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Tahmoor Coal Pty Ltd

SUBSIDENCE MONITORING PROGRAM

Tahmoor North - Western Domain
Longwalls West 3 and West 4

August 2021

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Document Control

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1 Introduction

1.1 Background

Tahmoor Coal Mine (Tahmoor Mine) is an underground coal mine located approximately 80 kilometres (km) south-west of Sydney between the towns of Tahmoor and Bargo, New South Wales (NSW) (refer to **Figure 1-1**).

Tahmoor Mine has been operated by Tahmoor Coal Pty Ltd (Tahmoor Coal) since Tahmoor Mine commenced in 1979 using bord and pillar mining methods, and via longwall mining methods since 1987. Tahmoor Coal is a subsidiary within the SIMEC Mining Division of the GFG Alliance group.

Tahmoor Coal has previously mined 34 longwalls to the north and west of the Tahmoor Mine's current pit top location. The current mining area, the 'Western Domain', is located north-west of the Main Southern Railway (MSR) between the townships of Thirlmere and Picton. The Western Domain is within the Tahmoor North mining area and is within Mining Lease (ML) 1376 and ML 1539.

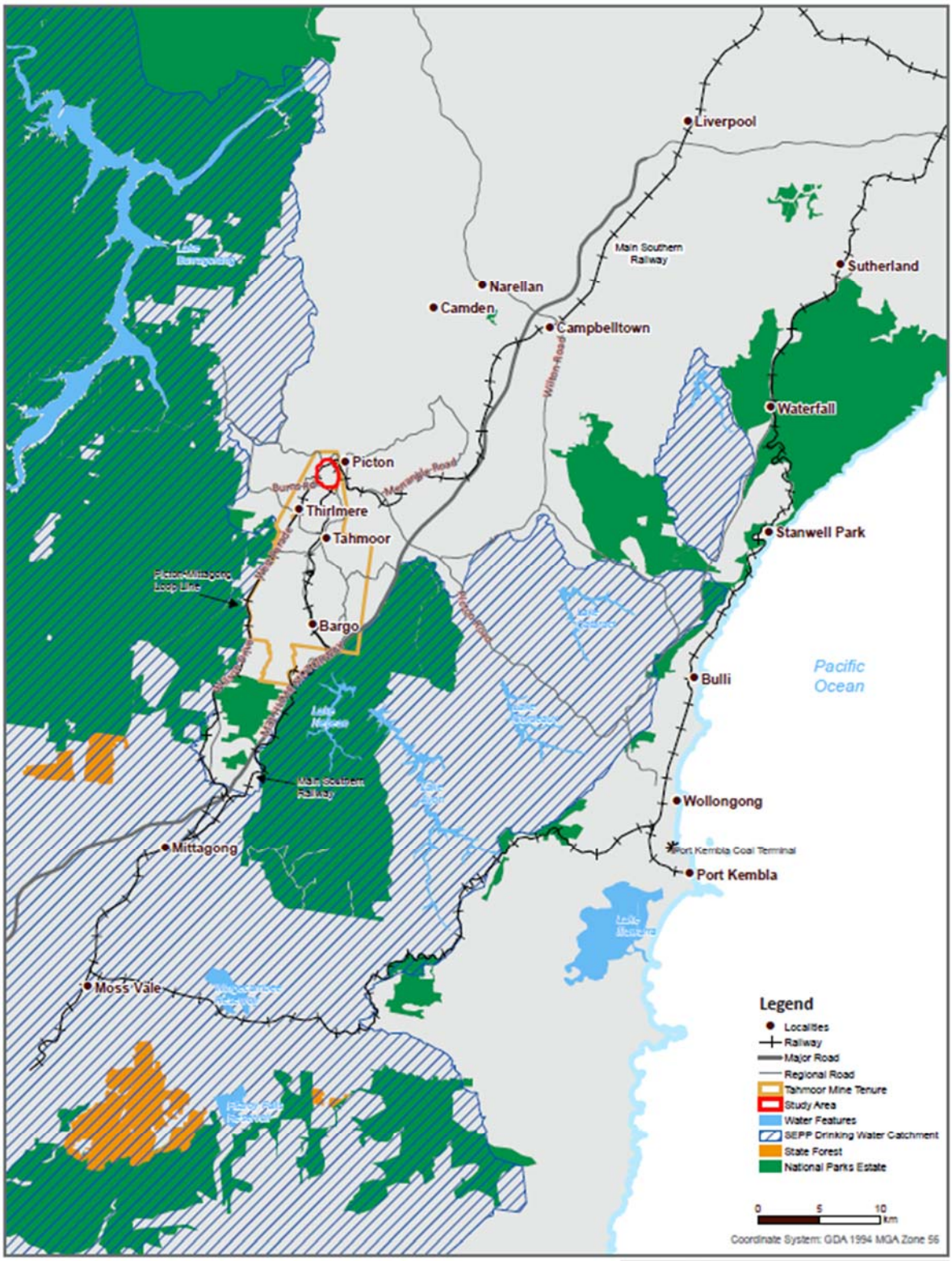
The mine plan for the Western Domain includes four longwalls - Longwalls West 1 to West 4. An Extraction Plan for the first two longwalls in the Western Domain, Longwalls West 1 and West 2 (LW W1-W2), was approved by the NSW Department of Planning, Industry and Environment (DPIE) on 8 November 2019. Longwall West 1 (LW W1) extraction was completed on 6 November 2020, and the extraction of Longwall West 2 (LW W2) commenced on 7 December 2020.

