



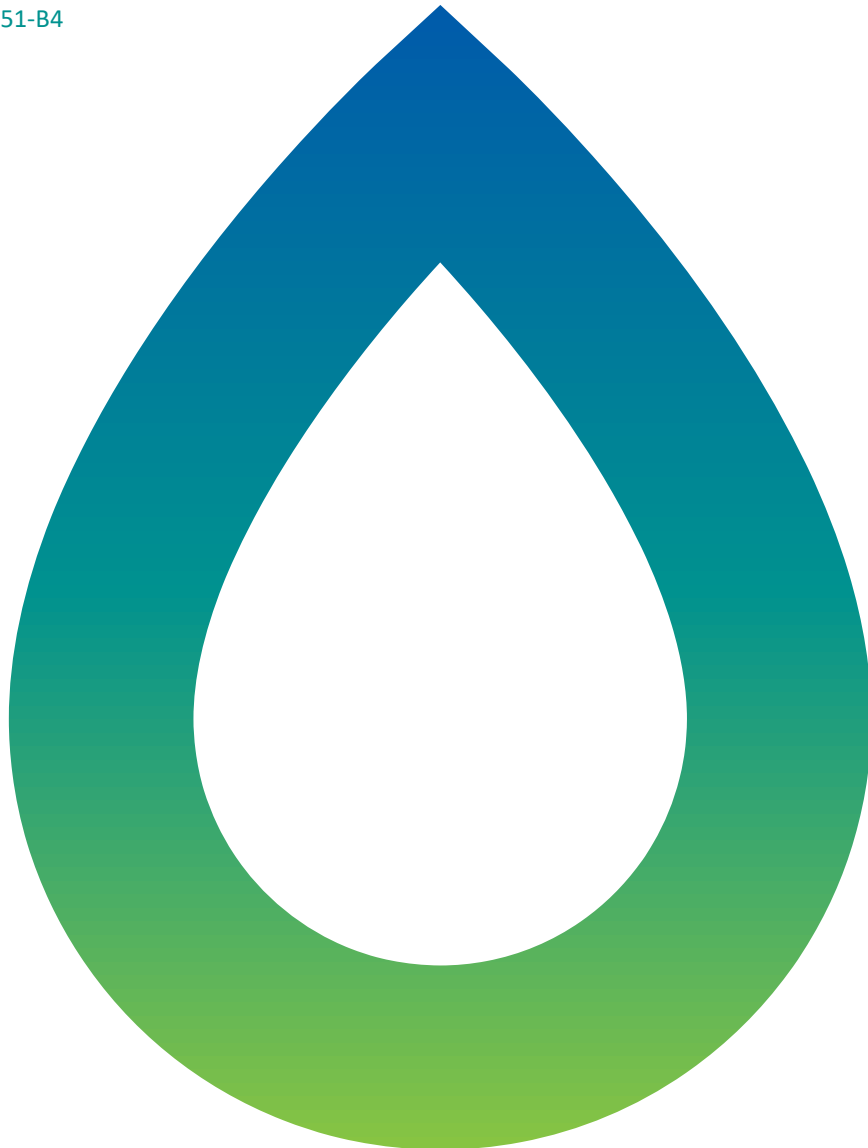
UG4 LONGWALLS 409 TO 414 EXTRACTION PLAN

Surface Water Technical Report

Moolarben Coal Operations Pty Ltd

2 October 2024

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DETAILS

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1 INTRODUCTION

1.1 PROJECT OVERVIEW

The Moolarben Coal Complex is an open cut and underground coal mining operation located approximately 40 kilometres north of Mudgee in the Western Coalfield of New South Wales (NSW) (Figure 1.1).

Moolarben Coal Operations Pty Ltd (MCO) is the operator of the Moolarben Coal Complex on behalf of the Moolarben Joint Venture (Moolarben Coal Mines Pty Ltd [MCM], Yancoal Moolarben Pty Ltd [YM] and a consortium of Korean power companies). MCO, MCM and YM are wholly owned subsidiaries of Yancoal Australia Limited.

The Underground Mine 4 (UG4) is a component of the approved Moolarben Coal Complex (Figure 1.1). First workings for UG4 North Mains commenced in October 2020 (Figure 1.2). Secondary extraction in UG4 of the first Longwall (LW) 401 commenced in July 2022. LW401 to LW403 were completed by December 2023. The extraction of LW 409 to 414 (hereafter referred to as LW409-414) within UG4 is scheduled to commence in March 2026.

The surface water impacts of the UG4 project were assessed in a Subsidence Impact Assessment investigation undertaken by Strata Engineering (SE, 2006), in support of the Stage 1 environmental assessment (EA). After the SE (2006) assessment was completed, the proposed coal seam extraction height was reduced from 4.2 metres (m) to 3.0 m. Approval was subsequently granted for an updated UG4 layout referred to in this report as the 'Approved Layout', which is based on a 3.0 m extraction height.

Mining operations at the Moolarben Coal Complex are currently approved until 31 December 2038 and continue to be carried out 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).

1.2 SCOPE OF THIS REPORT

This Surface Water Technical Report, prepared by WRM Water & Environment Pty Ltd, has been prepared to support an extraction plan for Longwalls 409 to 414 (LW409-LW414) of UG4 to satisfy the requirements of Project Approval (05_0117) (as modified). The relevant Study Area for the extraction plan (LW409-LW414) is shown in Figure 1.1 and Figure 1.2.

Updated subsidence predictions for LW409-414 have been undertaken by Mine Subsidence Engineering Consultants (MSEC, 2024) for the Approved Layout as well as for the Extraction Plan Layout. The Extraction Plan Layout incorporates minor shortening of LW413 compared to the Approved Layout.

This Surface Water Technical Report:

- reviews the recent subsidence predictions (prepared by MSEC [2024]) for the Extraction Plan Layout in comparison to MSEC (2024) subsidence predictions for the Approved Layout and the previous subsidence predictions (prepared by SE [2006]) for the Stage 1 EA Layout;
- discusses the key surface water risk issues for LW409-414; and
- presents proposed monitoring and management measures to minimise these surface water environmental risks.

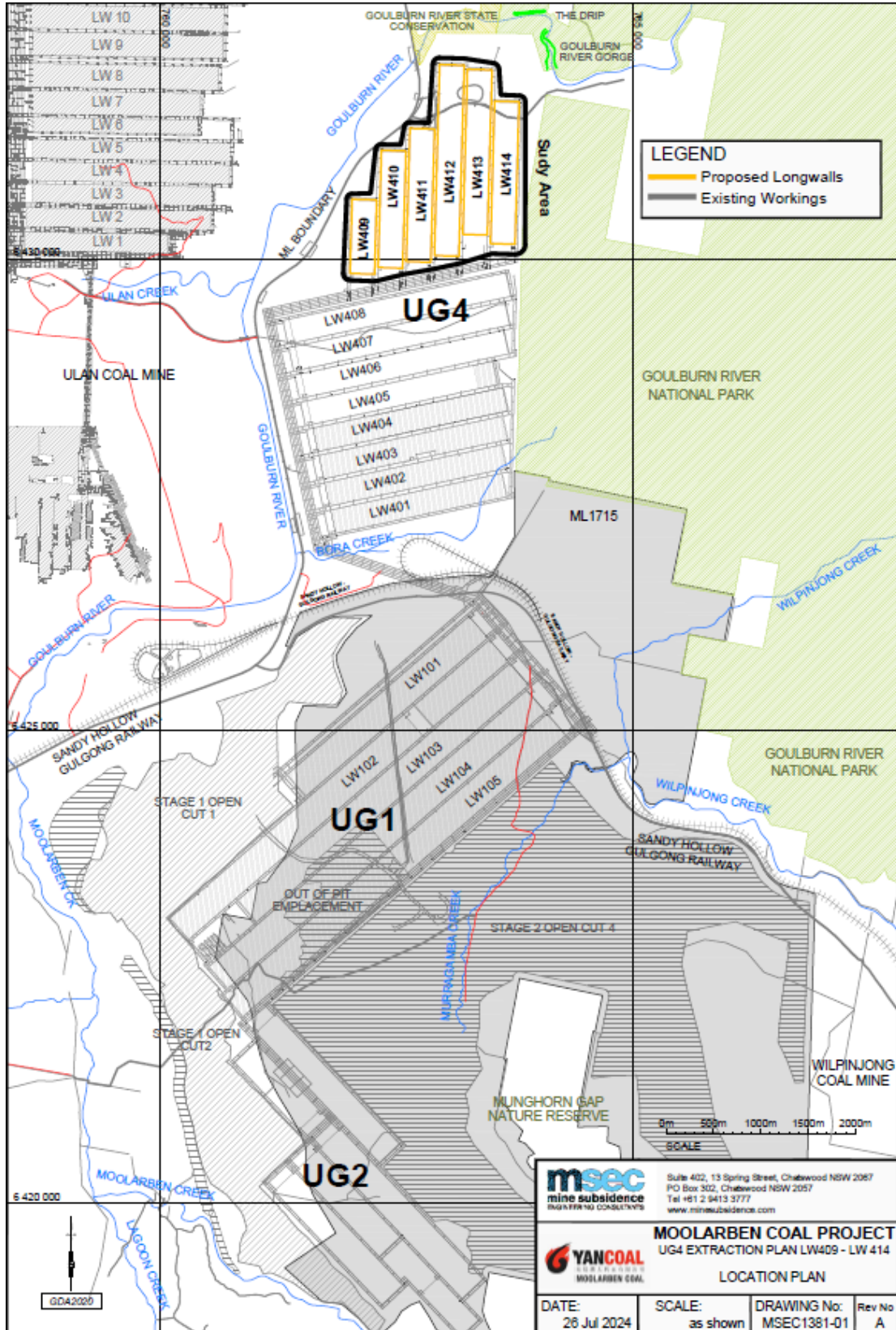


Figure 1.1 Locality plan – UG4 (source: MSEC, 2024)

