October 2023.*
- MCO, 2023b *UG4 Longwalls 401 to 408 Water Management Plan, Version 2, October 2023.*
- MCO, 2024 *UG4 LW401-408 Post-mining Monitoring Bora Creek – April 2024, Version 1, June 2024.*
- MCO, 2025 *UG4 LW401-408 Post-mining Monitoring Goulburn River – October 2025, Version 1, November 2025.*
- MCO, 2026 *UG4 LW401-408 Post-mining Monitoring Drainage Line 1 – March 2026, Version 1, March 2026.*
- MSEC, 2021 *Moolarben Coal Complex: Moolarben Project Stage 1 – Longwalls 401 to 408, Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan, Mine Subsidence Engineering Consultants Pty Ltd, November 2021.*
- WRM, 2021 *UG4 Longwalls 401 to 408 Extraction Plan, Surface Water Technical Report, prepared by WRM Water & Environment Pty Ltd for Moolarben Coal Operations Pty Ltd, ref. 0926-40-B5, 2 November 2021.*

Please do not hesitate to contact me if you have any queries.

For and on behalf of

WRM Water & Environment Pty Ltd

David Newton

Senior Principal Engineer



ATTACHMENT 1

Excerpts of Monitoring Reports (Source: MCO, 2024; MCO, 2026)

UG4 – BC105

Upstream – Pre-mining (29 June 22)	Downstream – Pre-mining (29 June 22)
	
Upstream – Post-mining LW401 (18 October 22)	Downstream – Post-mining LW401 (18 October 22)
	

Upstream – Post-mining LW402 (26 April 23)	Downstream – Post-mining LW402 (26 April 23)
	

Pre- Mining Conditions							
Site	UG4-BC105	Date	29/06/22	E (m)	763,389	N (m)	6,427,512
DL Shape		DL Substrate		DL Walls			
Cross-Section	Long-Section	Material	Cover	Material	Cover		
Stable	Flat	Rock	Algae	Sandy gravel with Rock on RL	Dense		
Erosion and Depositional Features		Water					
		Flow	Turbidity	Colour	Odour		
Small incision on RR		Trickle	Clear	Clear	Nil		
Water			Gas				
Iron Staining	Recent Flows	Pools	Bubbles present	Type			
Some iron bacteria	Recent high rainfall run-off events.	N/A	No	—			
Cracking							
Rock Bar	Bed	Cracking Evident	Width	Orientation	Comments		
No	Yes	No	—	—	Some plains of weakness		
Comments			Changes from Previous				
Flow consistent with DS.			N/A - Pre Mining				

Post Mining Conditions: 18 October 22: Site dry where previously trickling. Vegetation consistent with previous. Minor cracking and slabbing of creek bed evident. Evidence of high velocity flow events scouring creek bed. Evidence of freshly broken cobbles being transported downstream. Observations consistent with the MSEC (2021) predictions of fracturing, dilation and buckling of the bedrock and that a portion of surface water flow could be diverted into the strata below the beds. 	
Erosion in stream bed with potential to develop into active head cut upstream of UG4-BC105 (~763,411mE; 6,427,551mN) was noted.	
26 April 23: Site dry. Channel conditions and vegetation consistent with previous considering seasonal conditions. Minor cracking and slabbing of creek bed consistent with previous. Observations consistent with the MSEC (2021) predictions of fracturing, dilation and buckling of the bedrock and that a portion of surface water flow could be diverted into the strata below the beds. Location of potential head cut upstream of UG4-BC105 consistent. 	

Upstream – Post-mining LW402 (6 October 23) 	Downstream – Post-mining LW402 (6 October 23) 	6 October 23: Site dry. Channel conditions and vegetation consistent with previous. Minor cracking and slabbing of creek bed consistent with previous. Observations consistent with the MSEC (2021) predictions of fracturing, dilation and buckling of the bedrock and that a portion of surface water flow could be diverted into the strata below the beds. Location of potential head cut upstream of UG4-BC105 consistent with previous. 
Upstream – Post-mining LW402 (30 April 24) 	Downstream – Post-mining LW402 (30 April 24) North East Elevation 	30 April 24: Site dry. Channel conditions and vegetation consistent with previous. Minor cracking and slabbing of creek bed consistent with previous. Observations consistent with the MSEC (2021) predictions of fracturing, dilation and buckling of the bedrock and that a portion of surface water flow could be diverted into the strata below the beds. Location of potential head cut upstream of UG4-BC105 consistent with previous. Burrow evident in base on river right of head cut. 

UG4_DL01-03																																																																																																																												
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APPENDIX D

MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 408 – 2025 SPRING MONITORING PROGRAM (NICHE, 2025)

Moolarben UG4: Longwalls 401-408 Spring Monitoring Program

Spring 2025

Prepared for Moolarben Coal Operations Pty Ltd
10 December 2025





Document control

Project number	Client	Project manager	LGA
9170	Moolarben Coal Operations Pty Ltd	Tamya Wynne	Mid-western Regional

Version	Author	Review	Status	Comments	Date
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Glossary and list of abbreviations

Term or abbreviation	Definition
BAM	NSW Biodiversity Assessment Method
BAM-C	NSW Biodiversity Assessment Method Calculator
BC Act	NSW <i>Biodiversity Conservation Act 2016</i>
BMP	Biodiversity Management Plan
BOA	Biodiversity Offset Area
DBH	Diameter at Breast Height
DPIE	NSW Department of Planning, Industry and Environment
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
kHz	kilohertz
LW	Longwall
MCO	Moolarben Coal Operations Pty Ltd
OPS	Octaves per second
PCT	Plant Community Type
Project	The secondary extraction of Longwalls 401 to 408 within UG4
Reference site/s	Analogue monitoring plots and microbat monitoring sites in the Reference Area
Reference Area	Red Hills BOA 1 and Red Hills BOA 2
Study Area	UG4 LW 401-408
Study site/s	Monitoring plots and microbat monitoring sites above UG4
UG	Underground
VIS	Vegetation Integrity Score



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1. Introduction

1.1 Project background

Moolarben Coal Operations Pty Ltd. (MCO) received approval for Moolarben Coal Project Stage 1 under Project Approval 05_0117, which includes the No. 4 Underground Area (UG4) (the Project). The Moolarben Coal Mine is located at 12 Ulan-Wollar Road, Ulan, New South Wales (NSW). An Extraction Plan (MCO 2021) has been prepared for secondary extraction of Longwalls 401 to 408 (the Project) within UG4 (the Study Area) (Table 2, Figure 1).

The Extraction Plan contains an annual monitoring program that has been developed based on recommendations from the Vegetation Validation and Baseline Assessment Report (Niche 2021) to monitor the impacts of the secondary extraction of Longwalls 401-408 on terrestrial flora and fauna (in particular, threatened fauna, flora and ecological communities). The monitoring requires a baseline survey prior to mining and for two years following longwall mining beneath the monitoring location.

The baseline assessment (Niche 2021) was undertaken in May 2021 to support the development of the UG4 Longwalls 401-408 Extraction Plan, including the UG4 Longwalls 401-408 Biodiversity Management Plan (LW401-408 BMP) and the UG4 Longwalls 401-408 Subsidence Monitoring Program (LW401-408 SMP). The baseline assessment resulted in field mapping to validate Plant Community Types (PCT) throughout the Study Area (Figure 2) and establishment of the monitoring sites to be utilised for the duration of the Project.

The 2025 Spring monitoring report has been prepared to satisfy the requirements of the LW401-408 BMP and LW401-408 SMP and includes the following:

- A description of the survey methodology and data analysis utilised for the annual monitoring program, including monitoring locations in the Study Area and Reference Sites
- Monitoring survey results including:
 - Condition and health of PCTs in the study sites and reference sites
 - Threatened ecological communities (TEC) recorded within the Study Area and status under State and Commonwealth legislation
 - Threatened flora and/or their habitats recorded within the Study Area
 - Threatened fauna and/or their habitats recorded within the Study Area
 - Priority weeds and pest animals recorded within the Study Area.
- A summary of the biodiversity values current condition within the Study Area as compared to the Reference Area (Red Hills Biodiversity Offset Area [BOA] 1 and Red Hills BOA 2) (Figure 2)
- Recommendations and conclusion.

1.2 Monitoring aims

The primary aim of the annual monitoring program is to determine the status of vegetation integrity, comprising health, structure and function, of the vegetation overlying the Study Area. The baseline assessment data (Niche 2021) as well as the 2022, 2023 and 2024 and monitoring survey data (Niche 2022; Niche 2023; Niche 2024) have been utilised for comparative assessment of the Spring 2025 monitoring data. The aim of monitoring is to demonstrate whether longwall mining has resulted in impacts to native vegetation forming habitat for threatened biota (threatened species, populations or ecological communities) within the Study Area.



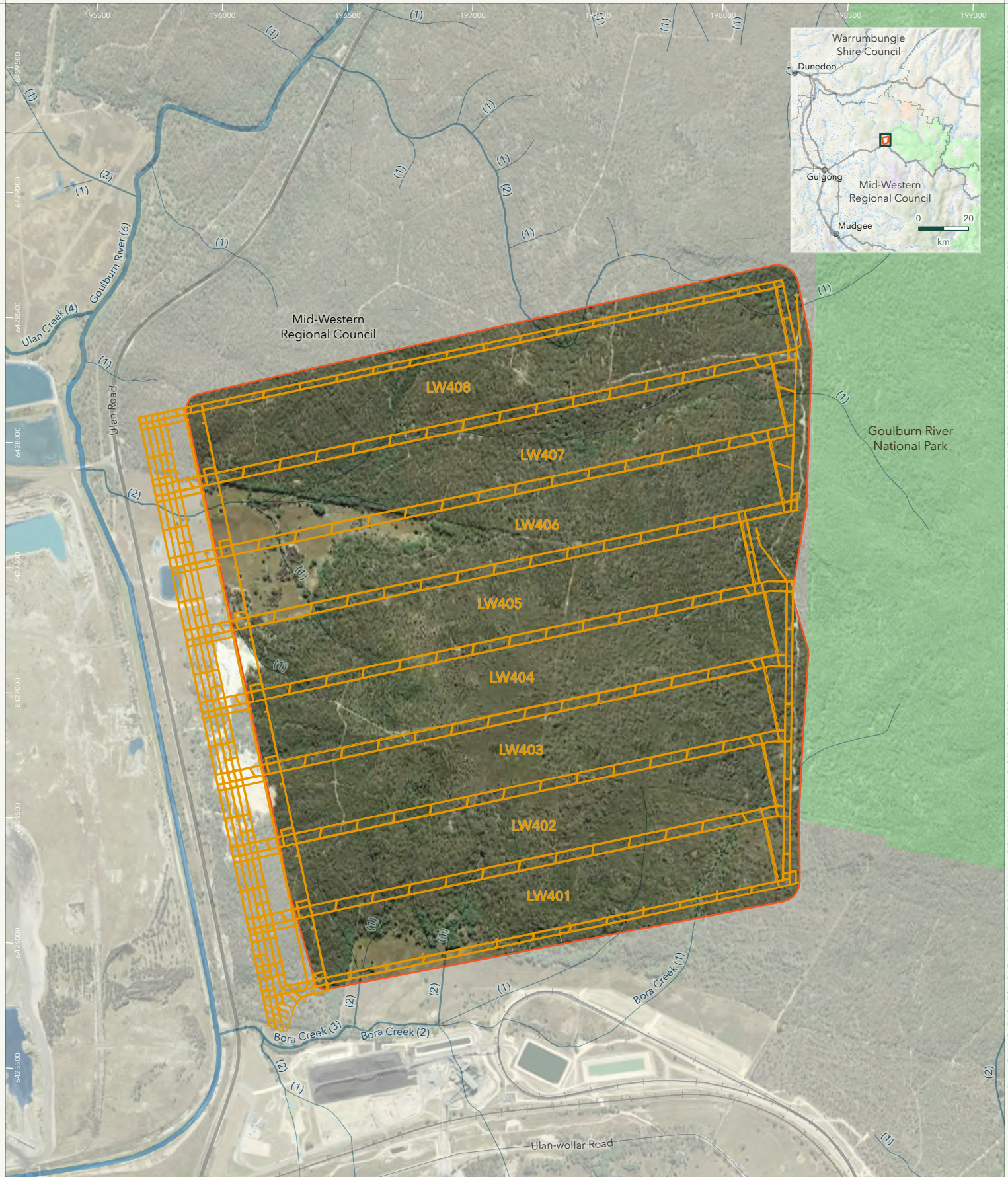
1.3 Performance measures and indicators

As stated in the LW401-408 BMP (MCO 2022), project approval condition 77 (i) requires the management of potential impacts and/or environmental consequences of the proposed second workings on aquatic and terrestrial flora and fauna, with a specific focus on threatened species, populations and their habitats; endangered ecological communities and water dependent ecosystems.

Fauna species selected for monitoring are those which are considered to occur in habitats sensitive to direct impacts (DPIE 2020), which in the case of UG4 consist of geological features such as caves, crevices, and fissures in minor cliff lines (Niche 2021).

Performance indicators have been developed to assess subsidence impacts on TECs, threatened flora and fauna. MCO will assess Longwalls 401-408 against the following biodiversity performance indicators:

- PCT 281 in the Study Area aligns to *White Box - Yellow Box - Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions* listed as a Critically Endangered Ecological Community (CEEC) under both the *Biodiversity Conservation Act 2016* (BC Act) and *Environment Protection Biodiversity Conservation Act 1999* (EPBC Act).
 - No significant reduction in Vegetation Integrity Score (VIS) greater than observed at reference sites (decrease of VIS by 20% for two consecutive survey periods post mining) combined with observed subsidence impacts; or
 - No significant reduction in species diversity greater than observed at reference sites (a significant reduction being greater than 5 species consistently absent from established monitoring plots for 4 consecutive years) combined with observed subsidence impacts.
- Threatened fauna - Threatened Cave-dwelling bat species
 - No significant reduction in threatened species presence greater than observed at the reference site (at least 1 species absent from acoustic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.
- Threatened flora - *Androcalva procumbens*
 - Threatened flora remains present within the Study Area.



 Study Area
 LW401-408
Transport
 Major road
 Minor road

 Rail
Hydrography
 Strahler stream order
 1
 2

 3
 4
 6
 Waterbody

Protected Areas of NSW
 National Park
Administrative and Property Boundaries
 Local Government Area



 0 500
 m
 GDA2020 MGA Zone 55



Figure 1

Study Area

MCO UG4 Longwall 401-408 Monitoring Program - Spring 2025

Niche PM: Tanya Wynne
 Niche Proj. #: 9170
 Client: MCO



2. Methodology

A summary of the monitoring methods undertaken during the Spring 2025 survey is provided in Table 1 and a detailed description of the methods are provided in sections 2.1.1. Monitoring locations are displayed on Figure 2.

Table 1. UG4 LW401-408 Spring 2025 survey methods

Survey type	Methods
Monitoring plot	Monitoring survey at specific locations in the Study Area and Reference Area consisting of a BAM Plot (50 x 20 metre [m] function plot including a nested 20 x 20 m floristic plot) along a fixed transect, recording the composition, structure and functional attributes of extant PCTs.
Canopy health	Assessment of canopy health in each monitoring plot, including: – Cover (%) of epicormic foliage – Cover (%) of discoloured canopy foliage – Cover (%) of dieback – Cover value (%) of bare branches – Count of any stags encountered.
Photo point monitoring	Two photographs (portrait and landscape) taken at the established pickets at the start and end of each 50m transect of all monitoring plots.
Visual assessment	Count and inspection of threatened flora populations.
Acoustic monitoring	Five acoustic devices targeting bats (four deployed in the Study Area and one deployed in the Reference Area) for four nights.
Subsidence	Evidence of subsidence impacts (cracking or ponding) within the monitoring plot.

2.1 Monitoring plots

Ten permanent monitoring plots above the Study Area (hereafter referred to as the study sites) and ten permanent monitoring plots established in corresponding PCTs in the nearby Reference Area (hereafter referred to as the reference sites) have been established (Figure 2). Study site UG4_08a was established in PCT 477 above LW408 in the Spring 2023 monitoring round (Niche 2023).

As part of the baseline assessment and field validation, it was identified that certain PCTs mapped as present within the Study Area had been decommissioned (e.g. PCT 864) and/or were difficult to locate in the locality. As such, when determining locations to establish the reference sites, surrogate PCTs were chosen. The surrogate PCTs were determined based on having the same vegetation class and formation, and generally similar species richness and structure (Niche 2021).

All reference sites were situated in the same PCTs (same vegetation class) in similar condition state to study sites, with the aim of establishing two reference sites for each surveyed PCT in the Study Area. Table 2 provides the longwall number, the names, PCT and vegetation class of the study sites and associated reference sites, the year the monitoring plot was established and its mining status.



Table 2. Monitoring plots

Longwall number	Study site	Study site PCT	Associated reference sites	Reference site PCT	Vegetation class	Year plots established	Status	Date plot undermined	Final monitoring year
LW401	UG4_01	479	BOA_OU3 BOA_OU4	479	Western Slopes Dry Sclerophyll Forests	2021	Undermined	October 2022	2024
LW402	UG4_02					2021	Undermined	November 2022	2025
LW403	UG4_03					2021	Undermined	April 2023	2025
LW404	UG4_04	1711	BOA2_OU4 BOA2_OU5	1711	Western Slopes Dry Sclerophyll Forests	2021	Undermined	August 2023	2026
LW405	UG4_05	1656	BOA_OU1 BOA_OU2	1656	Western Slopes Dry Sclerophyll Forests	2021	Undermined	July 2024	2026
LW406	UG4_06a	281	BOA1_14a BOA1_14b	281	Grassy Woodlands	2021	Undermined	June 2025	2026
	UG4_06b	1656	BOA_OU1 BOA_OU2	1656	Western Slopes Dry Sclerophyll Forests	2021	Undermined	February 2025	2026
LW407	UG4_07	1656				2021	Undermining ongoing	Not yet undermined	2027
LW408	UG4_08	1656				2021	Pre mining	Not yet undermined	2027
LW408	UG4_08a	477	BOA1_06a BOA1_06b	477	Western Slopes Dry Sclerophyll Forests	2023	Pre mining	Not yet undermined	2027



Monitoring of all study sites and reference sites were undertaken in accordance with the NSW Biodiversity Assessment Method (BAM) (DPIE 2020). Each site consists of a 20 x 50 m plot (centred around a 50 m transect) for recording of functional attributes and a nested 20 x 20 m quadrat for recording composition (species richness) and structural (foliage cover) attributes (refer to Plate 1). Each plot has been permanently marked with a capped star picket at the start and end upon which the plot number and orientation has been inscribed, to ensure the site location remains consistent between monitoring events.

Data recorded within each 20 x 20 m nested quadrat constitutes the composition and structure score, and includes:

- A full count of native and exotic species richness (this constitutes the composition score)
- Projected foliage cover (PFC) of all species in increments of 0.1-1, 1-10 then 5% increments capped at 100% (this constitutes the structure score)
- Abundance of all species recorded within the quadrat measured at 1-10 then in increments of 10 up to 100. Upon reaching 100 individuals, further measurements will be recorded in increments of 500
- A record of the structural layer/s occupied by each species including the dominant species occupying the canopy, mid-storey and ground layers.

The data recorded within the 20 x 50 m plot constitutes the function score and includes:

- The presence/absence of the diameter at breast height (DBH) size increments (<5 cm, 5-10 cm, 11-20 cm, 21-30 cm, 31-40 cm, 41-50 cm etc) of species in the tree growth form group
- Number of large trees (>50 cm DBH) and presence of regenerating trees (<5 cm DBH)
- Number of hollow-bearing trees
- Length of coarse woody debris measured in metres.

Additional data recorded within the 20 x 50 m plot constitutes the native vegetation stress analysis and includes:

- Cover (%) of epicormic foliage relative to total cover of foliage within the plot
- Cover (%) of discoloured canopy foliage relative to total cover of healthy foliage within the plot
- Cover (%) of dieback relative to live vegetation within the plot and the PCT patch
- Cover value (%) of bare branches
- Count of any stags encountered within the plot
- Evidence of subsidence impacts (cracking or ponding)
- Presence and extent of subsidence impacts (cracking or ponding) as a percent of the plot area.

Landscape characteristics recorded at each plot include aspect, slope (expressed as a percentage), type and percentage cover of surface rock, cryptograms, bare soil, presence/absence of rock outcrop, cliffs or caves, proximity to nearest waterway or waterbody in addition to soil colour and texture.

Observations were recorded on vegetation condition within the Study Area and at each monitoring plot location, focusing on presence of exotic species, herbivory and disturbance by feral pest species.

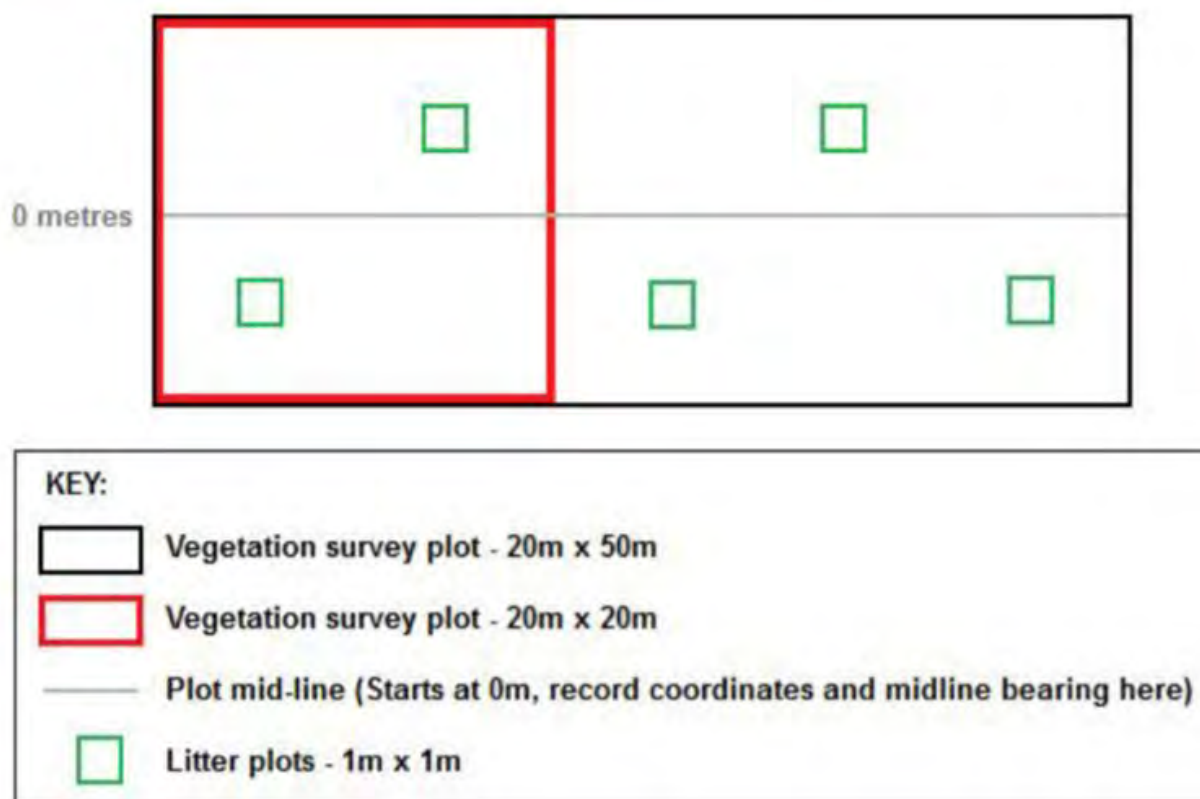


Plate 1. Monitoring plot layout as per the *NSW Biodiversity Assessment Method 2020 Operational Manual - Stage 1* (DPIE 2020)

2.1.1 Monitoring plot analysis

Spring 2025 monitoring plot data was prepared for entry into the NSW Biodiversity Assessment Method Calculator (BAM-C) to generate a VIS in accordance with the BAM (DPIE 2020). The data was entered into the BAM-C to generate composition, structure and function scores in addition to an overall VIS (i.e. high condition [VIS ≥ 70], moderate condition [VIS 40-69], low condition [VIS < 40], derived native grassland (no canopy and VIS < 40). Benchmark data used in the BAM-C analysis, utilised at the initiation of the annual monitoring program to present, is displayed in Table 3. Regional benchmarks used by the BAM-C are established at the IBRA/vegetation class scale and assume average past rainfall (DPIE 2020).

A comparative assessment of the composition, structure and function attributes derived from the study sites and the corresponding reference sites were undertaken using the 2021, 2022, 2023, 2024 and 2025 monitoring data. This data is presented in Chart 1 to Chart 28 (undermined) and Chart 43 to Chart 54 (not undermined). Comparative analysis and descriptions were applied between the study sites and reference sites based on the results.

An additional comparative assessment of native vegetation stress derived from the study sites and corresponding reference sites was undertaken using the 2021 to 2025 monitoring data. This data is presented in Chart 29 to Chart 37 (undermined) and Chart 55 to Chart 63 (not undermined). Comparative analysis and descriptions were applied between the study sites (undermined) and reference sites based on the results.

Monitoring plot data, including detailed composition and structure data (20 x 20 m quadrat) and functional attributes (20 x 50 m plot) and the vegetation stress data has been provided to MCO as a separate spreadsheet.



Table 3. Benchmark data for each PCT used in the BAM-C analysis

PCT Number	Vegetation Class	Composition (number of species in 20 x 20m plot)						Structure (% cover in 20 x 20m plot)						Function (Count, cover, meters and presence/absence within 20 x 50 m plot)				
		Tree	Shrub	Grass and Grass-like	Forb	Fern	Other	Tree	Shrub	Grass and Grass-like	Forb	Fern	Other	Number of large trees (count)	Litter cover (cover %)	Total Length Fallen Logs (m)	Tree stem size classes present (count)	Tree Regeneration (<5 cm diameter) (presence/absence)
281	Grassy Woodlands	3	6	10	11	1	3	21	5	43	8	0	1	2	35	34	4	Present
477	Western Slopes Dry Sclerophyll Forests	5	16	8	8	1	3	66	68	23	6	1	1	1	63	55	4	Present
479	Western Slopes Dry Sclerophyll Forests	5	16	8	8	1	3	66	68	23	6	1	1	1	63	55	4	Present
1656	Western Slopes Dry Sclerophyll Forests	5	16	8	8	1	3	66	68	23	6	1	1	1	63	55	4	Present
1711	Western Slopes Dry Sclerophyll Forests	5	16	8	8	1	3	66	68	23	6	1	1	1	63	55	4	Present



2.2 Photo-point monitoring

Photo points were established at the start and end of the monitoring plots on the central 50 m transect. Two photographs (portrait and landscape) were taken to retain a visual record of the vegetation at each plot (Annex 3).

2.3 Microbat Analysis

2.3.1 Ultrasonic monitoring

Ultrasonic monitoring devices were deployed to determine the presence, species richness and potential for residency of microbat populations within the Study Area.

Five ultrasonic detectors targeting microbats were deployed for a period of four nights. BOA_FM01, UG4_FM01, UG4_FM02, UG4_FM03 and UG4_FM04 were deployed from 13 October to 17 October 2025. The devices were deployed within flyways in vegetation adjacent to potential cave-dependent microbat habitat identified within the Study Area and the nearby Reference Area, in the same locations as the Spring 2024 monitoring (Figure 2).

2.3.2 Spring 2025 methodology

The ultrasonic data was analysed using Anabat Insight version 2.3 by Titley Scientific. A specific filter was employed within Anabat Insight to automatically identify files containing bat calls. This filter required a file to contain >4 bat pulses that met the following criteria:

- 10-200 kHz -200 kHz characteristic frequency
- Calls with a 2-100 milliseconds (ms) duration, and
- Calls with 5-1500 ms between pulses (Time Between Calls).

All non-bat files (files that did not meet the above filter criteria) were deleted. All "bat" files were run through a per-pulse decision tree in Anabat Insight. The decision tree is comprised of filters that compress files to remove noise and isolate pulses in a file that meet specified metric conditions and search for calls containing defining characteristics attributed to certain species in the dataset which automatically labels files with either a species or species complex. The labelled calls were then manually verified to confirm the identified calls for each species and species complex.

The references *Bat Calls of New South Wales* (Pennay et al. 2004) and *Key to the Bat Calls of South-East Queensland and North-East New South Wales* (Reinhold et al. 2001) were used to guide the selection of specific metrics within the filters and for species identification. Calls with fewer than three valid were not analysed due to poor call quality and increased chance of species identification error. Similarly, call sequences that exhibited excited, feeding buzz, or attack-phase pulses characterised by changes in frequency, shape, and structure were discarded if they lacked sufficient search-phase pulses typically required for reliable species identification.

Calls were positively identified to the species level when the unique and distinct characteristics were present and there was limited chance of error between species with overlapping and/or similar calls. Call sequences of sympatric species with frequency and characteristic overlap that could not be positively identified to species level were assigned to species complexes containing two or three potential species, depending on the characteristics displayed in the recorded call sequences. Recordings containing multiple bats calling simultaneously were manually filtered and analysed to isolate individual species calls. This process enabled the identification of specific metrics for each individual bat call, including characteristic frequencies and other defining features critical for accurate species identification.



All passes for threatened cave-dwelling bats that can be reliably distinguished by call metrics (*Miniopterus orianae oceanensis* (Large Bent-winged Bat) and *Chalinolobus dwyeri* (Large-eared Pied Bat)) were recorded. Presence or absence was recorded for all other species.

M. o. oceanensis calls can overlap in frequency with those of *Vespadelus regulus* (Southern Forest Bat) and *Vespadelus vulturnus* (Little Forest Bat) in the Sydney Basin. The calls of Large Bent-winged Bats can be distinguished from *Vespadelus sp.* by the presence of a down-sweeping tail on most calls, variability in pulse shape and time between pulses, and a pre-characteristic section of <2 kHz however, these distinguishing characteristics are not always present. If calls were of overlapping frequency and longer duration with no tail or a short up-sweeping tail, they could not be confidently assigned to species level. They were instead classified as species complex (*M. o. oceanensis* or *Vespadelus sp.*) based on the features that best matched the call profiles.

Nyctophilus spp. (long-eared bats) are difficult to confidently identify or differentiate at the species level based on the similarity of recorded calls. As a result, we did not attempt to identify any *Nyctophilus spp.* within the dataset. One threatened *Nyctophilus* species (*N. corbeni*) and two non-threatened *Nyctophilus* species, *N. geoffroyi* (Lesser Long-eared Bat) and *N. gouldii* (Gould's Long-eared Bat), are potential inhabitants of the Study Area. Additionally, the threatened *Myotis macropus* (Southern Myotis) also display a complete overlap in frequency with *Nyctophilus* species. However, there are some distinctive characteristics of *M. macropus* calls that can be used to differentiate between *Nyctophilus* calls. *M. macropus* mostly have a pulse interval is <75ms and an initial slope of >400 octaves per second (OPS) while *Nyctophilus* have a pulse interval is >75 and an initial slope of <300 OPS. If the call sequence is between 75-95ms and 300-400 OPS, then the above species cannot be distinguished and subsequently assigned a species complex both *Nyctophilus* and *Myotis*.

Calls of *Scoteanax rueppellii* (Greater Broad-nosed Bat), *Falsistrellus tasmaniensis* (Eastern False Pipistrelle), *Scotorepens greyii* (Little Broad-nosed Bat) and *Scotorepens balstoni* (Inland Broad-nosed Bat) can be difficult to differentiate due to overlapping frequencies and other similar call characteristics.

- *Falsistrellus tasmaniensis* calls typically exhibit a characteristic frequency of 35–39 kHz, with curved, often steep pulses that lack up-sweeping tails and may include short down-sweeping tails. These calls also have a distinct pre-characteristic section exceeding 3 kHz. Accurate differentiation from *Scoteanax rueppellii* and *Scotorepens orion* is possible only when the characteristic frequency exceeds 37 kHz.
- *Scoteanax rueppellii* calls are identifiable by their characteristic frequency of 32–36 kHz. They typically lack a tail or may include a short down-sweeping tail. The frequency at the "knee" is above 37 kHz, and there is a drop of more than 3 kHz from the knee to the characteristic frequency. Calls with a longer pre-characteristic section at frequencies below 36.5 kHz can help distinguish *S. rueppellii* from *F. tasmaniensis*.
- *Scotorepens greyii* calls are typically 35–40 kHz, curved, with a tail that is usually up-sweeping but may be down-sweeping or absent in some pulses. Can be differentiated from *F. tasmaniensis* and *S. rueppellii* by the time of the characteristic section and tail is usually half or less of the total pulse.
- *Scotorepens balstoni* calls fall within a frequency range of 28–34 kHz, are curved, and often display down-sweeping or absent tails, although up-sweeping tails may occur. This species can be distinguished from *F. tasmaniensis* and *S. rueppellii* by its lower knee frequency, generally 37 kHz and below.

The calls of *Chalinolobus morio* (Chocolate Wattled Bat; 46.5–53 kHz), *V. regulus* (Southern Forest Bat; 50.5–58 kHz), *V. troughtoni* (Eastern Cave Bat; 49–52 kHz), and *V. vulturnus* (Little Forest Bat; 48.5–53 kHz) overlap in the frequency range of 49–52 kHz.

Chalinolobus morio calls typically exhibit curved pulses with a down-sweeping tail, while the calls of *V. regulus*, *V. troughtoni*, and *V. vulturnus* are curved with up-sweeping tails. Calls with profiles above 49 kHz featuring upward-facing tails were attributed to a complex comprising *V. regulus*, *V. troughtoni*, and *V. vulturnus*. Calls with profiles below 48.5 kHz with upward-facing tails were assigned to *V. vulturnus*.



2.4 Monitoring of threatened flora populations – *Androcalva procumbens*

An estimated population count was undertaken during the Spring 2021, 2022, 2023, 2024 and 2025 annual monitoring surveys in the two known populations of *Androcalva procumbens*. A comparative analysis of the estimated population count between the 2021 baseline, 2022, 2023, 2024 and 2025 annual monitoring surveys was also undertaken to quantify any changes.

Due to the large number of *Androcalva procumbens* individuals present in the Study Area (a total of 368, 302 and 282 individuals counted in 2021, 2022 and 2023, respectively) and the prostrate, trailing habit of the plant, it was difficult to visually detect individuals. It was determined that the populations cannot be counted with reasonable confidence (Niche 2023). The threatened flora survey guidelines (DPIE 2020a) states that ‘for larger populations (e.g., >50 plants), extrapolating the mean density by sampling over the areas of occupancy may be required. Where sampling is conducted, the count of individuals from quadrats or transects can be used to estimate the population within occupied habitat’.

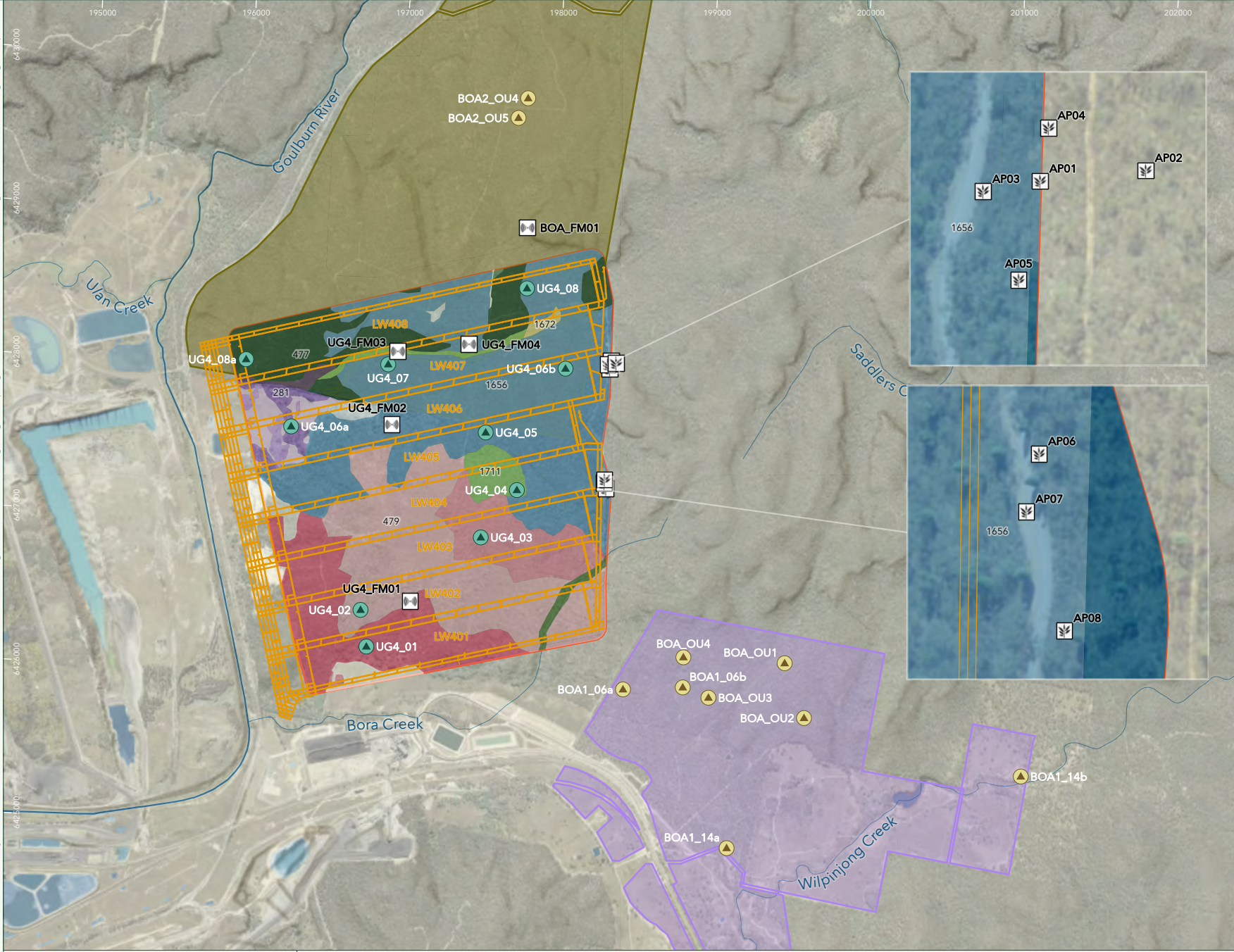
Following these guidelines, a total of eight permanent 5 m by 5 m monitoring quadrats were established in the *Androcalva procumbens* populations during the Spring 2023 survey (Niche 2023a). The location of each monitoring quadrat was chosen in order to provide a representative sample of the species population density. This included five monitoring quadrats in the larger, northern population and three in the smaller, southern population (Annex 4, Table 10). In Spring 2023 (Niche 2023a), Spring 2024 (Niche 2024) and this monitoring report, the number of individuals in each monitoring quadrat was counted and the size of the total population was extrapolated.