The proposed Longwalls W3 and W4 (LW W3-W4) are an extension of LW W1-W2 and will be the focus of this Subsidence Monitoring Program.

LW W3 is approximately 283 metres (m) wide (rib-to-rib) and 1,552 m long. LW W4 is approximately 285 m wide and 1,004 m long. The width of the chain pillar is 39 m between LW W2 and LW W3, and 44 m between LW W3 and LW W4.

This Subsidence Monitoring Program describes the inspection regimes, layout of monitoring points, parameters to be measured, monitoring methods and accuracy, timing and frequencies of surveys and inspections, and recording and reporting of monitoring results.

The Subsidence Monitoring Program is consistent with the monitoring commitments that are described in the following plans, which are submitted as part of the Extraction Plan for LW W3-W4. The study area of the Extraction Plan is shown in **Figure 1-2**.



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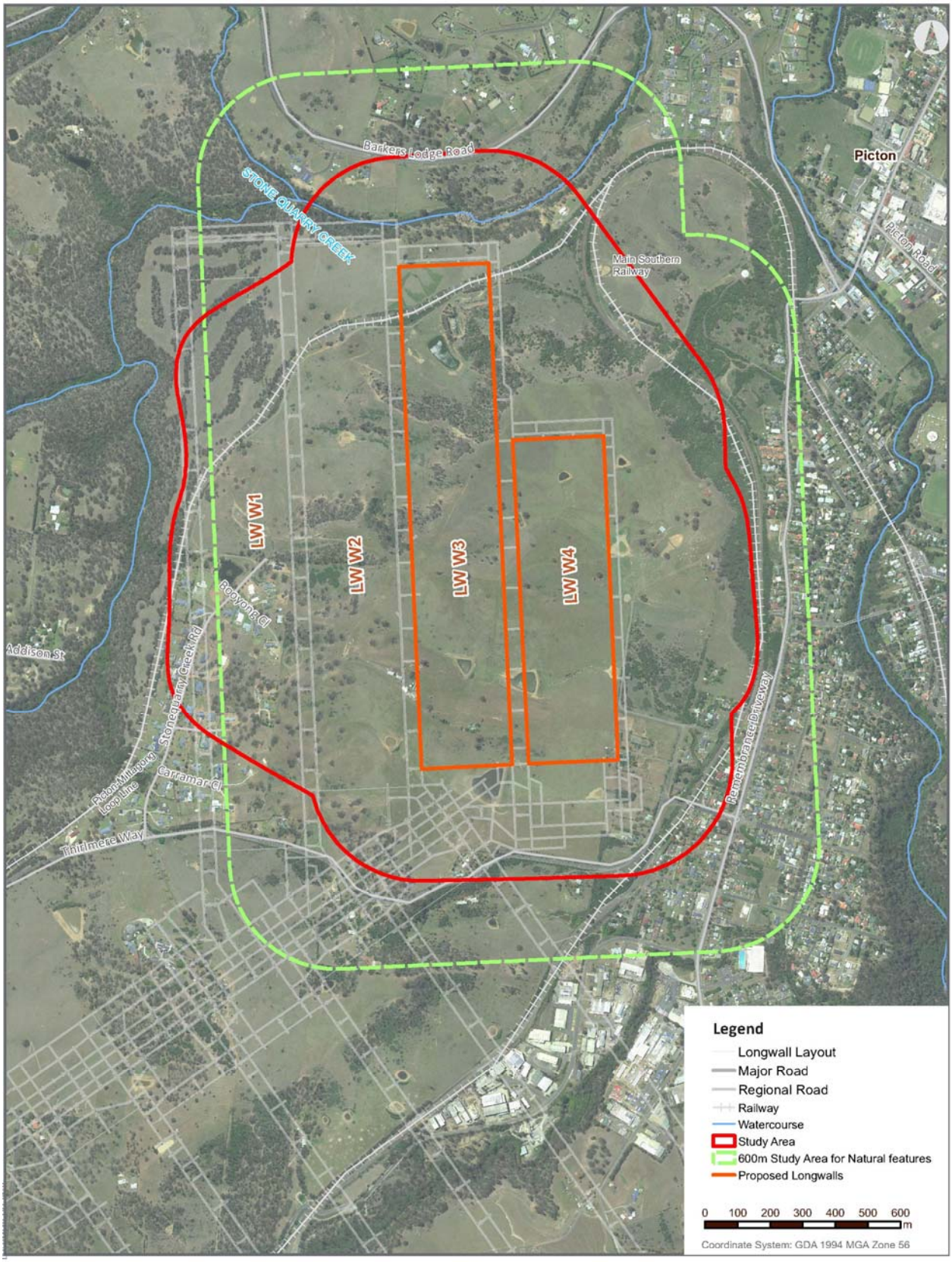
REGIONAL CONTEXT