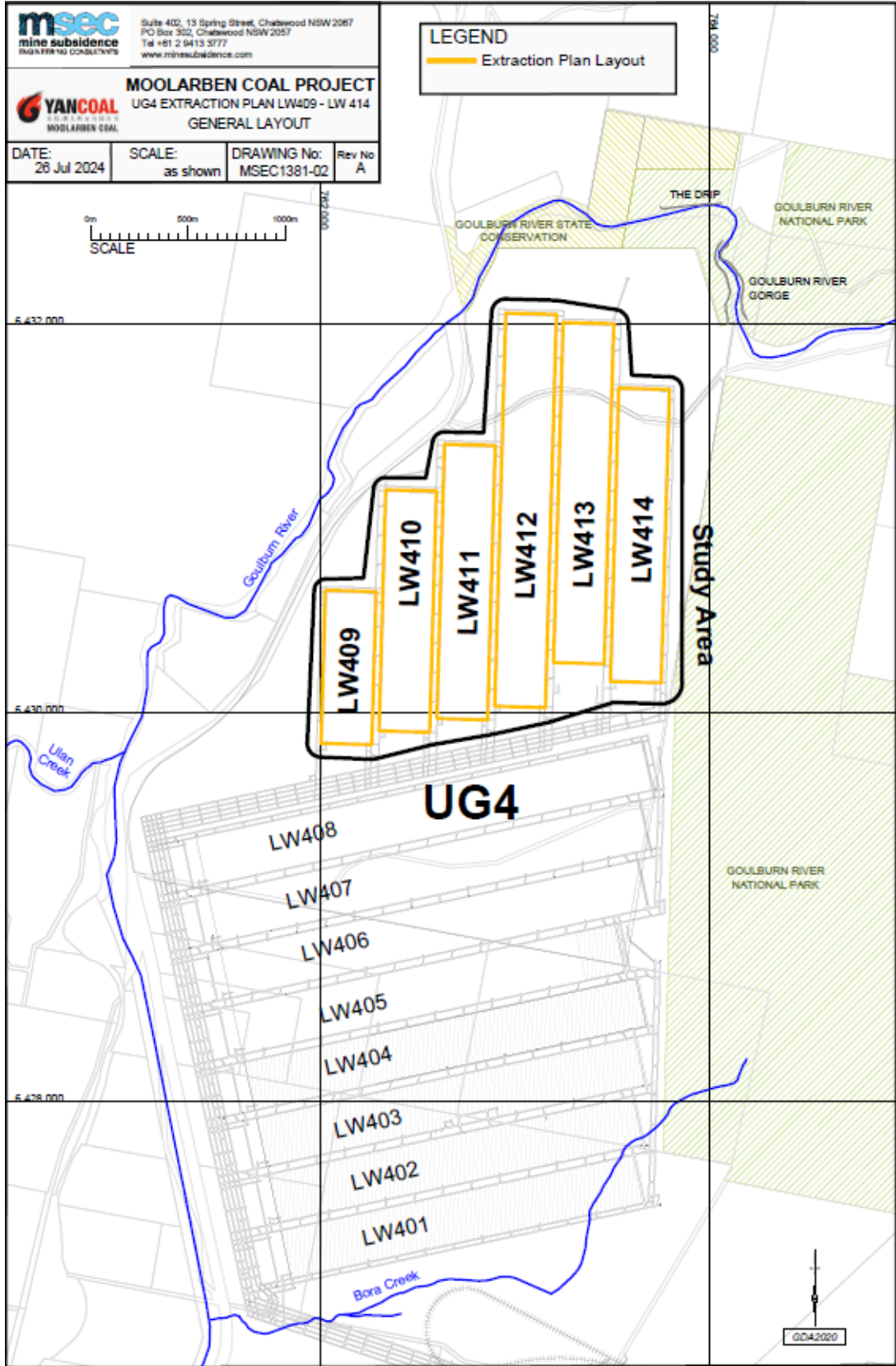


Figure 1.2 Extraction Plan Layout – LW409-414 (source: MSEC, 2024)

2 BASELINE CONDITIONS

2.1 TOPOGRAPHY AND SURFACE DRAINAGE

Figure 2.1 shows the various drainage lines overlying LW409-414. LW409-414 are located beneath a topographical plateau (referred to as the ‘Moolarben Plateau’ in SE (2006)). Catchment topography is steep with numerous minor drainage lines falling to the north towards the Goulburn River. One key drainage line with stream order 2 (Drainage Line 2) crosses LW409-LW411, discharging to the Goulburn River west of the Study Area.

Figure 2.2 shows the surface level contours and natural features including drainage lines and cliff lines (CLs) above LW409-LW414. Surface drainage over the area of LW409-414 is characterised by steep, first and second order gullies draining steep forested catchments. Stream gradients in the upper reaches of the gullies within the area affected by subsidence are typically in the range of 5% to 20%. The upper reaches of these gullies typically drain to steep rock features or cliffs (with gradients of 20% to 80%) and then to flatter areas in the downstream reaches before joining the Goulburn River.

2.2 VEGETATION AND GEOMORPHOLOGY – MINOR GULLIES

The Moolarben Plateau itself consists of deeply incised gullies and sub-vertical cliff lines. Numerous sandstone boulders exist along the cliff bases due to natural weathering processes. Shallow alluvial/slope wash-filled gullies and flats exist between the broad, prominent ridges.

In the upper reaches of the gullies above LW409-414, topographic data and aerial imagery indicate that the first order drainage lines typically consist of deeply incised drainage paths with numerous trees and significant quantities of large woody debris.

The SE (2006) report noted that the soil profile on the upper to mid-slopes of the ridges typically comprises residual gravelly, sandy clays, overlying extremely to highly weathered sandstone and conglomerate.

The MSEC (2024) report notes that the drainage lines within the Study Area comprise a rounded gravel to sandy and silty base. There is also debris along sections of the streams, including boulders, tree branches and other vegetation. The valley profiles of the drainage lines are predominantly broad and shallow with some incised sections as shown in Figure 2.3.

A major cliff feature (CL3 – see Figure 2.2) is located in the upper reaches of the Drainage Line 2 catchment.