Where additional populations of *Androcalva procumbens* are detected or should the habitat extent of the current populations increase or decrease during future monitoring rounds, their locations and extents will be recorded in the annual monitoring report.

2.5 Opportunistic observation

Opportunistic observations of fauna species in the Study Area were undertaken where possible during the survey. A list of recorded species is presented in Annex 5.

Drawn by: MikeFairlie File: C:\OneDriveSync\Folder\Niche\GIS - APRX - APRX\9100\9170_MCO_UC4_Longwall_401_408_MonitoringProgram.aprx Last



Study Area

Reference Area - Red Hills BOA 1

Reference Area - Red Hills BOA 2

LW401 - 408

Reference site

Study site

Threatened Plant Survey

Bat Recorder

0, Not Native, Not Native

281, Rough-Barked Apple - red gum - Yellow Box woodland, High

281, Rough-Barked Apple - red gum - Yellow Box woodland, Moderate

281, Rough-Barked Apple - red gum - Yellow Box woodland, Low

281, Rough-Barked Apple - red gum - Yellow Box woodland, DNG

477, Inland Scribbly Gum Open Forest, High

477, Inland Scribbly Gum Open Forest, Moderate

479, Narrow-leaved Ironbark Shrubby Open Forest, High

479, Narrow-leaved Ironbark Shrubby Open Forest, Low

479, Narrow-leaved Ironbark Shrubby Open Forest, Moderate

1656, Narrow-leaved Ironbark Grassy Open Forest, High

1656, Narrow-leaved Ironbark Grassy Open Forest, Moderate

1656, Narrow-leaved Ironbark Grassy Open Forest, Low

1672, Red Ironbark heath Woodland, High

1711, Tanton - Lepyrodia leptocaulis shrubland, High

1711, Tanton - Lepyrodia leptocaulis shrubland, Moderate

Hydrography

Perennial Stream

Non Perennial Stream

Waterbody

0

750

m

GDA2020 MGA Zone 55

Figure 2
Monitoring Locations
MCO UG4 Longwall 401-408 Monitoring Program - Spring 2025

Niche PM: Tamya Wynne
Niche Proj. #: 9170
Client: MCO

Bat Recorder: / Threatened Plant Survey: / Monitoring location: / LW401 - 408: / Field-verified Vegetation Zones: / Reference Area - Red Hills BOA 1: / Study Area: / Watercourse: / Waterbody: / Hillshade: Esri, Geoscience Australia, NASA, NGA, USGS/ public/NSW. Imagery: © Department of Customer Service 2020/ Hillshade: Sources: Esri, Vantor, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, and the GIS user community | Watercourses, Waterbodies, Road and Rail alignments, Protected areas of NSW © Spatial Services 2021. | Niche uses GDA2020 as standard for all project-related data. In order to ensure that data from numerous sources and coordinate systems is aligned, on-the-fly transformation to GDA2020 MGA Zone 55 is used in the map above. For ease of reference, the grid tick marks and labels shown around the border of the map are presented in GDA2020 MGA Zone 55.



3. Results and discussion

3.1 Monitoring plots

During the Spring 2025 monitoring period, longwall mining beneath study sites UG4_01, UG4_02, UG4_03, UG4_04, UG4_05, UG4_06a and UG4_06b had been completed and longwall mining was had not begun beneath study site UG4_07 (Table 2).

The results for the BAM plot, native vegetation stress and subsidence data collected for each of these study sites (undermined) and their associated reference sites is displayed and described below in Section 3.1 , Section 3.1.1 and Section 3.1.2, respectively.

The monitoring plot and native vegetation stress data collected for each of the study sites (not undermined) (Table 2) and the associated reference sites has not been discussed in detail in this section as mining has not yet commenced below these study sites. However, the data is presented in Annex 2, Chart 43 to Chart 54.



3.1.1 Monitoring plot data recorded in the study sites (not yet undermined) and references sites

UG4_01 (LW401)

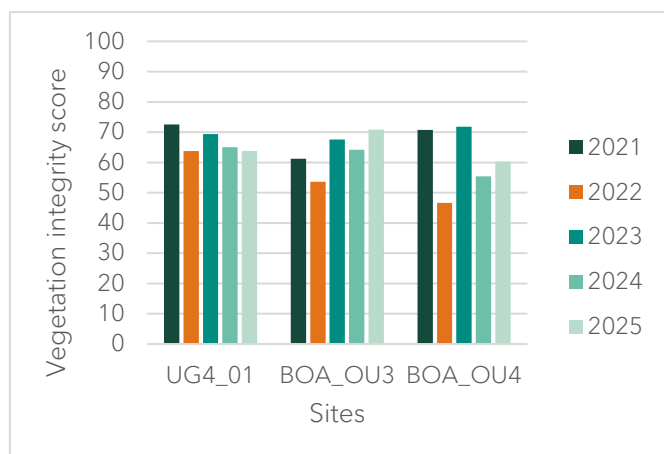


Chart 1: VIS at UG4_01 and associated reference sites (2021-25)

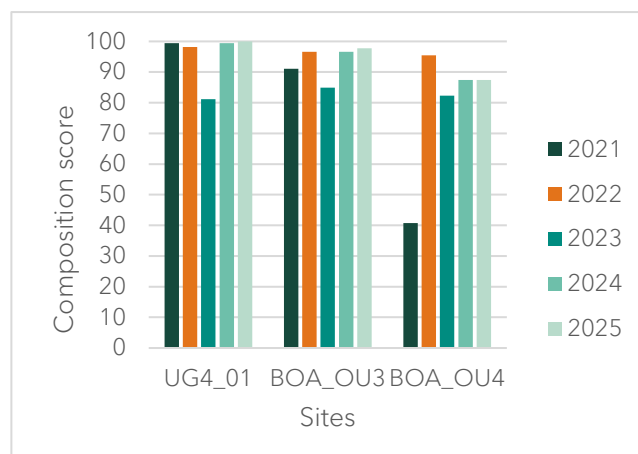


Chart 2: Composition scores at UG4_01 and associated reference sites (2021-25)

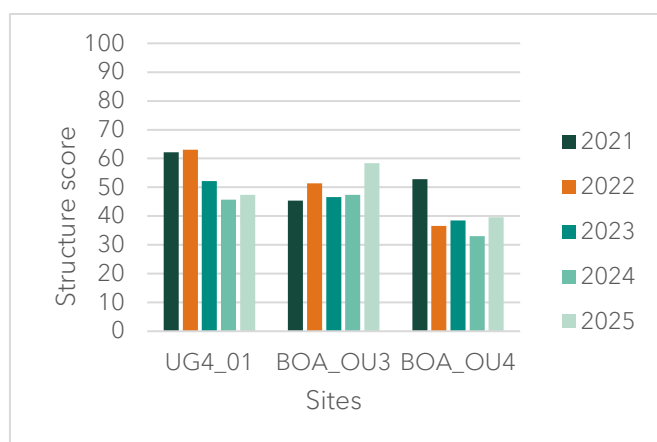


Chart 3: Structure scores at UG4_01 and associated reference sites (2021-25)

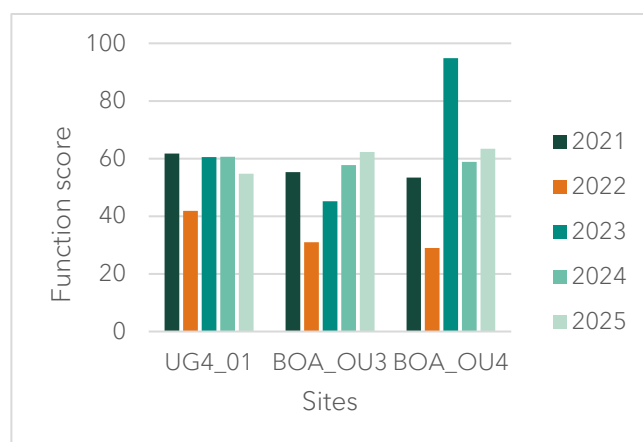


Chart 4: Function scores at UG4_01 and associated reference sites (2021-25)

The fluctuations in VIS and composition scores in UG4_01 were relatively consistent with those observed in the reference sites from 2022 to 2025 (Chart 1, Chart 2). A marked increase in the composition score was observed in BOA_OU4 from 2021 to 2022 (Chart 2), driven by an increase in shrub richness.

Moderate decreases were observed in the structure score in UG4_01 from 2022 to 2024, driven by a reduction in canopy and grass cover; however, a marginal increase was observed in 2025. The moderate overall decline in structure may have been influenced by decreased rainfall over the same period (Annex 1). A decrease in canopy cover and increase in shrub cover was observed in BOA_OU3 over the same period, while canopy cover remained consistent and shrub cover reduced in BOA_OU4 (Chart 3).

Function scores in UG4_01 remained relatively consistent with that observed in reference site BOA_OU3. However, BOA_OU4 decreased from 2023 to 2024, increasing marginally in 2025 (Chart 4).



UG4_02 (LW402)

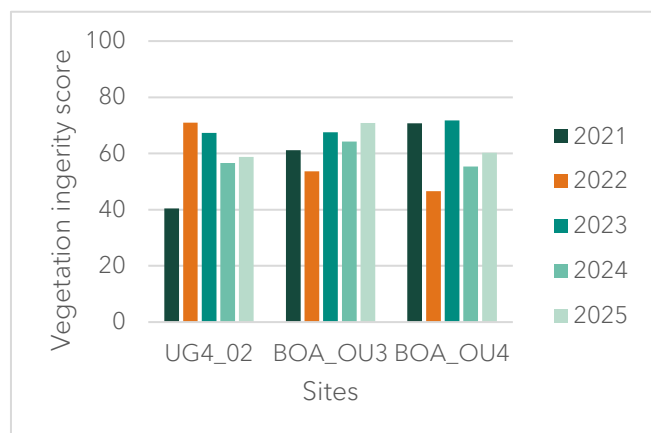


Chart 5: VIS at UG4_02 and associated reference sites (2021-25)

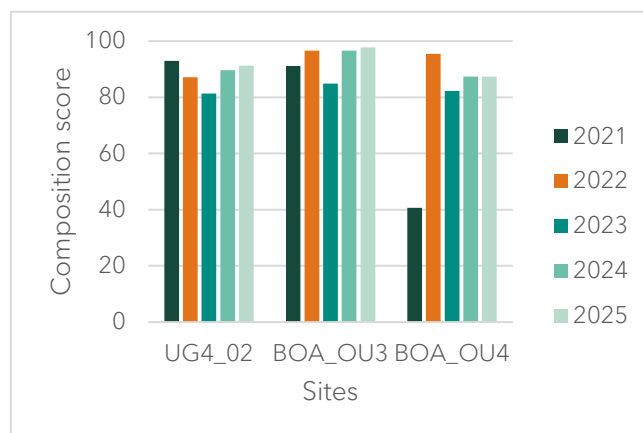


Chart 6: Composition scores at UG4_02 and associated reference sites (2021-25)

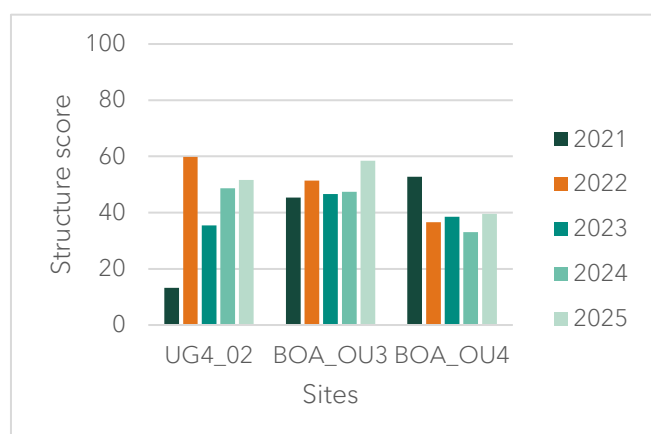


Chart 7: Structure scores at UG4_02 and associated reference sites (2021-25)

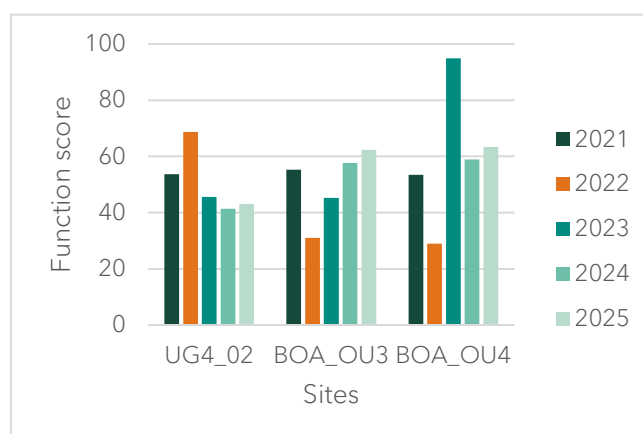


Chart 8: Function scores at UG4_02 and associated reference sites (2021-25)

The VIS score in UG4_02 increased markedly from 2021 to 2022 and moderately decreased from 2022 to 2024, with a marginal increase in 2025. Both reference sites showed fluctuations in the VIS from 2021-2024, and a slight increase in 2025 (Chart 5).

The composition scores in UG4_02 remained comparable to that of the reference sites from 2022-2025. The composition score in BOA_OU4 increased markedly from 2021 to 2022 (Chart 6), driven by an increase in shrub richness.

The structure score in UG4_02 increased markedly between 2021 and 2022 which may have been influenced by a period of higher than average rainfall over this period (Annex 1) and decreased moderately between 2022 and 2023, driven by increases and decreases in canopy and shrub cover, respectively. Marginal increases were observed from 2023 to 2025 where canopy and shrub cover remained relatively constant. A decrease in canopy cover and increase in shrub cover was observed in BOA_OU3 over the same period, while canopy cover remained consistent and shrub cover reduced in BOA_OU4 (Chart 7).



Function scores in UG4_02 decreased moderately compared to 2021, and marked fluctuations were observed in both reference sites (Chart 8).



UG4_03 (LW403)

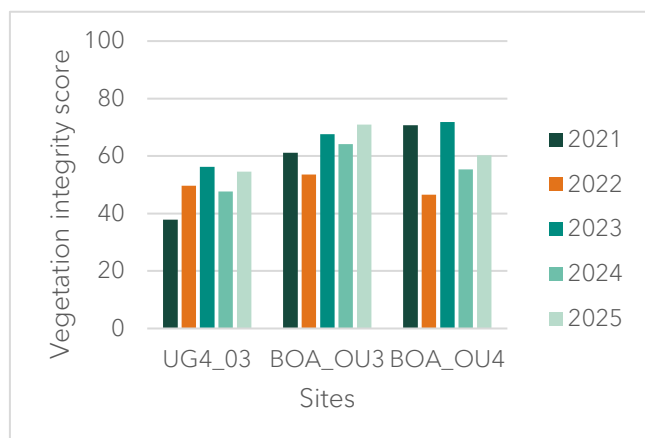


Chart 9: VIS at UG4_03 and associated reference sites (2021-25)

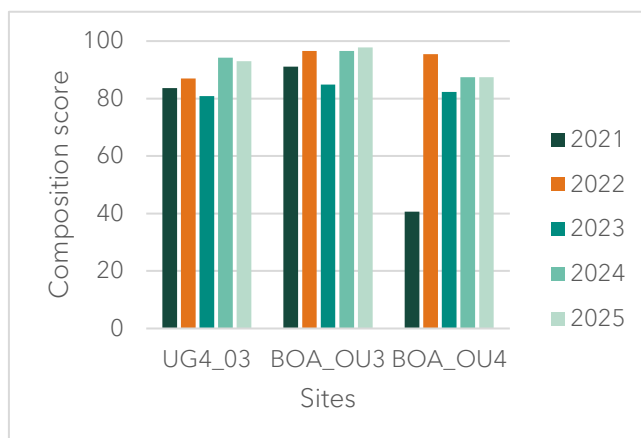


Chart 10: Composition scores at UG4_03 and associated reference sites (2021-25)

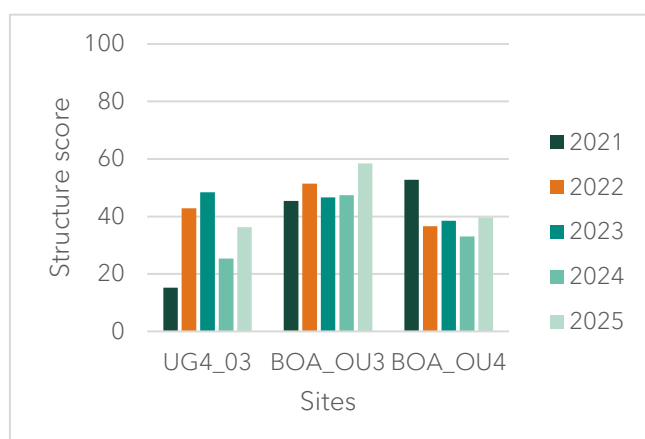


Chart 11: Structure scores at UG4_03 and associated reference sites (2021-25)

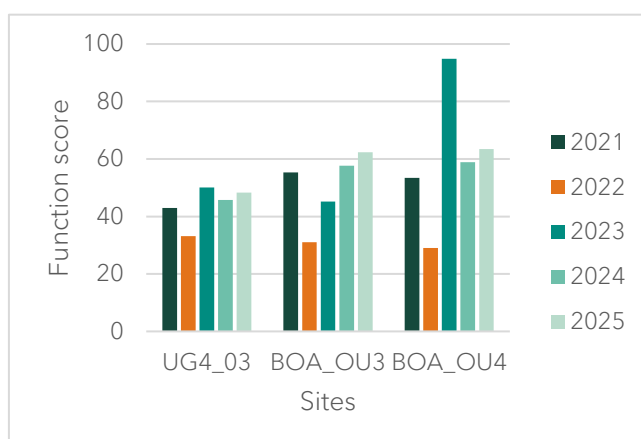


Chart 12: Function scores at UG4_03 and associated reference sites (2021-25)

Fluctuations in the VIS in UG4_03 from 2021 to 2025 were comparable to those observed in the reference sites (Chart 9).

Fluctuations in the composition score in UG4_03 from 2021 to 2025 was also comparable to that of reference site BOA_OU3. The composition score in BOA_OU4 increased markedly from 2021 to 2022 (Chart 10) driven by an increase in shrub diversity.

The structure score in UG4_03 increased markedly from 2021 to 2022 which may have been influenced by above average rainfall over this period (Annex 1) and decreased moderately between 2023 and 2024 (Chart 11). This was driven by an increase in canopy and shrub cover, and a decrease in forb cover, respectively. The structure score also fluctuated in both reference sites. A decrease in canopy cover and increase in shrub cover was observed in BOA_OU3 over the same period, while canopy cover remained consistent and shrub cover reduced in BOA_OU4 (Chart 11).

Function scores in UG4_03 were relatively consistent with the fluctuations observed at both reference sites BOA_OU3 and BOA_OU4 (Chart 12).



UG4_04 (LW404)

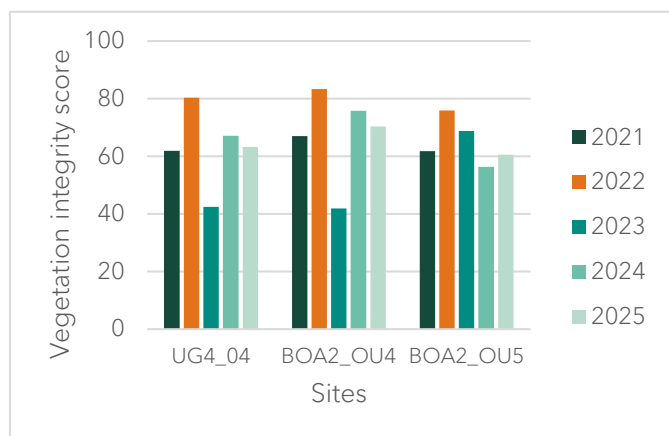


Chart 13: VIS at UG4_04 and associated reference sites (2021-25)

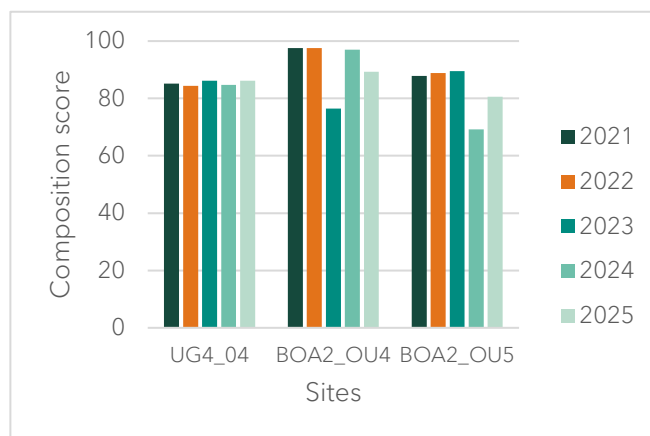


Chart 14: Composition scores at UG4_04 and associated reference sites (2021-25)

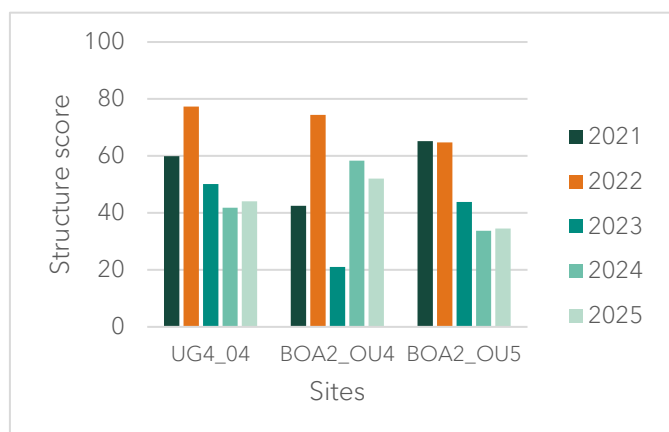


Chart 15: Structure scores at UG4_04 and associated reference sites (2021-25)

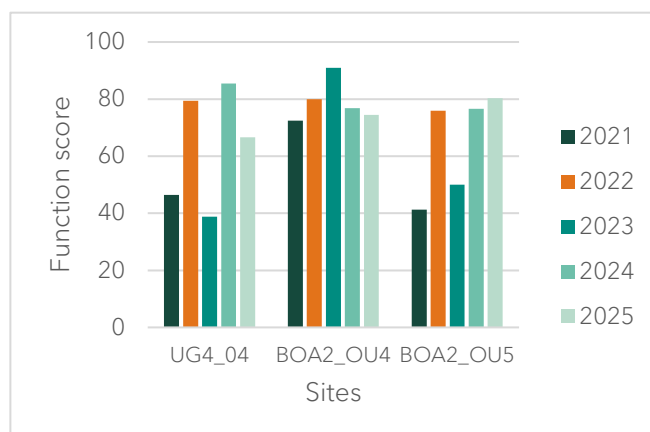


Chart 16: Function scores at UG4_04 and associated reference sites (2021-25)

The VIS scores in UG4_04 remained relatively consistent with results at reference site BOA2_OU4, with BOA2_OU5 beginning to decrease from 2024 to 2025 (Chart 13).

The composition scores in UG4_04 were consistent between 2021 to 2025, with reference sites displaying fluctuations over the same period (Chart 14).

The structure score in UG4_04 and BOA2_OU4 increased from 2021 to 2022 driven by increases in shrub cover, which may have been influenced by above average rainfall over this period (Annex 1) All sites experienced overall structure decreases from 2022 to 2025 (Chart 15). The decrease in UG4_04 was driven by a reduction in shrub cover, while the reference site decreases were driven by a reduction in grass and forb cover.

The function scores in UG4_04 and the references sites fluctuate markedly from 2021-2025 (Chart 16).



UG4_05 (LW405)

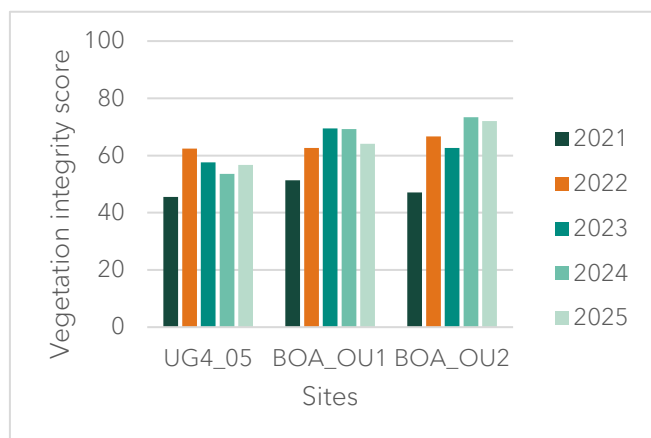


Chart 17: VIS at UG4_05 and associated reference sites (2021-25)

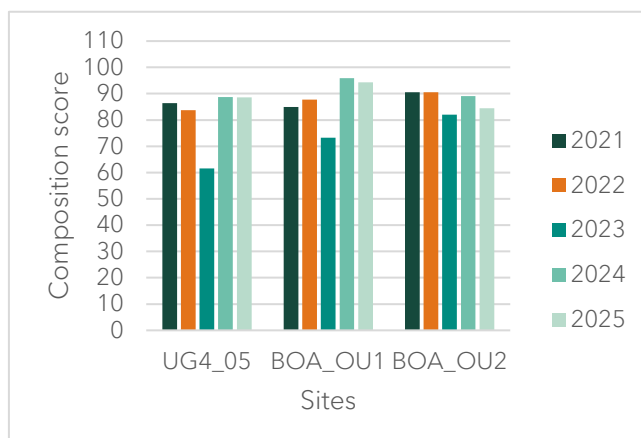


Chart 18: Composition scores at UG4_05 and associated reference sites (2021-25)

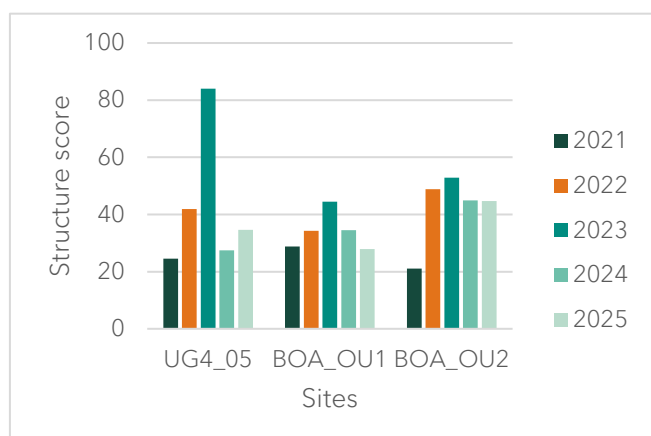


Chart 19: Structure scores at UG4_05 and associated reference sites (2021-25)

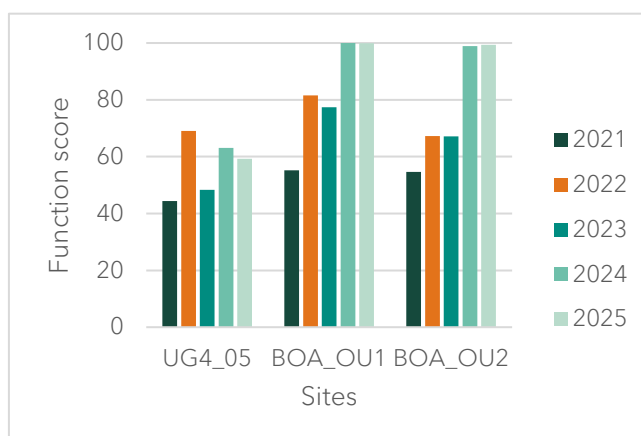


Chart 20: Function scores at UG4_05 and associated reference sites (2021-25)

Fluctuations in the VIS in UG4_05 between 2021 and 2025 were comparable to those observed in the reference sites (Chart 17).

Fluctuations in composition scores in UG4_05 between 2021 and 2025 were also comparable to those observed in the reference sites (Chart 18).

The structure score in UG4_05 increased markedly between 2022 and 2023 and decreased markedly between 2023 and 2025 during a period of reduced rainfall (Annex 1), driven by an increase and a decrease in grass cover. Moderate increases and decreases were also observed in the reference sites over the same period (Chart 19).

The function scores in UG4_05 have increased since 2023, which was also observed in both reference sites (Chart 20).



UG4_06a (LW406)

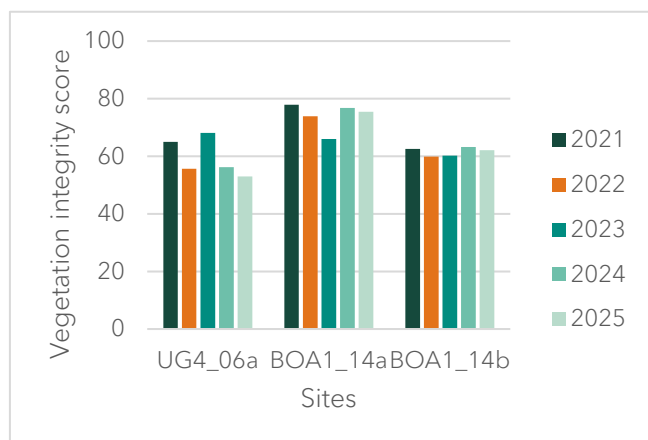


Chart 21: VIS at UG4_06a and associated reference sites (2021-25)

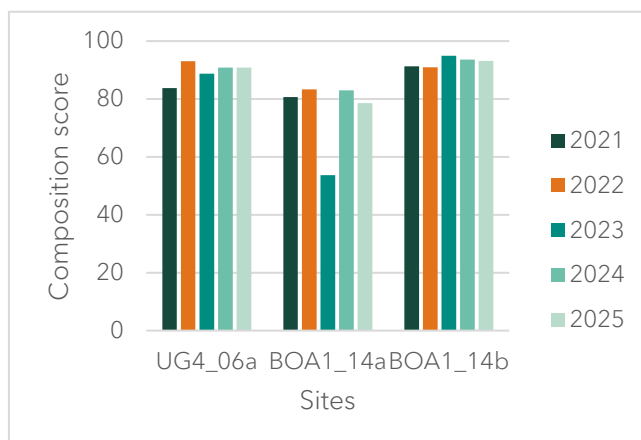


Chart 22: Composition scores at UG4_06a and associated reference sites (2021-25)

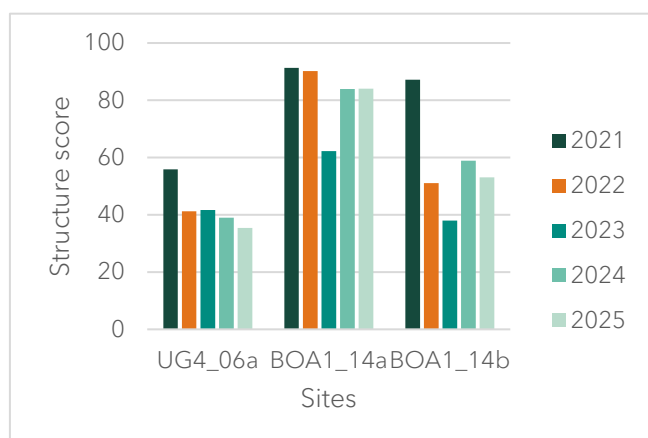


Chart 23: Structure scores at UG4_06a and associated reference sites (2021-25)

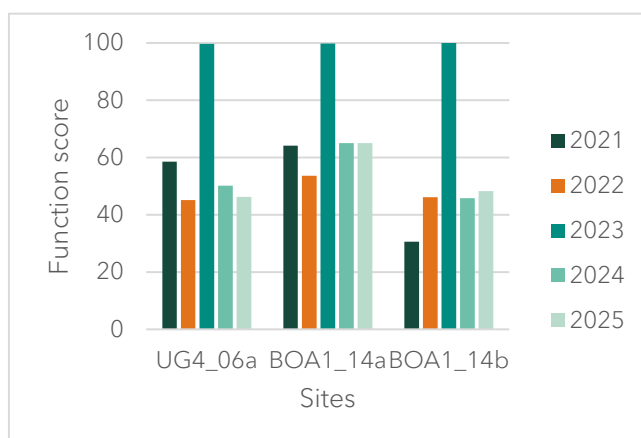


Chart 24: Function scores at UG4_06a and associated reference sites (2021-25)

The VIS in UG4_06a fluctuated between 2021 to 2025 resulting in an overall decrease. Fluctuations were also observed in reference site BOA1_14a over the same period, however the VIS in 2025 is still similar to that from 2021. Reference site BOA1_14b remained relatively consistent over the same period (Chart 21).

The composition scores in UG4_06a and reference site BOA1_14b remained relatively consistent. A marked decrease and increase was observed in reference site BOA1_14a between 2022 and 2023 and 2023 and 2024, respectively (Chart 22). This was driven by a reduction in forb richness.

The structure score in UG4_06a decreased moderately from 2021 to 2022, driven by a reduction in grass cover, with marginal decreases observed from 2023 to 2025. A marked decrease and increase was observed in reference site BOA1_14a between 2022 and 2023 and 2023 and 2024, respectively (Chart 23). This was driven by a reduction in shrub cover and an increase in canopy cover, respectively.

The function scores in UG4_06a fluctuated significantly from 2022 to 2025. However, the fluctuations observed were consistent with results at both reference sites (Chart 24).



UG4_06b (LW406)

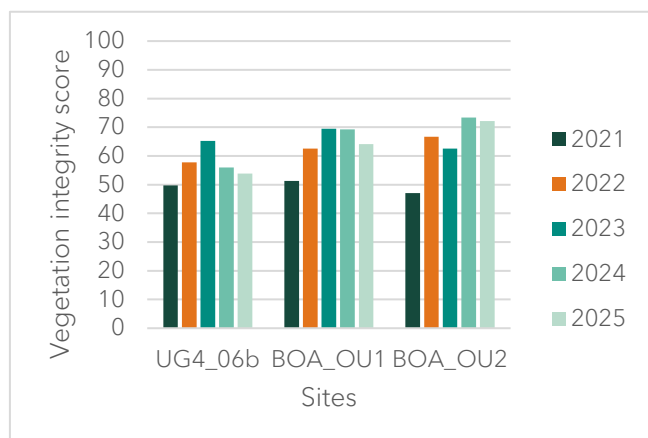


Chart 25: VIS at UG4_06b and associated reference sites (2021-25)

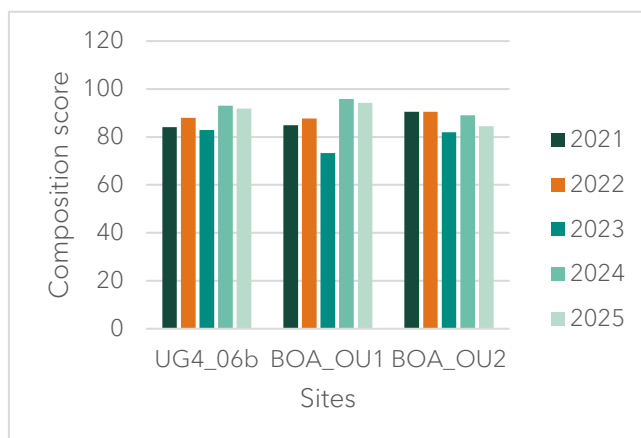


Chart 26: Composition scores at UG4_06b and associated reference sites (2021-25)

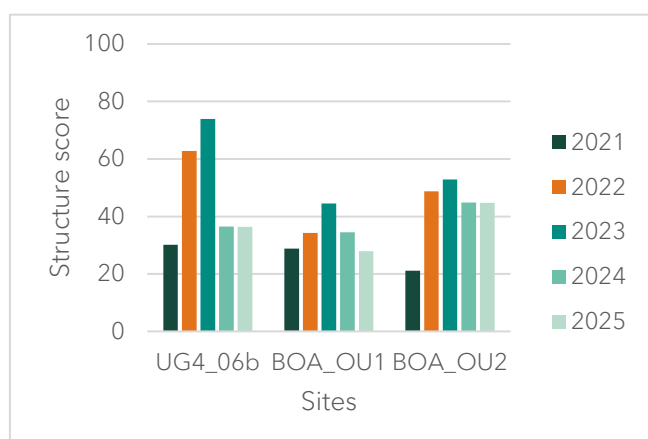


Chart 27: Structure scores at UG4_06b and associated reference sites (2021-25)

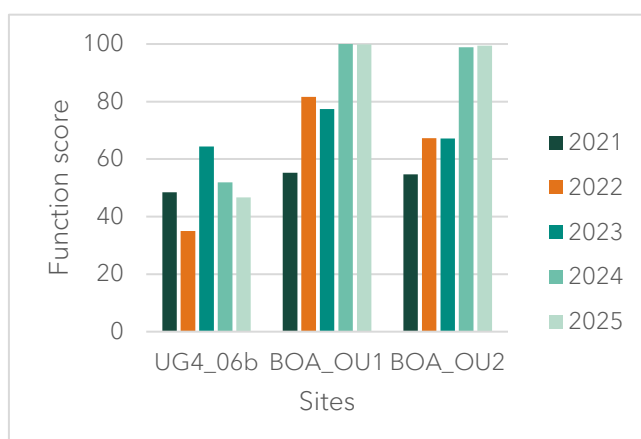


Chart 28: Function scores at UG4_06b and associated reference sites (2021-25)

Fluctuations in the VIS and composition scores in UG4_06b were comparable to those observed in the reference sites (Chart 25, Chart 26).

The structure scores in UG4_06b increased markedly between 2021 and 2022, which may have been influenced by above average rainfall over this period (Annex 1), and decreased markedly between 2023 and 2024 driven by an increase and a decrease in canopy cover, respectively. Similar moderate fluctuations were observed in the reference sites (Chart 27).

The function scores in UG4_06b decreased from 2023 to 2025, while both reference sites BOA_OU1 and BOA_OU2 experienced large increases (Chart 28).