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-1

Date: 22/12/2020

Data Sources:
© NSW DPI (2019), © NSW Mining (2019), © SIMEC (2019)



EXTRACTION PLAN STUDY AREA

Tahmoor North Western Domain Longwalls West 3 and West 4 Extraction Plan

FIGURE 1-2

Date: 7/04/2021

Data Sources:
© NSW DFSI (2019); © NSW Mining (2019); © SIMEC (2019)
Aerial Imagery: © Photomapping Services (November 2018)

The Subsidence Monitoring Program is consistent with the monitoring commitments as described in the following plans, which are submitted as part of Tahmoor Coal's Extraction Plan for LW W3-W4:

- Tahmoor Coal – Water Management Plan for LW W3-W4, 2021;
- Tahmoor Coal – Land Management Plan for LW W3-W4, 2021;
- Tahmoor Coal – Biodiversity Management Plan for LW W3-W4, 2021;
- Tahmoor Coal – Heritage Management Plan for LW W3-W4, 2021;
- Tahmoor Coal – Built Features Management Plan for LW W3-W4, 2021; and
- Tahmoor Coal – Public Safety Management Plan for LW W3-W4, 2021.

The Subsidence Monitoring Program is consistent with detailed Infrastructure Management Plans, which have been developed by Tahmoor Coal in consultation with stakeholders prior to the influence of subsidence on each relevant feature. Each of these management plans describes measures that will be undertaken to monitor subsidence movements and physical changes and/or impacts that occur during mining. The management plans include:

- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Wollondilly Shire Council Infrastructure, Report No. MSEC1173-02, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Stonequarry Wastewater Treatment Plant, Report No. MSEC1173-04, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Endeavour Energy Infrastructure, Report No. MSEC1173-06, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Transport for NSW Infrastructure, Report No. MSEC1173-18, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Telstra Infrastructure, Comms Network Solutions, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for NBN Co Infrastructure, Comms Network Solutions, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Built Structures, Report No. MSEC1173-12, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Picton-Mittagong Loop Line, Report No. MSEC1168, 2021; and
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Main Southern Railway, Report No. MSEC1163, 2021.
- Tahmoor Coal – Stonequarry Creek Rockbar Management Plan, Report No. TAH-HSEC-333, August 2021.

This Subsidence Monitoring Program is a live document that can be amended at any stage of mining to meet the changing needs of Tahmoor Coal and its stakeholders.

The Subsidence Monitoring Program may be updated in the future to be consistent with Infrastructure Management Plans that have been drafted but are yet to be submitted to stakeholders for review and approval:

- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Sydney Water Potable Water Infrastructure, Report No. MSEC1173-03, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Sydney Water Sewerage Infrastructure, Report No. MSEC1173-09, 2021;

- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to Jemena Gas Infrastructure, Report No. MSEC1173-05, 2021;
- Tahmoor Coal – LW W3-W4 Management Plan for Potential Impacts to No. 796-800 Thirlmere Way (Weatherboard Cottage), Report No. MSEC1173-13-03, 2021;

The Management Plans will be completed prior to the influence of LW W3-W4 on each feature. The Sydney Water Potable Water Management Plan and Jemena Gas Management Plan are required before the length of extraction of LW W3 exceeds 700 metres. The Sydney Water Sewerage Management Plan and the Weatherboard Management Plan are required before the influence of LW W4.

1.2 Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 m in front of the longwall face to an area 450 m behind the longwall face.