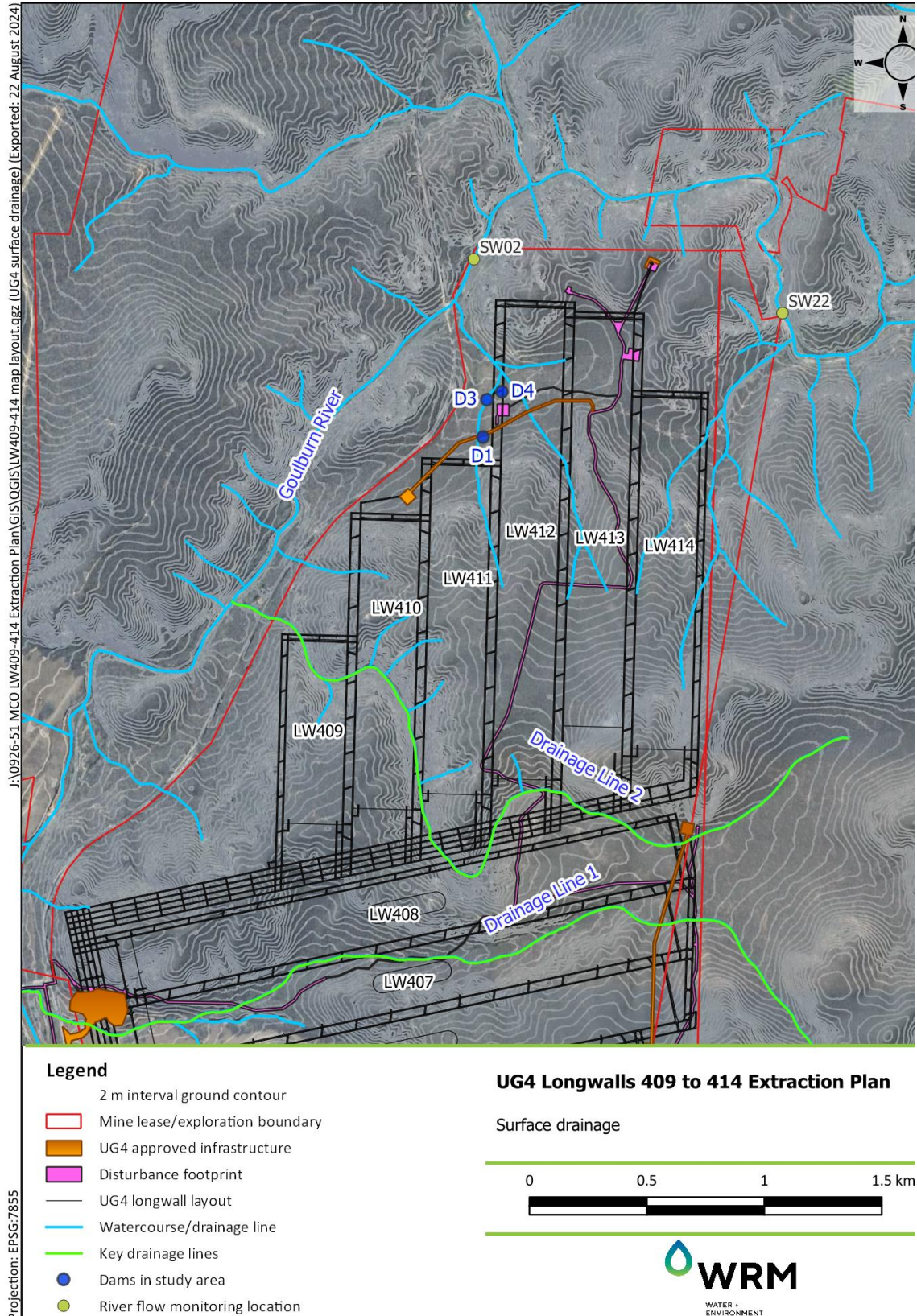


Figure 2.1 Ground level contours and surface drainage features above LW409-LW414

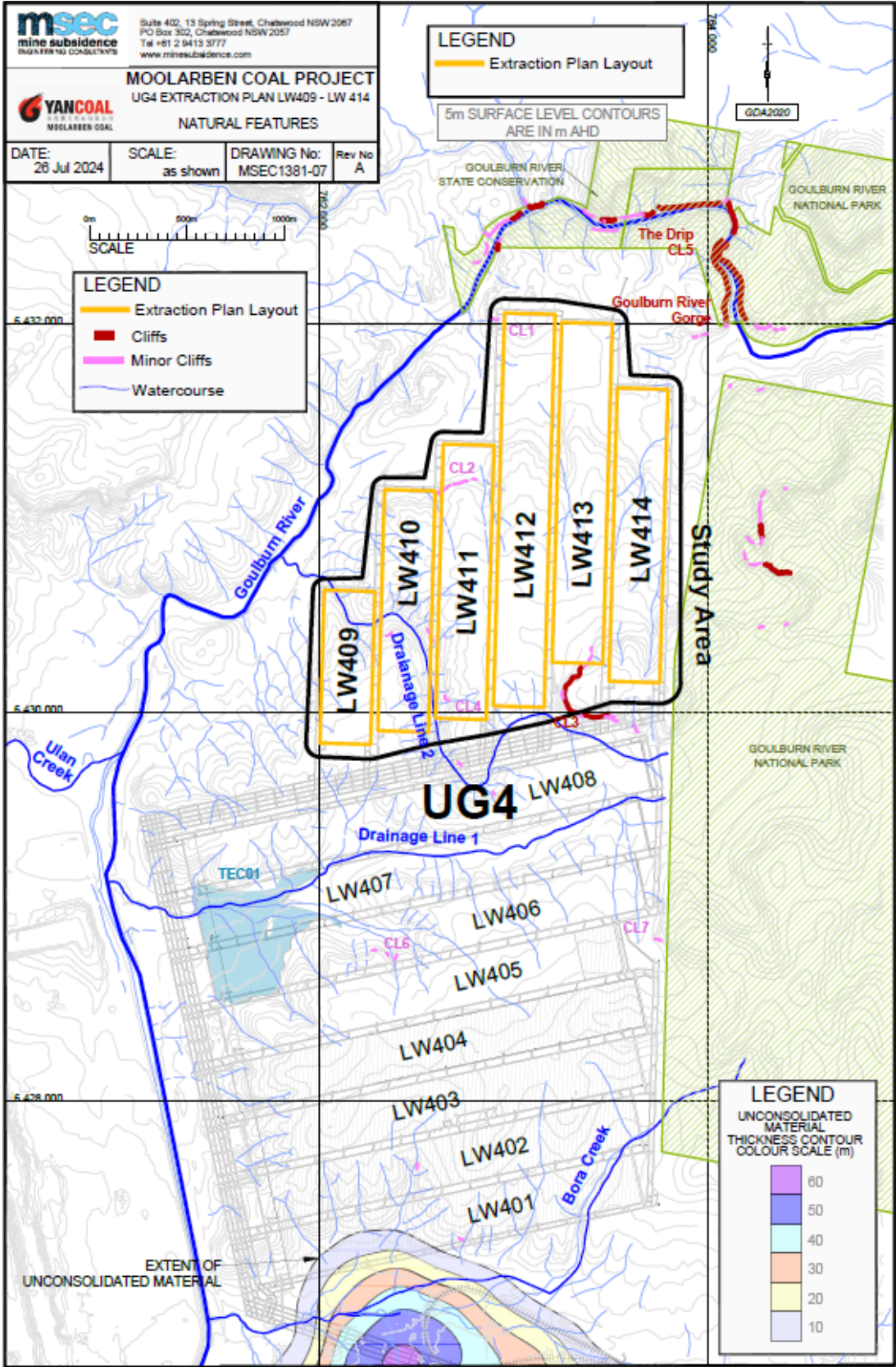


Figure 2.2 Natural features across the UG4 Domain (source: MSEC, 2024)



Figure 2.3 Photograph showing Drainage Line 2 (source: MSEC, 2024)

2.3 FLOW, WATER QUALITY, STREAM HEALTH AND CHANNEL STABILITY

Surface water monitoring for receiving watercourses is undertaken for flow, water quality, stream health and channel stability as described in the Surface Water Management Plan (MCO, 2024). The locations of flow, water quality and stream health monitoring are shown in Figure 2.4. A summary of baseline flow, water quality, stream health and channel stability data is provided in the Surface Water Management Plan (MCO, 2024).

MCO installed two flow monitoring gauges (SW02 and SW22) on the Goulburn River upstream and downstream of The Drip in 2022 as part of the approval of LW401-408. The Drip is a natural south-facing cliff feature adjacent to the Goulburn River channel, north of the study area (see Figure 2.1). The locations of SW02 and SW22 are shown in Figure 2.1. Both of these river flow gauges are located downstream of treated water discharges from MCC and Ulan Coal Operations (UCO).