In summary, during the Spring 2025 monitoring period, the following conclusions were drawn for the study sites (undermined):

- In UG4_01, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites and there were no visible signs of subsidence. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_02, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites and there were minimal visible signs of subsidence. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_03, there were considerable signs of subsidence in the form large cracks; however, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_04, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites and there were no visible signs of subsidence. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_05, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites and there were minimal visible signs of subsidence. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_06a, there were extensive signs of subsidence in the form large cracks and holes; however, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites. The results observed are therefore considered to be due to natural variation and/or observer bias.
- In UG4_06b, there was no discernible declining trend on floristics or vegetation stress when compared to the reference sites and there were minimal visible signs of subsidence. The results observed are therefore considered to be due to natural variation and/or observer bias.



3.1.2 Native vegetation stress recorded in the study sites (undermined) and associated reference sites

Ground cover

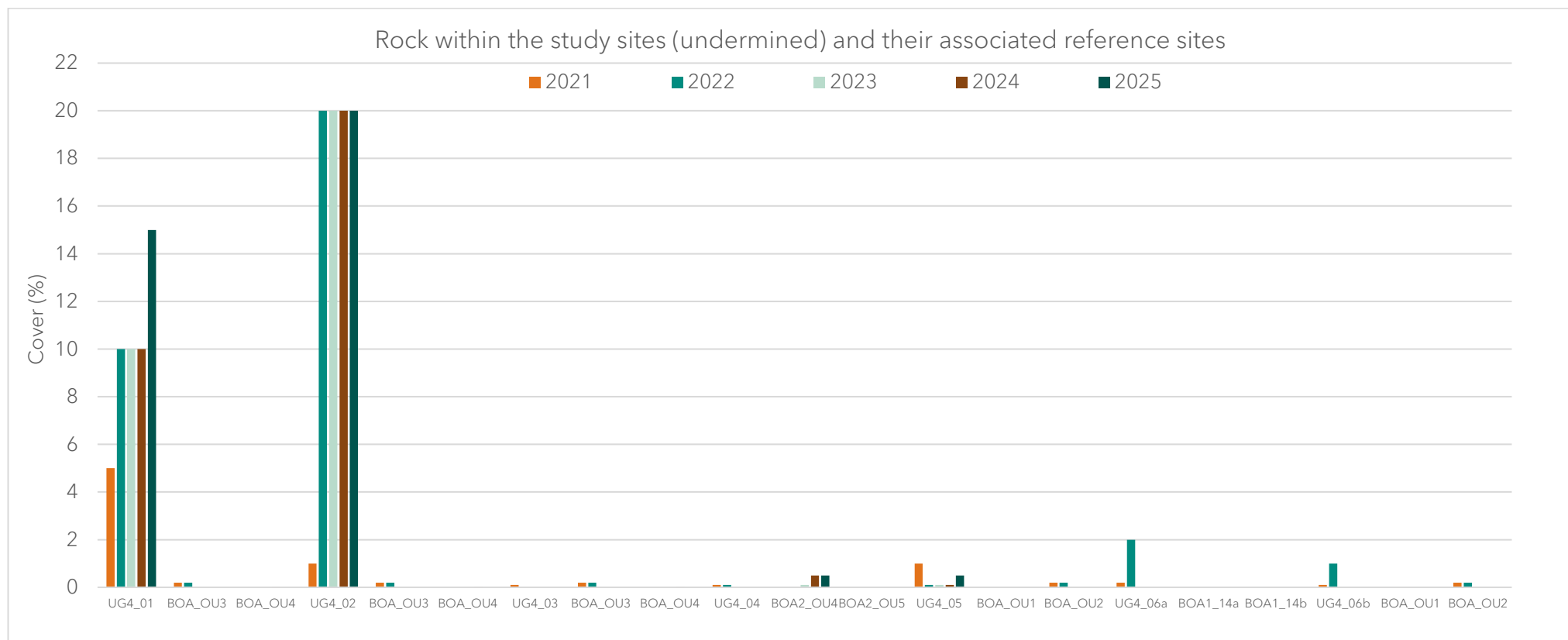


Chart 29. A comparison of the rock cover (%) in the study sites (undermined) and their associated reference sites from 2021 – 2025

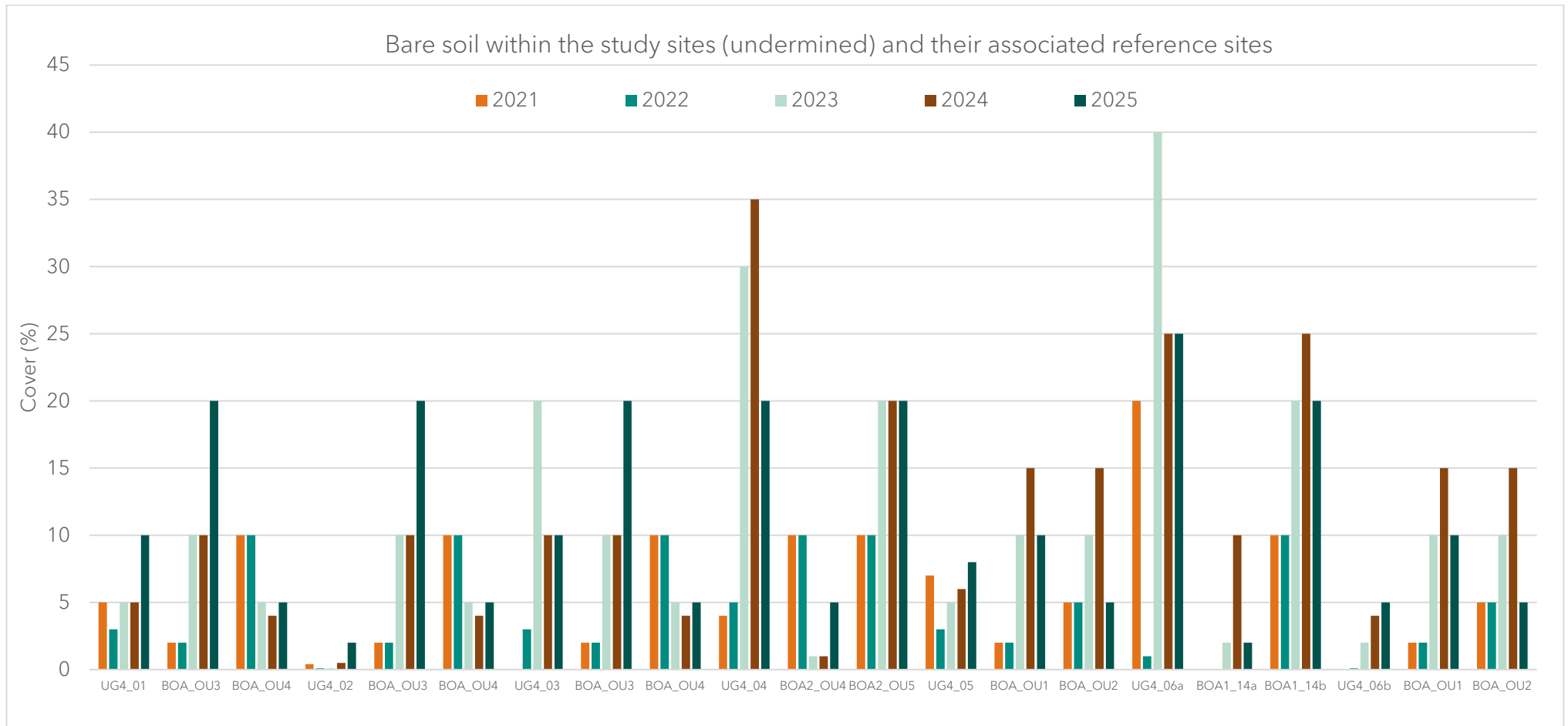


Chart 30. A comparison of the bare soil cover (%) in the study sites (undermined) and their associated reference sites from 2021 - 2025

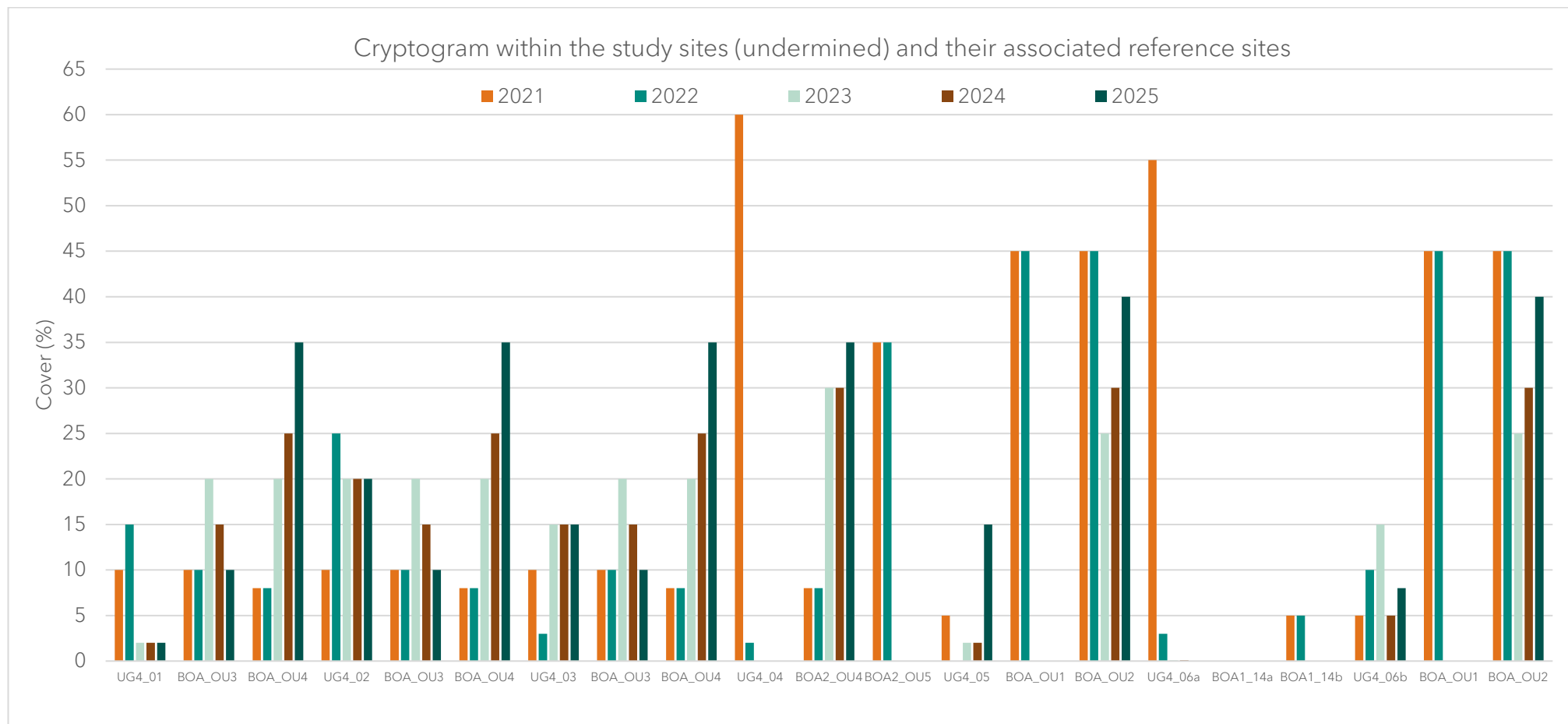


Chart 31. A comparison of the cryptogram cover (%) in the study sites (undermined) and their associated reference sites from 2021 - 2025



From Spring 2021 to Spring 2025, rock cover remained relatively consistent in the study sites and their associated reference sites (Chart 29).

Bare soil cover remained relatively consistent between 2021 and 2022 and increased in 2023 in the study sites and their associated reference sites, which may have been influenced by a decline in yearly rainfall since 2023 (Annex 1). It remained elevated in 2024, excluding UG4_03 and UG4_06a which experienced moderate decreases. Bare soil cover either maintained a similar level to 2024 or marginally increased in 2025, except for UG4_04 and reference sites BOA_OU1, BOA_OU2, BOA1_14a and BOA1_14b (Chart 30).

Cryptogram cover (primarily Coral Lichen *Pulchrocladia retipora*) remained relatively consistent in UG4_02, UG4_03, and UG4_06b between 2021 and 2025. UG4_01 experienced a moderate decrease in 2023 which was also observed in 2024 and 2025, while the associated reference sites experienced moderate increases in cover. A marked decrease in cover was observed in UG4_04 in 2022, decreasing further to no cover in 2023-2025. This reduction may have been influenced by a reduction in yearly rainfall since 2022 (Annex 1), as a marked decrease was also observed in the associated reference site BOA2_OU5. In UG4_05, a moderate increase in cryptogram cover was observed in 2025 which was also observed in the associated reference site BOA_OU2. In UG4_06a, cryptogram cover decreased markedly from 2021 to 2025, which was also observed in both associated reference sites (Chart 31). This reduction may have also been influenced by a reduction in yearly rainfall since 2022 (Annex 1)

The increase in the cover of bare soil and the fluctuation of cryptogram cover observed was likely due to natural variation, driven by the wetter than average conditions experienced in 2022 followed by drier conditions in 2023-2025 (Annex 1).

Overall, fluctuations in the cover of rock, bare soil and cryptogram cover observed from 2021 to 2025 in the study sites (undermined) were consistent with those observed in the associated reference sites (Chart 29 to Chart 31). The fluctuations observed were also consistent with the study sites (not undermined) and their associated reference sites (Annex 2, Chart 55 to Chart 57). Due to this, the fluctuations and/or trends observed are therefore considered to be due to natural variation (i.e., rainfall) and/or observer bias. These observations suggest that underground mining has not had a discernible impact on the ground cover attributes recorded in the study sites (undermined).



Canopy stress

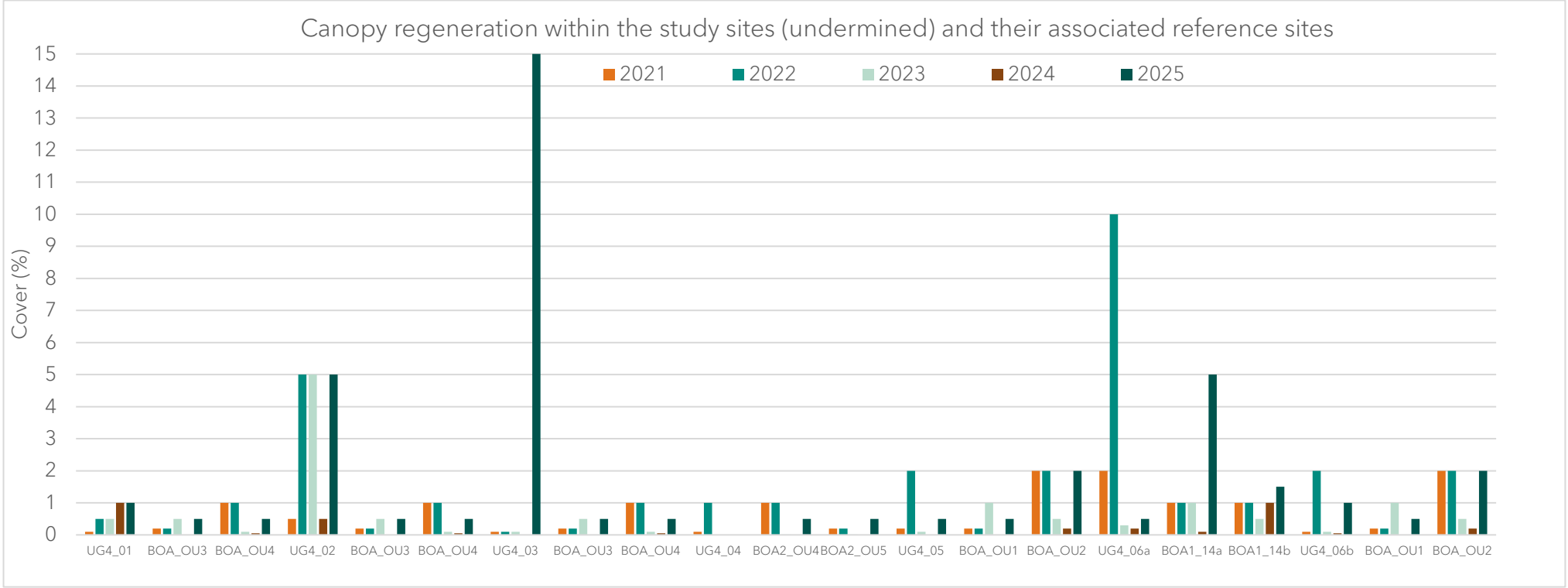


Chart 32. A comparison of the cover (%) of canopy regeneration in the study sites (undermined) and associated reference sites from 2021 - 2025



Chart 33. A comparison of the cover (%) of epicormic growth in the study sites (undermined) and associated reference sites from 2021 – 2025

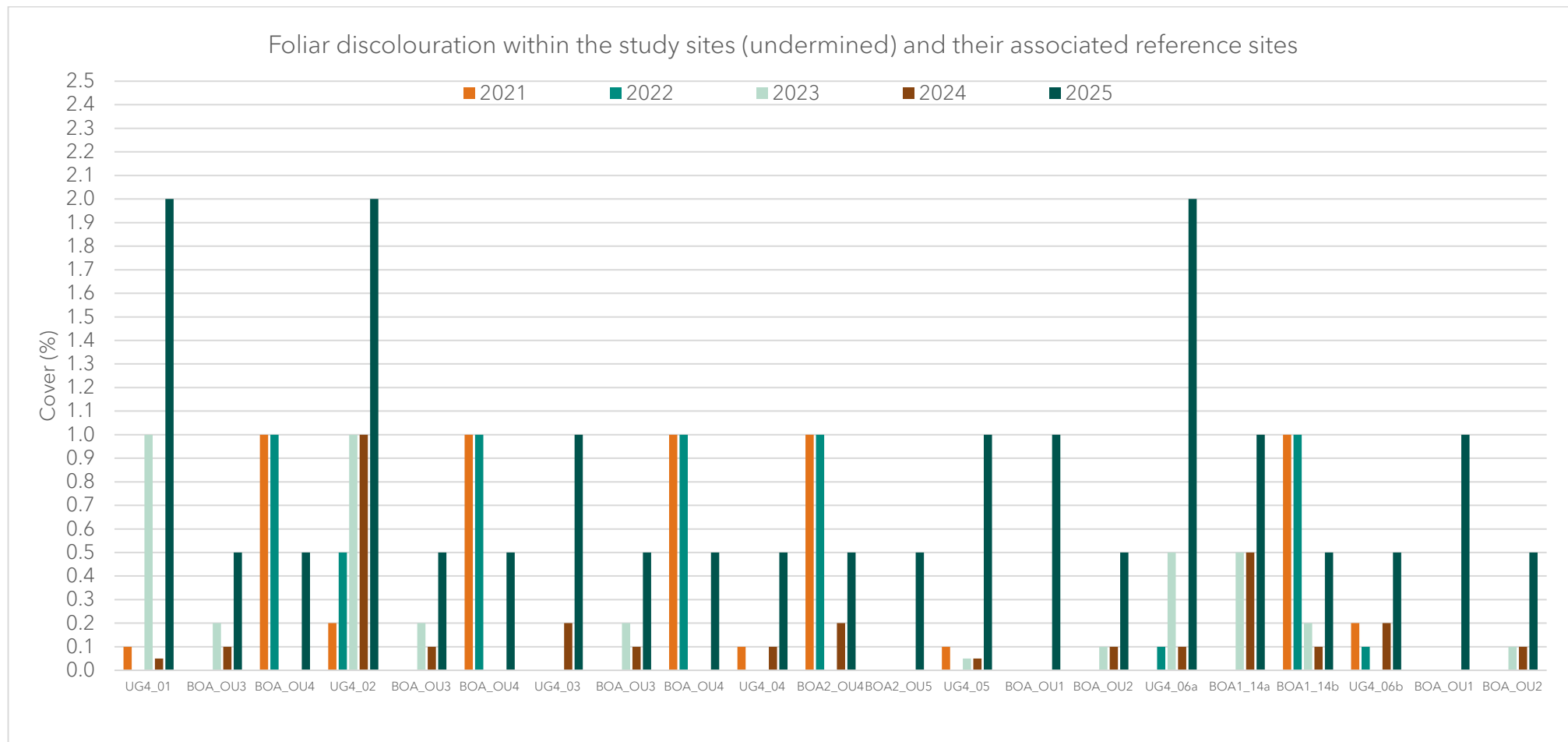


Chart 34. A comparison of the cover (%) of foliar discolouration in the study sites (undermined) and associated reference sites from 2021 – 2025

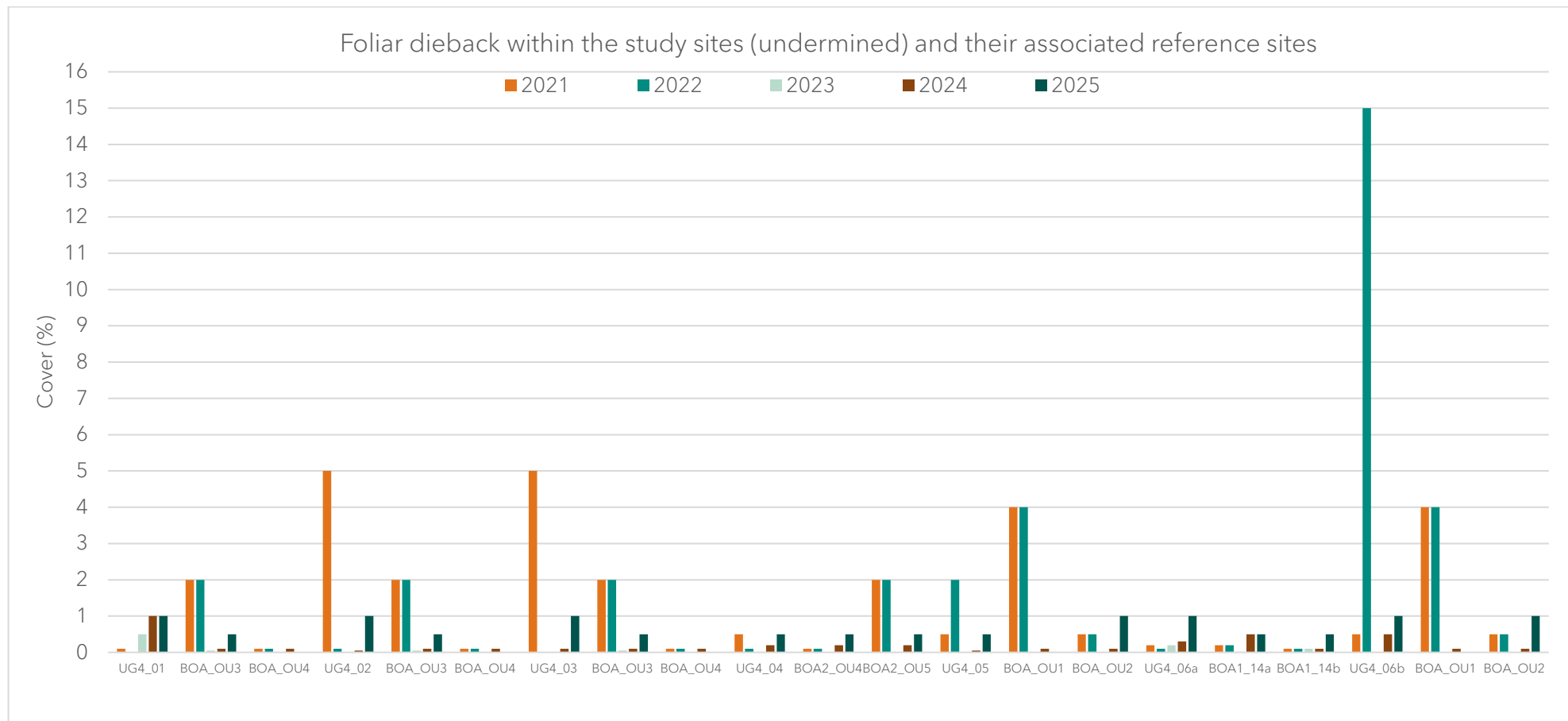


Chart 35. A comparison of the cover (%) of foliar dieback in the study sites (undermined) and associated reference sites from 2021 – 2025



Chart 36. A comparison of the cover (%) of bare branches in the study sites (undermined) and associated reference sites from 2021 – 2025



Chart 37. A comparison of the count of stags in the study sites (undermined) and associated reference sites from 2021 - 2025



Canopy regeneration cover was between 0 – 5% from 2021 to 2025 except for UG4_03 and UG4_06a. UG4_01, UG4_04 and UG4_06b experienced marginal fluctuations, with larger fluctuations observed in UG4_02, UG4_03, UG4_05 and UG4_06a. UG4_02 decreased in canopy regeneration cover in 2024, which was also observed in the associated reference sites, but then returned to pre-existing levels in 2025 across all three sites. In UG4_03, canopy regeneration cover remained at almost 0% for most years until 2025 when it increased to 15%. UG4_05 also decreased in cover in 2023, remained low in 2024, and then increased again in 2025, with similar decreases and then increases in cover also observed in the associated reference sites. Both UG4_06a and UG4_06b (and their reference sites) all experienced an increase in canopy regeneration cover from 2024 to 2025 (Chart 32).

Epicormic growth cover was between 0.1 and 15% from 2021 to 2025 and experienced the largest fluctuations of the measured canopy stress attributes in both the study sites and reference sites. UG4_01 experienced marginal increases (+0.1 to +1%), while the associated reference sites experienced marginal decreases (-0.4 to -3%) and increases (+0.5 to +2.4%). Moderate fluctuations were observed in UG4_03 (-5.9 to +1.9%) representing an overall decrease in cover from 2021 to 2025, with decreases also observed in the associated reference sites (-0.4 to -3.5%). Moderate fluctuations were also observed in UG4_04 (-4.8 to +0.8%) also representing an overall decrease in cover from 2021 to 2025, in contrast to the associated reference sites which both experienced an overall increase in cover. Marked fluctuations were observed in both UG4_02 and UG4_05 (-14 to +9% and -8 to +7%, respectively). However, these fluctuations also represented an overall decrease in cover from 2021 to 2025. Epicormic growth cover also decreased in one of UG4_02 associated reference sites (BOA_OU3), while UG4_05 associated reference sites experienced an overall increase in cover or remained the same. Both UG4_06a and UG4_06b (and associated reference sites) all experienced an increase or plateau in epicormic growth cover from 2024 to 2025 back to or above pre-existing levels in 2021-2022 (Chart 33).

Foliar discolouration cover was between 0 and 1.5% and experienced marginal fluctuations remaining relatively consistent from 2021 to 2025. UG4_01 cover fluctuated marginally (-0.95 to +1.45%) resulting in an overall increase in cover since 2021, which was also observed partially in the associated reference site BOA_OU3. UG4_02 steadily increased in cover of foliar discolouration from 2021 to 2025, while the associated reference site BOA_OU3 also increased marginally from 2024-2025 (0.4%), and BOA_OU4 experienced a decrease of 0.5% from 2021-2022 levels, but an increase from 2023-2024 levels. UG4_03 increased in cover and an overall increase in cover was also observed in reference site BOA_OU3. Reference site BOA_OU4 fluctuated in cover but also experienced an increase in the 2024-2025 period. UG4_04 marginally fluctuated (-0.1 to +0.4%) resulting in an increase since 2021, with the same observation appearing in the associated reference site BOA2_OU5. UG4_05 marginally fluctuated (-0.1 to +0.05) from 2021 to 2024; however, in 2025 a marked increase was observed. This marked increase was also reflected in the associated reference sites in 2025. Both UG4_06a (-0.4 to +1.0%) and UG4_06b (-0.1% to +0.3%) experienced alternate years of fluctuations, with foliar discolouration cover in 2025 being the highest year. An increase in cover in 2025 was also reflected in the associated reference sites (Chart 34).

Foliar dieback was between 0 and 5% cover from 2021 to 2025, except for UG4_06b which had up to 15% cover in 2022. All study sites experienced overall decreases from 2021-2024 and then an increase in 2025, excluding UG4_01, which increased, then remained at the same level 2024-2025 (Chart 35).

Bare branch cover was between 0.1 and 15% from 2021 to 2025. UG4_03 and UG4_04 experienced an overall decrease, while UG4_02 fluctuated moderately (-5 to +5) resulting in no change in cover since 2021. The associated reference site BOA_OU3 fluctuated marginally (-3 to +2) resulting in an overall decrease and BOA_OU4 increased in 2024-2025. UG4_04 also experienced an overall decrease, while the reference sites BOA2_OU4 and BOA2_OU5 both increased in cover. UG4_01, UG4_05, UG4_06a and UG4_06b all saw an overall increase in bare branch cover from 2021-2025, while the reference site BOA_OU1 experienced a decrease and BOA_OU2 experienced a small overall increase (Chart 36).

Stag counts were between 0 and 20 from 2021 to 2025. All study sites and reference sites experienced an overall increase in the count of stags since 2021 (Chart 37). Many of the new stags counted had shrivelled epicormic



growth at the base of the trunk and were counted as 'living' in Spring 2022, with the majority being immature eucalypts with diameters at breast height (DBH) of <10 cm. The death of these were likely due to the latent effects of drought induced dieback, combined with below average rainfall in 2023 (Annex 1).

The presence of epicormic growth, foliar discolouration, foliar dieback and bare branches observed in both the study sites and the references sites may be due to hydraulic failure as a result of the severe three-year drought, from 2017 to 2019, in eastern New South Wales (NSW) (Nolan et al. 2021; Losso et al. 2022). The drought was followed by above average rainfall from 2020 to 2022 (Annex 1, Table 8). Trees that survive drought induced canopy dieback are known to replace leaf area mainly by increased epicormic growth (Losso et al. 2022).

Overall, the fluctuations and/or trends observed from 2021 to 2025 in the study sites (undermined) were consistent or marginal compared to those observed in the associated reference sites (Chart 32 to Chart 37). This was also observed in the study sites (not undermined) and the associated reference sites (Annex 2, Chart 58 to Chart 63). Due to this, the fluctuations and/or trends observed are therefore considered to be due to natural variation and/or observer bias, in conjunction with drought induced impacts and followed by above average years of rainfall. These observations suggest that underground mining has not had a discernible impact on the canopy stress attributes recorded in the study sites (undermined).

3.1.3 Subsidence impacts recorded in the study sites (undermined)

Subsidence impacts observed in the study sites (undermined) are described and displayed in Table 4 . The subsidence impacts observed were consistent with the predictions in the subsidence report by Mine Subsidence Engineering Consultants (MSEC 2021), and there was no discernible impacts on vegetation integrity or stress due to these subsidence impacts.

No subsidence impacts were observed in the study sites (not undermined) or any of the associated reference sites.



Table 4. Subsidence impacts observed in the 20 x 50 m study sites (undermined)

Study site (undermined)	Year subsidence first observed	Evidence of subsidence	Width of cracking	Length of cracking	Area of plot affected (%)	Location of subsidence	Example Photo
UG4_01	2023	Cracking observed (no change from 2023)	50 mm	2 m	0.01	Cracking observed at 44 m on the right hand side (while facing plot end) 6 metres from the centre tape.	
UG4_02	2025	Cracking observed	60 mm	0.7 m	0.0042	-	No photo available.



Study site (undermined)	Year subsidence first observed	Evidence of subsidence	Width of cracking	Length of cracking	Area of plot affected (%)	Location of subsidence	Example Photo
UG4_03	2023	Cracking observed (no change from 2023)	50 mm	1 m	0.225	Small crack observed at 1.5 m on the left hand side (while facing plot end) 1 m from central tape.	
	2023		150 mm	15 m		Large crack observed at 49 m spanning across the centre tape.	
UG4_04	No visual evidence of subsidence at site	None	-	-	-	-	-



Study site (undermined)	Year subsidence first observed	Evidence of subsidence	Width of cracking	Length of cracking	Area of plot affected (%)	Location of subsidence	Example Photo
UG4_05	2024	Cracking observed	50 mm	1 m	0.01	Two cracks of similar size, 1 metre apart, at the 15 m mark of central tape.	



Study site (undermined)	Year subsidence first observed	Evidence of subsidence	Width of cracking	Length of cracking	Area of plot affected (%)	Location of subsidence	Example Photo
UG4_06a	2025	Subsiding holes and cracking observed	Holes avg: 200mm; Cracks avg: 50mm	Holes avg: 0.5m; Cracks avg: 5m	Holes (0.03%; avg hole x3); Cracks (0.15%; avg crack x6)	Numerous subsidence holes and long, deep cracks	



Study site (undermined)	Year subsidence first observed	Evidence of subsidence	Width of cracking	Length of cracking	Area of plot affected (%)	Location of subsidence	Example Photo
UG4_06b	No visual evidence of subsidence at site	None	-	-	-	-	-



3.2 Threatened ecological communities

Of the PCTs mapped in the Study Area, only one aligns to a TEC listed under the BC Act and the EPBC Act. One study site and two reference sites are monitored in the TEC (Table 5).

Table 5. The study site and associated reference sites monitored in the TEC

Study site	Reference site	PCT (Niche 2021)	NSW Status (BC Act)	Commonwealth Status (EPBC Act)
UG4_06a	BOA1_14a	281 – Rough-Barked Apple - red gum - Yellow Box woodland on alluvial clay to loam soils on valley flats in the northern NSW South Western Slopes	White Box – Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland in the NSW North Coast, New England Tableland, Nandewar, Brigalow Belt South, Sydney Basin, South Eastern Highlands, NSW South Western Slopes, South East Corner and Riverina Bioregions	White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland
	BOA1_14b	Bioregion and Brigalow Belt South Bioregion	Critically Endangered Ecological Community	Critically Endangered Ecological Community

Analysis of the field validation and BAM plot data has determined that high and moderate condition patches of PCT 281 conform with the CEEC *White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland* under the EPBC Act and BC Act, whereas low and derived native grassland condition patches meet the listing criteria under the BC Act only (Figure 3). For a detailed justification of PCT 281 status under the EPBC Act and BC Act, please refer to Niche (2021) Vegetation Validation and Baseline Assessment Report and associated Annex 1.

The BMP (MCO 2022) has the set performance measures for the TEC in the Study Area:

- No significant reduction in VIS greater than observed at reference sites (decrease of VIS by 20% for two consecutive survey periods post mining) combined with observed subsidence impacts; or
- No significant reduction in species diversity greater than observed at reference sites (a significant reduction being greater than 5 species consistently absent from established monitoring plots for 4 consecutive years) combined with observed subsidence impacts.

Undermining occurred beneath UG4_06a in 2025 (Table 2) and there are considerable subsidence impacts observed at the study site (Table 4). There was also an increased amount of litter cover, decreased grass cover, and increased canopy dieback of *Angophora floribunda* present. However, the VIS in UG4_06a experienced only a marginal decrease of 3.2 (i.e., a relative decrease of approximately 6%), falling from 56.2 to 53 between 2024 and 2025. The VIS also marginally decreased in the associated reference sites BOA1_14a and BOA1_14b by 1.4 and 1.1, respectively (Section 3.1, Chart 21).

For this monitoring program, species diversity is measured through BAM plot composition scores. The composition score in UG4_06a remained the same (90.8) from 2024 to 2025, with a total native species count of 31 and 33 in 2024 and 2025, respectively. In comparison, the composition score of the reference sites BOA1_14a and BOA1_14b decreased marginally by 4.4 and 0.4 (Section 3.1, Chart 22). This represents a decrease from 30 to 27 and 44 to 40 native species identified in 2024 and 2025, respectively.

Therefore, the Spring 2025 annual monitoring meets the performance measures outlined for TECs in the Study Area.



3.3 Threatened flora

A total of 37 *Androcalva procumbens* (Vulnerable, BC Act and EPBC Act) individuals were counted within the eight quadrats in the northern population (AP1-AP5) and southern population (AP6-AP8), with an extrapolated total population size of 228. In comparison, a total of 53 individuals were counted in the eight quadrats in Spring 2024, with an extrapolated total population of 320. Between 2024 and 2025, less individuals were observed in AP1, AP3-6, and AP8, while an increase in individuals was observed in AP2.

Therefore, the population represented within the eight quadrats decreased by sixteen between 2024 and 2025, representing a decrease of 92 individuals in the extrapolated total population size.

Table 6. *Androcalva procumbens* individuals in the Study Area

<i>Androcalva procumbens</i> (AP) quadrat	2023	2024	2025
Northern Population			
AP1	9	15	14
AP2	9	11	12
AP3	12	9	1
AP4	2	3	1
AP5	1	1	1
Total northern individuals	33	39	29
Area of northern population extent (m ²)	836.52	836.52	836.52
Extrapolated northern population size	221	261	194
Southern Population			
AP6	14	11	6
AP7	1	1	1
AP8	1	2	1
Total southern individuals	16	14	8
Area of southern population extent (m ²)	315.91	315.91	315.91
Extrapolated southern population size	67	59	34
Total individuals	49	53	37
Total extrapolated population	288	320	228

No subsidence or decrease in vegetation health (in which the populations occur) was observed (habitat photos displayed in Annex 4, Table 10). The observation of both a reduction and an increase is likely due to natural changes in population dynamics. In both the northern and southern populations, a mix of age cohorts was observed. This includes large, senescent individuals with thickened runners, small and herbaceous individuals, with many individuals flowering (Annex 4, Table 11). *Androcalva procumbens* is also known to respond favourably to disturbance triggers, with seeds germinating after fire and vegetation clearing where there was



previously no apparent population (OEH 2022). A lack of favourable disturbance in the area over some time may therefore result in an above-ground population decline.

No additional *Androcalva procumbens* populations or any other threatened flora species were recorded as part of the 2025 monitoring program.

The BMP (MCO 2022) has the set performance measures for threatened flora in the Study Area:

- Threatened flora remains present within the Study Area.

There has been a decrease in the total number of recorded *Androcalva procumbens* individuals within the eight monitoring quadrats. However, there is no visual indication of subsidence in the species habitat, and the species remains present within the Study Area. Therefore, the performance measure for threatened flora has been met in the Spring 2025 monitoring.

3.4 Fauna habitat values

The following fauna habitat features are present in the Study Area:

- Hollow-bearing trees
- Low cliff lines containing small caves, overhangs and fissures
- Rock outcrops
- Coarse woody debris
- Abundant Mistletoe
- Moderately steep gullies
- Riparian woodland
- Open woodland
- Low woodland with heath understorey
- Disturbed Grassland
- Ephemeral waterways and drainage lines.