This is termed the "active subsidence zone" for the purposes of this Subsidence Monitoring Program, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 millimetres (mm) subsidence contour for the active longwall and a distance of 150 m in front of and 450 m behind the active longwall face, as shown by **Figure 1-3**.

In the case of the Main Southern Railway, the "active subsidence zone" has been extended beyond the predicted 20 mm subsidence contour. The active subsidence zone, which is described as Stage 2 in the Railway Management Plan, is bounded by the Main Southern Railway corridor and a distance of 200 m in front of and 400 m behind the active longwall face, as shown by **Figure 1-5**.

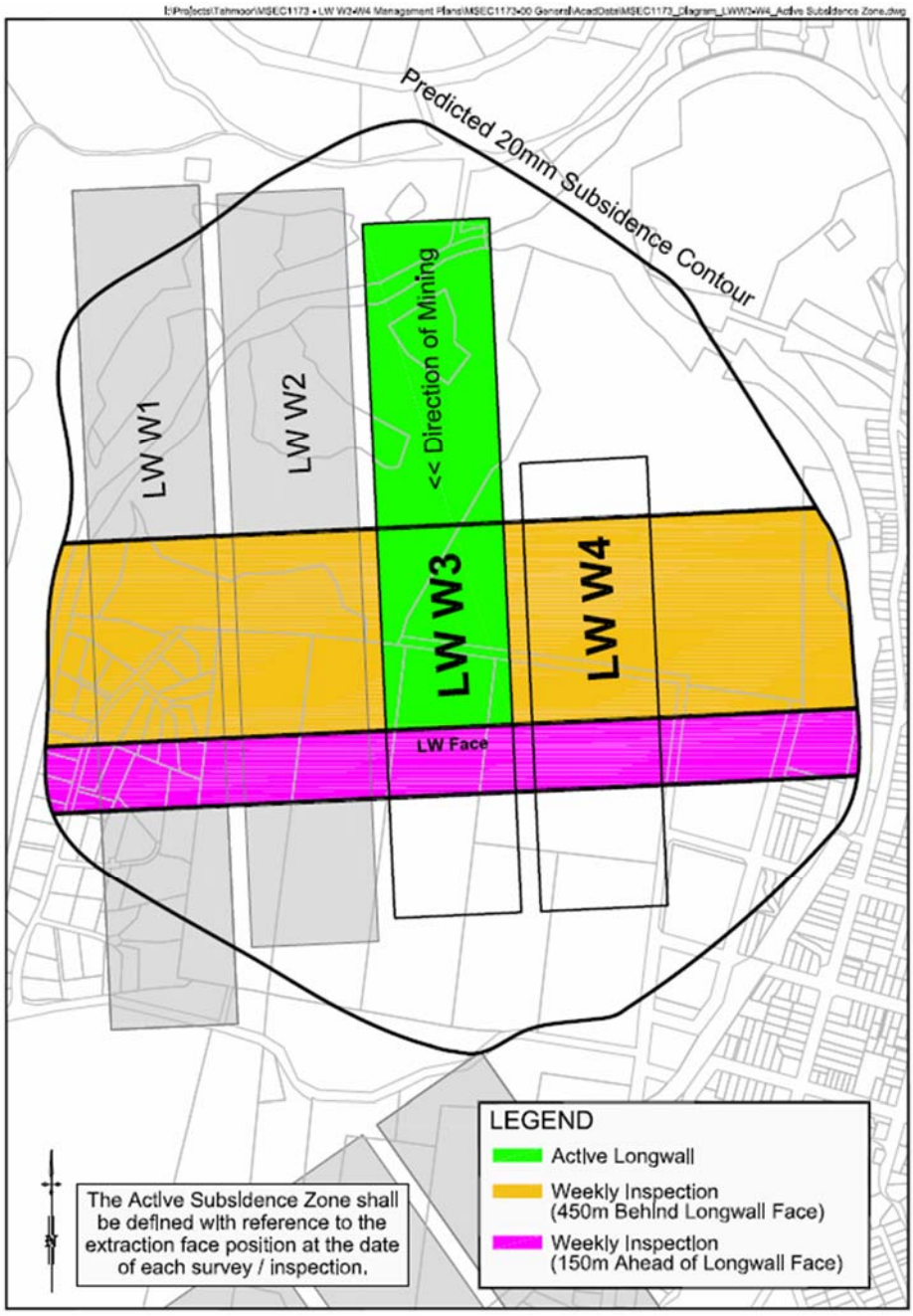


Figure 1-3 Diagrammatic Representation of Active Subsidence Zone

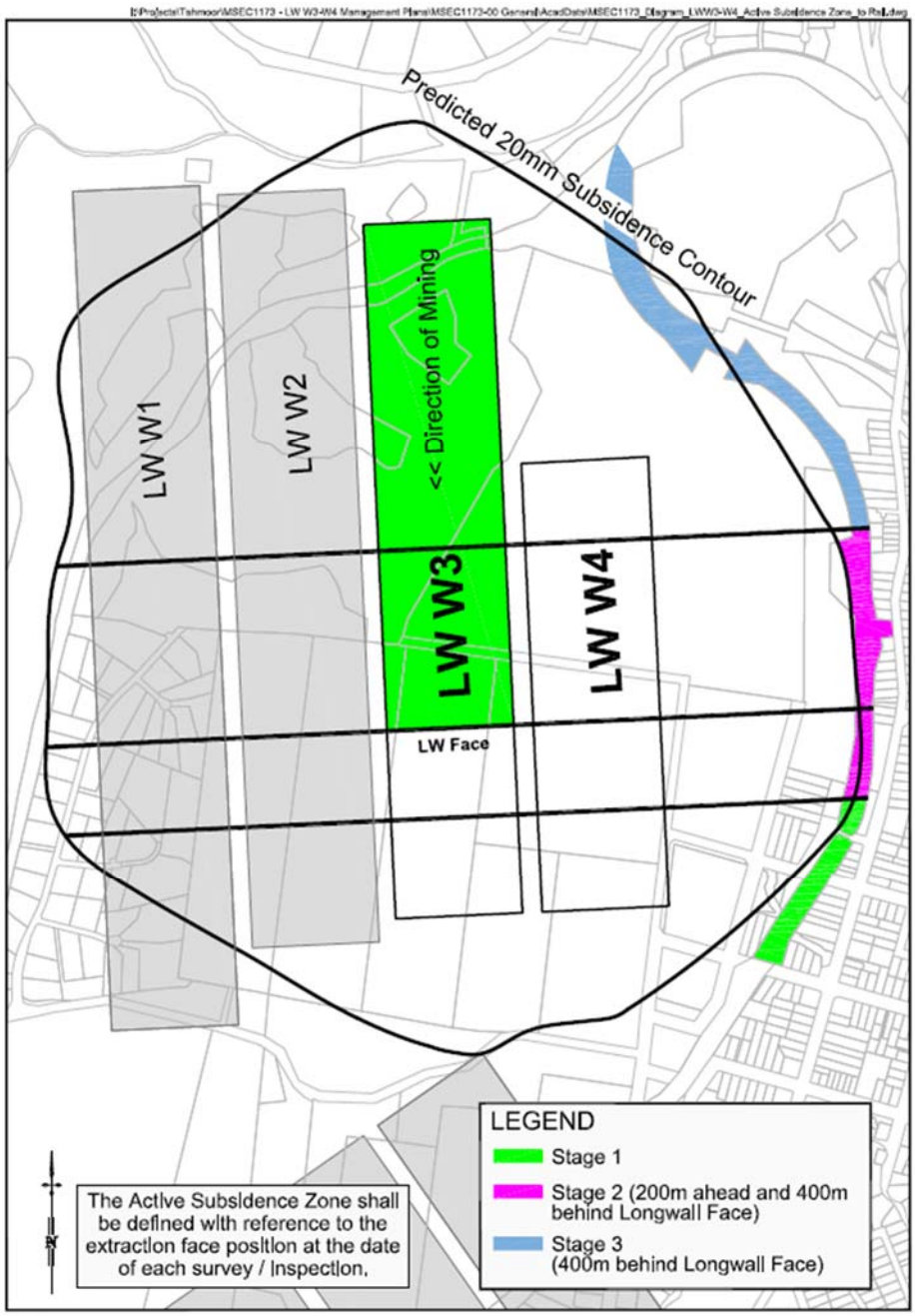


Figure 1-4 Diagrammatic Representation of Active Subsidence Zone

1.3 Maximum Predicted Conventional Subsidence Parameters

Predicted mining-induced conventional subsidence movements were provided in **Report No. MSEC1112**, which was prepared in support of Tahmoor Coal's Extraction Plan Application for LW W3-W4. A summary of the maximum predicted incremental subsidence parameters due to the extraction of LW W3-W4 is provided in **Table 1-1**.

Table 1-1 Maximum Predicted Incremental Conventional Subsidence Parameters

Longwall	Maximum predicted incremental vertical subsidence (mm)	Maximum predicted incremental tilt (mm/m)	Maximum predicted incremental hogging curvature (km^{-1})	Maximum predicted incremental sagging curvature (km^{-1})
LW W3	650	4.5	0.05	0.09
LW W4	600	4.5	0.05	0.08

A summary of the maximum predicted total subsidence parameters due to the extraction of LW W3-W4 is provided in **Table 1-2**. The predicted total parameters represent the accumulated movements due to the extraction of all proposed longwalls.