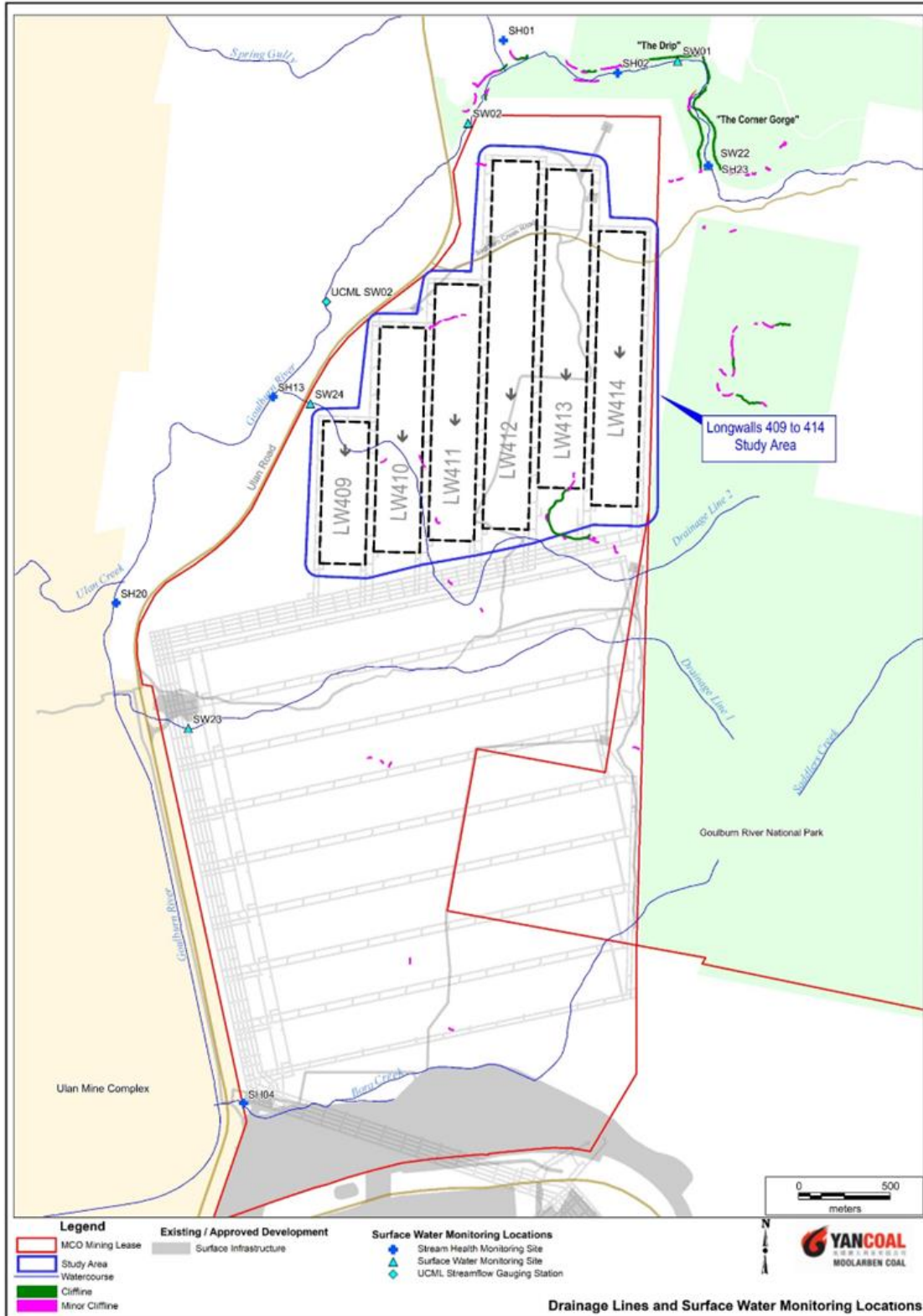


Figure 2.4 Surface water monitoring locations (source: Yancoal)

3 PREDICTED SUBSIDENCE

Figure 3.1 shows the predicted subsidence depth estimates for the Extraction Plan Layout from MSEC (2024). The maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of the longwalls based on the Extraction Plan Layout is provided in Table 3.1. The maximum predicted subsidence for each longwall panel is 1800 to 1900 millimetres (mm).

Table 3.1 Maximum predicted total conventional subsidence, tilt and curvature after the extraction of each of the Longwalls 409 to 414 (source: MSEC, 2024)

Longwall	Maximum Predicted Total Conventional Subsidence (mm)	Maximum Predicted Total Conventional Tilt (mm/m)	Maximum Predicted Total Conventional Hogging Curvature (km ⁻¹)	Maximum Predicted Total Conventional Sagging Curvature (km ⁻¹)
LW409	1800	40	2.0	1.6
LW410	1900	40	2.0	1.6
LW411	1900	40	2.0	1.6
LW412	1900	40	2.0	1.6
LW413	1900	40	2.0	1.6
LW414	1900	40	2.0	1.6

Table 3.2 compares the maximum predicted subsidence characteristics for the Extraction Plan Layout from MSEC (2024) against the subsidence predictions for the Approved Layout from MSEC (2024) and the subsidence predictions for the Stage 1 EA Layout from SE (2006). It shows that the maximum predicted total subsidence parameters based on the Approved Layout are the same as those for the Extraction Plan Layout for LW409-414. The maximum predicted total subsidence and tilt for the Extraction Plan Layout are less than the corresponding values for the Stage 1 EA Layout.

Table 3.2 Comparison of maximum predicted subsidence characteristics for the Extraction Plan Layout based on MSEC (2024), the Approved Layout based on MSEC (2024) and the Stage 1 EA Layout from SE (2006)

UG4 layout	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km ⁻¹)	Maximum predicted total conventional sagging curvature (km ⁻¹)
Approved Layout (MSEC, 2024)	1,900	40	2.0	1.6
Extraction Plan Layout (MSEC, 2024)	1,900	40	2.0	1.6

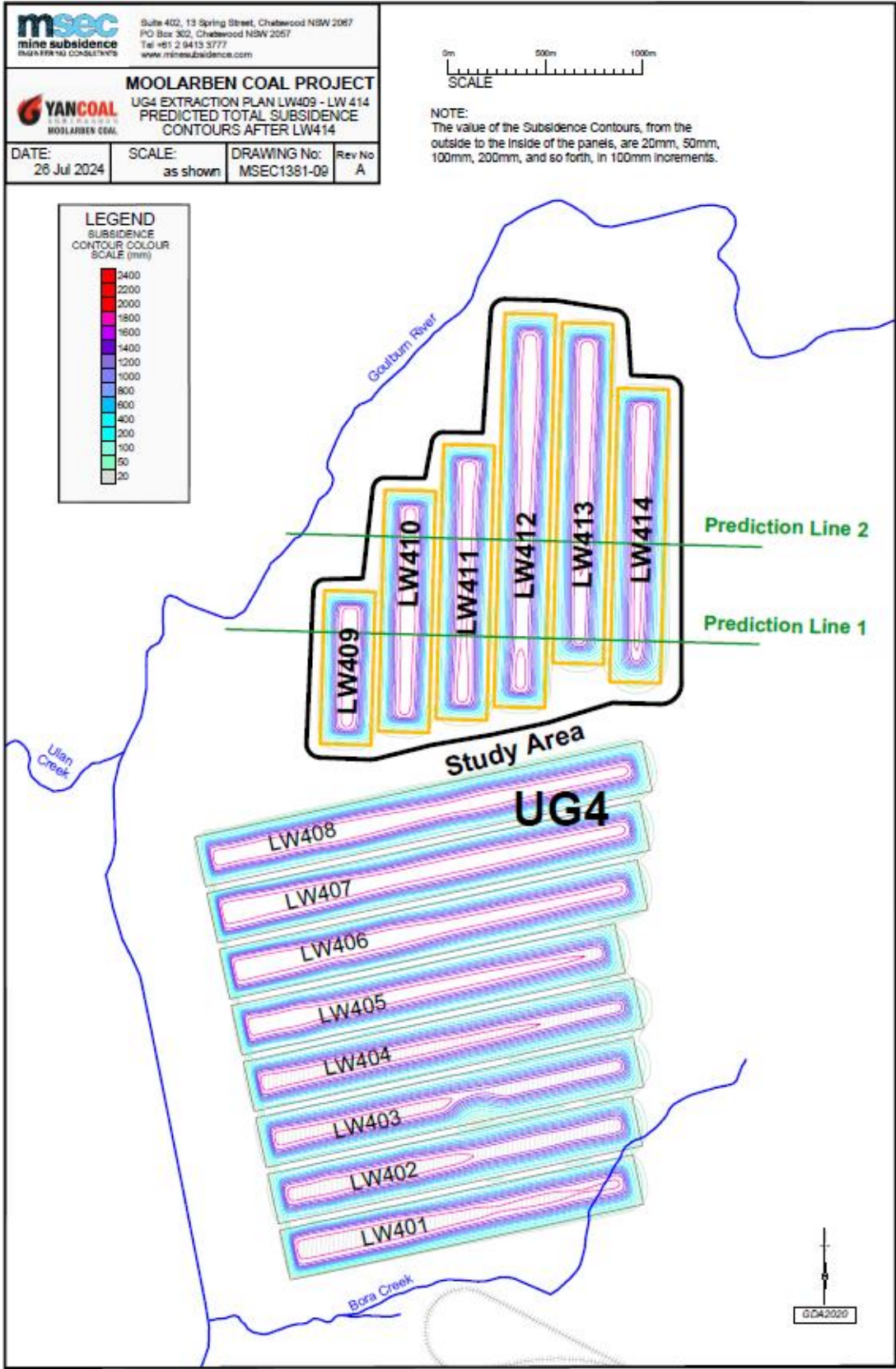


Figure 3.1 Predicted subsidence estimates for the Extraction Plan Layout (MSEC, 2024)

4 SUBSIDENCE IMPACTS

4.1 OVERVIEW

Subsidence impacts on surface water features for the Extraction Plan Layout are discussed in Section 5.2 (Drainage Lines), Section 5.3 (the Goulburn River), Section 5.4 (The Drip and Corner Gorge) and Section 8.2 (Farm Dams) of the MSEC (2024) Subsidence Impact Assessment. The following sections provide a summary of the relevant findings from the MSEC (2024) assessment.