Based on the presence of these fauna habitat types combined with opportunistic surveys undertaken during the baseline assessment and current monitoring session, native fauna resident in the Study Area largely consist of the following:

- Terrestrial mammals such as Eastern Grey Kangaroo (*Macropus giganteus*), Common Wombat (*Vombatus ursinus*) and Swamp Wallaby (*Wallabia bicolor*)
- Arboreal mammals such as Common Brushtail Possum (*Trichosurus vulpecula*) and Common Ringtail Possum (*Pseudocheirus peregrinus*)
- Hollow and cave dependent microbats
- Birds including large flightless birds such as Emu (*Dromaius novaehollandiae*), woodland birds, small and large parrots, nectivorous birds, large forest owls and diurnal raptors
- Small reptiles such as Boulenger's Skink (*Morethia boulengeri*) and medium reptiles such as Lace Monitor (*Varanus varius*)
- Amphibians such as Common Eastern Froglet (*Crinia signifera*) and Bibron's Toadlet (*Pseudophryne bibronii*).

Of the above fauna, birds and microbats are the most diverse and abundant fauna groups in the Study Area.



3.5 Threatened or migratory fauna

No migratory species was recorded during the current monitoring session.

Threatened cave-dwelling microbats that can be reliably identified by call metrics recorded in the study sites and reference site are detailed and discussed in Section 3.6 below.

Other threatened cave-dwelling microbat species recorded/potentially recorded on the ultrasonic devices include:

- Eastern Cave Bat (*Vespadelus troughtoni*) species complex with *V. vulturnus* (Little Forest Bat)
- Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Southern Myotis (*Myotis Macropus*) / *Nyctophilus corbeni* species complex with other *Nyctophilus* spp.
- Yellow-bellied Sheathtail-bat (*Saccolaimus flaviventris*).

The locations of the threatened cave-dwelling species recorded is displayed in Figure 3. A complete inventory of all fauna species recorded during the Spring 2025 monitoring round and their conservation listing is presented in Annex 5.

3.6 Ultrasonic recordings

Five ultrasonic detectors targeting microbats were deployed as described in Section 2.3. All raw data was analysed in accordance with the methodology outlined in Section 2.3.2.

Two threatened cave-dwelling microbat species were recorded during the Spring 2025 monitoring, including:

- Large-eared Pied Bat (*Chalinolobus dwyeri*) (Endangered, BC Act and EPBC Act)
- Large Bent-winged-Bat (*Miniopterus orianae oceanensis*) (Vulnerable, BC Act).

As the recordings of the possible Eastern Cave Bat could not be identified to species level, this species has been excluded from the comparative analysis. This species was not recorded in the previous monitoring years (Niche 2021a, Niche 2022, Niche 2023a, Niche 2024).

The threatened cave-dwelling microbat species identified in 2025, conservation status, the number of passes at each detection site and roost preference is provided in Table 7.

A comparison of the number of passes of threatened cave-dwelling microbat species recorded at each study site and the reference site from 2022 to 2025 is displayed in Chart 38 to Chart 42.



Table 7. Threatened cave-dwelling microbat species identified in 2025

Scientific name	Common name	Conservation status		Study site				Reference site	Roost preference
		BC Act	EPBC Act	UG4_FM01	UG4_FM02	UG4_FM03	UG4_FM04	BOA_FM01	
				Number of passes at each location (2025)					
Positively identified calls									
<i>Chalinolobus dwyerii</i>	Large-eared Pied Bat	E	E	12	37	12	2	17	Cave-dwelling/disused mine adits/occasionally Fairy Martin nests
<i>Miniopterus orianae oceanensis</i>	Large Bent-winged Bat	V	Not listed	38	27	79	65	17	Cave-dwelling/ disused mine adits/culverts
Unresolved calls									
<i>M. o. oceanensis</i> or <i>Vespadelus sp.</i>		-	-	163	21	258	174	59	-

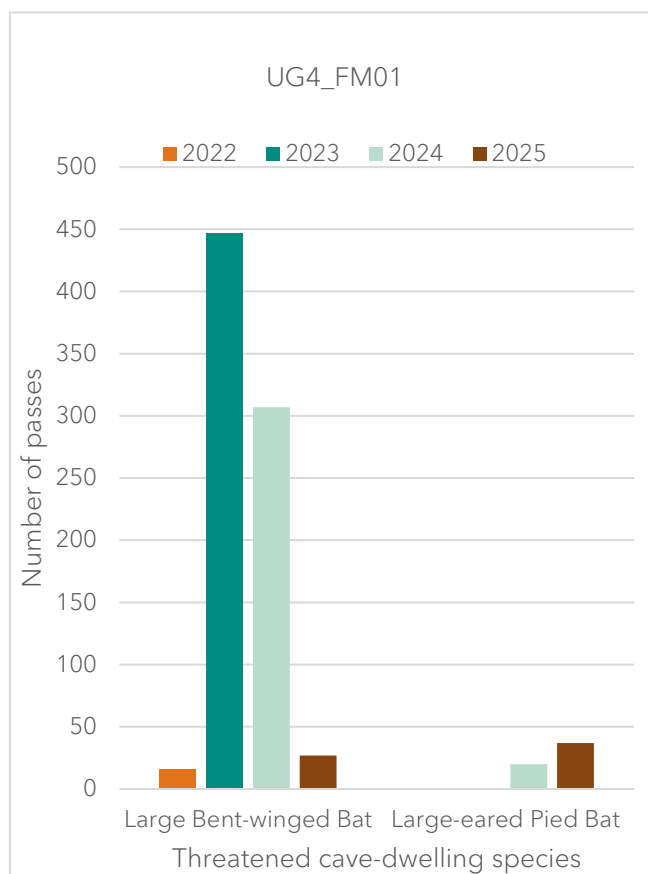


Chart 38: The number of passes of the threatened cave-dwelling microbat species in UG4_FM01 (2022-25)

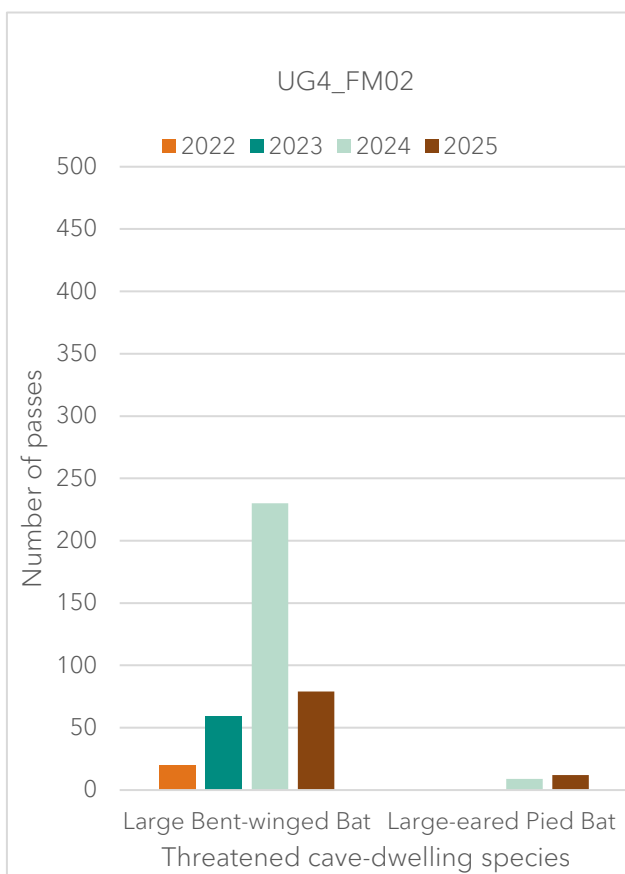


Chart 39: The number of passes of the threatened cave-dwelling microbat species in UG4_FM02 (2022-25)

In UG4_FM01, the Large Bent-winged Bat was recorded in 2022, 2023, 2024 and 2025, with the number of recorded passes markedly increasing from 16 to 447 from 2022 to 2023, respectively. The number of passes then decreased moderately to 307 in 2024, and markedly to 27 in 2025. The Large-eared Pied Bat was not recorded in 2022 or 2023; however, 20 passes were recorded in 2024 increasing marginally to 37 in 2025 (Chart 38). Visual evidence of subsidence, including extensive small cave and surface rock cracking and movement, has been observed in proximity to UG4_FM01 since the commencement of LW403 undermining in 2022 (Table 2).

In UG4_FM02, the Large Bent-winged Bat was recorded in 2022, 2023, 2024 and 2025 with the number of recorded passes increasing markedly from 20 to 59 to 230 in 2022, 2023 and 2024, respectively. The number of recorded passes then decreased markedly to 79 in 2025. The Large-eared Pied Bat was not recorded in 2022 or 2023; however, 9 passes were recorded in 2024 and marginally increased to 12 in 2025 (Chart 39). Visual evidence of subsidence, including extensive surface cracking, has been observed in proximity to UG4_FM02 since the commencement of LW406 undermining in 2025 (Table 2).

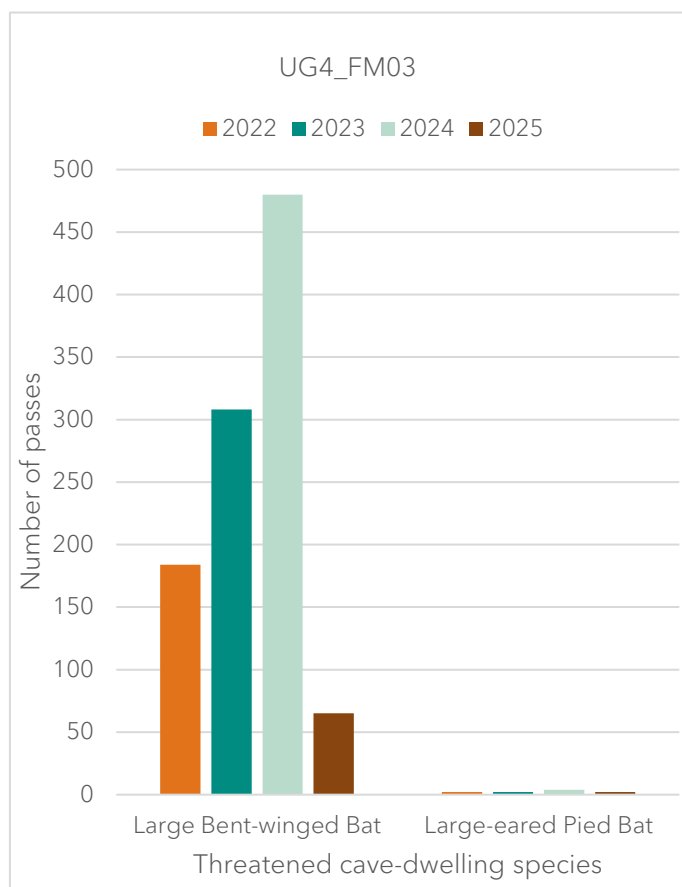


Chart 40: The number of passes of the threatened cave-dwelling microbat species in UG4_FM03 (2022-25)

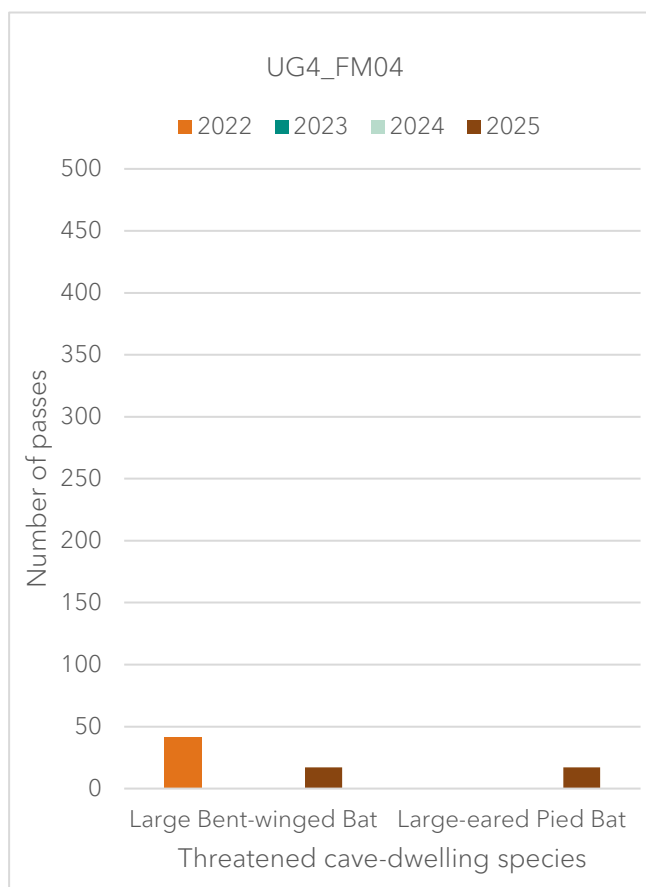


Chart 41: The number of passes of the threatened cave-dwelling microbat species in UG4_FM04 (2022-25)

In UG4_FM03, the Large Bent-winged Bat was recorded in 2022, 2023, 2024 and 2025 with the number of recorded passes increasing moderately from 184, to 308 to 480 in 2022, 2023 and 2024 respectively. The number of passes then markedly decreased to 65 in 2025. The Large-eared Pied Bat was also recorded in 2022, 2023, 2024 and 2025. The number of passes was 2 in both 2022 and 2023, increasing marginally to 4 in 2024 and decreasing marginally 2 passes in 2025 (Chart 40). There is no visual evidence of subsidence in proximity to UG4_FM03.

In UG4_FM04, data was only recorded in 2022 and 2025 due to ultrasonic recorder malfunctions (Niche 2024). The Large Bent-winged Bat was recorded in 2022 with 42 passes and 2025 with 17 passes. In 2022, there were no recorded passes for the Large-eared Pied Bat, and 17 passes were recorded in 2025 (Chart 42). There is no visual evidence of subsidence in proximity to UG4_FM04.

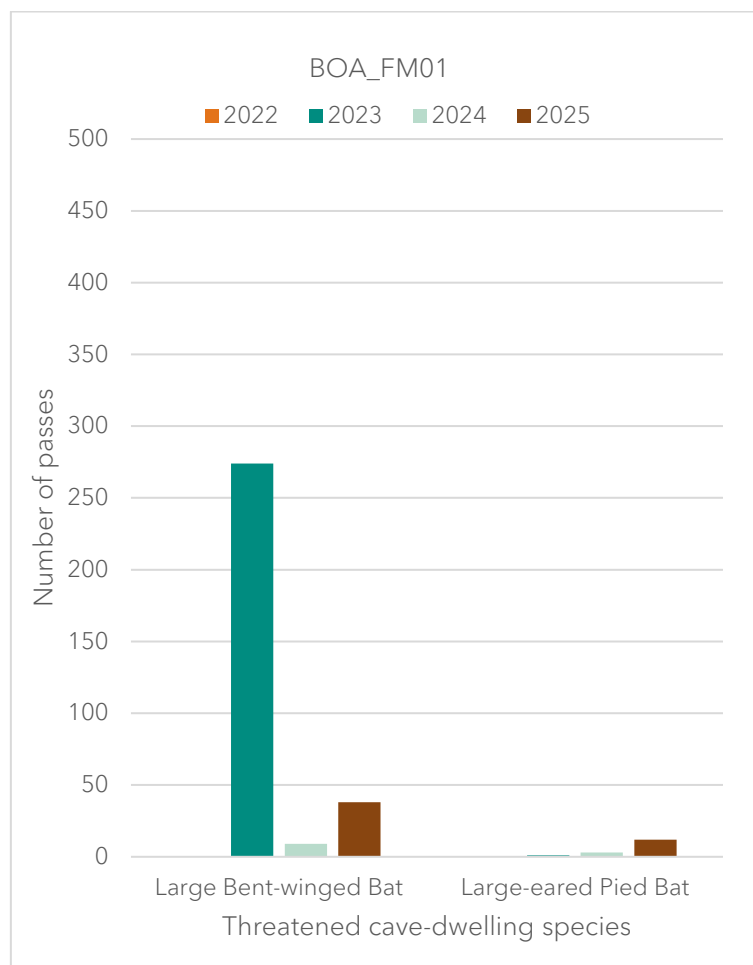


Chart 42: The number of passes of the threatened cave-dwelling microbat species in BOA_FM01 (2022-25)

In BOA_FM01 (the reference site), the Large Bent-winged Bat was not recorded in 2022. In 2023, 2024 and 2025 the species was recorded with the number of passes 274, markedly reducing to 9 and marginally increasing to 38, respectively. Similarly, the Large-eared Pied Bat was not recorded in 2022 and in 2023, 2024 and 2025 the number of passes for the species was 1, marginally increasing to 3 and 12, respectively (Chart 41). There is no visual evidence of subsidence in proximity to BOA_FM01.

The BMP (MCO 2022) has the set performance measures for Threatened Cave-dwelling bat species in the Study Area:

- No significant reduction in threatened species presence greater than observed at reference sites (at least 1 species absent from ultrasonic data analysis results for 4 consecutive years) combined with observed impacts to habitat directly related to subsidence.

The two threatened cave-dwelling microbat species, Large Bent-winged Bat and Large-eared Pied Bat, recorded during the 2025 monitoring efforts are the only threatened cave-dwelling microbat species that have been recorded in the Study Area since monitoring began.

Both threatened cave-dwelling microbat species were recorded in three study sites (UG4_FM01, UG4_FM02, UG4_FM03) and the reference site (BOA_FM01) in 2024 (Niche 2024) and were recorded at these locations as well as study site UG4_FM04 during the Spring 2025 monitoring period.



There was no significant reduction in the threatened species presence in the study sites greater than observed at the reference site, as defined in the performance measure.

Therefore, the 2025 monitoring round meets the performance measure outlined for threatened microbats.



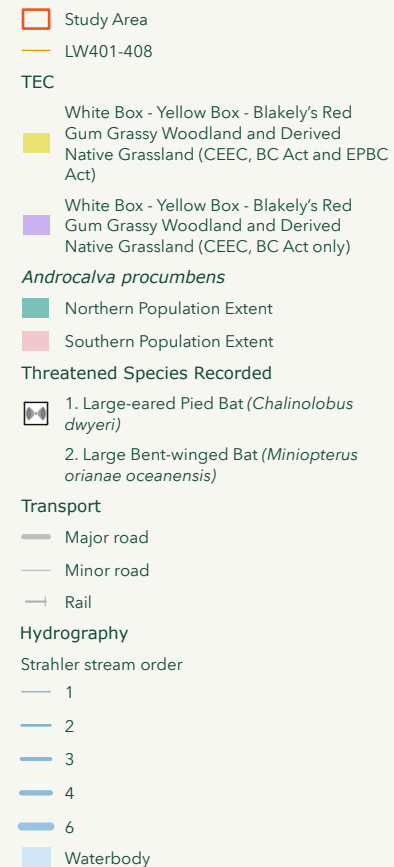
3.7 Priority weeds and pest animals

Priority weeds and pest animals are defined and regulated in accordance with the NSW *Biosecurity Act 2015*, under which all persons have a general biosecurity duty to contain or suppress of existing weeds, pest animals and pathogens and prevent new incursions. MCO currently treat priority weeds throughout the Moolarben Coal Complex as required in accordance with the Moolarben Coal Rehabilitation Management Plan (MCO 2022).

Exotic species observed within the Study Area during the Spring 2025 survey were restricted to study sites UG4_01 and UG4_06a, which occur within and adjacent to historically cleared and disturbed areas. The following species were recorded:

- *Sisyrinchium micranthum* (Blue Pigroot)
- *Hypochaeris radicata* (Catsear)
- *Taraxacum officinale* (Dandelion)
- *Briza minor* (Briza minor)
- *Aira elegantissima* (Delicate Hairgrass)
- *Vulpia myuros* (Rat's Tail Fescue)
- *Soliva sessilis* (Bindii)
- *Rumex acetosella* (Sheep Sorrel)
- *Echium plantagineum* (Patterson's Curse)
- *Arctotheca calendula* (Capeweed)
- *Hypochaeris radicata* (Flatweed)
- *Stellaria media* (Common Chickweed).

None of these exotic species are listed as priority weeds for the Central Tablelands Local Land Services region, and no priority weeds were observed elsewhere.





4. Conclusion

This monitoring report contains an overview of the fifth year of the Moolarben UG4 – Longwall 401-408 monitoring program. As stated in the LW401-408 BMP (MCO 2022), performance indicators have been developed to assess subsidence impacts on TECs and threatened flora and fauna.

There was no discernible declining trend on floristics or vegetation stress in the study sites (undermined) when compared to the reference sites. The results observed are therefore considered to be due to natural variation and/or observer bias, and/or wider landscape scale climatic factors, particularly average monthly/annual rainfall. These results suggest that the impact of mining and resultant subsidence has not caused a discernible decrease in vegetation integrity or vegetation stress in the Study Area as of the Spring 2025 monitoring period.

In 2025, mining occurred beneath UG4_06a (PCT 281 – TEC) and there are considerable subsidence impacts at the site in the form of numerous subsidence holes and cracks. However, the VIS in UG4_06a experienced only a marginal decrease of 3.2 (i.e., a relative decrease of approximately 6%) and the composition score remained the same as compared to 2024, with the total number of native species identified increasing from 31 to 33. Therefore, the 2025 monitoring period meets the performance measure outlined for threatened ecological communities in the Study Area.

The northern and southern populations of *Androcalva procumbens* experienced a decrease in the number of total individuals counted within the monitoring quadrats and a decrease in the total extrapolated population. However, the species remains present in the Study Area. Therefore, the 2025 monitoring round meets the performance measure outlined for threatened flora.

The two threatened cave-dwelling microbat species, Large Bent-winged Bat and Large-eared Pied Bat, recorded during the 2025 monitoring are the only threatened cave-dwelling microbat species that have been recorded in the Study Area since monitoring began. Both threatened cave-dwelling microbat species were recorded in the four study sites and the reference site in the Spring 2025 monitoring round. Therefore, the 2025 monitoring round meets the performance measure outlined for threatened fauna.

None of the introduced species recorded in the floristic plots in 2025 are listed as priority weeds for the Central Tablelands Local Land Services region, and no priority weeds were observed elsewhere.

This monitoring report concludes that the performance indicators (Section 1.3) have been met in 2025.

4.1 Recommendations

Niche recommends the following updates be made to the annual UG4 401-408 Spring monitoring program in 2026:

- To reduce the effects of observer bias on long-term monitoring data, improve the physical demarcation of each permanent vegetation monitoring plot via:
 - The installation of an additional 400 mm galvanised steel peg in each corner of the monitoring plot
 - Physically demarcate the monitoring plot via the installation of neon coloured, braided, 5 mm polyester twine (or similar).
- To date, the subsidence in the study sites which have been monitored for at least two years post-mining (UG4_01, UG4_02 and UG4_03; Table 2) has not had a discernible effect on vegetation integrity or stress. These study sites occur in PCT 479, which is unlikely to be markedly influenced by changes in groundwater or overland flow regimes. Therefore:



- Annual monitoring at study sites UG4_01, UG4_02 and UG4_03 may cease, provided:
 - MCO communicates to Niche whether there is a risk of long-term subsidence or delayed subsidence at these study sites
 - If there is a risk of long-term subsidence or delayed subsidence, annual monitoring at these study sites is recommended to continue until subsidence has ceased.
- Riparian PCTs or PCTs likely to be influenced by overland flows (i.e., PCT 1711 and PCT 281) are most at risk of subsidence and may require longer term monitoring to elucidate any effects of subsidence on vegetation integrity and stress.



References

BOM 2025. Climate statistics for Australian locations – Mudgee Airport AWS. Bureau of Meteorology. Available via URL: http://www.bom.gov.au/climate/averages/tables/cw_062101.shtml

DPIE 2020. NSW Biodiversity Assessment Method, NSW Government: Department of Planning, Industry and the Environment, Sydney.

DPIE 2020a. Surveying threatened plants and their habitats: Department of Planning, Industry & Environment, Sydney.

ELA 2019. UG4 Ancillary Works Modification – Biodiversity Development Assessment Report, report prepared for Moolarben Coal Operations Pty Ltd by Eco Logical Australia, Sydney.

Fitzgerald, D.L., Peters, S., Hurren, A. and Keppel, G. (2025), Vegetation Assessment Using Remote Sensing: A Systematic Review for Eucalypts in Australia. *Austral Ecology*, 50: e70061. <https://doi.org/10.1111/aec.70061>

Losso, A., Challis, A., Gauthey, A., Nolan, R. H., Hislop, S., Roff, A., Boer, M. M., Jiang, M. Medlyn, B. E. & Choat, B. (2022). Canopy dieback and recovery in Australian native forests following extreme drought. *Scientific Reports*, 12(1), 21608.

Mine Subsidence Engineering Consultants (MSEC) (2021) Moolarben Coal Complex: Moolarben Project Stage 1 – Longwalls 401 to 408. Report number MSEC1165, Revision A. Report prepared by Mine Subsidence Engineering Consultants Pty Ltd.

Moolarben Biota 2006. Moolarben Coal Project Flora, Fauna and Aquatic Ecology Assessment, report prepared for Moolarben Coal Operations Pty Ltd by Moolarben Biota.

Moolarben Coal Operations 2020. Moolarben Coal Biodiversity Management Plan, report prepared by Moolarben Coal Operations Pty Ltd.

Moolarben Coal Operations 2022. Moolarben Coal Extraction Plan Longwalls 401 to 408, report prepared by Moolarben Coal Operations Pty Ltd.

Niche 2021. Moolarben UG4 – Longwall 401-408 Vegetation Validation and Baseline Assessment Report. Prepared for Yancoal Moolarben Coal. Dated 9 August 2021.

Niche 2021a. Moolarben UG4 – Longwall 401-408 Monitoring Program Spring 2021. Prepared for Yancoal Moolarben Coal. Dated 2 November 2022.

Niche 2022. Moolarben UG4 – Longwall 401-408 Monitoring Program Spring 2022. Prepared for Yancoal Moolarben Coal. Dated 16 January 2023.

Niche 2023. Re: Moolarben UG4 – Longwall 401-408 Monitoring Program Spring 2022 – Recommendations (Niche ref: #7436). Letter of recommendations to Yancoal Moolarben Coal. Dated 1 February 2023.

Niche 2023a. Moolarben UG4 – Longwall 401-408 Monitoring Program Spring 2023. Prepared for Yancoal Moolarben Coal. Dated 18 January 2024.

Niche 2024. Moolarben UG4 – Longwall 401-408 Monitoring Program Spring 2024. Prepared for Yancoal Moolarben Coal. Dated 29 January 2025

Nolan, R. H., Gauthey, A., Losso, A., Medlyn, B. E., Smith, R., Chhajed, S. S., Fuller, K., Song, M., Li, X., Beaumont, L.J., Boer, M.M. & Choat, B. (2021). Hydraulic failure and tree size linked with canopy die-back in eucalypt forest during extreme drought. *New Phytologist*, 230(4), 1354-1365.



Office of Environment and Heritage (OEH) 2022. *Commersonia procumbens* – profile. Accessed 01 December 2024. Available via URL: <https://threatenedspecies.bionet.nsw.gov.au/profile?id=10735>

Pennay, M., Law, B., Reinhold, L. 2004. Bat calls of New South Wales: Region based guide to the echolocation calls of Microchiropteran bats. NSW Department of Environment and Conservation, Hurstville.

Reinhold, L., Law, B. S., Ford, G., Pennay, M. 2001. Key to the bat calls of south-east Queensland and north-east New South Wales. Report number: 2001-07 Affiliation: Forest Ecosystem Research and Assessment, Department of Natural Resources and Mines, Queensland.



Annex 1

Antecedent climate data



Table 8. Climate statistics – Mudgee, NSW - Mudgee Airport AWS (BOM 2025)

Month	Average minimum temp (°C)						Average maximum temp (°C)						Total rainfall (mm)					
	2021	2022	2023	2024	2025	Historical	2021	2022	2023	2024	2025	Historical	2021	2022	2023	2024	2025	Historical
Jan	14.7	17.2	15.1	17.7	16.2	16.2	29.2	28.7	30.6	31.1	30.9	30.9	23.8	106.4	80.8	104.4	48.0	67.9
Feb	15.4	15.1	14.3	17.6	15.7	15.7	28	28.2	30.6	30.8	30.3	29.4	99	40	7.4	81.6	98.2	63.3
Mar	13.1	14.9	13.2	13.8	16.4	12.9	25.6	26.1	29.8	28.8	28.6	26.9	145.8	125.4	NA	55.6	68.8	67.1
Apr	5.2	10	8.2	7.9	8.9	8.0	22.4	22.3	22	22.4	24.3	22.9	4.8	119.6	48.8	87	30.0	40.2
May	3.6	5.8	0.5	5.3	7.1	4.0	18.9	18.3	17.8	18.9	19.2	18.6	45.4	53.8	3.2	36.2	84.6	36.5
Jun	2.4	1.4	1.6	1.8	0.3	2.3	14.6	14	15.6	14.6	15.0	15	117.2	16.4	38.2	55.6	32.4	44.7
Jul	1.9	2.9	1.9	3.2	2.2	1.3	14	14.3	16.6	13.7	14.2	14.6	82.6	112	31	50.8	53.6	46.7
Aug	2	3.5	2.1	4.8	3.1	1.7	17	16.2	18.8	18.3	16.2	16.4	33.6	114.2	34.2	66.4	30.4	38
Sep	3.6	6	3.4	3.6	4.1	4.3	19.8	17.9	23.9	20.6	20.8	19.8	47.4	100.4	11.8	24.4	82.8	53.3
Oct	6.2	10.2	7.5	7.9	-	7.8	22	20.6	25.2	23.5	-	23.2	43	218.2	38.2	42.2	22.8	55.1
Nov	12.2	8.9	12.9	13.6	-	11.3	22.4	22.8	27.8	28.9	-	26.3	178	67.4	16.4	63.6	-	77.1
Dec	14	10.3	15.6	15.1	-	13.8	27.7	26.7	31.5	30.9	-	28.9	33.6	19.2	67.4	107.0	-	74.9
Annual	7.9	8.8	8	9.4	-	8.3	21.8	21.3	24.2	23.5	-	22.7	854.2	1093	-	774.8	-	663.5



Annex 2

Results of the study sites (not undermined)



UG4_07 (LW407)

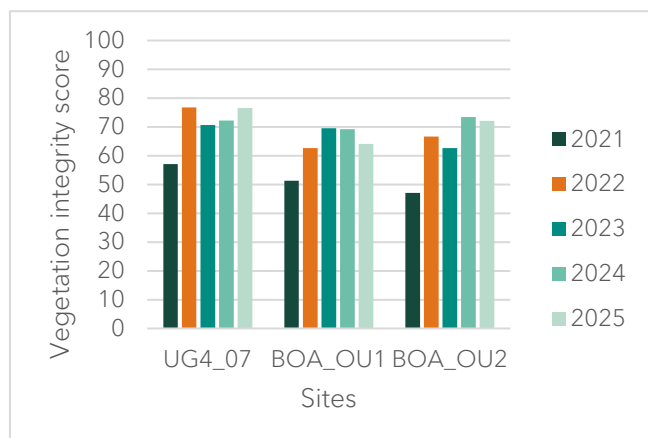


Chart 43: VIS at UG4_07 and associated reference sites (2021-25)

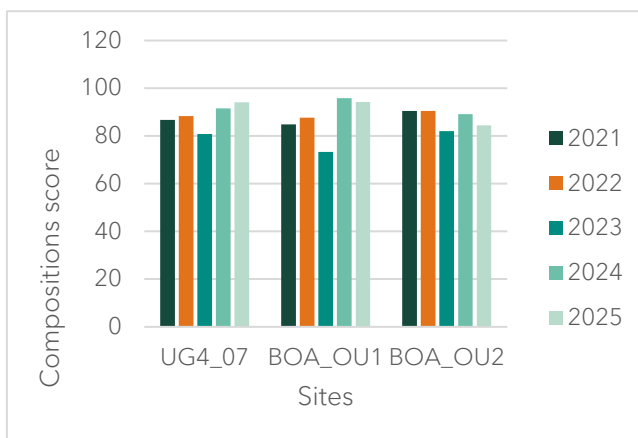


Chart 44: Composition scores at UG4_07 and associated reference sites (2021-25)

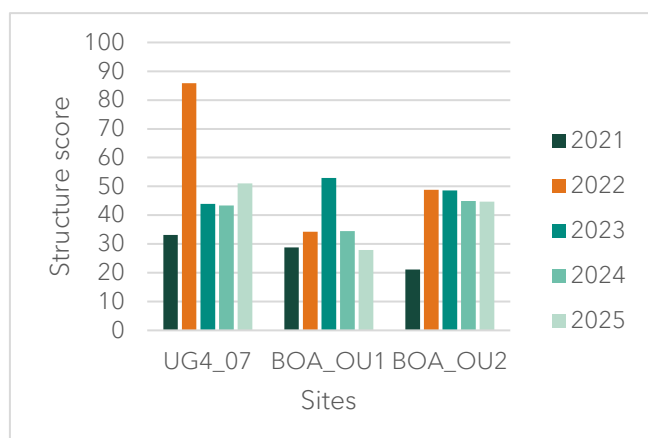


Chart 45: Structure scores at UG4_07 and associated reference sites (2021-25)

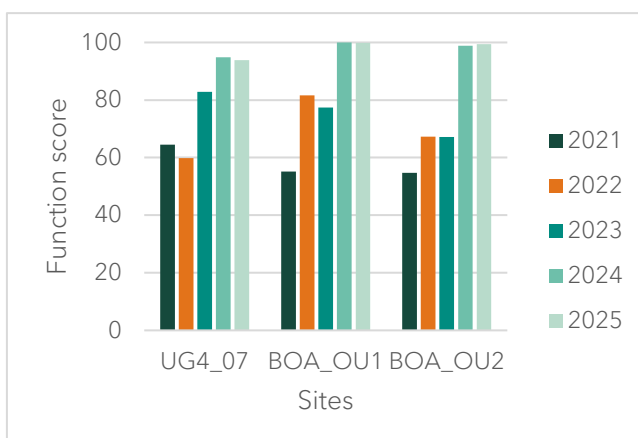


Chart 46: Function scores at UG4_07 and associated reference sites (2021-25)

Fluctuations in the VIS and composition scores in UG4_07 were comparable to those observed in the reference sites (Chart 43, Chart 44).

The structure scores in UG4_07 increased markedly from 2021 to 2022 and decrease markedly from 2022 to 2023 driven by an increase and decrease in shrub cover, respectively. Comparable moderate fluctuations were also observed in the reference sites over the same period (Chart 45)

The function scores in UG4_07 increased markedly between 2021 and 2025, which was also observed in the reference sites (Chart 46).



UG4_08 (LW408)

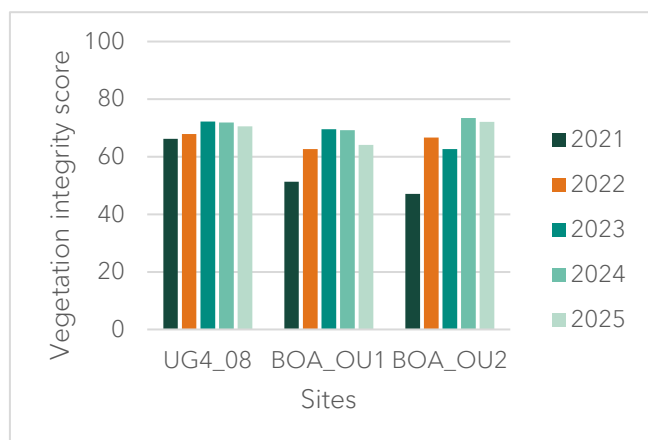


Chart 47: VIS at UG4_08 and associated reference sites (2021-25)

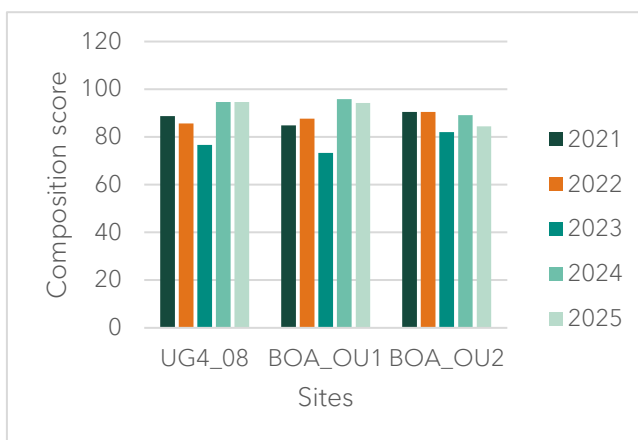


Chart 48: Composition scores at UG4_08 and associated reference sites (2021-25)

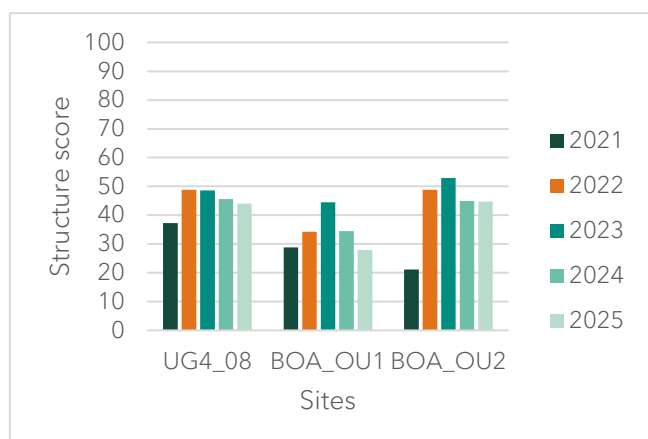


Chart 49: Structure scores at UG4_08 and associated reference sites (2021-25)

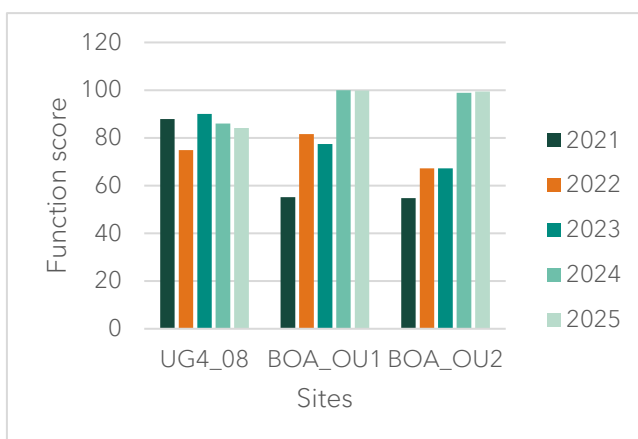


Chart 50: Function scores at UG4_08 and associated reference sites (2021-25)

Fluctuations in the VIS and composition scores in UG4_08 were comparable to those observed in the reference sites (Chart 47, Chart 48).