Table 1-2 Maximum Predicted Total Conventional Subsidence Parameters

Longwall	Maximum predicted total vertical subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (km^{-1})	Maximum predicted total sagging curvature (km^{-1})
LW W3	950	5.0	0.06	0.10
LW W4	1025	5.0	0.06	0.10

1.4 Comparison of Measured and Predicted Subsidence for LW W1-W2

Predictions using MSEC's Incremental Profile Method have been continually tested and refined during the mining of previous Longwalls 22 to 32, as described **Report No. MSEC1112**.

In this case, LW W1-W2 are being extracting in a new longwall series located to the north of completed LW 32.

LW W1

Observed subsidence above single panels is typically more variable than above subsequent longwall panels in a series. The variations are due to different strengths of the overburden strata above the panel, which is supported on all four sides of the longwall.

A study on observed subsidence above previously extracted single panels at Tahmoor Mine was conducted by MSEC, with results provided in **Report No. MSEC1112**.

Whilst a reasonable correlation between measured and predicted subsidence was found for LW 22, which was the most recently extracted single panel in the Tahmoor North lease, a study of the overall history of subsidence above single panels at Tahmoor Mine found that actual subsidence above LW W1 could be greater than predicted. There are also other cases in the Southern Coalfield where measured subsidence above a single panel has been substantially less than predicted. Therefore, there is greater uncertainty in subsidence predictions for single panels compared to predictions for subsequent longwalls in a series.

Observed subsidence above LW W1 has been less than predicted. An example is provided in **Figure 1-5**, which compares predicted and observed subsidence along the Picton-Mittagong Loop Line.