4.2 DRAINAGE LINES

One key drainage line with stream order 2 (Drainage Line 2) crosses LW409-LW414, discharging to the Goulburn River west of the Study Area.

Table 4.1 compares the maximum predicted subsidence characteristics for Drainage Line 2 after the extraction of LW409-414 for the Extraction Plan Layout (obtained from the MSEC [2024] assessment). Tilt and curvature are the key factors affecting ponding or erosion risk. However, the predicted maximum values occur only within about 100 m of where the drainage lines cross the chain pillars. There is minimal change in drainage characteristics in reaches where uniform subsidence occurs.

Figure 4.1 shows the predicted profiles of vertical subsidence, tilt and curvature along the alignment of Drainage Line 2 for the Extraction Plan Layout. Figure 2.1 show the location of Drainage Line 2.

Table 4.1 Comparison of maximum predicted subsidence parameters along Drainage Line 2, between the Approved Layout and the Extraction Plan Layout (MSEC, 2024)

UG4 layout	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km ⁻¹)	Maximum predicted total conventional sagging curvature (km ⁻¹)
Approved Layout (MSEC, 2024)	1900	40	1.9	1.6
Extraction Plan Layout (MSEC, 2024)	1900	40	1.9	1.6

MSEC (2024) noted that the predicted subsidence parameters for Drainage Line 2 based on the Extraction Plan Layout is the same as for the Approved Layout. The potential impacts for the Drainage Line 2, based on the Extraction Plan Layout are the same as those assessed based on the Approved Layout.

The drainage lines within the Study Area are ephemeral as water only flows during and for short periods after each rain event. Ponding naturally develops along some sections of the drainage lines, for short periods of time, after major rain events. The predicted changes in grade along the drainage lines after the completion of the longwalls are generally less than most of the natural grades, however the magnitudes of tilt will result in increases and decreases in grade and reversal of grade at some locations (see Figure 4.2). Additional ponding may occur along the drainage lines resulting from the extraction of Longwalls 409 and 410, predominantly upstream of the chain pillars. Figure 4.3 shows the pre and post-subsidence profile along Drainage Line 2 across LW409 and LW410, where the greatest subsidence is predicted to occur. Figure 4.4 shows the locations of predicted ponding due to subsidence. Ponding along Drainage Line 2 is only predicted to occur in one small area above LW410.

Sections of beds downstream of the additional ponding areas may erode during subsequent rain events, especially during times of high flow. It is expected that, over time, the gradients along the drainage lines would approach grades similar to those that existed before mining. The extent of additional ponding along the drainage lines would, therefore, be expected to decrease with time (MSEC, 2024).

Fracturing, dilation and buckling of the bedrock would occur as a result of the extraction of these longwalls. Surface cracking is expected to develop in the bases of the drainage lines (MSEC, 2024).

In times of heavy rainfall, the majority of the surface water runoff would be expected to flow over the surface cracking in the beds and only a small proportion of the flow would be diverted into the fractured and dilated strata below. In times of low flow, however, a larger proportion of the surface water flow could be diverted into the strata below the beds and this could affect the quality and quantity of this water flowing through the cracked strata beds. Nevertheless, during high flow or low flow times, this small quantity is expected to have little impact on the overall quality of water flowing out of the drainage lines (MSEC, 2024).

If adverse impacts were to develop as the result of increased ponding along the streams, then specialist advice on appropriate remediation works will be obtained, and potential drainage works to restore drainage line bed or bank will be investigated.

MSEC (2024) recommends that the drainage lines are visually monitored as the longwalls mine beneath them and that management strategies are developed for the drainage lines, such that the impacts can be identified and remediated if and as they are required. Management strategies based on extraction of the Extraction Plan Layout are the same as those for the Approved Layout.

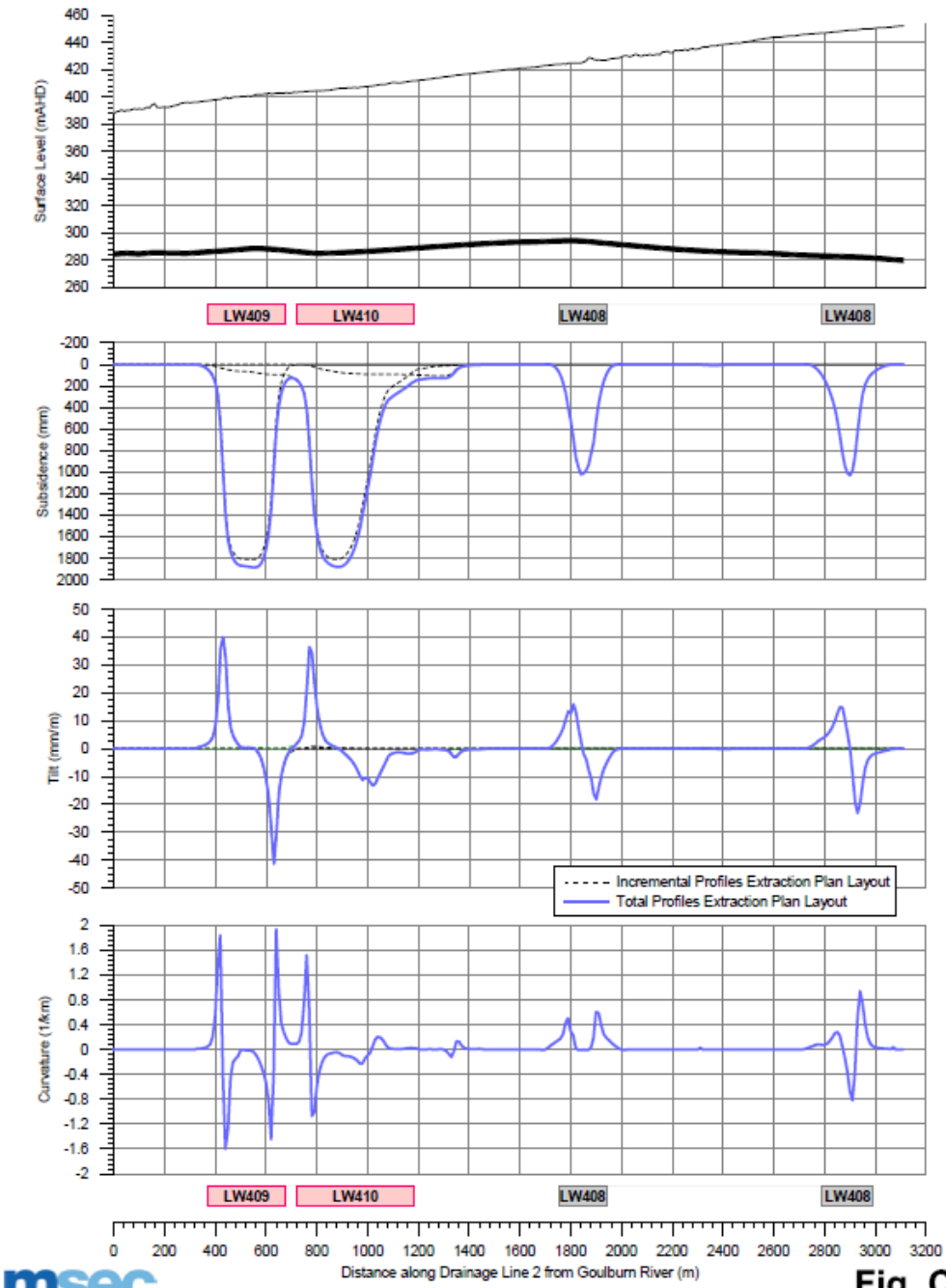


Fig. C.03

Figure 4.1 Predicted profiles of subsidence, tilt and curvature along Drainage Line 2 due to LW409 to 414 (source: MSEC, 2024)