The structure scores in UG4_08 fluctuated marginally between 2021 and 2025 and comparable moderate fluctuations were also observed in the reference sites over the same period (Chart 49).

The function scores in UG4_08 fluctuated marginally between 2021 and 2025, while marked increases were observed at both reference sites (Chart 50).



UG4_08a (LW408)

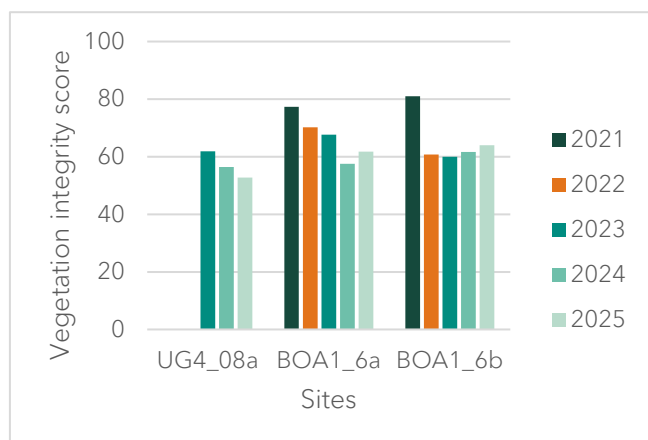


Chart 51: VIS at UG4_08a and associated reference sites (2021-25)

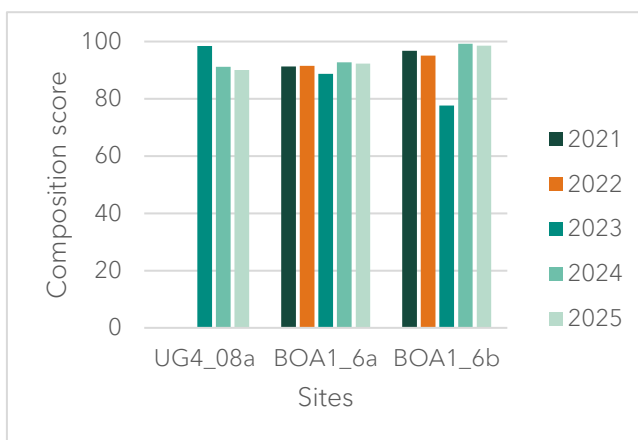


Chart 52: Composition scores at UG4_08a and associated reference sites (2021-25)

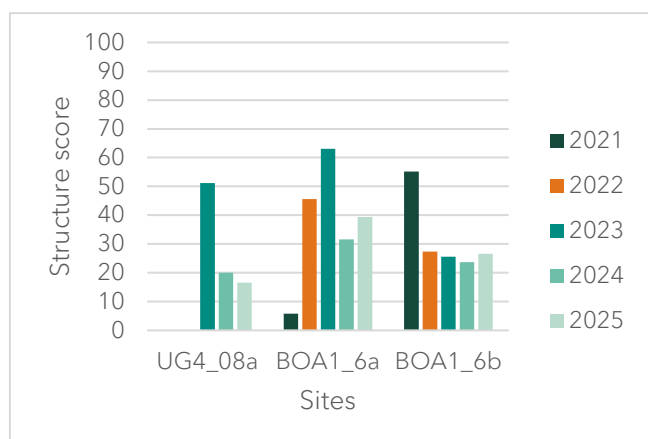


Chart 53: Structure scores at UG4_08a and associated reference sites (2021-25)

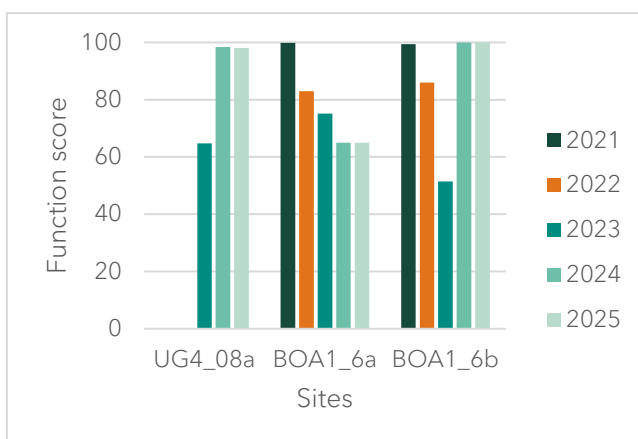


Chart 54: Function scores at UG4_08a and associated reference sites (2021-25)

Monitoring of UG4_08a only began in 2023. The VIS and composition scores in UG4_08a experienced fluctuations comparable to that of the reference sites (Chart 51, Chart 52).

The structure scores in UG4_08a decreased markedly between 2023 and 2025, with a comparable decrease in reference site BOA1_6a, and a very small increase in reference site BOA1_6b (Chart 53). This was driven by a reduction in shrub cover.

The function scores in UG4_08a increased markedly between 2023 and 2025, in line with reference site BOA1_6b (Chart 54). A marginal decrease was observed in reference site BOA1_6a.



Native vegetation stress recorded in the study sites (not undermined) and associated reference sites

Ground cover

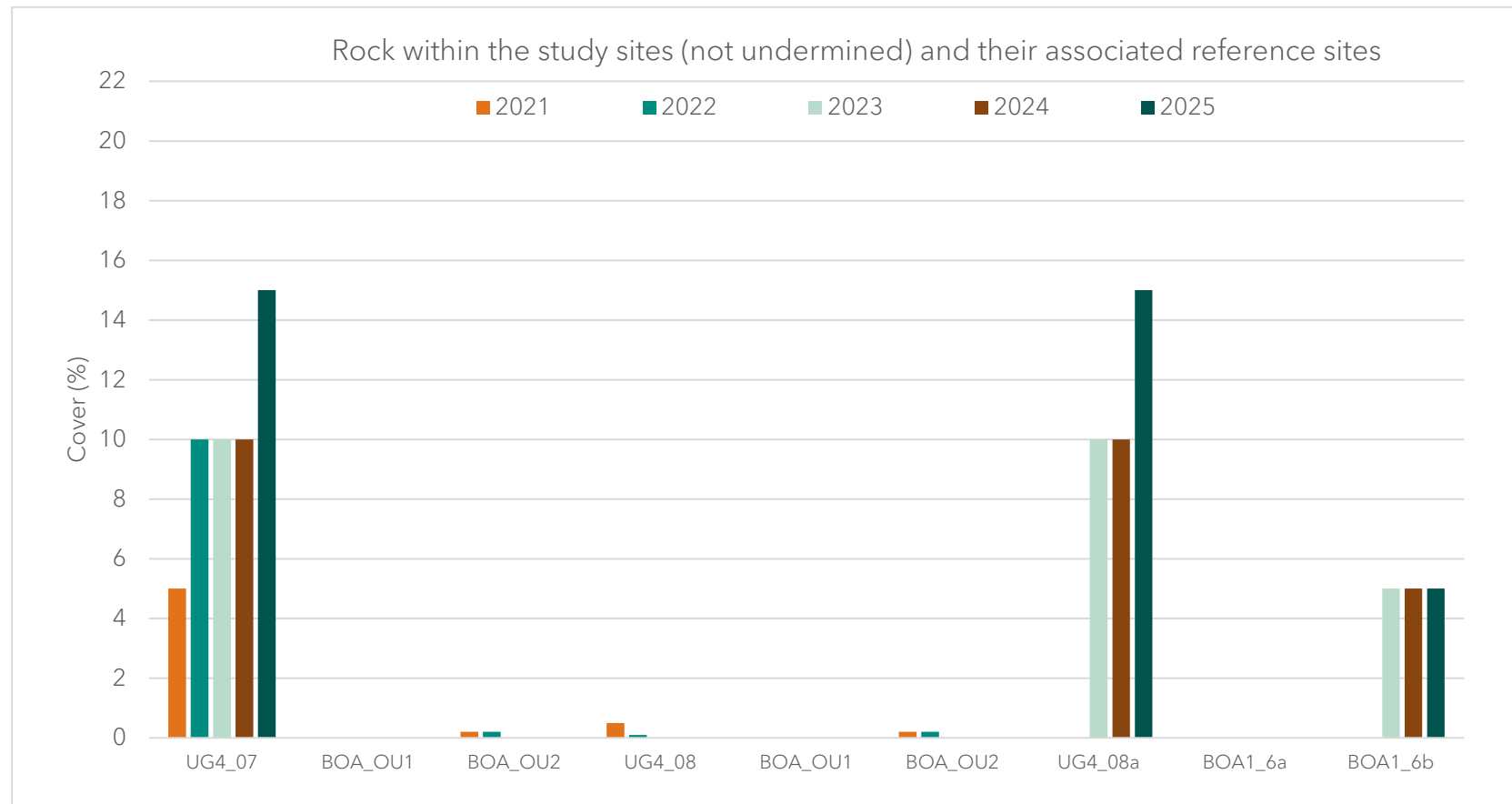


Chart 55. A comparison of the rock cover (%) in the study sites (not undermined) and their associated reference sites from 2021 - 2025



Chart 56. A comparison of the bare soil cover (%) in the study sites (not undermined) and their associated reference sites from 2021 – 2025

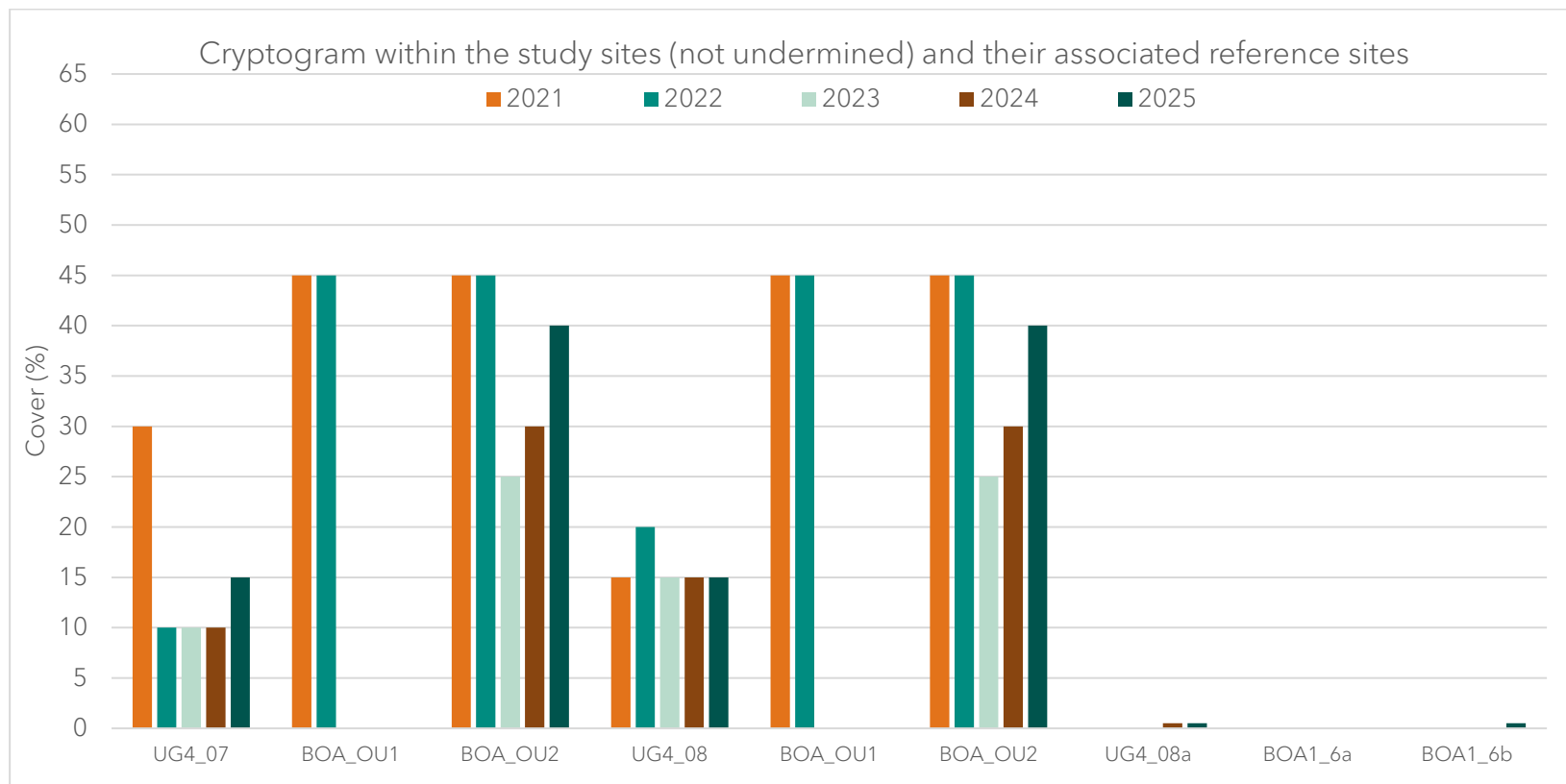


Chart 57. A comparison of the cryptogram cover (%) in the study sites (not undermined) and their associated reference sites from 2021 – 2025



Canopy stress

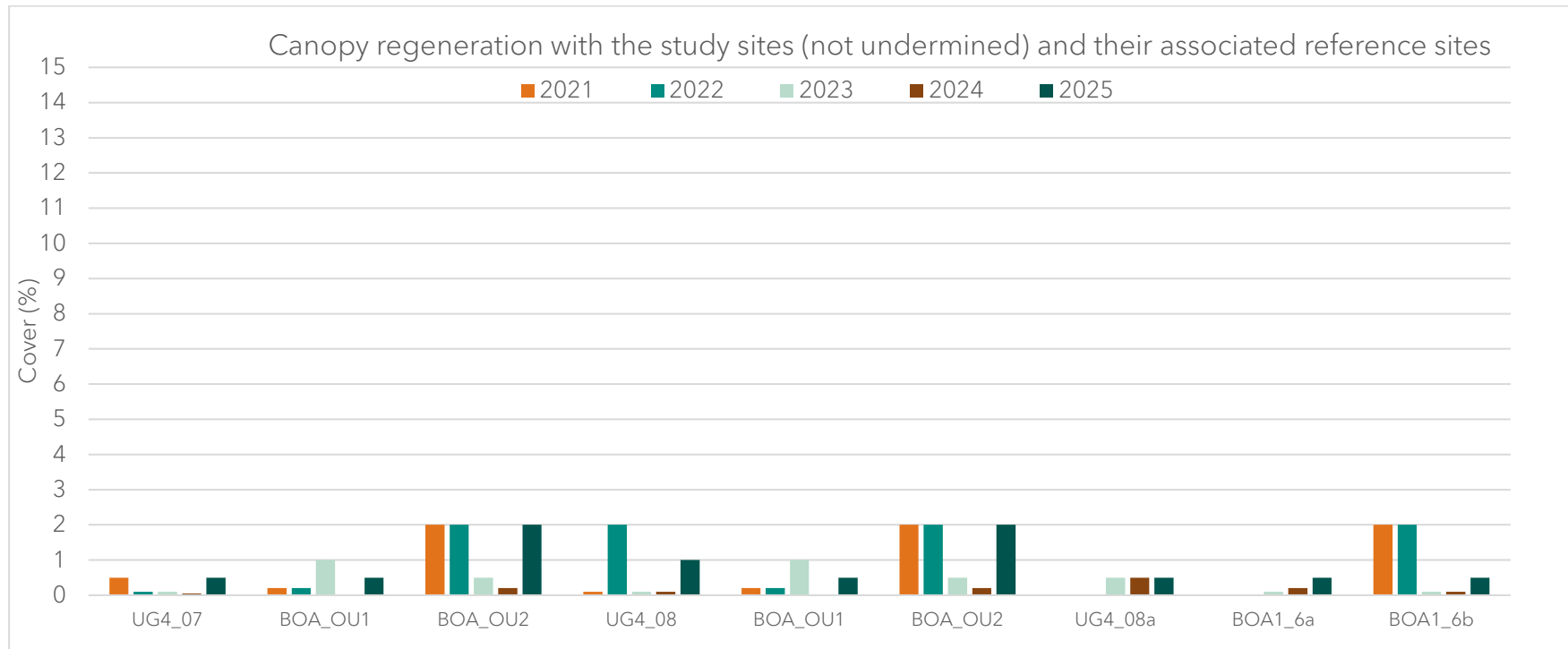


Chart 58. A comparison of the cover (%) of canopy regeneration in the study sites (not undermined) and associated reference sites from 2021 – 2025



Chart 59. A comparison of the cover (%) of epicormic growth in the study sites (not undermined) and associated reference sites from 2021 - 2025

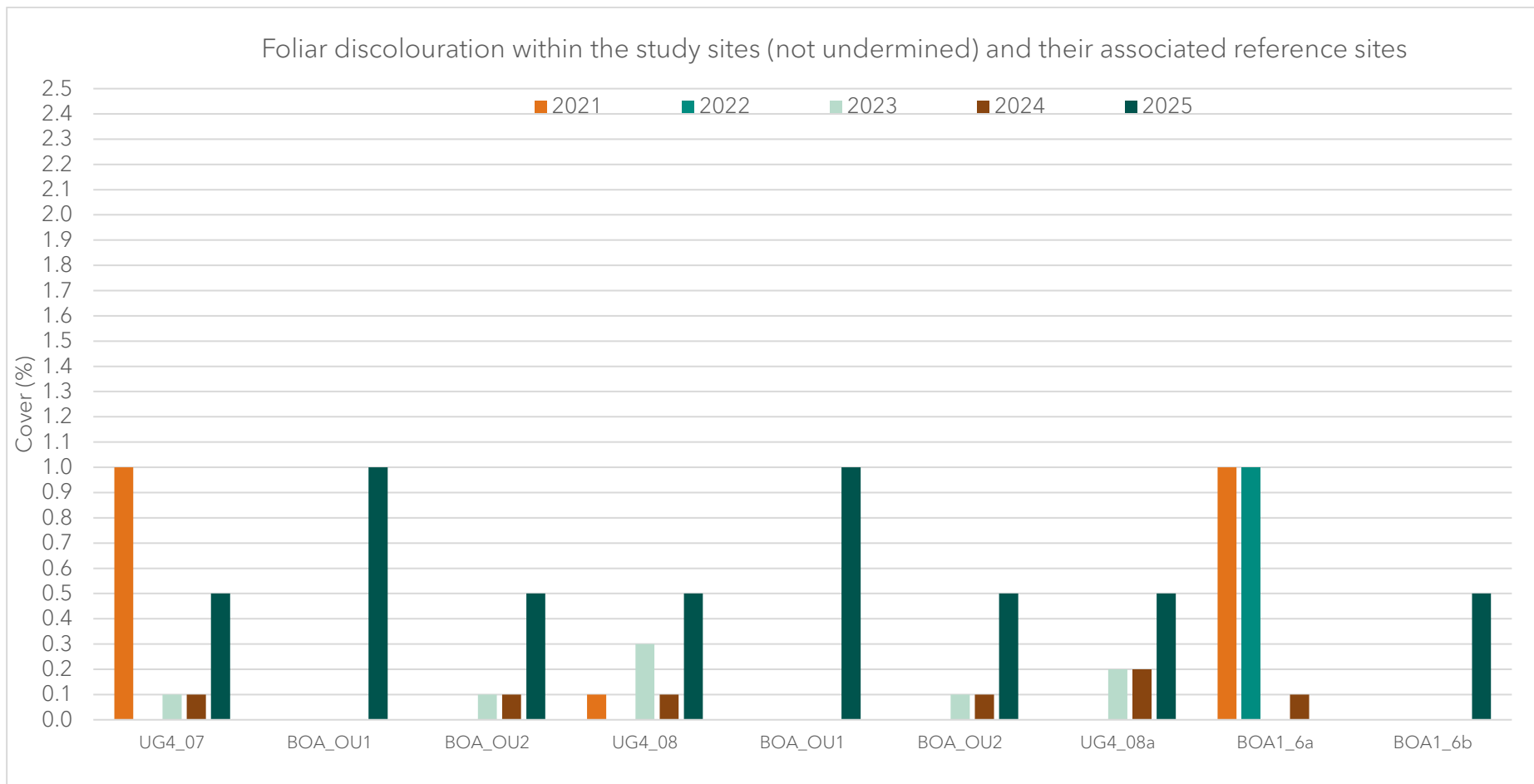


Chart 60. A comparison of the cover (%) of foliar discolouration in the study sites (not undermined) and associated reference sites from 2021 - 2025

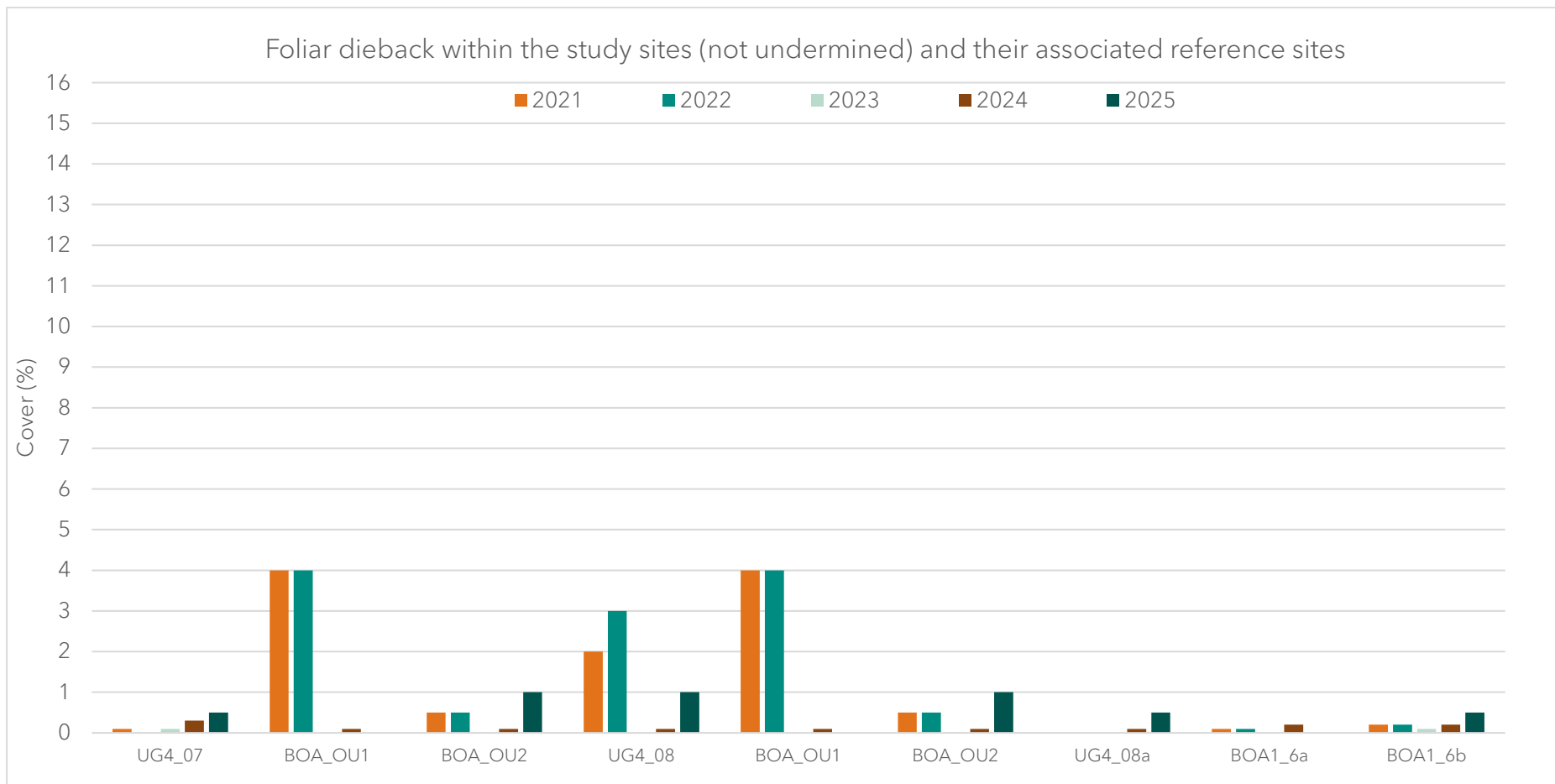


Chart 61. A comparison of the cover (%) of foliar dieback in the study sites (not undermined) and associated reference sites from 2021 – 2025



Chart 62. A comparison of the cover (%) of bare branches in the study sites (not undermined) and associated reference sites from 2021 – 2025

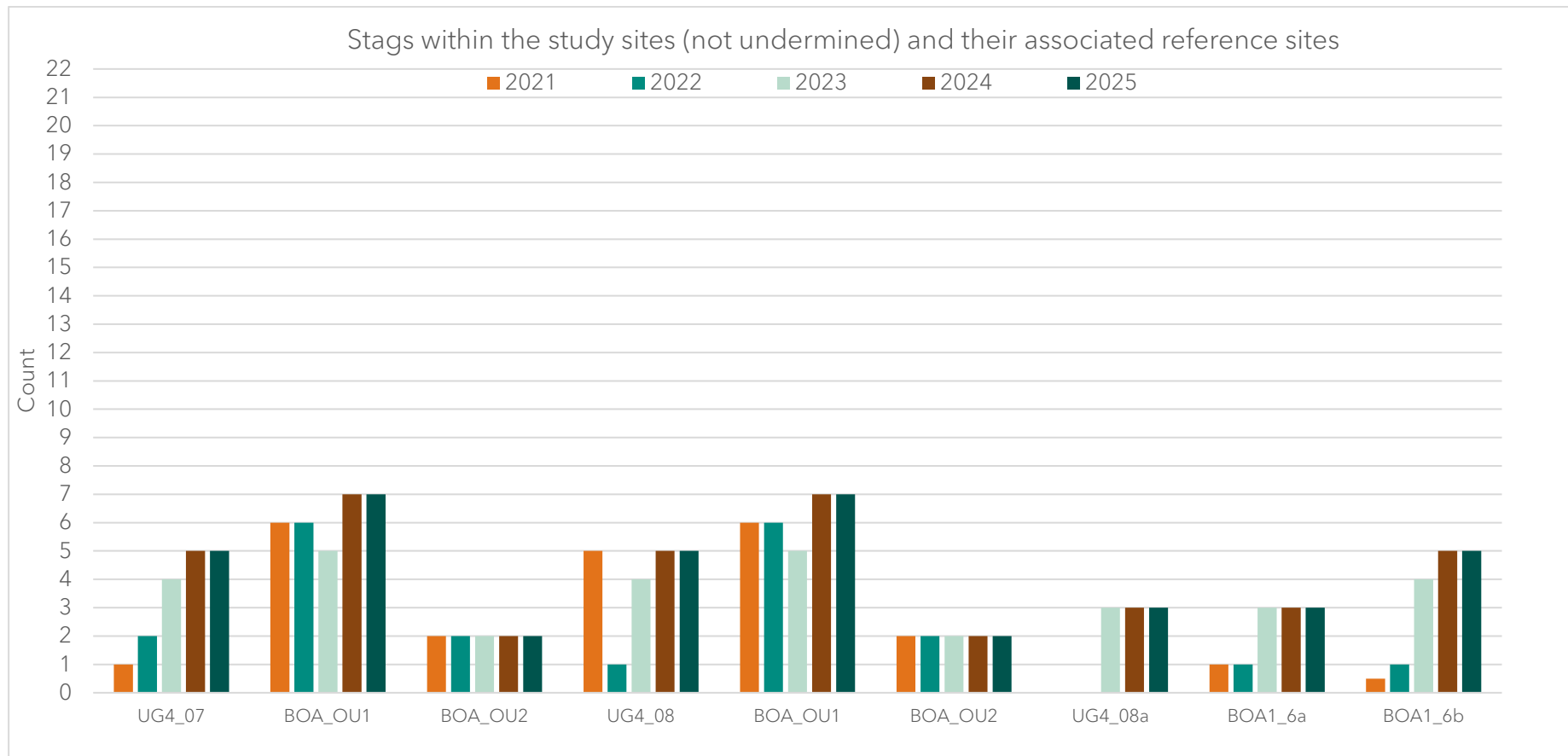


Chart 63. A comparison of the count of stags in the study sites (not undermined) and associated reference sites from 2021 – 2025



Annex 3

Study sites start and end photo points (2022-present)



Table 9. The photo at the start and end of the study sites (2022 - present)

2022	2023	2024	2025
 UG4_01 start	 UG4_01 start	 UG4_01 start	 UG4_01 start
 UG4_01 end	 UG4_01 end	 UG4_01 end	 UG4_01 end



2022



UG4_02 start



UG4_02 end

2023



UG4_02 start



UG4_02 end

2024



UG4_02 start



UG4_02 end

2025



UG4_02 start



UG4_02 end



2022



UG4_03 start

Photo not available

2023



UG4_03 start



UG4_03 end

2024



UG4_03 start



UG4_03 end

2025



UG4_03 start



UG4_03 end



2022



UG4_04 start



UG4_04 end

2023



UG4_04 start



UG4_04 end

2024



UG4_04 start



UG4_04 end

2025



UG4_04 start



UG4_04 end



2022



UG4_05 start



UG4_05 end

2023



UG4_05 start



UG4_05 end

2024



UG4_05 start



UG4_05 end

2025



UG4_05 start



UG4_05 end



2022



UG4_06a start



UG4_06a end

2023



UG4_06a start



UG4_06a end

2024



UG4_06a start



UG4_06a end

2025



UG4_06a start



UG4_06a end



2022



UG4_06b start



UG4_06b end

2023



UG4_06b start



UG4_06b end

2024



UG4_06b start



UG4_06b end

2025



UG4_06b start



UG4_06b end



2022



UG4_07 start



UG4_07 end

2023



UG4_07 start



UG4_07 end

2024



UG4_07 start



UG4_07 end

2025



UG4_07 start



UG4_07 end



2022



UG4_08 start



UG4_08 end

2023



UG4_08 start



UG4_08 end

2024



UG4_08 start



UG4_08 end

2025



UG4_08 start



UG4_08 end



2022	2023	2024	2025
N/A	 UG4_08a start	 UG4_08a start	 UG4_08a start
N/A	 UG4_08a end	 UG4_08a end	 UG4_08a end



Annex 4

Androcalva procumbens
quadrat and health photos
(2023-present)



Table 10. *Androcalva procumbens* habitat photos in the northern and southern populations during the Spring monitoring period (2023-present)

Quadrat	2023	2024	2025
Northern population			
AP1	Photo not available		
AP2			



Quadrat	2023	2024	2025
AP3			
AP4			
AP5			



Quadrat	2023	2024	2025
Southern population			
AP6			
AP7			
AP8			



Table 11. *Androcalva procumbens* population health photos

Photos and descriptions		
		
Plate 2. Senescent individual with thickened runners and leaf drop	Plate 3. Recently emerged individual with thin, herbaceous runners and new leaves	Plate 4. Larger individual with leaves and flowers



Annex 5

Fauna inventory



Table 12. Fauna species and conservation status recorded during Spring 2025 monitoring

Scientific name	Common name	BC Act	EPBC Act	Number of individuals	Observation method
Birds					
<i>Aquila audax</i>	Wedge-tailed Eagle	-	-	1	Observed
<i>Cacatua galerita</i>	Sulphur Crested Cockatoo	-	-	2	Observed
<i>Corcorax melanorhamphos</i>	White-winged Chough	-	-	4	Heard call
<i>Cormobates leucophaea</i>	White-throated Treecreeper				Observed
<i>Corvus coronoides</i>	Australian Raven	-	-	10	Observed
<i>Dacelo novaeguineae</i>	Kookaburra	-	-	4	Observed and heard call
<i>Dromaius novaehollandiae</i>	Emu	-	-	3	Observed
<i>Hirundo neoxena</i>	Welcome Swallow	-	-	10	Observed
<i>Manorina melanocephala</i>	Noisy Miner	-	-	5	Observed and heard call
<i>Melithreptus albogularis</i>	White-throated Honeyeater	-	-	5	Heard call
<i>Menura novaehollandiae</i>	Lyrebird			3	Observed nest and heard call
<i>Pardalotus punctatus</i>	Spotted Pardalote				Observed
<i>Gymnorhina tibicen</i>	Australian Magpie	-	-	5	Observed and heard call
<i>Rhipidura leucophrys</i>	Willy Wag Tail	-	-	10	Heard call
Mammals					
<i>Vombatus ursinus</i>	Wombat	-	-	-	Burrows and scats present
<i>Wallabia bicolor</i>	Swamp Wallaby	-	-	10	Observed
<i>Sus scrofa</i>	Pig^	-	-	-	Evidence of rooting behaviour, scats present
<i>Austronomus australis</i>	White-striped Freetail Bat	-	-	Detected	Ultrasonic recording
<i>Chalinolobus dwyeri</i>	Large-eared Pied Bat	E	E	Detected	Ultrasonic recording
<i>Chalinolobus gouldii</i>	Gould's Wattled Bat	-	-	Detected	Ultrasonic recording
<i>Chalinolobus morio</i>	Chocolate Wattled Bat	-	-	Detected	Ultrasonic recording
<i>Falsistrellus tasmaniensis</i>	Eastern False Pipistrelle	V	-	Detected	Ultrasonic recording
<i>Miniopterus orianae oceanensis</i>	Large Bent-winged-Bat	V	-	Detected	Ultrasonic recording
<i>Miniopterus orianae oceanensis</i> / <i>Vespadelus darlingtoni</i> / <i>Vespadelus regulus</i> Error! Bookmark not defined.	Large Bent-winged-Bat / Large Forest Bat / Southern Forest Bat	V	-	Detected	Ultrasonic recording
		-	-		
		-	-		
<i>Miniopterus orianae oceanensis</i> /	Large Bent-winged-Bat / Little Forest Bat /	V	-	Detected	Ultrasonic recording
		-	-		



Scientific name	Common name	BC Act	EPBC Act	Number of individuals	Observation method
<i>Vespadelus vulturnus</i> / <i>Vespadelus troughtoni</i> <i>Error! Bookmark not defined.</i>	Eastern Cave Bat	V	-		
<i>Myotis Macropus</i> / <i>Nyctophilus corbeni</i> / <i>Nyctophilus geoffroyi</i> / <i>Nyctophilus gouldi</i> <i>Error! Bookmark not defined.</i>	Southern Myotis	V	-	Detected	Ultrasonic recording
	Corben's Long-eared Bat / Lesser Long-eared Bat /	V	V		
	Gould's Long-eared Bat	-	-		
		-	-		
<i>Ozimops planiceps</i>	South-eastern Free-tailed Bat	-	-	Detected	Ultrasonic recording
<i>Ozimops ridei</i>	Rides Freetail Bat	-	-	Detected	Ultrasonic recording
<i>Rhinolophus megaphyllus</i>	Eastern Horseshoe Bat	-	-	Detected	Ultrasonic recording
<i>Saccolaimus flaviventris</i>	Yellow-bellied Sheath-tail-bat	V	-	Detected	Ultrasonic recording
<i>Scotorepens balstoni</i>	Inland broad-nosed bat	-	-	Detected	Ultrasonic recording
<i>Scotorepens greyii</i>	Little broad-nosed bat			Detected	Ultrasonic recording
<i>Vespadelus regulus</i>	Southern Forest Bat	-	-	Detected	Ultrasonic recording
<i>Vespadelus vulturnus</i> / <i>Vespadelus troughtoni</i> <i>Error! Bookmark not defined.</i>	Little Forest Bat /	-	-	Detected	Ultrasonic recording
	Eastern Cave Bat	V	-		
Reptiles					
<i>Pogona barbata</i>	Eastern Bearded Dragon	-	-	1	Observed
<i>Varanus varius</i>	Lace Monitor	-	-	2	Observed



Annex 6

Bat call sample spectrograms



Call graphics are displayed on a linear scale in compressed time between pulse mode with call expansion on F7.