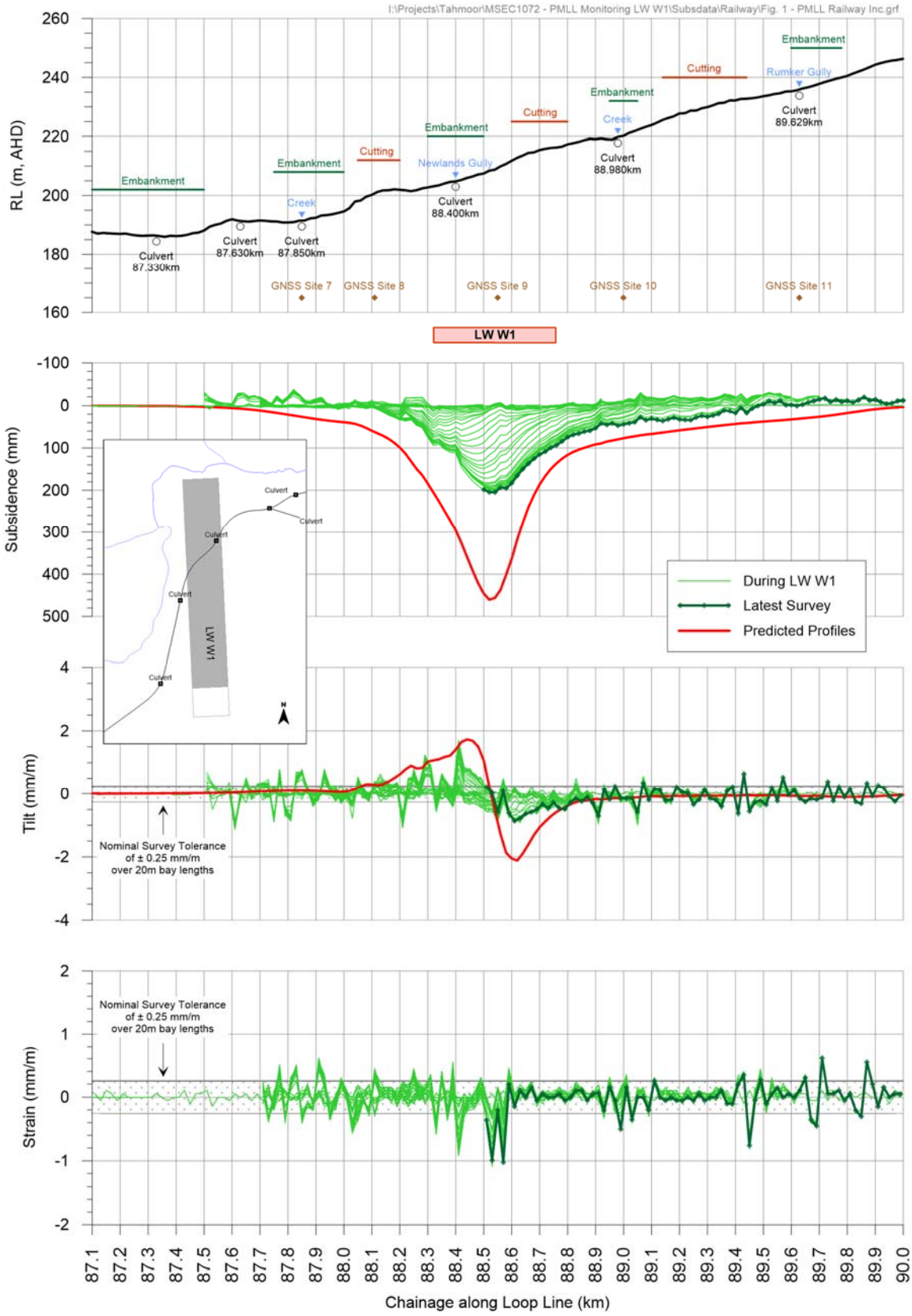


Figure 1-5 Observed subsidence along Picton-Mittagong Loop Line during the mining of LW W1

Peg 88.560 km on the Picton-Mittagong Loop Line, GNSS Site 9, Peg WX-08 on the LW W1-W2 Crossline, Peg S40 on Stonequarry Creek Road and Peg B4 on Booyong Close are located on the centreline of LW W1 and have been mined directly beneath by LW W1. The development of subsidence at these pegs, relative to their positions to the LW W1 face are shown in **Figure 1-6**.

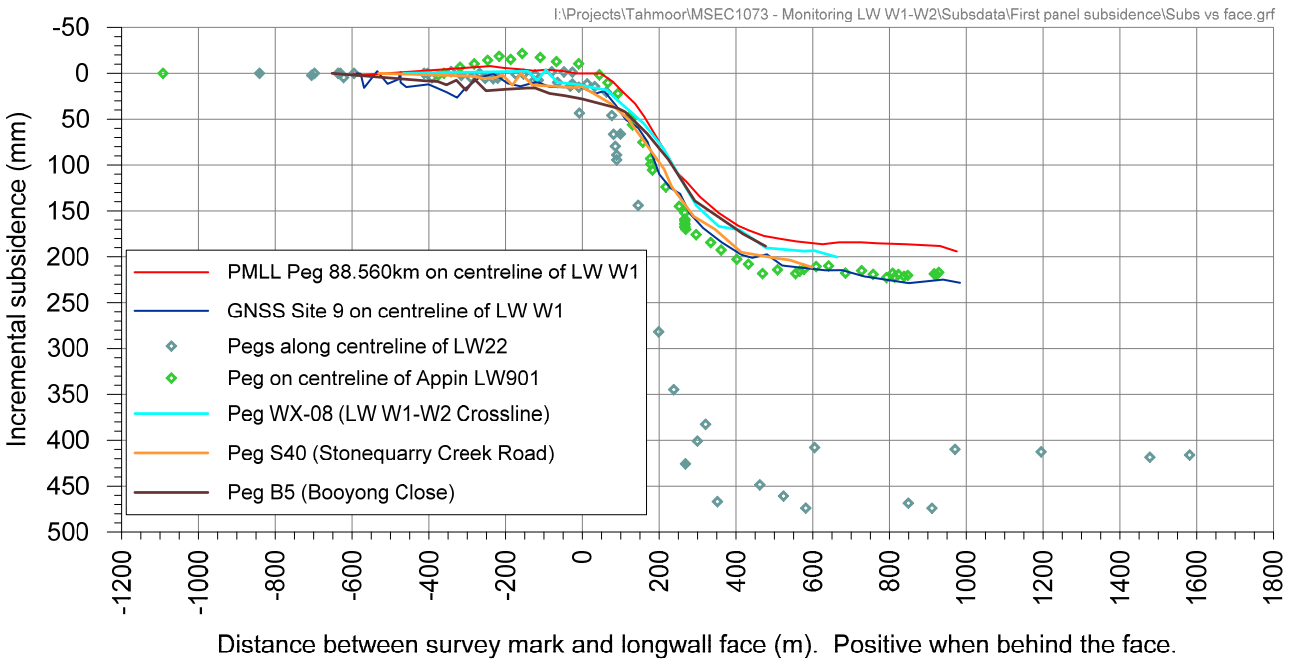


Figure 1-6 Development of subsidence along centreline of LW W1 compared to previously extracted single panels

Subsidence above LW W1 has been less than observed above LW 22 at Tahmoor Mine and closer to what was observed during the mining of LW901 at Appin Mine.