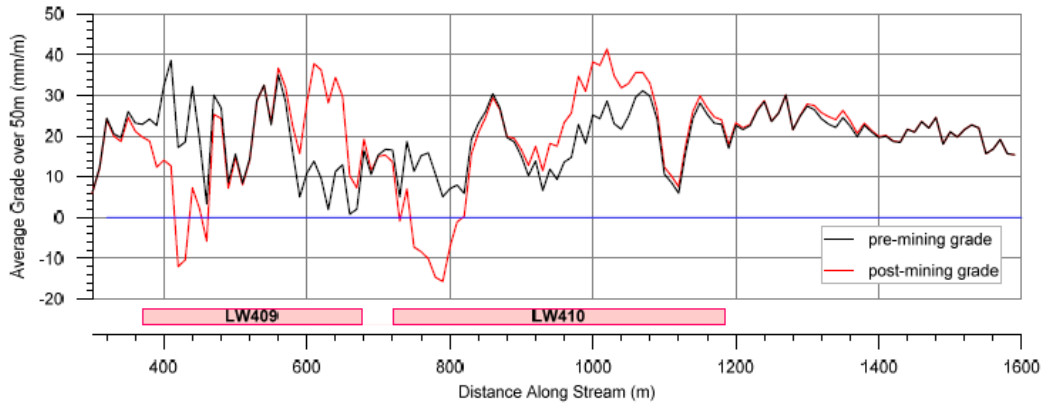


Figure 4.2 Pre and post-mining bed gradient along Drainage Line 2 (source: MSEC, 2024)

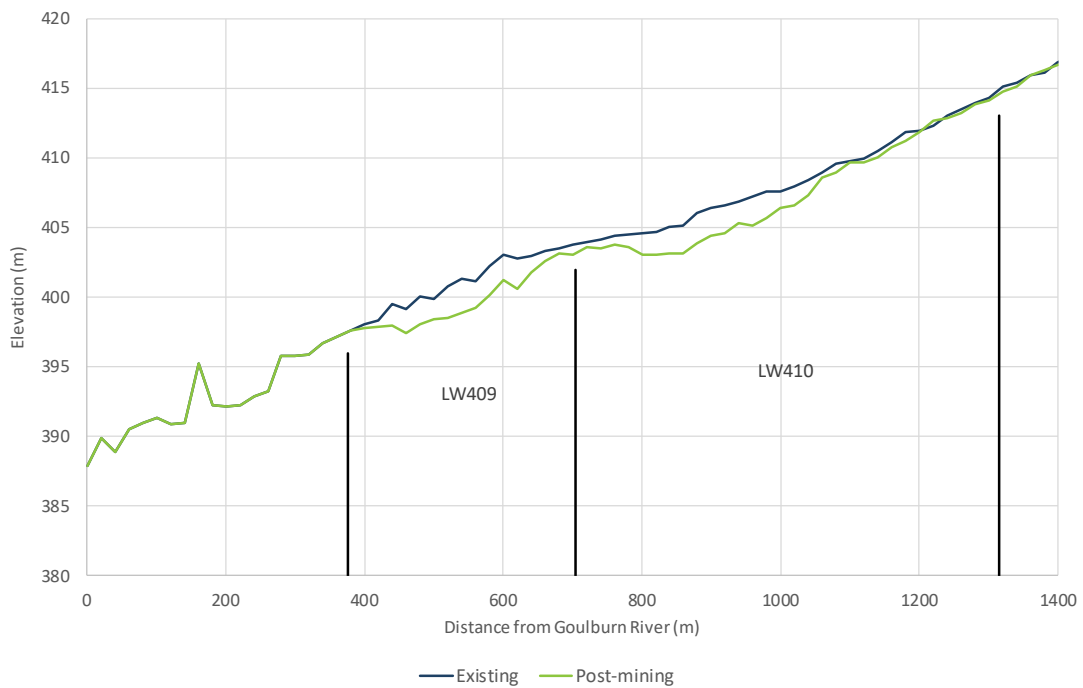


Figure 4.3 Existing and post-subsidence bed levels along Drainage Line 2 across LW409 and LW410

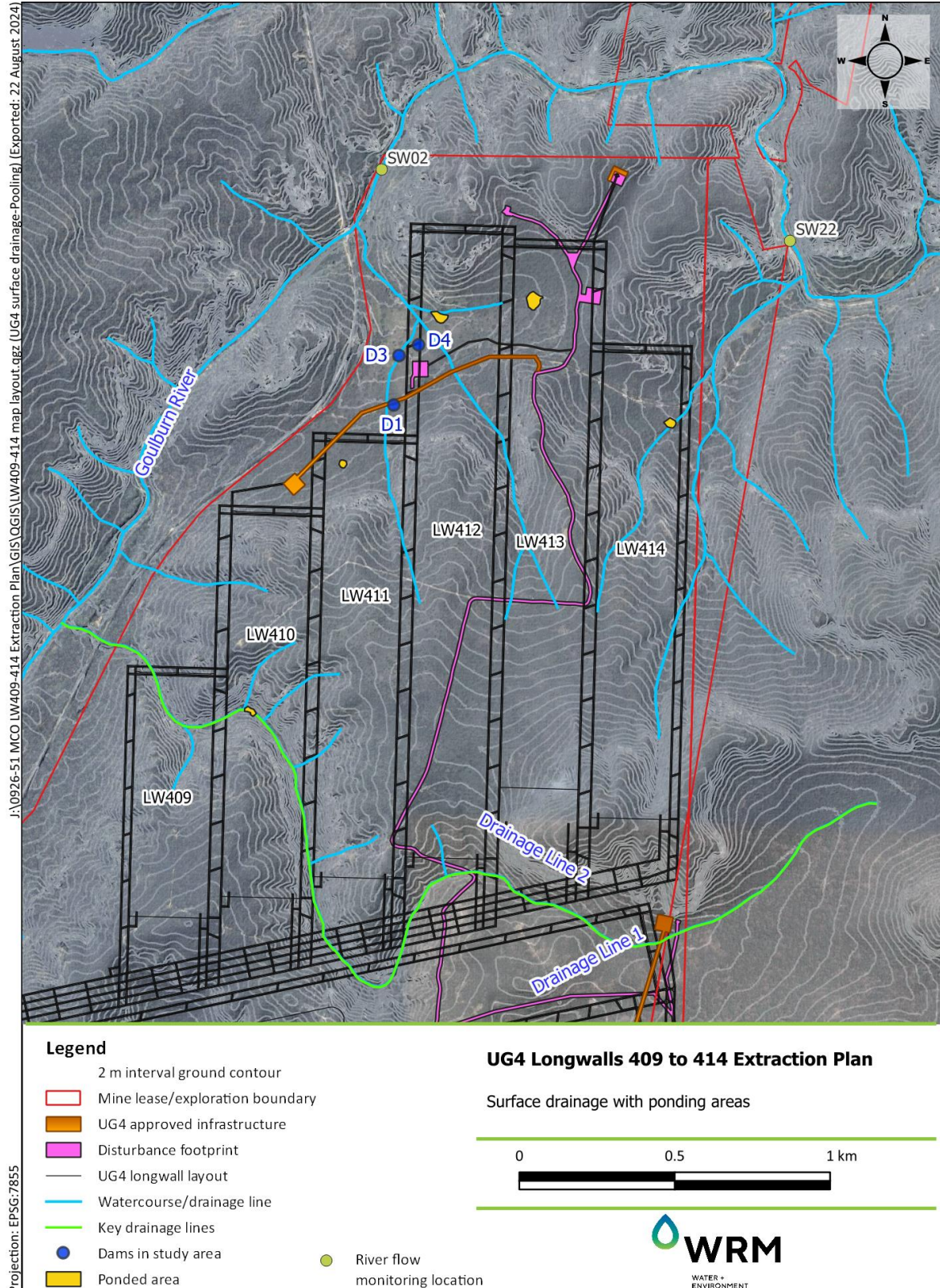


Figure 4.4 Areas of predicted ponding due to subsidence

4.3 GOULBURN RIVER

The Goulburn River is located on the north western side of Longwalls 409 to 412 at distances of 180 m to 440 m from the commencing ends of these longwalls, and to the north and north east of Longwalls 412 to 413 at distances of 460 m to 500 m. The location of the Goulburn River is shown in Figure 2.1.

MSEC (2024) noted that the Goulburn River is located outside the Study Area boundary. At its nearest point of 180 m from the longwalls, the distance to the Goulburn River represents about 1.3 times the depth of cover from the longwalls. Elsewhere, the Goulburn River is two or more times the depth of cover from the longwalls. At distances of 180 m to over 440 m between the longwalls and the Goulburn River, the maximum expected horizontal movement is 75 mm based on Moolarben Coal monitoring data and 40 mm to 50 mm total horizontal movement based on the Moolarben Coal Global Navigation Satellite System (GNSS) monitoring data. It is possible that where horizontal movement is observed at a valley location then valley related closure movement could be observed. A prediction of valley closure at the nearest location of the Goulburn River indicates a potential valley closure of 20 mm which is about the limit of accuracy for the survey data used in the valley closure prediction model.