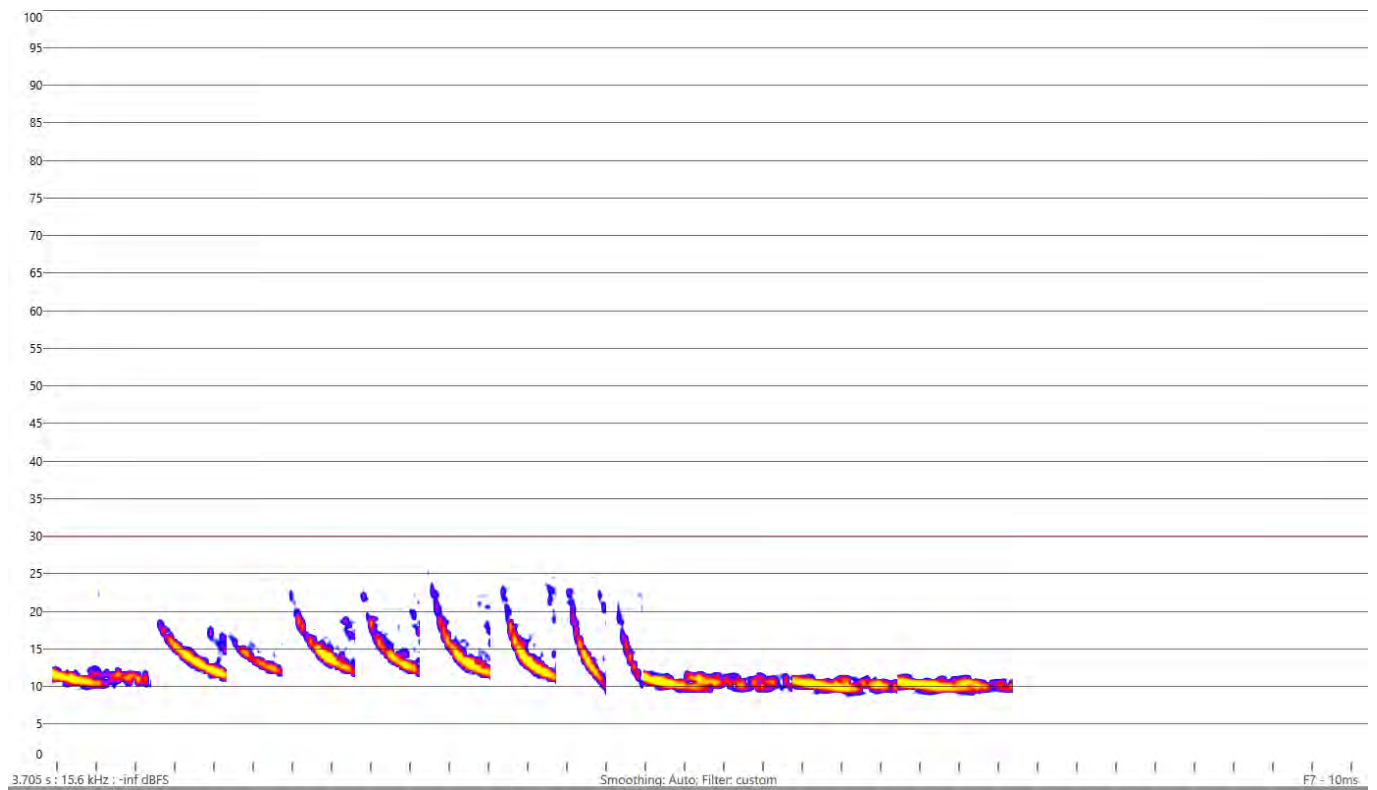


Plate 5: *Austronomus australis*

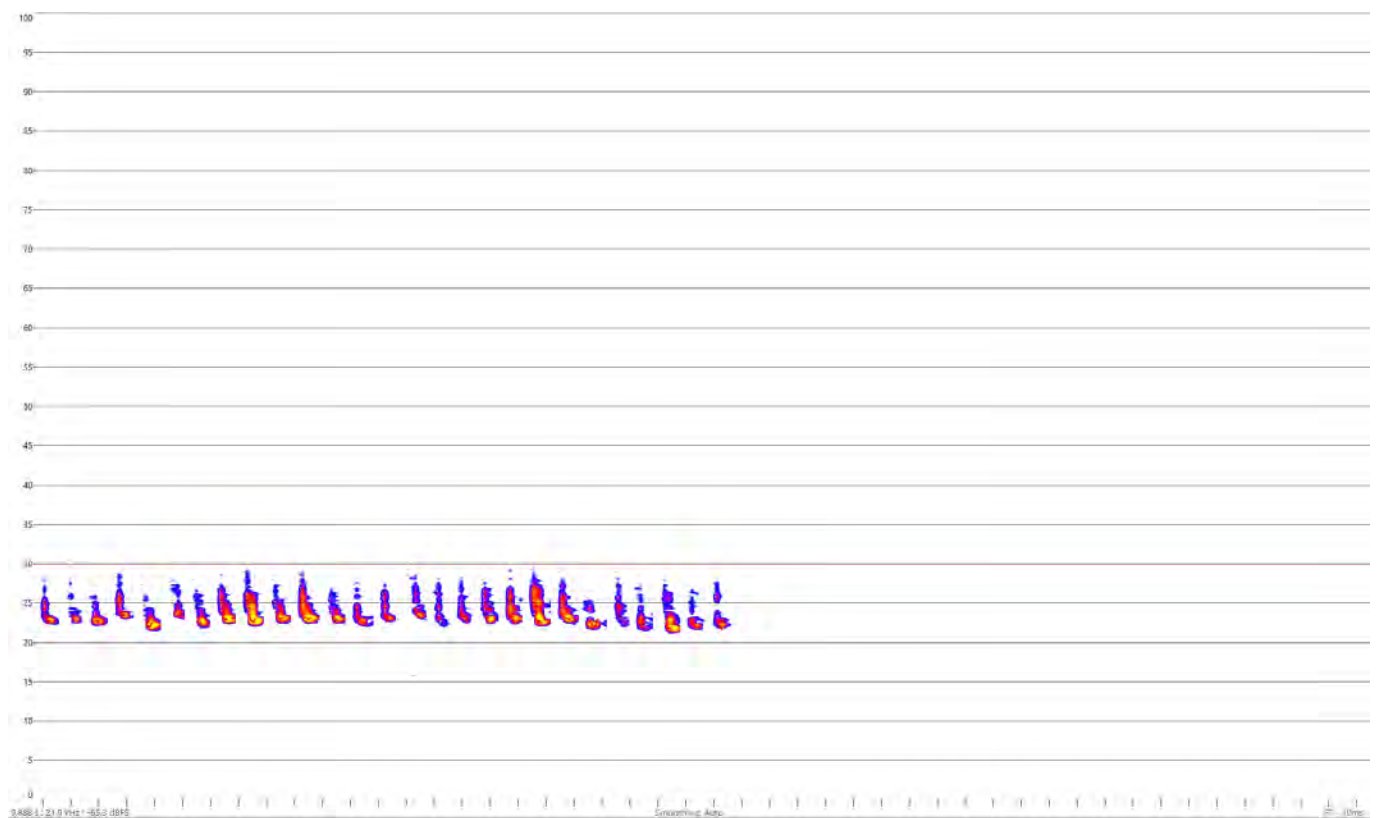


Plate 6: *Chalinolobus dwyeri*

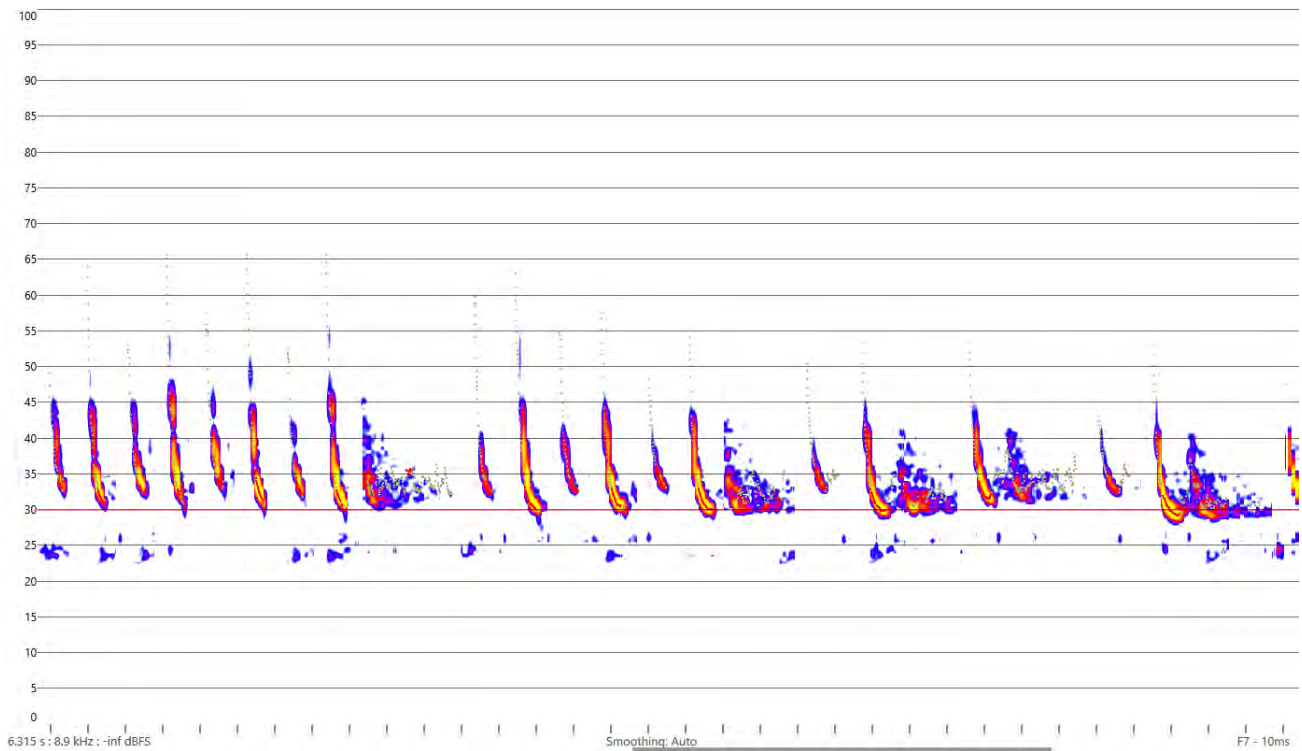


Plate 7: *Chalinolobus gouldii*

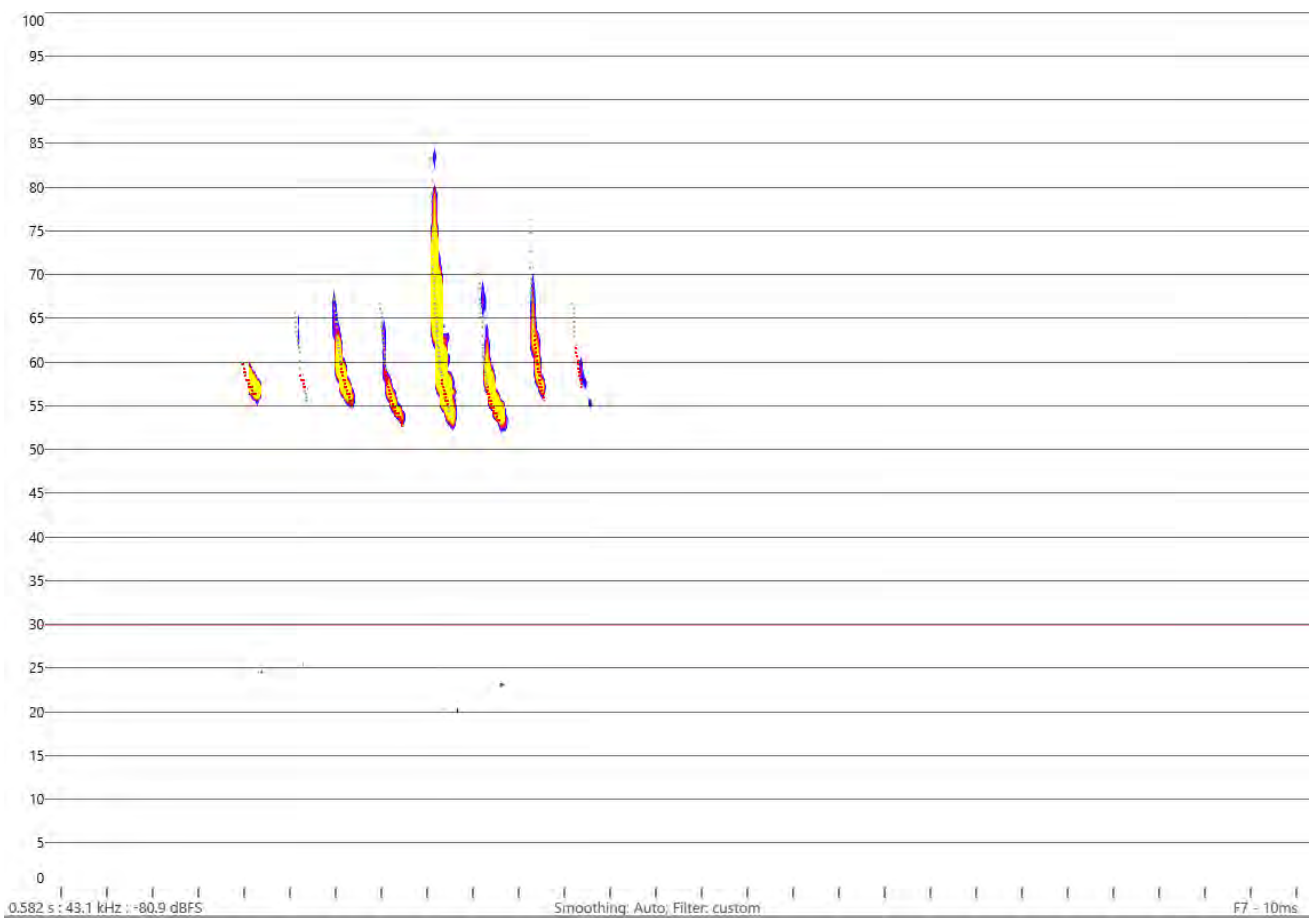


Plate 8: *Chalinolobus morio*

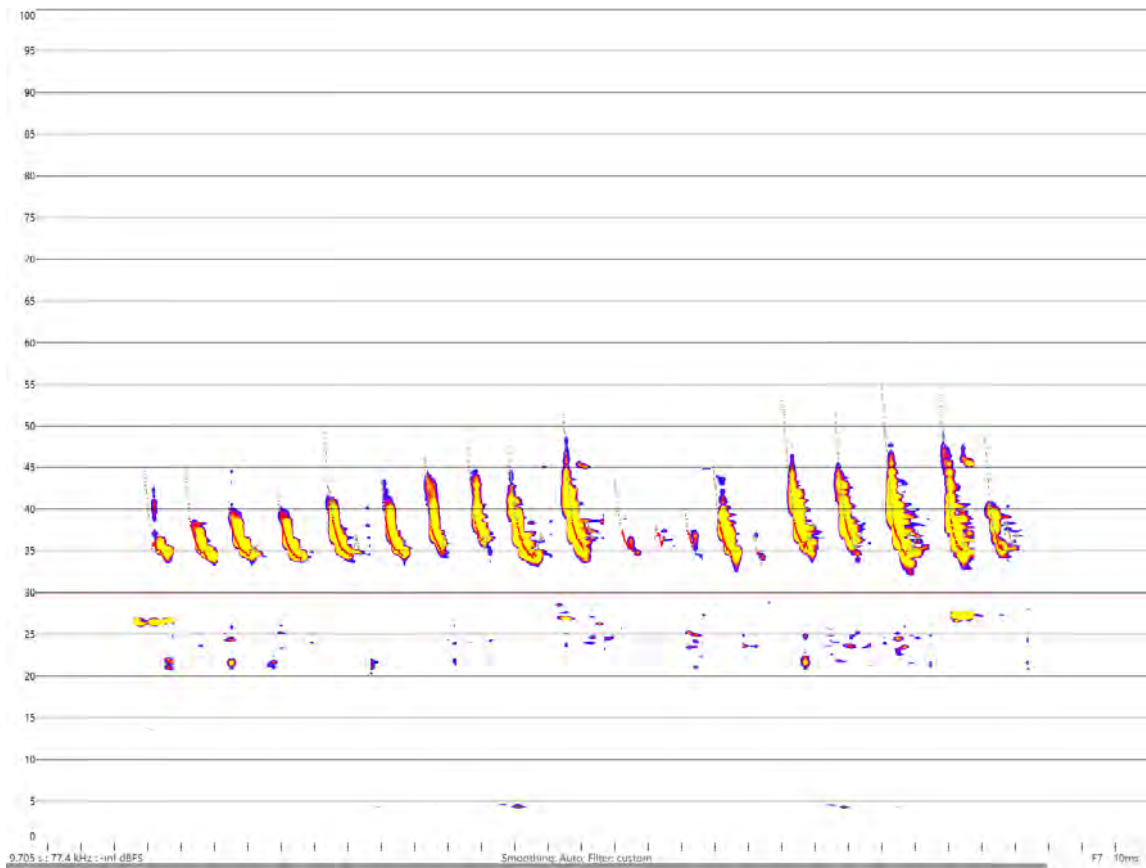


Plate 9: *Falsistrellus tasmaniensis*

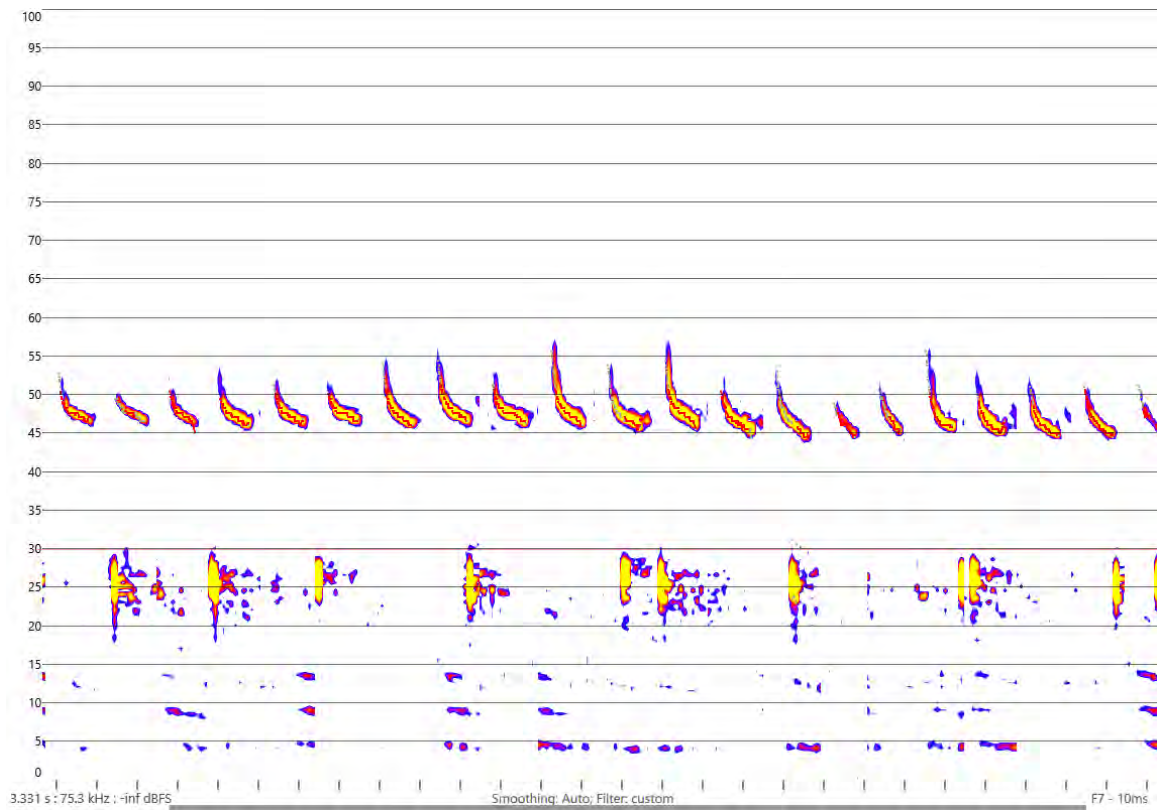


Plate 10: *Miniopterus orianae oceanensis*

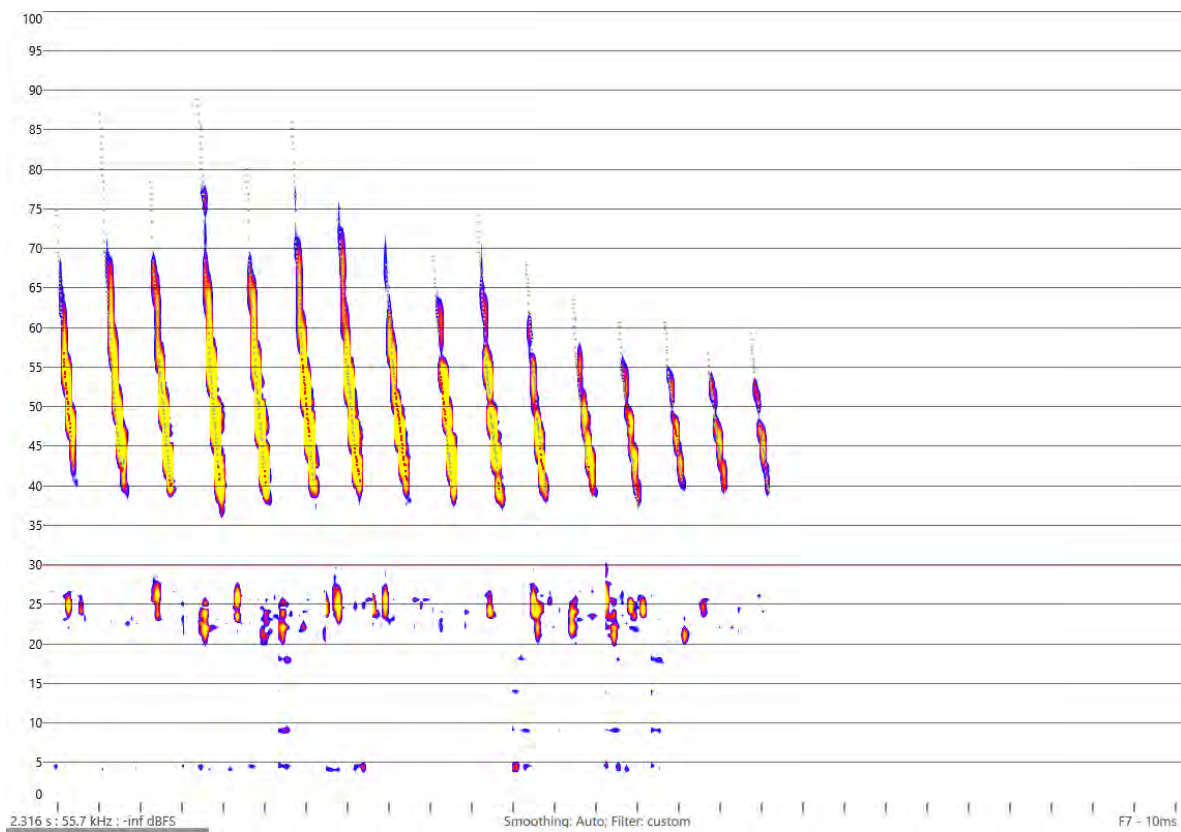


Plate 11: *Myotis Macropus* / *Nyctophilus* spp.

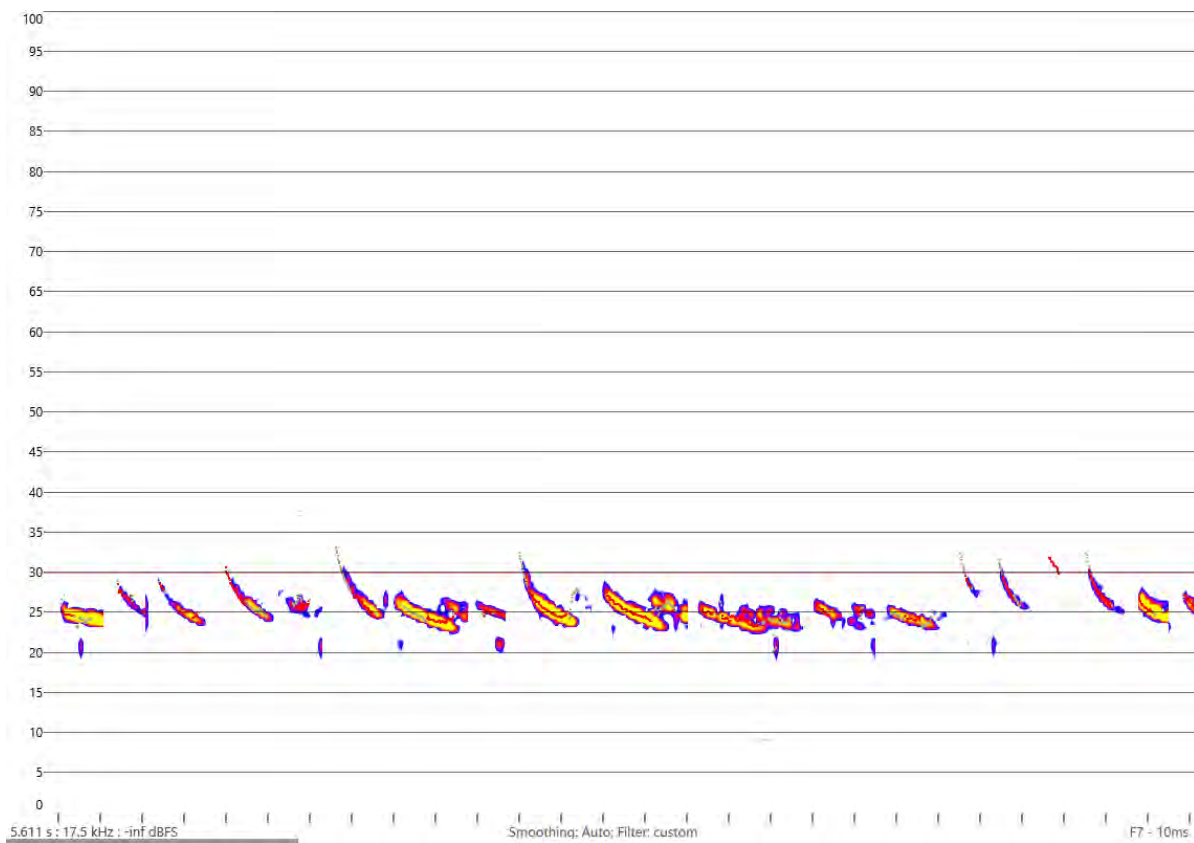


Plate 12: *Ozimops planiceps*

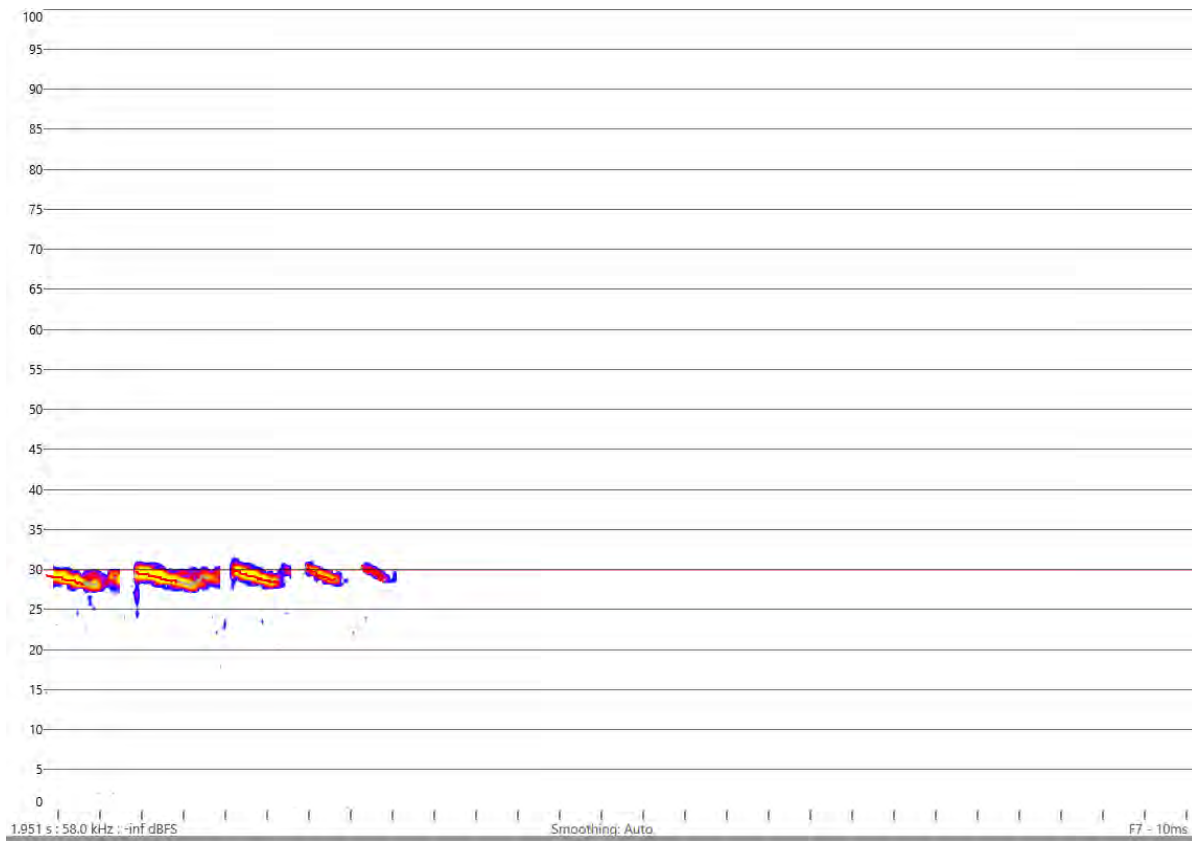


Plate 13: *Ozimops ridei*

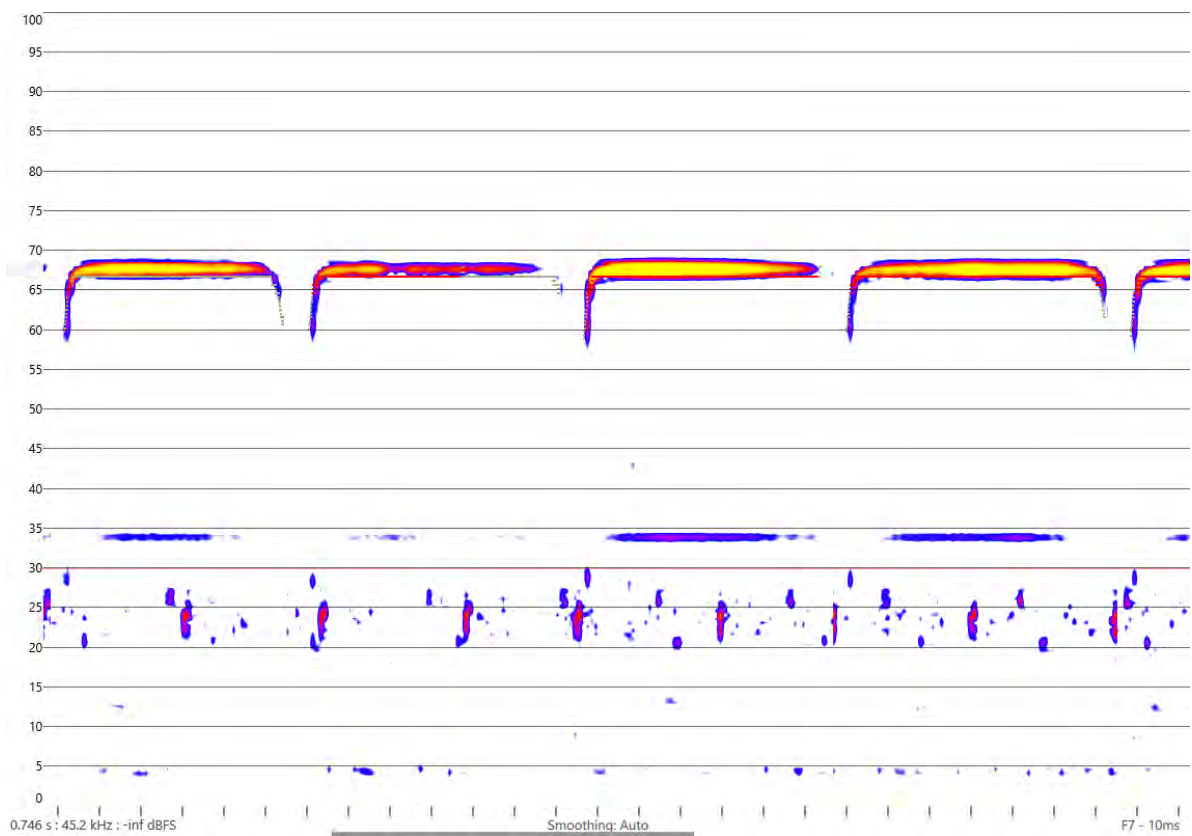


Plate 14: *Rhinolophus megaphyllus*



Plate 15: *Saccolaimus flaviventris*

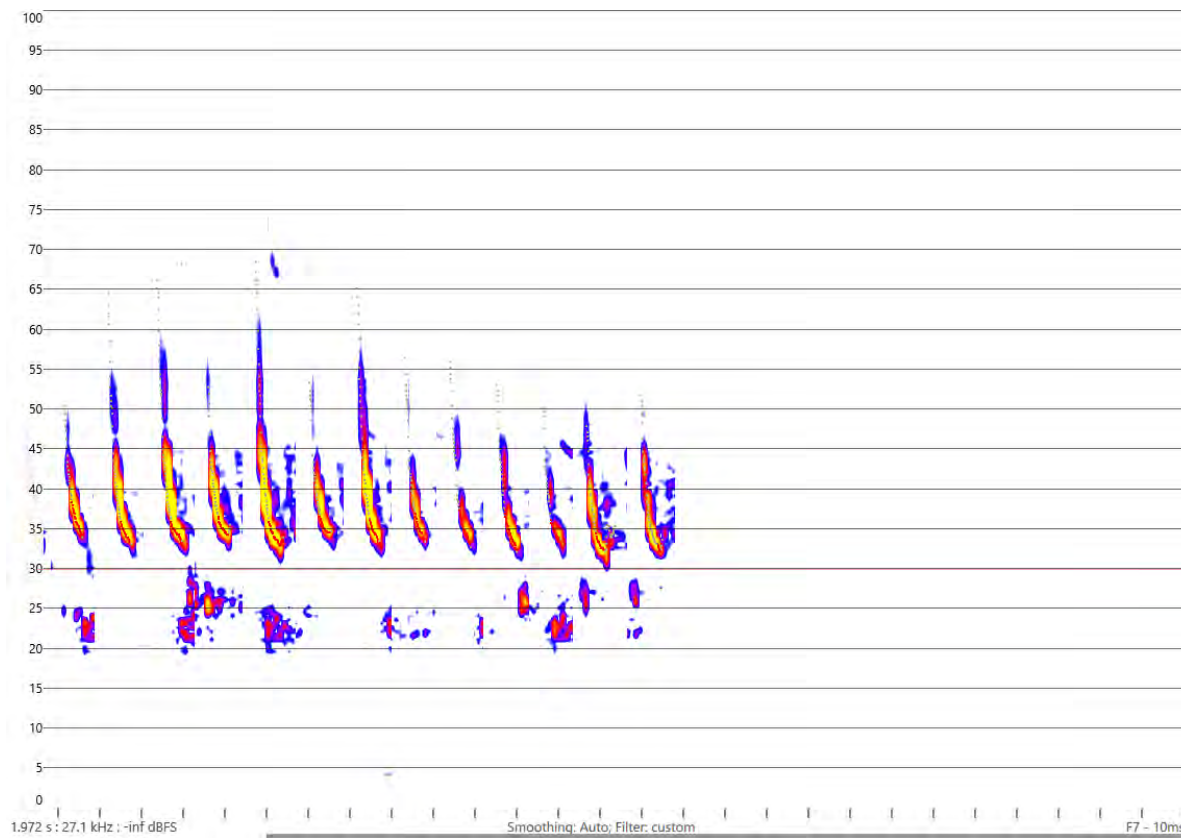


Plate 16: *Scotorepens balstoni*

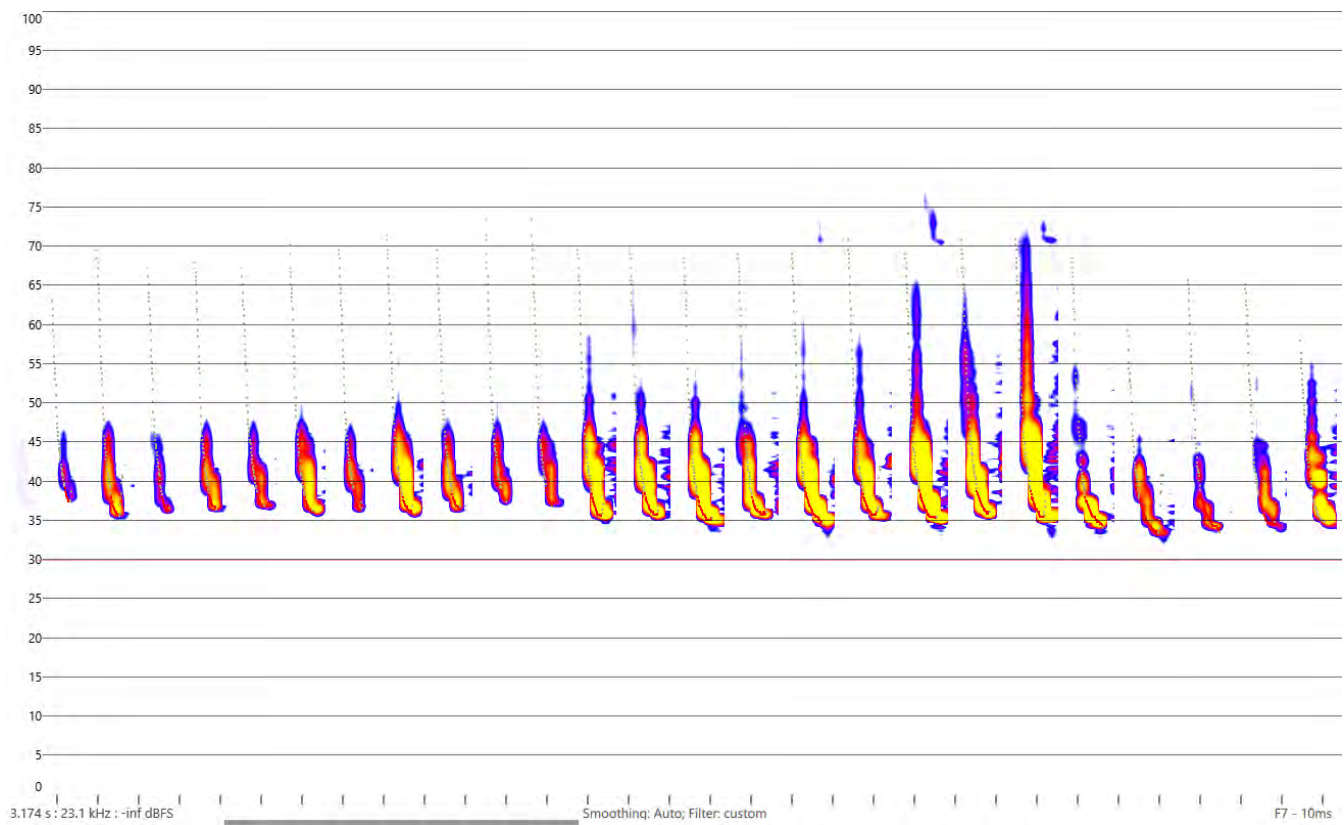


Plate 17: *Scotorepens greyii*

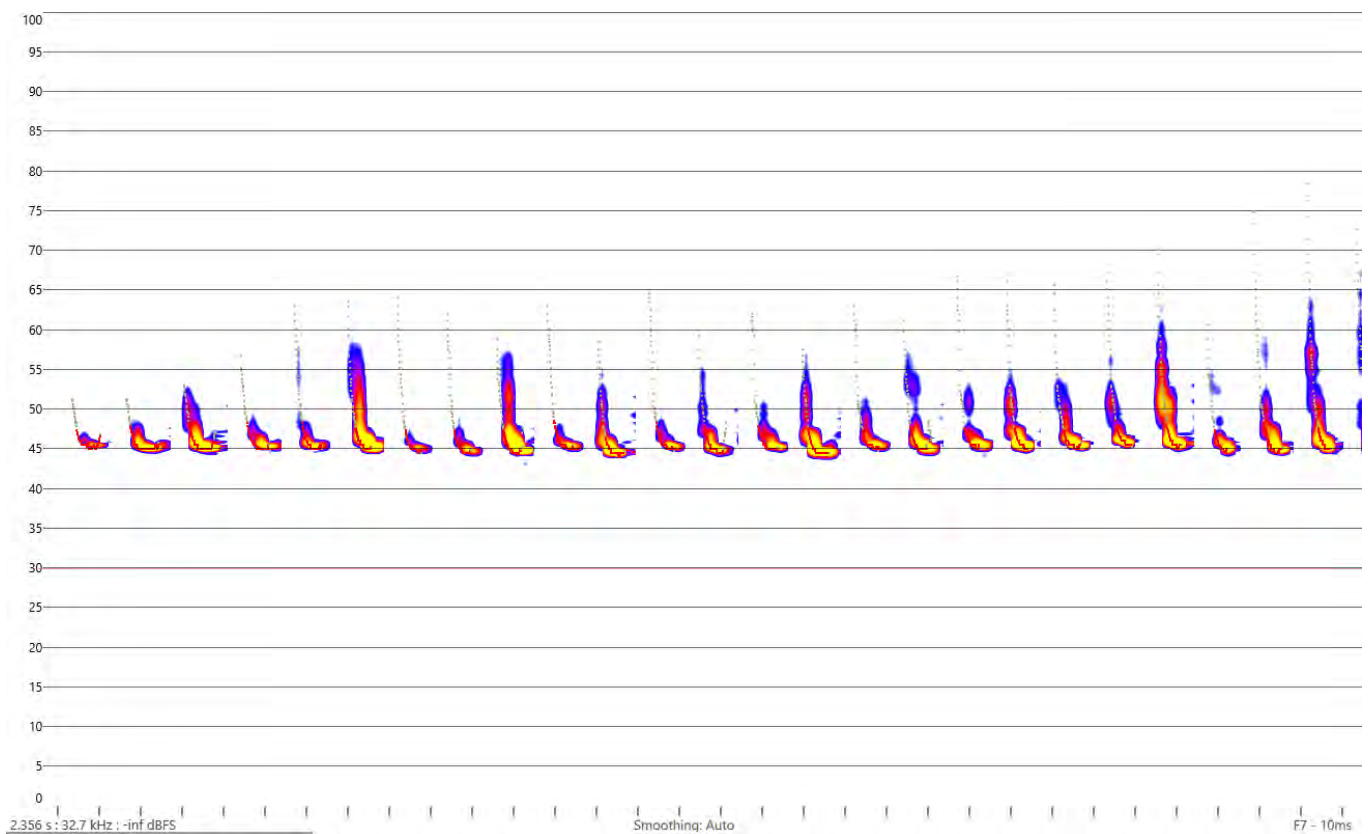


Plate 18: *Vespadelus regulus*

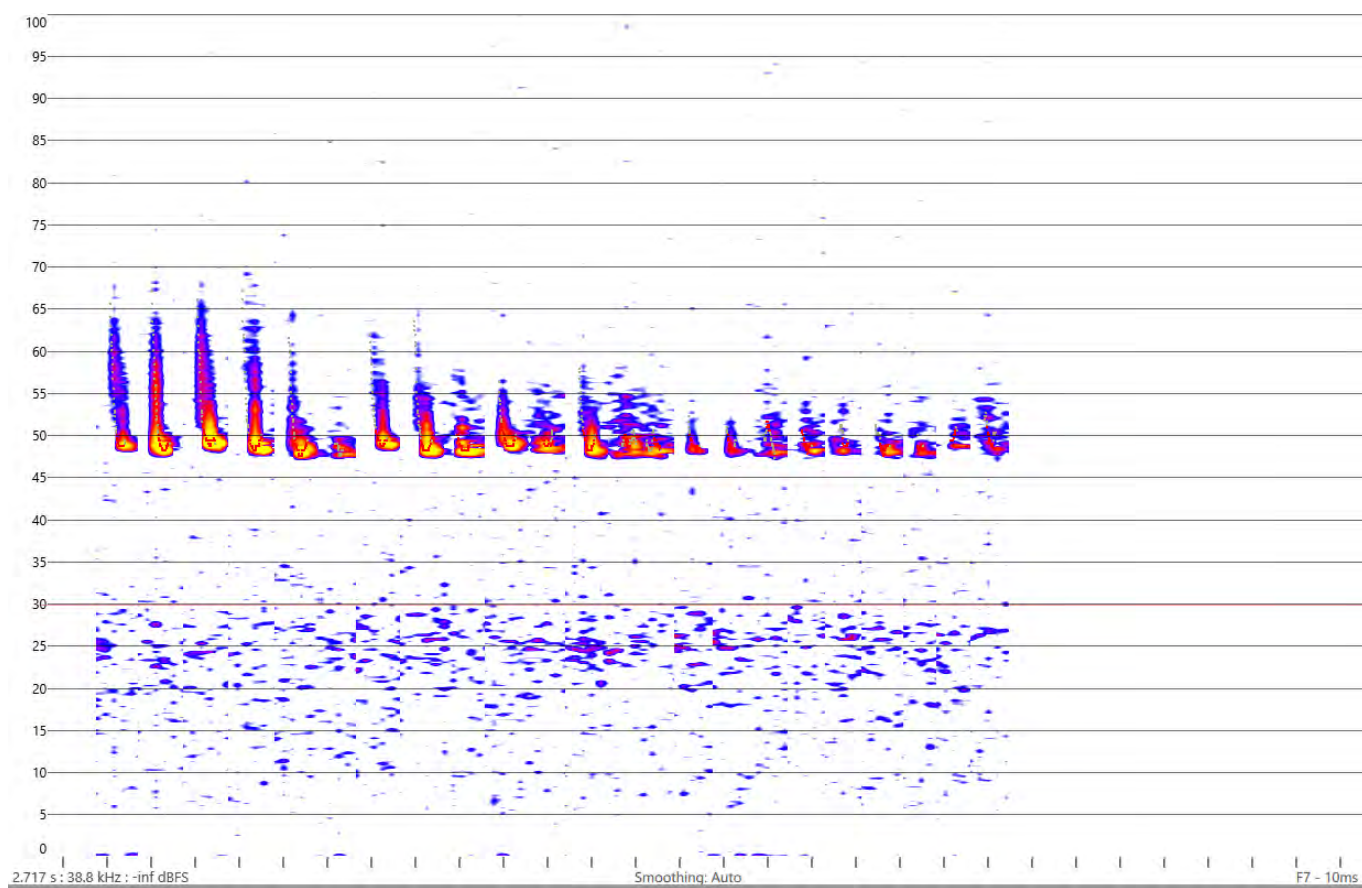


Plate 19: *Vespadelus vulturnus* / *Vespadelus troughtoni*



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Ecology



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management



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APPENDIX E

**MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT
– ABORIGINAL CULTURAL HERITAGE REPORT (NICHE, 2026)**



Moolarben UG4 LW401-407 End of Panel Assessment

Aboriginal Cultural Heritage Assessment

Prepared for Moolarben Coal Operations | August 2026

Document control

Project number	Client	Project manager	LGA
9103	Moolarben Coal Operations	Ben Slack	Mid-Western LGA

Version	Author	Recipient	Status	Comments	Date
Ver. 1	Shezani Nasoordeen	Moolarben Coal Operations and Resource Strategies	Final	End of Panel assessment	20 August 2026

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Executive Summary

Moolarben Coal Operations (MCO) commissioned Niche Environment and Heritage (Niche) to conduct an End of Panel (EoP) assessment of relevant Aboriginal cultural heritage rock shelter sites within the Underground 4 (UG4) Longwalls 401 to 407 (LW401-407) mining area.

Secondary extraction of LW401-407 commenced in July 2022 and was completed in January 2026.

This EoP Aboriginal heritage report includes a summary of:

- predicted subsidence movements;
- the results of monitoring inspections to assess any post-mining impacts due to extraction of LW401-407; and
- discussion and conclusion.

There are 11 Aboriginal cultural heritage sites located within the LW401-407 mining area that were subject to management under the UG4 Longwalls 401 to 408 Heritage Management Plan (LW401-408 HMP) (MCO 2022) and S1MC280 Subsidence Monitoring and Mitigation Program (MCO 2023).

The S1MC280 Subsidence Monitoring and Mitigation Program (MCO 2023) contains site-specific performance measures and indicators, a mitigation and monitoring program, and TARPs for S1MC280, a shelter with art, artefacts and grinding grooves assessed as being of high scientific significance.

Table ES-1 summarises results of post-mining monitoring inspections of the eleven (11) Aboriginal cultural heritage rock shelter sites within the LW401-407 mining area undertaken by Niche in December 2025.

Of the 11 sites subject to post-mining inspection for this EoP report, five sites were identified with observed mining or subsidence-related impacts from LW401-407. Although impacts can occur naturally, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the Mine Subsidence Engineering Consultants (MSEC) (2021) subsidence predictions.

No mining or subsidence-related impacts were observed for the remaining six sites due to the extraction of LW401-407, including no observed impacts to S1MC280. Based on this, the management plan for S1MC280 has been successfully implemented and the performance measure of 'reduce the likelihood of subsidence damage to moderate' for S1MC280 has been met.

No further monitoring/inspections are required for any of the eleven sites assessed in this report.



Table ES-1: Monitoring inspection results for UG4 LW401-407

Site Name	AHIMS No.	Site Type	Scientific (archaeological) significance	Mining or Subsidence-Related Impacts Observed?
S1MC271	36-3-1086	Shelter with Artefacts	Moderate	No
S1MC280; Ulan Creek 2	36-3-0042	Shelter with Art, Artefacts and Grinding Grooves	High	No
S1MC358b	36-3-3305	Shelter with PAD	Low	Yes
S1MC468	36-3-3801	Shelter with Artefacts and PAD	Low	Yes
S1MC472	36-3-3803	Shelter with Artefacts and PAD	Low	No
S1MC474	36-3-3785	Shelter with Artefacts and PAD	Moderate	No
S1MC475	36-3-3786	Shelter with Grinding Grooves, Artefacts and PAD	Moderate	Yes
S1MC484	36-3-3788	Shelter with Artefacts	Low	Yes
S1MC488	36-3-3790	Shelter with Artefacts and PAD	Low	No
S1MC491	36-3-3792	Shelter with PAD	Moderate	No
S1MC494	36-3-3793	Shelter with Artefacts and PAD	Moderate	Yes



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1 Introduction

1.1 Background

Moolarben Coal Operations (MCO) commissioned Niche Environment and Heritage (Niche) to conduct an End of Panel (EoP) assessment of the Aboriginal cultural heritage rock shelter sites within the Underground 4 (UG4) Longwalls 401 to 407 (LW401-407) mining area.

Secondary extraction of LW401-407 commenced in July 2022 and was completed in January 2026.

This EoP Aboriginal heritage report includes a summary of:

- predicted subsidence movements;
- the results of monitoring inspections to assess any post-mining impacts due to extraction of LW401-407; and
- discussion and conclusion.

1.2 Aboriginal cultural heritage rock shelter sites in LW401-407 mining area

Eleven (11) Aboriginal cultural heritage sites are addressed in this report as they were subject to the monitoring and management framework developed as part of the UG4 Longwalls 401 to 408 Heritage Management Plan (LW401-408 HMP) (MCO 2022), S1MC280 Subsidence Monitoring and Mitigation Program (MCO 2023) and UG4 LW401-408 Aboriginal Cultural Heritage Technical Report (Table 1) (Niche 2021).

Details of these sites and the status of other relevant management requirements are summarised in Table 1 and their locations are shown in Figure 1.

1.3 Subsidence predictions

The Subsidence Predictions and Impact Assessments for LW401-408 was prepared by Mine Subsidence Engineering Consultants (MSEC) in 2021. This assessment includes predicted subsidence effects for LW401-408 on natural and built features within the LW401-408 Study Area including Aboriginal cultural heritage sites. For this assessment, the MSEC predictions (MSEC 2021) are referred to in order to address any potential impacts at the sites due to extraction of LW401-407.

Specifically, in relation to matters that may affect Aboriginal cultural heritage values, Section 10.0 of MSEC (2021) provides maximum predicted total vertical subsidence, tilt and curvature for the archaeological sites resulting from the extraction of the proposed longwalls.

MSEC (2021) concluded that the rock shelters and overhangs in the LW401-408 Study Area and above the extracted longwalls were predicted to be subject to similar impacts as described for minor cliffs (i.e. potential for fracturing of sandstone and subsequent rockfalls).

Observed impacts to all the Aboriginal cultural heritage sites considered in this report are consistent with the subsidence predictions. Further details are provided in Section 3.



Table 1: Aboriginal cultural heritage rock shelter sites located within LW401-407 mining area

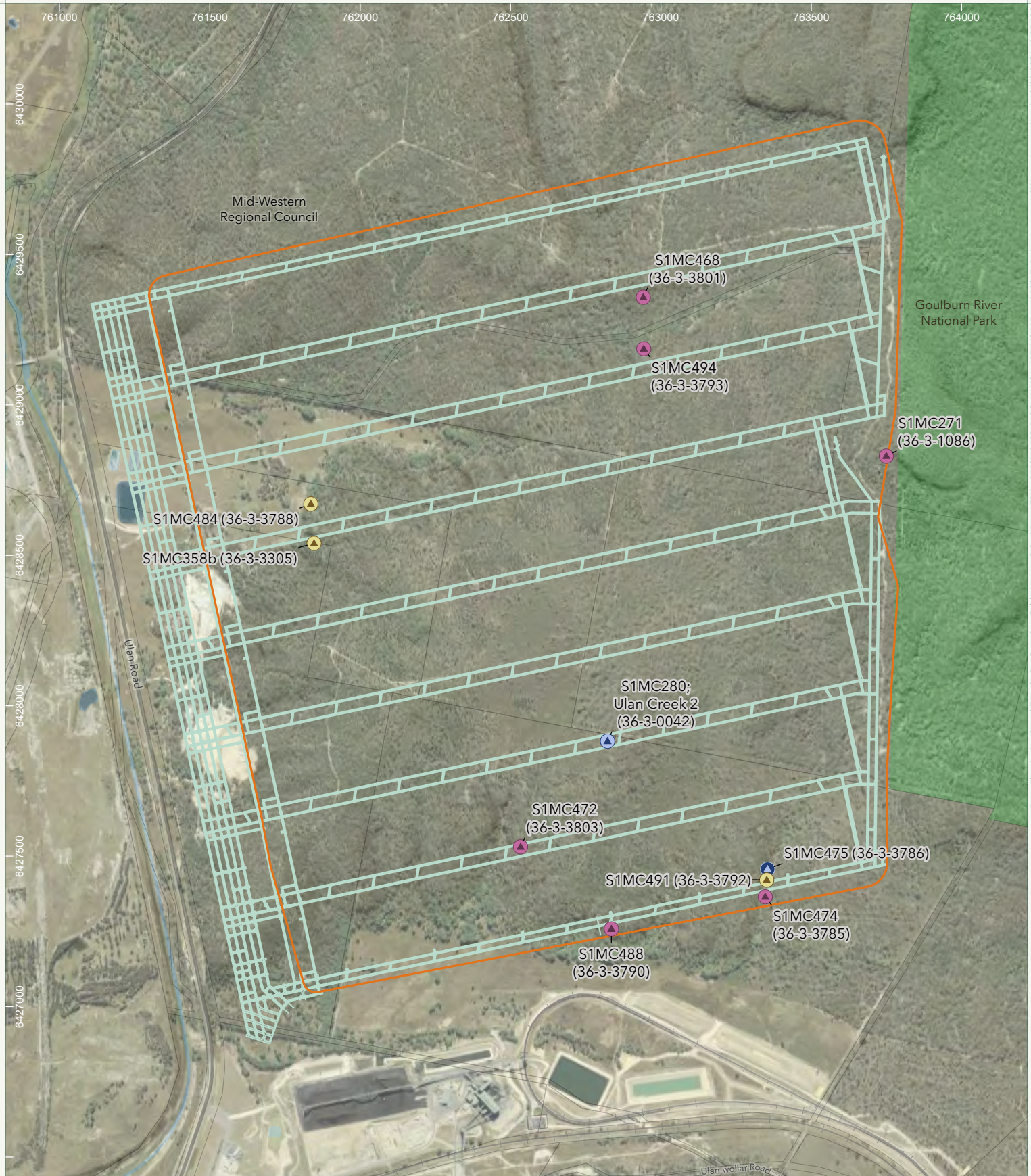
Site name	AHIMS number	Site type	Scientific significance	Management requirements	Management action completion date
S1MC271	36-3-1086	Shelter with Artefacts	Moderate	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection prior to extraction.	November 2022 Note, no surface artefacts found during collection
S1MC280	36-3-0042	Shelter with Art, Artefacts and Grinding Grooves	High	Baseline recording prior to extraction.	March 2021
				Undertake detailed recording of art. It is recommended this included detailed photography and photogrammetry. Consideration should be given to the geochemical analysis of art pigments where supported by the Registered Aboriginal Parties (RAPs).	September 2025
				Where impacts are deemed likely to occur, undertake surface collection and, if required, archaeological excavation prior to extraction.	May 2024
				Undertake a detailed archival recording of grinding grooves through means such as photography, photogrammetry, and 3D scanning prior to extraction. If supported by RAPs use wear and residue analysis of grinding surfaces should be undertaken during detailed archival recording phase.	September 2025
				Implement further management and engineering controls such cutting stress relief slots in the sandstone outcrop away from the site in consultation with RAPS.	April 2023



Site name	AHIMS number	Site type	Scientific significance	Management requirements	Management action completion date
S1MC358b	36-3-3305	Shelter with PAD	Low	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection prior to extraction.	November 2022
S1MC468	36-3-3801	Shelter with Artefacts and PAD	Low	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection.	November 2022 Note, no surface artefacts found during collection
S1MC472	36-3-3803	Shelter with Artefacts and PAD	Low	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection prior to extraction prior to extraction.	November 2022
S1MC474	36-3-3785	Shelter with Artefacts and PAD	Moderate	Baseline recording prior to extraction.	November 2021
				Where impacts are deemed likely to occur, undertake surface collection and, if required, archaeological excavation prior to extraction.	November 2021 - February 2023
S1MC475	36-3-3786	Shelter with Grinding Grooves, Artefact and PAD	Moderate	Baseline recording prior to extraction.	November 2021
				Where impacts are deemed likely to occur, undertake surface collection and, if required, archaeological excavation prior to extraction.	November 2021 - January 2022
				Where impacts are likely to the grinding groove, archival recording through means such as photography, photogrammetry or 3D scanning should be undertaken prior to extraction.	Grinding groove analysis completed in 2024



Site name	AHIMS number	Site type	Scientific significance	Management requirements	Management action completion date
S1MC484	36-3-3788	Shelter with Artefacts	Low	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection prior to extraction.	November 2022 Note, no surface artefacts found during collection
S1MC488	36-3-3790	Shelter with Artefacts and PAD	Low	Baseline recording prior to extraction.	November 2021
				Where impacts are deemed likely to occur, undertake surface collection prior to extraction.	November 2021
S1MC491	36-3-3792	Shelter with PAD	Moderate	Baseline recording prior to extraction.	December 2021
				Where impacts are deemed likely to occur, undertake surface collection and, if required, archaeological excavation prior to extraction.	Management actions completed in December 2021
S1MC494	36-3-3793	Shelter with Artefacts and PAD	Moderate	Baseline recording prior to extraction.	November 2022
				Where impacts are deemed likely to occur, undertake surface collection and, if required, archaeological excavation prior to extraction.	November 2022



- ▮ Subject area
- ▬ UG4 Longwalls 401 - 408 footprint
- Cultural heritage site**
 - Shelter with Art, Artefacts and Grinding Grooves

- Shelter with Artefacts (with/ without PAD)
- Shelter with Artefacts and Grinding Groove (with/ without PAD)
- Shelter with PAD

- Transport**
 - ▬ Major road
 - ▬ Minor road
 - + Rail
- Hydrography**
 - ▬ Waterbody

- Protected Areas of NSW**
 - ▬ National Park
- Administrative and Property Boundaries**
 - ▬ Lot
 - ▬ Local Government Area

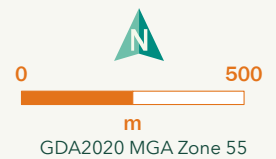


Figure 1

Location of Aboriginal Cultural Heritage Rock Shelter Sites Located Within LW401-407 Mining Area
MCO LW401-407 EoP

Niche PM: Ben Slack
Niche Proj. #: 9103
Client: Moolarben Coal Operations Pty Ltd





2 Post-mining inspection results

In accordance with the requirements of the LW401-408 HMP (MCO 2022), post-mining inspection of the 11 Aboriginal cultural heritage rock shelter sites addressed in this assessment was carried out between 10-12 December 2025 by Niche personnel, RAPs, and representatives of MCO. A summary of the findings of the site inspection is outlined below.

2.1 Sites with observed mining-related subsidence

The post-mining inspection identified five sites with observed mining-related subsidence impacts. A detailed outline of the findings with supporting visuals are outlined in Sections 2.1.1 to 2.1.5.

2.1.1 S1MC358b (AHIMS ID# 36-3-3305)

S1MC358b consists of a sandstone outcrop with overhang and shelter.

This site was baseline recorded and surface collection was completed by Niche in 2022 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, major collapse of the shelter opening was observed. Cracking throughout the shelter was evident, with a large (>50 centimetres [cm]) vertical crack identified to the far right of the shelter. The results of the monitoring inspection are detailed in Table 2 below, and Plate 1 to Plate 12 show the monitoring photographs and comparison images for the site.



Table 2: S1MC358b (AHIMS ID#36-3-3305) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3305	S1MC358b	Major collapse of roof of shelter - fissuring of roof extends perpendicular to the original drip line. The southeast roof portion has collapsed. The remains of the roof have broken up and is now blockfall that extends up to 5 m in a debris field in front and downslope of the shelter. Fissuring that caused the collapse of the shelter extends through the rock strata behind the shelter. Remaining shelter roof has wasp nests, chemical weathering, some exfoliation, and a PAD deposit remains in shelter floor. Sand from the collapsed roof section has added to this and deposited outside the shelter mouth. Cross section of the collapsed roof shows that an existing fissure behind the roof increased the chance of collapse. This was not visible previously. Roots and weathering patterns that would have previously been intruding into this natural fissure reinforce this conclusion. Southeast shelter opening has major fissure cracking which extends across the southeast portion of shelter roof, back wall and floor. Presence of beehive on roof at this point. Some surface fissuring in roof section. Southeast section roof is supported by remaining frontal wall, this wall has fissuring and is at risk of collapse. Overall shelter retains PAD deposit and potential for artefacts but is structurally at risk of further collapse. Quartz artefact found outside the shelter area was not relocated. Although these types of impacts can occur naturally at sandstone overhangs, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions. <u>RAP comments recorded during S1MC358b site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
	



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
	
Plate 5: Detail of rear wall at S1MC358b (AHIMS ID#36-3-3305) with graffiti and fresh exfoliation. Photo taken on 21 November 2022.	Plate 6: Interior of shelter with collapsed block. Photo taken on 11 December 2025.
Plate 7: Detail internal shelter at S1MC358b (AHIMS ID#36-3-3305), facing west. Photo taken on 21 November 2022.	Plate 8: View from east of interior (due to safety reasons), looking at crack. Photo taken on 11 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 9: View from location of quartz flake to S1MC358b (AHIMS ID#36-3-3305) shelter. Photo taken on 21 November 2022. <i>No prior baseline photographs available.</i>	 Plate 10: View from location of quartz flake to S1MC358b (AHIMS ID#36-3-3305) shelter. Photo taken on 11 December 2025.  Plate 11: Major fissure cracking located within the Southeast shelter opening of the site. Crack extends across the southeast portion of shelter roof, back wall and floor. Photo taken on 11 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
<i>No prior baseline photographs available.</i>	 Plate 12: View of major fissure cracking located within the Southeast shelter from the south of the shelter opening. Photo taken on 11 December 2025.



2.1.2 S1MC468 (AHIMS ID# 36-3-3801)

S1MC468 consists of a conglomerate sandstone rock shelter with two stone artefacts and a PAD. Prior to LW401-407, S1MC468 has been subjected to cavernous weathering, minor block fall, and spalling and exfoliation. The PAD is approximately 15 m x 20 m and estimated at 40 cm deep, located downslope of the dripline of the rock shelter. Two artefacts were identified in the PAD, a tuff proximal flake with weathered cortex, and a quartz broken flake.

This site was baseline recorded by Niche in 2022 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, the site demonstrated existing blockfall and fissuring. A crack was observed lining the rear boundary of the rock and continues in an east-west direction. The results of the monitoring inspection are detailed in Table 3 below, and Plate 13 to Plate 16 show the monitoring photographs and comparison images for the site.

Table 3: S1MC468 (AHIMS ID# 36-3-3801) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3801	S1MC468	Two artefacts were previously recorded but were not found due to leaf litter surrounding the outside of the shelter. No additional fissuring or blockfall was seen. Branches have fallen in front of the shelter, some that are physically resting on the shelter's exterior. Behind the left-hand side of the sandstone block that covers the top of the shelter, a crack was observed lining the rear boundary of the rock and continues in an east-west direction. Although these types of impacts can occur naturally at sandstone overhangs, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions. <u>RAP comments recorded during S1MC468 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site mentioned that they prefer that fallen branches obstructing the shelter be cleared away from its area.



Baseline recording (November 2022)	Post-mining recording (Dec 2025)
 Plate 13: General photo of site S1MC468 (AHIMS ID#36-3-3801), facing north. Photo taken on 28 November 2022.	 Plate 14: General photo of site S1MC468 (AHIMS ID#36-3-3801), facing north. Photo taken on 9 December 2025.
 Plate 15: General photo of site S1MC468 (AHIMS ID#36-3-3801), facing north. Photo taken on 28 November 2022.	 Plate 16: General photo of site S1MC468 (AHIMS ID#36-3-3801), facing north. Crack shown to right behind twigs of branch. Photo taken on 9 December 2025.



2.1.3 S1MC475 (AHIMS ID# 36-3-3786)

S1MC475 consists of two shelters located either side of Bora Creek. The creek line is sandstone lined with sediment build up. Both shelters consist of conglomerate sandstone with horizontal bedding, formed along a continuous ridgeline. S1MC475 has formed due to cavernous weathering and blockfall. A singular grinding groove was identified in front of the southern shelter which measures 14 cm long by 4 cm wide and 0.6 cm deep. The northern shelter contained a PAD with a chalcedony complete flake on the surface.

This site was baseline recorded and surface collection undertaken in 2021 and test excavation management actions were completed by Niche in 2022 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, a new fissure 1 – 2 cms wide was found on the northern end of the eastern shelter's interior which has impacted its roof. The results of the monitoring inspection are detailed in Table 4 below, and Plate 17 to Plate 36 show the monitoring photographs and comparison images for the site.

Table 4: S1MC475 (AHIMS ID# 36-3-3786) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3786	S1MC475	Some recent blockfall from exfoliation on the eastern shelter's interior. A new fissure was found on the northern end of the eastern shelter's interior which has impacted its roof. The fissure is 1-2 cm wide. South of the eastern shelter's interior, some blockfall from the ridge can be seen. Within the southern end of the eastern shelter's interior, a large hornet's nest was found. At the western shelter's interior where test excavations were conducted to investigate the PAD, two open pits, tent pegs and sediment erosion fencing still exists from the works. No further erosion or blockfall was seen at the western shelter's interior. No changes were seen to the recorded grinding groove. Although these types of impacts can occur naturally at sandstone overhangs, the changes observed since the baseline in question were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions. <u>RAP comments recorded during S1MC475 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site suggested backfilling and cleaning locations of open pits at the western shelter's interior.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 17: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing south-east. Photo taken on 21 November 2021.	 Plate 18: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing south-east. Photo taken on 10 December 2025.
 Plate 19: Location of Grinding Groove relative to Rock Shelter, site S1MC475 (AHIMS ID#36-3-3786), facing north-east. Photo taken on 21 November 2021.	 Plate 20: Location of Grinding Groove relative to Rock Shelter, site S1MC475 (AHIMS ID#36-3-3786), facing north-east. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 21: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-east. Photo taken on 21 November 2021.	 Plate 22: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-east. Photo taken on 10 December 2025.
 Plate 23: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing south-east. Photo taken on 21 November 2021.	 Plate 24: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing south-east. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 25: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-west. Photo taken on 21 November 2021.	 Plate 26: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-west. Photo taken on 10 December 2025.
 Plate 27: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-west towards overhang containing artefact. Photo taken on 21 November 2021.	 Plate 28: General photo of site S1MC475 (AHIMS ID#36-3-3786), facing north-west towards overhang containing artefact. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 29: Site S1MC475 (AHIMS ID#36-3-3786) (north), containing stone artefact, facing south-west. Photo taken on 21 November 2021.	 Plate 30: Site S1MC475 (AHIMS ID#36-3-3786) (north), containing stone artefact, facing south-west. Photo taken on 10 December 2025.
 Plate 31: Site S1MC475 (AHIMS ID#36-3-3786) (north), containing stone artefact, facing north-east. Photo taken on 21 November 2021.	 Plate 32: Site S1MC475 (AHIMS ID#36-3-3786) (north), containing stone artefact, facing north-east. Open pits in foreground. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 33: Grinding Groove at creeks edge of site S1MC475 (AHIMS ID#36-3-3786). Photo taken on 21 November 2021.	 Plate 34: Grinding Groove at creeks edge of site S1MC475 (AHIMS ID#36-3-3786). Increased lichen on surface. Photo taken on 10 December 2025.
 Plate 35: Grinding Groove at creeks edge at S1MC475 (AHIMS ID#36-3-3786). Photo taken on 21 November 2021.	 Plate 36: Grinding Groove at creeks edge at S1MC475 (AHIMS ID#36-3-3786). Lichen in grinding groove. Photo taken on 10 December 2025.



2.1.4 S1MC484 (AHIMS ID# 36-3-3788)

S1MC484 is a conglomerate sandstone shallow overhang situated at the break of slope on the footslopes, approximately 125 m north of the Dronvisa Quarry. It has a sloped and curved floor with shallow PAD, estimated less than 10 cm in depth. An isolated quartz flake was located in the dripline.

This site was baseline recorded by Niche in 2022 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025)

During the post-mining inspections undertaken in December 2025, major collapse of the shelter roof was observed caused by a large fissure in the south side of the shelter back wall. The results of the monitoring inspection are detailed in Table 5 below, and Plate 37 to Plate 50 show the monitoring photographs and comparison images for the site.

Table 5: S1MC484 (AHIMS ID# 36-3-3788) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3788	S1MC484	Shelter roof collapsed - total roof collapse with large fissure in the south side of the shelter back wall. Smaller fissure cracking in and around this larger crack shows this to be a weak point that failed. No obvious surface fissuring but potential for the weak point to line up with direction of subsidence cracking from nearby shelter, S1MC356b. PAD preserved under collapsed roof section. Some of the collapsed roof has remained intact, with some associated blockfall. Although these types of impacts can occur naturally at sandstone overhangs, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions. <u>RAP comments recorded during S1MC484 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 37: General photo of site S1MC484 (AHIMS ID# 36-3-3788), facing north. Photo taken on 21 November 2022.	 Plate 38: General photo of site S1MC484 (AHIMS ID# 36-3-3788) with shelter roof collapsed. Photo taken on 11 December 2025.
 Plate 39 General photo of site S1MC484 (AHIMS ID#36-3-3788), facing north-east. Photo taken on 21 November 2022.	 Plate 40: General photo of site showing roof collapse, facing north-east. Photo taken on 11 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
Plate 41: General view of shelter area. Photo taken on 21 November 2022.	Plate 42: General view of shelter area with recent roof collapse. Photo taken on 11 December 2025.
	
Plate 43: Northern section of shelter view to the west. Photo taken on 21 November 2022.	Plate 44: Northern section of shelter affected by roof collapse, facing west. Photo taken on 11 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 45 Northern area of shelter mid section, view to the west. Photo taken on 21 November 2022.	 Plate 46: Northern area of shelter mid section affected by roof collapse, facing west. Photo taken on 11 December 2025.
 Plate 47: Midsection with deposit floor detail. Photo taken on 21 November 2022.	 Plate 48: Midsection affected by roof collapse obscuring deposit floor detail. Photo taken on 11 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
Plate 49: Southern end of shelter, wall and overhang exposure detail. Photo taken on 21 November 2022.	Plate 50: Southern end of shelter and wall affected by roof collapse debris. Photo taken on 11 December 2025.



2.1.5 S1MC494 (AHIMS ID# 36-3-3793)

S1MC494 consists of a sandstone outcrop with overhang and shelter. Located at the base of a ridge, it is positioned with a creek to the north and an actively running drainage line to the west. The shelter comprises of conglomerate sandstone with horizontal bedding, with bands of thicker conglomerate pebbles and ironstone (approximately 5 to 10 cm thick). The shelter is graffitied. A PAD consists of a sandy deposit, estimated to be > 50 cm in depth at the dripline. A small overhang is located to the east and contains an artefact scatter.

This site was baseline recorded and surface collection was completed in 2022 by Niche as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, minimal change to blockfall and fissure cracking was observed in the interior western wall of the shelter. The results of the monitoring inspection are detailed in Table 6 below, and Plate 51 to Plate 62 show the monitoring photographs and comparison images for the site.

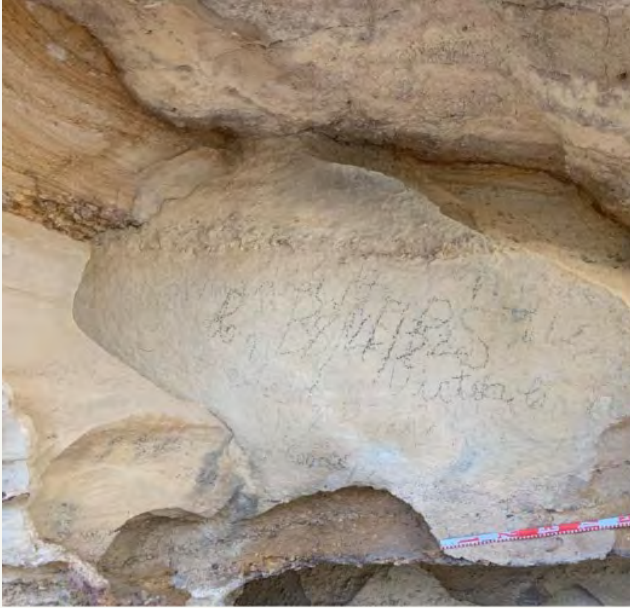
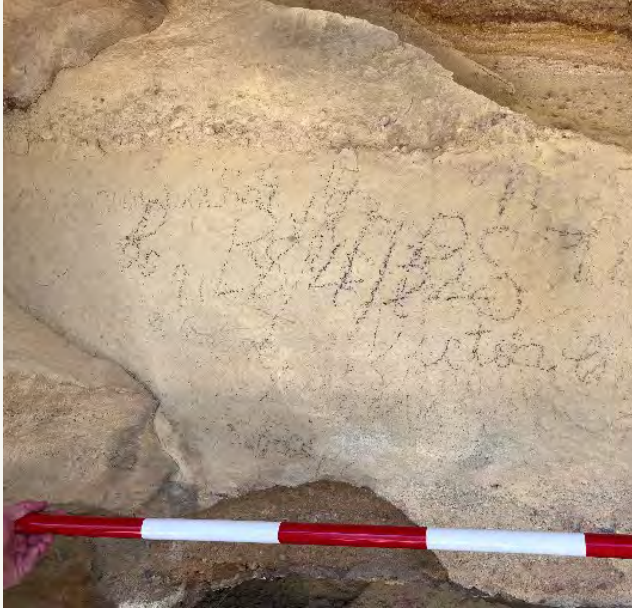
Table 6: S1MC494 (AHIMS ID# 36-3-3793) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3793	S1MC494	Minimal change to blockfall and weathering elements that affect the shelter. Fissuring noted. Some transverse fissuring can be seen on the shelter roof. Cracking was identified in front of the eastern overhang running in an east west direction. Other fissure cracks were found behind the top of rock that covers the top of the shelter. Other recent fissuring was also found to the east outside of the site (Plate 61). Although these types of impacts can occur naturally at sandstone overhangs, the changes observed since the baseline inspection were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions. <u>RAP comments recorded during S1MC494) site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 51: S1MC494 (AHIMS ID#36-3-3793), overhang containing stone artefacts, primary deposit and overhang is to the west (right of this frame). Photo taken on 29 November 2022.	 Plate 52: Eastern shelter (smaller shelter). Photo taken on 9 December 2025.
 Plate 53: S1MC494 (AHIMS ID#36-3-3793) Shelter (primary overhang) with Artefacts and PAD, stone artefacts were identified to the east (left of this frame). Photo taken on 29 November 2022.	 Plate 54: Primary overhang with artefacts and PAD. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 55: S1MC494 (AHIMS ID#36-3-3793), facing east. Photo taken on 29 November 2022.	 Plate 56: View of main shelter facing northeast. Photo taken on 9 December 2025.
 Plate 57: Graffiti panel 1 detail. Photo taken on 29 November 2022.	 Plate 58: Graffiti panel 1 detail. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
Plate 59: Graffiti panel 2. Photo taken on 29 November 2022.	Plate 60: Graffiti panel 2 in background with fissure crack in front of shelter in foreground. Photo taken on 9 December 2025.
No prior baseline photographs available.	
	Plate 61: Evidence of fissure cracks found on top of the rock that covers the shelter. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
<i>No prior baseline photographs available</i>	 Plate 62: Evidence of fissure cracks found on top of the rock that covers the shelter. Photo taken on 9 December 2025.