MSEC (2024) also noted that the impact assessments for the Goulburn River based on the Approved Layout do not change based on the Extraction Plan Layout. It is unlikely that fracturing of the bed of the Goulburn River would occur due to the Extraction Plan Layout based on the magnitude of expected movements discussed above and the offset distances of the Extraction Plan Layout from the Goulburn River. If fracturing does occur, it is likely that the fractures will be localised in nature and relatively minor in size, and they will only be visible in areas where the bedrock is exposed. It is expected that the majority of the bedrock in the bed of the river will be covered with alluvial deposits, which would cover any minor fractures that may develop in the bedrock. Minor fractures that potentially develop outside extracted longwalls are not generally associated with any increased rate of diversion of surface water into near-surface substrata. Therefore, it is expected the performance measure of negligible impact or environmental consequences will be achieved (MSEC, 2024).

4.4 FARM DAMS

Three minor farm dams have been identified within the Study Area. The locations of the dams (D1, D3 and D4) are shown in Figure 4.4.

The SE (2006) assessment noted that the farm dams within the UG4 footprint are typically small earth embankment dams, with a storage capacity of about 0.1 - 0.2 ML (10 m to 20 m x 10 m x 1 m deep). All three farm dams are located on land owned by MCO. MSEC (2024) noted that these dams were understood to be previously used for livestock watering but are no longer in use.

Table 4.2 summarises the maximum predicted subsidence characteristics for the farm dams within the Study Area resulting from extraction of LW409-414 based on the Extraction Plan Layout (obtained from the MSEC [2024] assessment). Table 4.3 compares the maximum predicted subsidence characteristics for these farm dams between the Extraction Plan Layout and the Approved Layout.

Table 4.2 Summary of maximum predicted subsidence parameters or the farm dams within the Study Area (MSEC, 2024)

Dam	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km ⁻¹)	Maximum predicted total conventional sagging curvature (km ⁻¹)
D1	< 20	< 0.5	< 0.01	< 0.01
D3	< 20	< 0.5	< 0.01	< 0.01
D4	325	17	> 3.0	0.40

Table 4.3 Comparison of maximum predicted subsidence parameters or the farm dams within the Study Area, between the Approved layout and the Extraction Plan Layout (MSEC, 2024)

UG4 layout	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km ⁻¹)	Maximum predicted total conventional sagging curvature (km ⁻¹)
Approved Layout	325	17	> 3.0	0.4
Extraction Plan Layout	325	17	> 3.0	0.4

The maximum predicted total subsidence characteristics for the farm dams within the Study Area based on the Extraction Plan Layout are the same as the Approved Layout.

MSEC (2024) noted the following potential impacts to the farm dams due to extraction of LW409 to LW414:

- Changes in freeboard of up to 200 mm are predicted for the farm dams located above the extracted longwalls.
- Farm dams are typically constructed of cohesive soils with reasonably high clay contents and are likely to be capable of withstanding tensile ground strains up to 3 mm/m without impact. The predicted strains based on the Extraction Plan Layout are greater than 3 mm/m.

The farm dams located above the extracted longwalls are expected to experience cracking and leakage of water. Any loss of water from the farm dams would flow into the drainage line in which the dam was formed. Impacts to the farm dams located outside the longwall footprints is considered unlikely to occur.

MSEC (2024) recommends that farm dams, where not decommissioned, are visually monitored as the longwalls are extracted, such that any impacts can be identified and remediated accordingly. In this way the farm dam within the Study Area can be maintained in a safe condition throughout the mining period.

4.5 ENVIRONMENTAL RISK ASSESSMENT

A quantitative environmental risk assessment for LW409-414 is presented in the risk assessment report (AXYS, 2024). Surface water issues identified in the risk assessment are shown in Table 4.4.

Proposed monitoring and management measures to control the identified risks are provided in Section 5.

Table 4.4 Surface water risks assessed in Risk Assessment (AXYS, 2024)

Risk	Risk Level
Changes to the gradient of natural drainage lines and a corresponding impact on erosion risk or ponding.	Medium
Changes in water flow and quality as a consequence of cracking or erosion caused by subsidence over Longwall 409 to 414.	Medium
Impacts to Goulburn River greater than negligible. e.g. baseflow *	Medium

* Identified in risk assessment as groundwater risk, but relevant to surface water

5 MONITORING AND MANAGEMENT MEASURES

5.1 SUBSIDENCE IMPACT PERFORMANCE MEASURES

Subsidence impacts and potential environmental consequences for surface drainage features are discussed in Section 4 of this report.

The Stage 1 approval conditions (05_0117) include the following subsidence impact performance measure for water resources:

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

The subsidence impacts on the Goulburn River are discussed in Section 4. The Goulburn River is not undermined by LW409-414 and is not expected to experience conventional subsidence movements or bed fracturing. Based on the subsidence predictions, the performance measure of negligible impact or environmental consequences for the Goulburn River will be achieved.

The Stage 1 approval conditions do not include any performance measures for specific drainage lines within the Study Area. However, the following monitoring and management measures are proposed for the Goulburn River and Drainage Line 2:

- Objectives and performance indicators for subsidence impacts;
- Monitoring activities for surface water subsidence impacts;
- Remedial measures and contingencies; and
- Triggers for proposed management actions.

5.2 OBJECTIVES AND PERFORMANCE INDICATORS

Table 5.1 shows the recommended objectives and performance indicators for the risks identified in Section 4.

Table 5.1 Recommended surface water subsidence management objectives and performance indicators

Risk	Subsidence Impact Performance Indicator	Proposed monitoring
Changes to the gradient of natural drainage lines and a corresponding impact on erosion risk or ponding.	Change in visible bed or bank erosion	Walkover visual inspection of Drainage Line 2
	Development of or change in headcut erosion	Photographic record of potential ponding or erosion locations along Drainage Line 2
	Change in vegetation character such as vegetation loss through erosion or drowning by ponded water Extent and duration of water ponding	Walkover visual inspection of Drainage Line 2 Photographic record of potential ponding or erosion locations along Drainage Line 2
Changes in water flow and quality as a consequence of cracking or erosion caused by subsidence over Longwall 409 to 414.	Receiving water quality	Continue current receiving water quality monitoring program
	Appearance of unsealed surface cracking across the bed of Drainage Line 2	Walkover visual inspection of Drainage Line 2 Photographic record of potential ponding or erosion locations along Drainage Line 2
Impacts to the Goulburn River and the bed of the Goulburn River greater than negligible.	Reduction in river baseflow	Monitoring of river flow Periodic visual inspection for the reach of the Goulburn River adjacent to Longwalls 409-414.

5.3 MONITORING OF IMPACTS

Details of the proposed monitoring activities are given in Table 5.2.

As described in Section 4, the surface water impacts of subsidence for LW409-414 are likely to be limited in spatial extent. The monitoring of potential impacts will focus on the Goulburn River and Drainage Line 2 above LW409 and LW410. Periodic visual inspection is also recommended for the reach of Goulburn River adjacent to UG4 LW409-414 (although subsidence is not predicted to impact Goulburn River).

Due to the small catchment areas of the affected drainage lines, surface runoff will occur infrequently and only for a very short time during and immediately after significant rainfall. Water quality sampling under these conditions is not a reliable method to assess impacts because:

- runoff occurs infrequently;
- baseline water quality is likely to be highly variable depending on the magnitude of rainfall; and
- accessing sampling locations in the upper catchments during the very short time that surface runoff is flowing is likely to be extremely difficult.

For these reasons, water quality sampling of the minor drainage lines is not proposed.

Water quality sampling of receiving streams will continue to be undertaken in accordance with the Surface Water Management Plan (MCO, 2024). However, it is unlikely that this sampling could detect any impacts due to subsidence because the expected impacts on runoff quality are minimal and the receiving watercourses collect runoff from a catchment larger than the subsidence area, making it impossible to isolate the water quality impacts of subsidence.

Due to the difficulty in detecting subsidence impacts by water quality monitoring, the primary monitoring activity for surface water subsidence impacts will be visual inspection, including collection of photographic records to confirm changes in erosion and vegetation over time along the impacted reaches of Drainage Line 2.

A detailed assessment of Goulburn River flow monitoring data shows that comparison of weekly average flows is a suitable method of identifying potential impacts on flow in the Goulburn River. Further details of the proposed trigger for investigation of potential loss of river flow is provided in Section 5.4.1.

5.4 TRIGGER ACTION RESPONSE

Table 5.3 shows trigger events for each of the performance indicators, as well as required actions to manage the potential impacts. A key principle for the remediation of surface water impacts due to subsidence is to minimise land disturbance associated with intervention measures. Hence, once an issue is identified, it is recommended that specialist advice be obtained to ensure that any proposed intervention is effective. Wherever possible, proposed remediation works should be undertaken using soft engineering measures that minimise land disturbance and maximise vegetative cover.

5.4.1 Goulburn River flow monitoring trigger

Flow in the Goulburn River at each of the gauges is estimated by recording water level and using a rating curve to convert the measured levels to flow rates. The calculated flow rates are very sensitive to water level and therefore small variations in water level caused by environmental factors, such as vegetation growth or sediment deposition, can have a large effect on the estimated flow rate. For this reason, any trigger based on the difference in flow between the upstream and downstream gauges needs to be averaged over a suitable time scale and include some allowance for factors such as evaporation, infiltration to bed sediments and inaccuracy in the rating curves.