2.2 Sites with no observed mining-related impacts

The post-mining inspection identified six sites with no observed impact from mining-related subsidence. A detailed outline of the findings with supporting visuals are outlined in Sections 3.3.1 to 3.3.6.

2.2.1 S1MC271 (AHIMS ID# 36-3-1086)

S1MC271 consists of a conglomerate sandstone rock shelter, originally identified by Hamm (2006). Prior to commencement of LW401-407, S1MC271 has been subjected to cavernous weathering, minor block fall, and spalling and exfoliation, originally identified with eight stone artefacts.

This site was baseline recorded by Niche in November 2022 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025). Site management actions are considered complete.

During the post-mining inspection undertaken in December 2025, the site demonstrated minor blockfall, and some fissuring/cracking in the midsection and eastern section of the shelter. The results of the monitoring inspection are detailed in Table 7 below, and Plate 63 to Plate 76 show the monitoring photographs and comparison images for the site.

Table 7: S1MC271 (AHIMS ID# 36-3-1086) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-1086	S1MC271	The shelter was found still characterised by weathering, blockfall and spalling. Eight artefacts were originally recorded, but no artefacts were visible during this survey (or the baseline survey in 2022). Evidence of a PAD was found in the Eastern and Western sector of the sand. Signs of recent blockfall was observed coinciding with missing pieces of weathered sandstone, concentrated in the middle section and across the shelter. Transverse cracking was observed on the roof of the western section, cracks did not penetrate the surface of the roof beyond 5 mm. Fissures associated with undercut sandstone were observed around the border of the shelter's openings, some recently formed. Pre-existing fissuring still evident but unchanged from previous survey. Evidence of animal activity can also be observed in the western section of the shelter site at its base. No mining or subsidence-related impacts to the site were observed. The observed impacts are natural in origin, as they are known to occur naturally in sandstone overhangs. The weathering through exfoliation of a cavernous weathered shelter is a natural progression of the post depositional agents acting on the bedding plane of sandstone. RAP comments recorded during S1MC271 site inspection: The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site. The western section of the shelter was noted by RAPs as containing signs of a hearth/fire use.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 63: General photo of site S1MC271 (AHIMS ID# 36-3-1086). Photo taken on 29 November 2022.	 Plate 64: General photo of site S1MC271 (AHIMS ID# 36-3-1086). Photo taken on 9 December 2025.
 Plate 65: Western section of site - view north. Photo taken on 29 November 2022.	 Plate 66: Western section of site - view north. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 67: Midsection of shelter. Photo taken on 29 November 2022.	 Plate 68: Midsection of shelter. Photo taken on 9 December 2025.
 Plate 69: Western section of site - interior details, view north. Photo taken on 29 November 2022.	 Plate 70: Western section of site - interior details, view north. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 71: Midsection of site - floor fissure details. Photo taken on 29 November 2022.	 Plate 72: Midsection of site - floor fissure has not widened or become compressed. Photo taken on 9 December 2025.
 Plate 73: Midsection of site - roof interior details. Photo taken on 29 November 2022.	 Plate 74: Midsection of site - roof interior details. Minor cracking in the midsection roof was apparent. Photo taken on 9 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
	
Plate 75: Eastern section of shelter, view to the north east. Photo taken on 29 November 2022.	Plate 76: Some natural erosion processes continued to remove roof spall in the eastern section of the shelter. Minor cracking was observed in the roof and back wall. Photo taken on 9 December 2025.



2.2.2 S1MC280 Ulan Creek 2 (AHIMS ID# 36-3-0042)

S1MC280 (Ulan Creek 2; AHIMS ID# 36-3-0042) contains a shelter with art, artefacts, grinding grooves and PAD and is located above the chain pillar between LW402 and LW403. S1MC280 (Ulan Creek 2; AHIMS ID# 36-3-0042) was first recorded in 1989 with the dimensions 14 x 6.5 x 2 m. Rock slabs with areas of polish were identified, in addition to seven grinding grooves and an artefact scatter. Potential for further grooves, obscured by soil and vegetation was noted. The artefact scatter included a core and several flakes of dark grey chert, brown chert, milky quartz, and basalt raw materials.

This site was baseline recorded by Niche in 2021. Test excavation and photogrammetry were completed in 2025 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

S1MC280 was subject to detailed monitoring and management during extraction of LW401-407 in accordance with the LW401-408 HMP. The post-mining inspection undertaken in December 2025 identified no mining or subsidence-related impacts to this site. The results of the monitoring inspection are detailed in Table 8 below, and Plate 77 to Plate 92 show the monitoring photographs and comparison images for the site.

Table 8: S1MC280; Ulan Creek 2 (AHIMS ID# 36-3-0042) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-0042	S1MC280	No mining or subsidence-related impacts to the site were observed, which is consistent with the MSEC (2021) subsidence predictions. Previously recorded fissures do not appear to have been impacted by subsidence related movement. A pre-existing crack located on the rear wall of the shelter contains increased modern soil deposition but shows no evidence of widening, propagation, or additional structural movement. The blockfall surface within the shelter retains a smooth polish consistent with previous assessments indicating food processing activity. Eight grinding grooves remain present on the blockfall/sandstone outcrop situated to the north of the shelter, arranged in three groupings (1, 4 and 3), and these features remain intact and unchanged. The art panel containing a hand stencil motif on the back wall also remains unchanged, with an additional iron oxide motif still visible near the central portion of the shelter wall. The post depositional conditions and environmental agents held relatively consistent since the baseline recording, with continuing waterwash damage evident. Graffiti documented during earlier inspections persists on sections of the roof and back wall. Charcoal and carbonisation remain evident on the roof surface. Waterwash continues to affect the exterior surfaces of the shelter and minor erosion, including areas of exfoliation and scalping, is visible on portions of the roof. Six stone artefacts were identified within the shelter and along the dripline during the inspection. Subsurface mitigation measures previously installed above the shelter remain in place. The stress relief cuts have begun to infill with sediment along the western lower wall. Additional channels visible across the upper and rear surfaces of the shelter appear consistent with previously installed drainage and subsidence relief works. <u>RAP comments recorded during S1MC280 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.

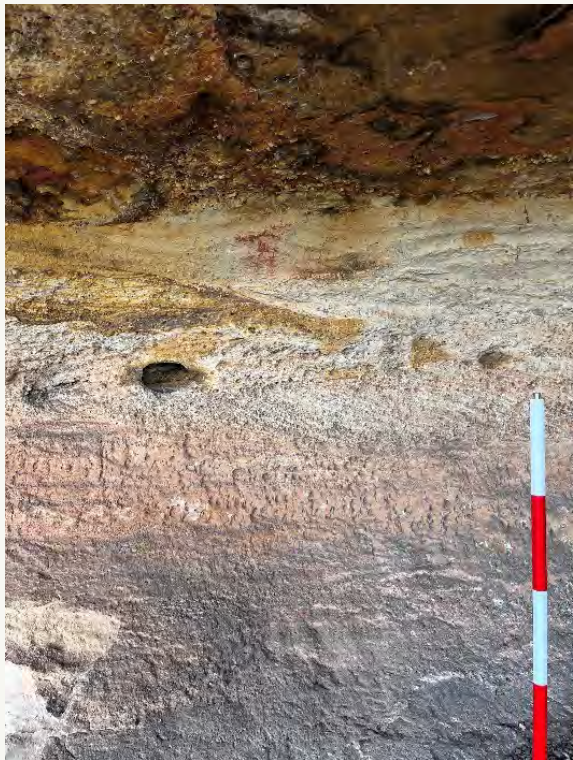


Baseline recording (Mar 2021)	Post-mining recording (Dec 2025)
 Plate 77: S1MC280 (AHIMS ID#36-3-0042) site overview photograph. Photo taken on 17 March 2021.	 Plate 78: S1MC280 (AHIMS ID#36-3-0042) site overview photograph. Photo taken on 11 December 2025.
 Plate 79: S1MC280 (AHIMS ID#36-3-0042), facing north from centre of shelter towards grinding groove blockfall, towards hand stencils. Photo taken on 17 March 2021.	 Plate 80: S1MC280 (AHIMS ID#36-3-0042), facing north from centre of shelter towards grinding groove blockfall, towards hand stencils. Photo taken on 11 December 2025.



Baseline recording (Mar 2021)	Post-mining recording (Dec 2025)
Plate 81: Detail of rear wall at S1MC280 (AHIMS ID#36-3-0042), with graffiti and fresh exfoliation. Photo taken on 17 March 2021.	Plate 82: Detail of rear wall at S1MC280 (AHIMS ID#36-3-0042), with graffiti and fresh exfoliation. Photo taken on 11 December 2025.
Plate 83: Detail of rear wall at the southern end of S1MC280 (AHIMS ID#36-3-0042). Floor covered in charcoal. Photo taken on 17 March 2021.	Plate 84: Detail of rear wall at the southern end of S1MC280 (AHIMS ID#36-3-0042). Floor covered in charcoal. Photo taken on 11 December 2025.



Baseline recording (Mar 2021)	Post-mining recording (Dec 2025)
 Plate 85: Detail of southern end of S1MC280 (AHIMS ID#36-3-0042), showing vertical and diagonal cracks through rear wall and blockfall with smooth polish. Photo taken on 17 March 2021.	 Plate 86: Detail of southern end of S1MC280 (AHIMS ID#36-3-0042), showing vertical and diagonal cracks through rear wall and blockfall with smooth polish. Photo taken on 11 December 2025.
 Plate 87: Detail of iron oxide staining on rear wall of S1MC280; Ulan Creek 2 (AHIMS ID#36-3-0042). Photo taken on 17 March 2021.	 Plate 88: Detail of iron oxide staining on rear wall of S1MC280; Ulan Creek 2 (AHIMS ID#36-3-0042). Photo taken on 11 December 2025.



Baseline recording (Mar 2021)	Post-mining recording (Dec 2025)
 Plate 89: Grinding groove detail at S1MC280; Ulan Creek 2 (AHIMS ID#36-3-0042). Photo taken on 17 March 2021.	 Plate 90: Grinding groove detail at S1MC280; Ulan Creek 2 (AHIMS ID#36-3-0042). Photo taken on 11 December 2025.
 Plate 91: S1MC280 (AHIMS ID#36-3-0042) hand stencil detail. Photo taken on 17 March 2021.	 Plate 92: S1MC280 (AHIMS ID#36-3-0042) hand stencil motif detail, taken in December 2025. Photo taken on 11 December 2025.



2.2.3 S1MC472 (AHIMS ID# 36-3-3803)

S1MC472 consists of a sandstone outcrop in a continuous ridgeline with overhang and shelter with a PAD and isolated find. Located within a ridgeline, S1MC472 has been subjected to cavernous weathering and block fall. The interior consists of conglomerate sandstone with horizontal bedding. The shelter floor is sloped with a PAD of approximately 20 cm deep. It has been disturbed by animal burrowing. A complete quartz flake was identified in the dripline of the shelter.

Baseline recording, surface collection and test excavation for this site were all completed in 2022, controlled salvage excavation was finalised in 2023, and post-excavation artefact analysis was concluded in 2025 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

The post-mining inspection undertaken in December 2025 identified no mining or subsidence-related impacts to this site. The results of the monitoring inspection are detailed in Table 9 below, and Plate 93 to Plate 100 show the monitoring photographs and comparison images for the site.

Table 9: S1MC472 (AHIMS ID# 36-3-3803) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3803	S1MC472	No mining or subsidence-related impacts to the site were observed, which is consistent with the MSEC (2021) subsidence predictions. Original inspection noted fissuring to the back wall of the shelter. No changes to the fissure as noted by the current inspection. This site was subject to salvage investigations in 2023 (three test pits), and the PAD was salvaged and backfilled within the shelter. Lack of current animal activity noted. No change to the previously noted erosion processes that affect the shelter. Fallen branches beside the shelter remain in the same location. <u>RAP comments recorded during S1MC472 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 93: S1MC472 (AHIMS ID#36-3-3803) general overview, facing northeast. Photo taken on 23 November 2022.	 Plate 94: S1MC472 (AHIMS ID#36-3-3803) general overview, facing northeast. Photo taken on 10 December 2025.
 Plate 95: S1MC472 (AHIMS ID#36-3-3803) general overview, facing northeast (Incorrect site photo taken of different site that was published in baseline report). Photo taken on 23 November 2022.	 Plate 96: S1MC472 (AHIMS ID#36-3-3803) general overview, facing northeast (Incorrect site photo taken of different site that was published in baseline report). Photo taken on 10 December 2025.



Baseline recording (Nov 2022)	Post-mining recording (Dec 2025)
 Plate 97: S1MC472 (AHIMS ID#36-3-3803) general overview, facing east. Photo taken on 23 November 2022.	 Plate 98: S1MC472 (AHIMS ID#36-3-3803) general overview, facing east. Photo taken on 10 December 2025.
 Plate 99: S1MC472 (AHIMS ID#36-3-3803) fissuring occurring through sandstone banding. Photo taken on 23 November 2022.	 Plate 100: S1MC472 (AHIMS ID#36-3-3803) fissuring occurring through sandstone banding has not widened or compressed. Some reddening of profile likely fire or chemical weathering induced. Photo taken on 10 December 2025.



2.2.4 S1MC474 (AHIMS ID# 36-3-3785)

S1MC474 consists of a sandstone outcrop within a continuous overhang and shelter with PAD. Located along the ridgeline of a gully, S1MC474 has been subjected to cavernous weathering, and block fall along the dripline prior to LW401-407. The interior consists of conglomerate sandstone with fissuring occurring along the ceiling. The PAD is approximately 30 - 40 cm deep and extends beyond the dripline downslope. Six surface artefacts were identified along with a PAD, sourced from various materials including quartz, tuff, chert, fossilised wood, and fine-grained volcanic material.

Baseline recording, surface collection and test excavation for this site was completed in 2021, controlled salvage excavation was finalised in 2023, and post-excavation artefact analysis was concluded in 2024 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, the site demonstrated that minor fissuring that was observed previously may have increased on the rear wall and roof of the eastern and western shelter due to natural weathering patterns. The results of the monitoring inspection are detailed in Table 10 below, and Plate 101 to Plate 106 show the monitoring photographs and comparison images for the site.

Table 10: S1MC474 (AHIMS ID# 36-3-3785) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3785	S1MC474	No mining or subsidence-related impacts to the site were observed, which is consistent with the MSEC (2021) subsidence predictions. Minor fissuring that was observed previously may have increased on the rear wall and roof of the eastern and western shelter. This has been caused by the process of existing exfoliation already evident in the shelter. This shelter has been subjected to previous archaeological investigations of the recorded PAD. The entirety of the PAD has been removed from the shelter spaces. Two quartz artefacts were found within the vicinity of the shelter. <u>RAP comments recorded during S1MC474 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site suggested it would be beneficial to backfill the areas where the PAD was excavated within the shelter spaces. The RAPs requested that backfill be sourced from the same location as the sieve backfill.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 101: General photo of site S1MC474 (AHIMS ID#36-3-3785), facing east. Stone artefacts eroding from dripline and visible at exposure around tree. Twin, stone floored shelter located to the south-east (right of frame). Photo taken on 30 November 2021.	 Plate 102: General photo of site S1MC474 (AHIMS ID#36-3-3785), facing east. Photo taken on 10 December 2025.
 Plate 103: General photo of primary overhang at S1MC474 (AHIMS ID#36-3-3785), facing east. Photo taken on 30 November 2021.	 Plate 104: View of primary overhang and test excavation location at S1MC474. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
	
Plate 105: General photo of twin shelter at S1MC474 (AHIMS ID#36-3-3785), facing east. Stone artefacts present at front of shelter. Photo taken on 30 November 2021.	Plate 106: View of S1MC474 (AHIMS ID#36-3-3785) facing south towards shelter from opposite angle to baseline photograph. Photo taken on 10 December 2025.



2.2.5 S1MC488 (AHIMS ID# 36-3-3790)

S1MC488 consists of sandstone outcrop with overhang and shelter located in a continuous ridgeline. S1MC488 has formed through cavernous weathering and has been undermined and extended through animal burrowing to a depth of 9 m. Animal fur and animal bones were located within the shelter. The shelter contains a PAD, with a quartz flake located on the surface and within the dripline.

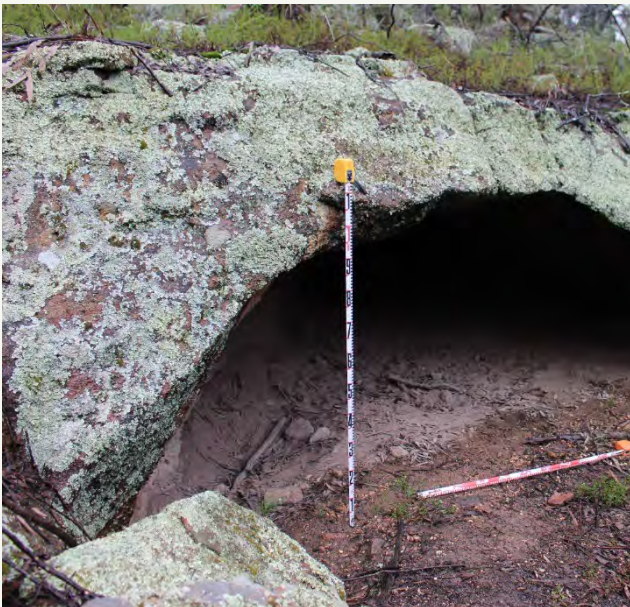
Baseline recorded and surface collection were completed by Niche in 2021 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

During the post-mining inspection undertaken in December 2025, minor roof fall and fissure cracking was observed in the interior western wall of the shelter. The results of the monitoring inspection are detailed in Table 11 below, and Plate 107 to Plate 114 show the monitoring photographs and comparison images for the site.

Table 11: S1MC488 (AHIMS ID# 36-3-3790) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3790	S1MC488	No mining or subsidence-related impacts to the site were observed, which is consistent with the MSEC (2021) subsidence predictions. The observed impacts to the site are natural in origin. Shelter was found with minimal change compared to the previous recording. One tibia bone was identified inside the shelter. The other animal bone and the artefact were not observed and may be buried within the deposit inside the shelter. Transverse cracking can be seen on the roof of the shelter and extends to the walls. Hornets and a nest were found inside the shelter. Another tibia bone was found in the dry drainage line outside the shelter. <u>RAP comments recorded during S1MC488 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 107: General photo of site S1MC488 (AHIMS ID# 36-3-3790), facing north. Photo taken on 30 November 2021.	 Plate 108: Shelter opening and structurally intact S1MC488 (AHIMS ID# 36-3-3790), facing north. Photo taken on 10 December 2025.
 Plate 109: General photo of site S1MC488 (AHIMS ID# 36-3-3790), facing north. . Photo taken on 30 November 2021.	 Plate 110: Close up of shelter dripline, facing north. Photo taken on 10 December 2025.



Baseline recording (Nov 2021)	Post-mining recording (Dec 2025)
 Plate 111: Close up of the shelter interior at site S1MC488 (AHIMS ID# 36-3-3790), facing north west. Photo taken on 30 November 2021.	 Plate 112: Close up of the shelter interior at site S1MC488 (AHIMS ID# 36-3-3790), facing north west. Photo taken on 10 December 2025.
 Plate 113: Close up of the shelter interior at site S1MC488 (AHIMS ID# 36-3-3790), facing north. Photo taken on 30 November 2021.	 Plate 114: Close up of interior, some reddening of interior suggests fire or chemical weathering processes. Photo taken on 10 December 2025.



2.2.6 S1MC491 (AHIMS ID# 36-3-3792)

S1MC491 is located approximately 50 m north of S1MC474 and comprises a large overhang with PAD. The site is situated in a gully along Bora Creek. The formation consists of a conglomerate sandstone exposure, formed through cavernous weathering and blockfall. The shelter is large, measuring 8 m wide and 2 m deep, with a height ranging from 1 to 3 m. The floor is rocky with minor to moderate blockfall, though areas at and downslope of the dripline are reported as relatively level.

The site contains a PAD estimated to be greater than 30 cm deep. This sandy PAD extends into the dripline and downslope of the shelter. However, there are significant disturbances from animal burrowing, and the site generally shows signs of active weathering. Condition reports note extensive natural damage, including salt/granular loss and microvegetals, along with fissuring, spalling/exfoliation (especially in the rear of the shelter), and extensive waterwash. Evidence of fire damage is also noted. While no Aboriginal objects were identified within the PAD area during initial baseline recording, baseline recording indicated that the site contains a number of sandstone overhangs, two of which contained visible stone artefacts.

This site was baseline recorded by Niche in 2021 as part of the UG4 LW401-408 Baseline Report - Aboriginal Heritage Recording Program (Niche 2025).

The post-mining inspection undertaken in December 2025 identified no mining or subsidence-related impacts to this site. The results of the monitoring inspection are detailed in Table 12 below, and Plate 115 to Plate 130 show the monitoring photographs and comparison images for the site.

Table 12: S1MC491 (AHIMS ID# 36-3-3792) monitoring inspection results

AHIMS number	Site name	Results of monitoring inspection
36-3-3792	S1MC491	No mining or subsidence-related impacts to the site were observed, which is consistent with the MSEC (2021) subsidence predictions. Shelter may have experienced further deposition of sand on some of the rock benches within its interior as a result of weathering. Natural erosion processes including exfoliation, granular loss and waterwash have continued in between inspections. Also, lichen vegetation is confined to the western end of the shelter. Minor fissuring associated with exfoliation and granular loss can be observed on the roof of the shelter and parts of the rear wall. Area of previous waterwash from interior seepage within the shelter is no longer active as shown by dead vegetation. This may also be evident of a reduction of water or rainfall source. It also must be noted that the nearby Bora Creek was dry and did not have any running water at the time of the inspection. The shelter's condition remains the same from the previous inspection. <u>RAP comments recorded during S1MC491 site inspection:</u> The RAP field representatives present during the monitoring inspection of the site did not submit comments regarding the management of the site.



Baseline recording (Dec 2021)



Plate 115: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north-west. Photo taken on 2 December 2021.

Post-mining recording (Dec 2025)



Plate 116: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north-west. Photo taken on 10 December 2025.



Plate 117: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north. Photo taken on 2 December 2021.



Plate 118: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north. Photo taken on 10 December 2025.



Baseline recording (Dec 2021)



Plate 119: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north. Photo taken on 2 December 2021.

Post-mining recording (Dec 2025)



Plate 120: General photo of site S1MC491 (AHIMS ID# 36-3-3792), facing north. Photo taken on 10 December 2025.



Plate 121: Close up of shelter interior at site S1MC491 (AHIMS ID# 36-3-3792), facing west. Photo taken on 2 December 2021.



Plate 122: Close up of shelter interior at site S1MC491 (AHIMS ID# 36-3-3792), facing west. Photo taken on 10 December 2025.



Baseline recording (Dec 2021)



Plate 123: Close up of shelter interior at site S1MC491 (AHIMS ID# 36-3-3792), facing north-east. Photo taken on 2 December 2021.

Post-mining recording (Dec 2025)



Plate 124: Close up of shelter interior at site S1MC491 (AHIMS ID# 36-3-3792), facing north-east. Photo taken on 10 December 2025.

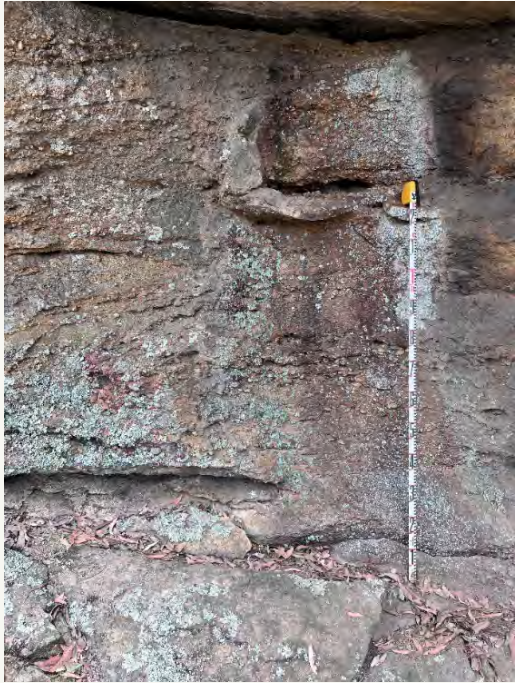


Plate 125: Close up of weathered sandstone at site S1MC491 (AHIMS ID# 36-3-3792), showing the salt/granular loss and microvegetals present. Photo taken on 2 December 2021.



Plate 126: Close up of weathered sandstone at site S1MC491 (AHIMS ID# 36-3-3792), showing the salt/granular loss and microvegetals present. Photo taken on 10 December 2025.



Baseline recording (Dec 2021)	Post-mining recording (Dec 2025)
 Plate 127: Close up of shelter at site S1MC491 (AHIMS ID# 36-3-3792), showing an area of extensive waterwash. Photo taken on 2 December 2021.	 Plate 128: Close up of shelter at site S1MC491 (AHIMS ID# 36-3-3792), showing an area of extensive waterwash. Photo taken on 10 December 2025.
 Plate 129: Close up of shelter at site S1MC491 (AHIMS ID# 36-3-3792), showing the presence of spalling/exfoliation in the rear of the shelter. Photo taken on 2 December 2021.	 Plate 130: Close up of shelter at site S1MC491 (AHIMS ID# 36-3-3792), showing the presence of spalling/exfoliation in the rear of the shelter. Photo taken on 10 December 2025.



3 Discussion and conclusions

Of the eleven sites subject to post-mining inspection for this EoP report, five sites were identified with observed mining or subsidence-related impacts from LW401-407. Although impacts can occur naturally, the changes observed since the baseline in question were attributed to mining subsidence as a result of an extraction of LW401-407, which is supported by the MSEC (2021) subsidence predictions.

No mining or subsidence-related impacts were observed for the remaining six sites due to the extraction of LW401-407, including no observed impacts to S1MC280. Based on this, the management plan for S1MC280 has been successfully implemented and the performance measure of 'reduce the likelihood of subsidence damage to moderate' for S1MC280 has been met.

No further monitoring/inspections are required for any of the eleven sites assessed in this report.

It is recommended that a copy of this report is distributed to the RAPs, Heritage NSW and the Department of Planning, Housing and Infrastructure in accordance with the LW401-408 HMP (MCO 2022).



4 References

Hamm G (2006) Moolarben Coal Project Aboriginal Cultural Heritage Assessment Report. A report to Moolarben Coal Mines Pty Limited.

Mine Subsidence Engineering Consultants (2021) Moolarben Project Stage 1 - Longwalls 401 to 408: Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan.

Moolarben Coal Operations Pty Ltd (2022) UG4 Longwalls 401 to 408 Heritage Management Plan.

Moolarben Coal Operations Pty Ltd (2023) UG4 Longwalls 401 to 408 Subsidence Monitoring Program.

Niche Environment and Heritage (2021) UG4 Longwalls 401-408 Extraction Plan Aboriginal Cultural Heritage Technical Report.

Niche Environment and Heritage (2025) UG4 LW 401-408 Baseline Report - Aboriginal Heritage Recording Program.



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Our expertise



Natural
capital
and offsetting



Ecology



Heritage
management



Spatial
Services

APPENDIX F

**MOOLARBEN COAL COMPLEX UG4 LONGWALLS 401 TO 407 END OF PANEL REPORT
– INDEPENDENT REVIEW OF GROUNDWATER AND SURFACE WATER IMPACTS FROM LW401-407
(DR LLOYD TOWNLEY, 2026)**

Moolarben Coal Operations Pty Ltd
12 Ulan-Wollar Road
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Attention: Ian Flood, Environment & Community Manager

26 August 2026

Dear Ian

Review of MCO UG4 LW401-407 End of Panel (EoP) Report – Groundwater and Surface Water

I understand the requirement for Moolarben Coal Operations (MCO) to prepare an End of Panel (EoP) Report following completion of UG4 LW401-407. I also understand that the Department of Planning, Housing and Infrastructure (DPHI) has requested that I undertake an independent review of predicted versus observed groundwater and surface water impacts, as part of the EoP Report.

DPHI has advised that the EoP Report needs to address the following water-related components:

- *data and trends for all underlying groundwater systems, and an assessment of impacts to the Triassic sandstone aquifer and its environmental and cultural assets adjacent to and downstream of the UG4 area, and*
- *surface water data and trends for the Goulburn River adjacent to and downstream of the UG4 area.*

Since early in 2026 I have read many reports related to impacts of mining at MCO and neighbouring mines, specifically related to impacts on regional groundwater and surface water, including the Goulburn River, its tributaries and The Drip. I have prepared reviews that have been provided to DPHI and DPHI has agreed that MCO can engage me as an independent expert. I have recently been engaged by MCO as an independent expert on groundwater and surface water in relation to the Extraction Plan for LW409-414. In the future I will be a member of the Technical Committee regularly reviewing impacts of mining at LW409-414, panel by panel, as mining proceeds. I have also been endorsed by DPHI as a suitably qualified technical expert to undertake an independent peer review of the update of the regional groundwater model for the Moolarben Coal Complex (MCC). This recent experience means that I have sufficient recent and relevant experience to provide this review of the UG4 LW401-407 EoP Report.

Groundwater

I have reviewed the Groundwater Review report prepared by AGE (2026), which is a component of MCO's UG4 LW401-407 EoP Report. The report starts by describing the groundwater monitoring network and agreed investigation threshold values for groundwater levels and groundwater quality. The overarching performance measure related to water management, hence groundwater, is that there should be nil impact on the water supply to The Drip (Table 2.2 of the report).

Section 3 of the report provides discussions of (i) groundwater inflows into MCO underground mining areas UG1 and UG4, (ii) groundwater levels, (iii) groundwater quality, (iv) interaction between groundwater and surface water in relation to Goulburn River baseflows, (v) private bores and (vi) The Drip. In most cases, the discussion relies on comparisons against trigger levels to demonstrate that observed changes are less than or consistent with predictions. In the following I provide brief discussion of each of the topics listed above:

- i. Combined groundwater inflows to UG1 and UG4 during the period from July 2020 to June 2022 exceeded model predictions (Table 3.1 in AGE (2026)), this being a period during which first workings for UG4 were being developed, before the start of UG4 LW401. Mining commenced in UG4 LW401-402 in the year from July 2022 to June 2023 (Table 1.1 in AGE (2026)) and combined groundwater inflows again exceeded predictions, but this was an extremely wet year, and there is no suggestion that model predictions were inadequate. In the next 2.5 years to January 2026, total estimated groundwater inflows were less than predicted. The estimated cumulative inflow to UG1 and UG4 from the start of LW401 in July 2022 to the end of LW407 is less than predicted. It should be noted that groundwater inflows to mines are estimated rather than measured (as is an approved practice for large mines), because several different types of measurements need to be combined. Overall, the agreement between observations and predictions is remarkably good.
- ii. It has always been anticipated that drawdown of the water table in the Triassic sandstone would occur directly over the footprint of longwall panels and otherwise only very close to the perimeter of the footprint of UG4. Table 3.2 in AGE (2026) shows that significant drawdown was only predicted in three observation bores, two near the perimeter of LW401-408 and one inside the footprint of mining, between LW407 and LW408 (bore locations are shown in Figure 2.1 of AGE (2026)); two of these observation bores are now dry, so drawdown can no longer be measured; at the third location, PZ194B, near the eastern end of LW404, observed drawdown is much less than predicted. Negligible drawdown was predicted at other bores further to the north, near the extremities of future mining at LW409-414, and observations are consistent with these predictions. Three of these distant bores were nominated as trigger bores for the LW401-408 Extraction Plan and observed water table elevations remain 1.2 to 2 m above trigger levels.
- iii. There was never an expectation that development of LW401-408 would influence water quality in the Triassic sandstone. Observations of electrical conductivity (EC) and pH are consistent with expectations, within previously observed ranges and lower than defined trigger levels.
- iv. During mining of LW401-407, additional monitoring of water table elevations and surface water elevations has provided new insights into the interaction between groundwater and surface water in relation to Goulburn River baseflows near UG4. The water table elevation at PZ237A near surface water gauge SW2 has remained higher than the surface water elevation during mining of LW401-407, implying groundwater flow towards the Goulburn River at that location. At PZ234A near SW22, further downstream, the reverse is true, suggesting possible discharge of river water towards the aquifer in the Triassic sandstone. There has been a steady downward trend in water table elevation at PZ234A, about 0.3 m/y. The current interpretation of these observations is that drawdown may be due to a slightly drier climatic period. The lowering of the water table at PZ234A is not caused by mining in LW401-407 because other monitoring bores closer to UG4 mining do not show this trend.
- v. No impact was predicted at the nearest private bore (GW800279, see Figure 2.1 in AGE (2026)) and no drawdown has been observed at monitoring bores between UG4 and that bore during mining of LW401-407, other than at PZ234A, as mentioned above.
- vi. There is no evidence that water supply to The Drip has been or is being affected by mining operations at UG4. No drawdown has been observed at monitoring bores in the Triassic sandstone closest to The Drip during mining of LW401-407, i.e. at PZ128 (VWP 20m) and PZ129 (VWP 35m) until they were decommissioned or at replacement bores PZ256A and PZ257A since August 2025.

Based on the above, AGE (2026, Section 4) conclude that MCO has complied with all groundwater-related performance measures outlined in Condition 32 and Condition 73 Schedule 3 of Project Approval (05_0117) during mining of UG4 LW401-407. This seems to be a fair conclusion.

Surface Water

I have reviewed the Surface Water report prepared by WRM (2026), which is a component of MCO's UG4 LW401-407 EoP Report. The report starts by describing the drainage network near UG4 LW401-408 and the surface water monitoring program.

Section 4 of the report provides discussions of predicted versus observed impacts on surface water features caused by mining of LW401-407, specifically (i) subsidence impacts on Bora Creek, (ii) subsidence impacts on Drainage Line 1 (DL1), with comments on surface water quality and (iii) subsidence impacts on the Goulburn River, surface water quality in the Goulburn River and surface water flow in the Goulburn River. In the following I provide brief discussion of each of the topics listed above:

- i. The extent and magnitude of LiDAR measurements of subsidence along the main tributary of Bora Creek where it overlies LW401 is consistent with predictions made previously by MSEC (2021) (Figures 4.1 and 4.2 in WRM (2026)). The elevation change along Bora Creek of approximately 30 m over a distance of approximately 1,000 m above the southeast corner of LW401 and LW402 means that the creek has an average bed slope at this location of about 3 percent. This means that, even with predicted vertical subsidence of up to 2 m caused by mining of LW401, surface water runoff in Bora Creek will still flow freely towards the Goulburn River.
- ii. The same is true along DL1 (Figures 4.1 and 4.3 in WRM (2026)), where an elevation change of approximately 80 m over approximately 3,500 m means that there would be minimal impacts due to vertical subsidence of up to 2 m caused by mining of LW407. Note that the most recent LiDAR measurements were made in December 2025, before the end of mining in LW407, but given the remarkable agreement between predictions and observations at Bora Creek and above the eastern two thirds of LW407, there is good reason to expect similar accuracy in the remaining 700 m for which LiDAR data are not available. Surface water monitoring site SW23 lies at the western downstream end of DL1 (Figure 3.1 in WRM (2026)) and according to Table 3.2 (WRM 2026), the Water Management Plan for LW401-408 (MCO 2023) requires regular water quality analyses if DL1 is flowing and also after heavy rainfall events; WRM (2026) explain that flows were insufficient for this sampling to take place.
- iii. There is no evidence of observed subsidence effects along the Goulburn River, since mining has taken place more than 400 m from the river. Analysis of water quality at three locations where trigger investigation values had been defined show that pH has always been within range, four samples had slightly elevated EC and 13 samples had elevated turbidity. Trigger events occur when a trigger level is exceeded in two consecutive months: this happened once for EC in December 2022 – January 2023 and once for turbidity in July-August 2022, but investigations showed that these exceedances were caused by inflow of poor quality water from the upstream catchment. Measurements of flow in the Goulburn River suggest that from December 2023 to December 2025, there was no evidence of loss of flow between Ulan SW01 and MCO SW02 gauges. Analysis of 7-day average flows in the same 2-year period show that there is nearly always a gain in flow from Ulan SW01 to MCO SW02 and also to MCO SW22. Since MCO SW02 and SW22 are located upstream and downstream of The Drip, respectively, within the accuracy of stream flow estimation, there is no reduction of flow along the Goulburn River in the reach that passes The Drip.

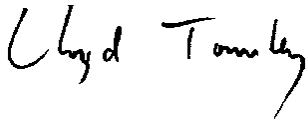
Based on the above, WRM (2026, Section 5, Table 5.1, Section 6) conclude that MCO has complied with surface water and subsidence-related performance measures and TARPs during mining of UG4 LW401-407. Exceedances of EC and turbidity observations on two occasions were investigated appropriately. Their conclusion seems to be consistent with their reporting.

Concluding remarks

Two reports have been prepared to compare predicted and observed groundwater and surface water impacts on relevant features due to mining of LW401-407. They provide good summaries and explanations of data that have been collected during mining. The reports present observed monitoring data and discuss trends related to groundwater drawdown, specifically in the Triassic sandstone aquifer, and surface water quality and flow in the Goulburn River and other ephemeral drainage lines. The reports show no evidence of impact on water supply to The Drip due to mining of LW401-407.

Overall, observed data are consistent with predictions. Agreement between predicted subsidence and LiDAR measurements is remarkably good, suggesting that the methods used by MSEC are mature and reliable. Predictions related to mine inflows and drawdown of groundwater are supported by observations, and the belief that there would be no impact of mining at LW401-407 and groundwater quality is confirmed by data. The prediction that mining at LW401-407 would affect neither surface water flow nor surface water quality has also been confirmed by observations, the only exceedances of water quality thresholds in the Goulburn River in two consecutive months being explained by activities upstream of LW401-407.

Yours sincerely

A handwritten signature in black ink, appearing to read 'Lloyd Townley', with a stylized, cursive script.

Lloyd Townley

References

AGE (2026), *UG4 LW401 to LW407 End of Panel Report – Groundwater Review*, v04.01, 24 August, 45 pp.

MCO (2023), *UG4 Longwalls 401 to 408 Water Management Plan*, Version 2, October, 48 pp.

MSEC (2021), *Moolarben Coal Complex: Moolarben Project Stage 1 – Longwalls 401 to 408, Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan*, November, 87 pp.

WRM (2026), *LW401-407 End-of-Panel Surface Water Report*, 21 August, 24 pp.