A detailed review has been undertaken of river flow monitoring data collected at the recently installed MCO SW2 and MCO SW22 gauges. Initial results of this review indicate that comparison of recorded weekly average flow at MCO SW2 and MCO SW22 may be a suitable trigger for investigation of potential changes in river flow. If the flow at both gauges is the same, points would plot along the equivalence line in Figure 5.1. Points that plot above the equivalence line represent a gain in flow between the two gauges (i.e. flow at MCO SW22 is larger than at MCO SW2). Points below the equivalence line represent a flow loss (i.e. flow at MCO SW2 is larger than at MCO SW22).

Upon receipt of downloaded flow data each month, weekly average flow at MCO SW2 (megalitres per day (ML/d)) should be compared to the corresponding value at MCO SW22 (as per Figure 5.1). Based on the scatter of recorded historical data, some allowable flow difference is required to account for evaporation, infiltration to bed sediments and inaccuracy in the rating curves. The trigger for investigation is a flow loss between the gauges that continually exceeds the allowable flow difference over multiple consecutive weeks. This is illustrated as the red shaded “Trigger Zone” in Figure 5.1. Additional data needs to be collected and analysed for baseline conditions to determine a suitable value for the allowable flow difference to avoid frequent unnecessary triggers.

Once the allowable flow difference is established, weekly flow data that plots within the Trigger Zone over multiple consecutive weeks will initiate an investigation to check whether the data indicates a true loss of flow or has some other cause, such as accumulation of sediment, instrument error, debris or vegetation growth at a gauging site.

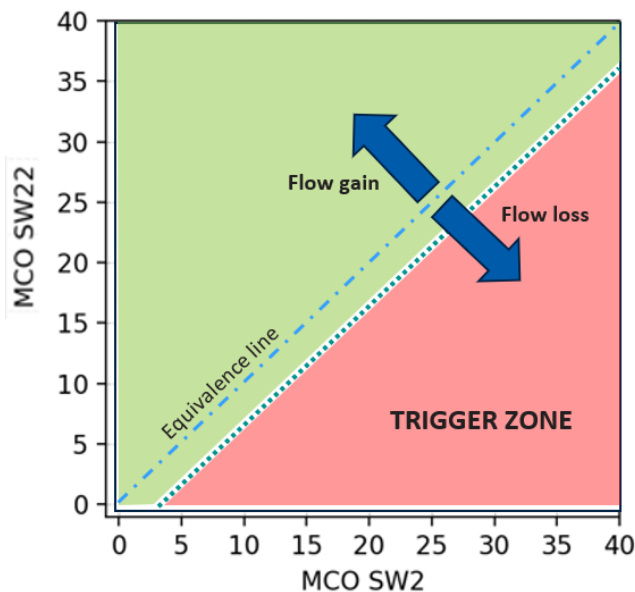


Figure 5.1 Goulburn River trigger based on weekly average flow (ML/d)

Table 5.2 Proposed monitoring for surface water impacts

Monitoring task	Methodology	Timing
Water quality & stream health monitoring	As per Surface Water Management Plan	As per Surface Water Management Plan
Walkover visual inspection and photographic record of Drainage Line 2	Identify and mark the upstream and downstream limits of LW409 and LW410 along Drainage Line 2	Prior to undermining of Drainage Line 2
	Undertake a baseline inspection by walking along Drainage Line 2 over LW409 and LW410 and noting the condition of vegetation in the channel and any areas of active erosion, sediment deposition, water ponding or streambed cracking	Prior to undermining of Drainage Line 2
	Collect photographic record of channel condition along Drainage Line 2 over LW409 and LW410	Prior to undermining of Drainage Line 2
	Undertake periodic walkover inspection and update photographic record	Within 3 months of undermining of Drainage Line 2 Ongoing inspections every 6 months for one year after undermining
Visual inspection at access points along Goulburn River	Undertake a baseline inspection at access points along Goulburn River adjacent to UG4 LW409-414, 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 along Goulburn River.	Prior to completion of first longwall panel in LW409-LW414
	Undertake periodic walkover inspection and update photographic record	Ongoing inspections every 6 months until 1 year after completion of UG4 LW409-414 extraction
Goulburn River flow monitoring	Continuous monitoring of Goulburn River flow at SW02 and SW22 Weekly average flow at SW02 and SW22 to be collated monthly and reviewed in accordance with Trigger Action Response Plan (see Table 5.3).	Continuous flow monitoring with monthly reporting
	Dry weather (less than 2 mm rainfall in preceding 7 days) at-site gauging at SW02 and SW22. Continuous flow gauge rating curves to be reviewed after each gauging,	Twice per year

Table 5.3 Surface water response actions – subsidence drainage impacts

Feature	Performance indicator	Trigger event	Action
Drainage Line 2	Change in visible bed or bank erosion	Noticeable new areas of erosion or expansion of existing erosion	Obtain specialist advice on appropriate remediation works. Investigate potential drainage works to restore drainage line bed or bank.
	Development of or change in headcut erosion along Drainage Line 2	Initiation of headcut or noticeable upstream advance of existing headcut	Obtain specialist advice on appropriate remediation works. Preferred management strategies would include slope stabilisation, revegetation and bed control using natural materials such as local rock and large woody debris.
	Extent and duration of water ponding	Development of new pools or drainage of existing pools	Obtain survey of ponded area to identify ponding depth and extent. Investigate potential drainage works with specialist advice to restore existing drainage characteristics.
Goulburn River	Unpredicted impacts on Goulburn River	Visible indication of mining-related movement identified during monitoring inspections	Engage suitably qualified subsidence expert to determine if impact is related to UG4 LW409-414 extraction. If impacts are related to UG4 LW409-414 extraction: <ul style="list-style-type: none"> Engage suitably qualified hydrologist to determine any potential downstream impacts. Obtain specialist advice on appropriate remediation works. Notify DPHI that performance measure has been exceeded immediately, and complete Preliminary investigation report and provide to DPHI within 7 days of the date of the incident identifying the performance measure exceedance.
	Loss of flow in Goulburn River	Weekly average flow loss between MCO SW22 and MCO SW2 (reviewed on a monthly basis) exceeds the allowable flow loss (Figure 5.1) for more than 3 consecutive weeks including most recent value. Allowable flow loss to be confirmed through a minimum of 12 months of baseline monitoring.	Review groundwater monitoring data at adjacent groundwater monitoring bores PZ234A and PZ237A. If these bores show no impact from mining, no further investigation required. Review additional flow data including Ulan and MCO daily treated water discharges and the Ulan river flow gauge to confirm any change in discharge. Consult stream gauge maintenance contractor to assess whether a change in stream conditions or the rating curve at either gauge has occurred. Revise rating curves if necessary and reassess flow loss. Engage suitably qualified subsidence expert to determine if impact is potentially related to UG4 LW409-414 extraction. If impacts may be related to UG4 LW409-414 extraction: <ul style="list-style-type: none"> Engage suitably qualified hydrologist to determine any potential downstream impacts. Obtain specialist advice on appropriate remediation works. Notify DPHI that performance measure has been exceeded immediately, and complete preliminary investigation report and provide to DPHI within 7 days of the date of the incident identifying the performance measure exceedance.

6 CONCLUSION

The Stage 1 approval conditions (05_0117) include the following subsidence impact performance measure for water resources:

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

The Goulburn River is not undermined by LW409-414 and is not expected to experience conventional subsidence movements or bed fracturing. Based on the subsidence predictions, the performance measure of negligible impact or environmental consequences for the Goulburn River will be achieved. Ongoing monitoring of Goulburn River flow will be undertaken and regularly reviewed to ensure that the performance measure is achieved.

7 REFERENCES

MCO, 2024	<i>'Surface Water Management Plan', Version 7, June 2024.</i>
MSEC, 2024	<i>'Moolarben Coal Complex: Moolarben Project Stage 1 – Longwalls 409 to 414, Subsidence Predictions and Impact Assessments for the Natural and Built Features in Support of the Extraction Plan', Mine Subsidence Engineering Consultants Pty Ltd, April 2024.</i>
AXYS, 2024	<i>'Moolarben Coal Operations, Potential Impact of UG4 Longwalls 409 to 414 on the Environment Risk Assessment Report', AxyS Consulting, Revision 1, 2 May 2024.</i>
SE, 2006	<i>'Preferred Project Report for the Proposed Longwalls 1 to 14 in the No. 4 Underground Area, Moolarben (Stage 1)', Strata Engineering Pty Ltd, December 2006.</i>



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