Observed ground strains have also been relatively low, with maximum compressive ground strains currently less than 1.5 mm/m.

LW W2

Subsidence surveys above LW W2 have measured less subsidence than predicted. Observed subsidence along the centreline of LW W2 is shown in **Figure 1-7.** Observed subsidence along the LW W1 W2 crossline after the extraction of LW W2 is shown in **Figure 1-8**.

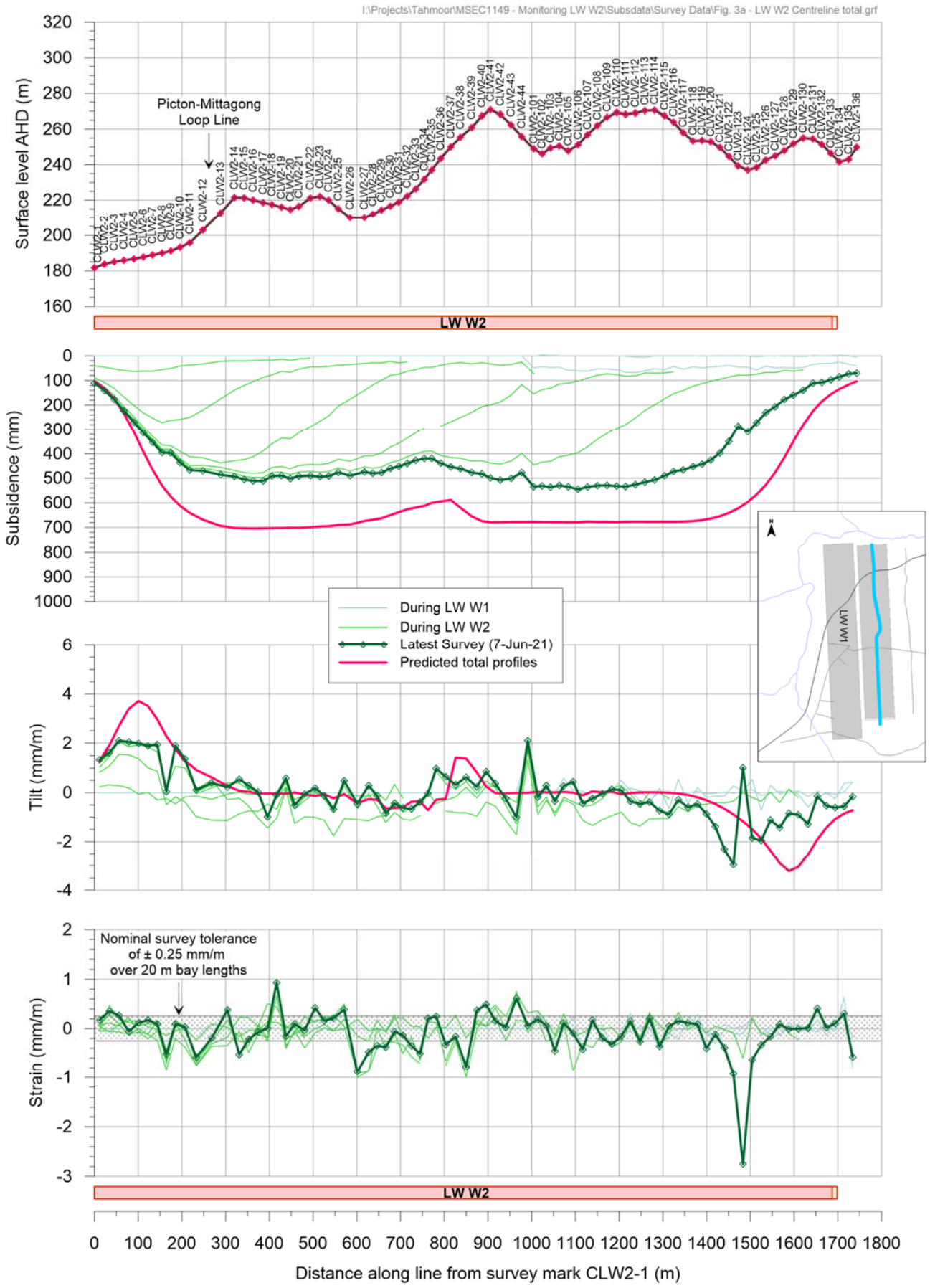


Figure 1-7 **Comparison between measured and predicted subsidence, tilt and strain profiles along LW W2 Centreline during the mining of LW W2**

As shown in **Figure 1-8**, subsidence developed gradually above the commencing end of LW W2 is expected to have developed at this length of extraction.

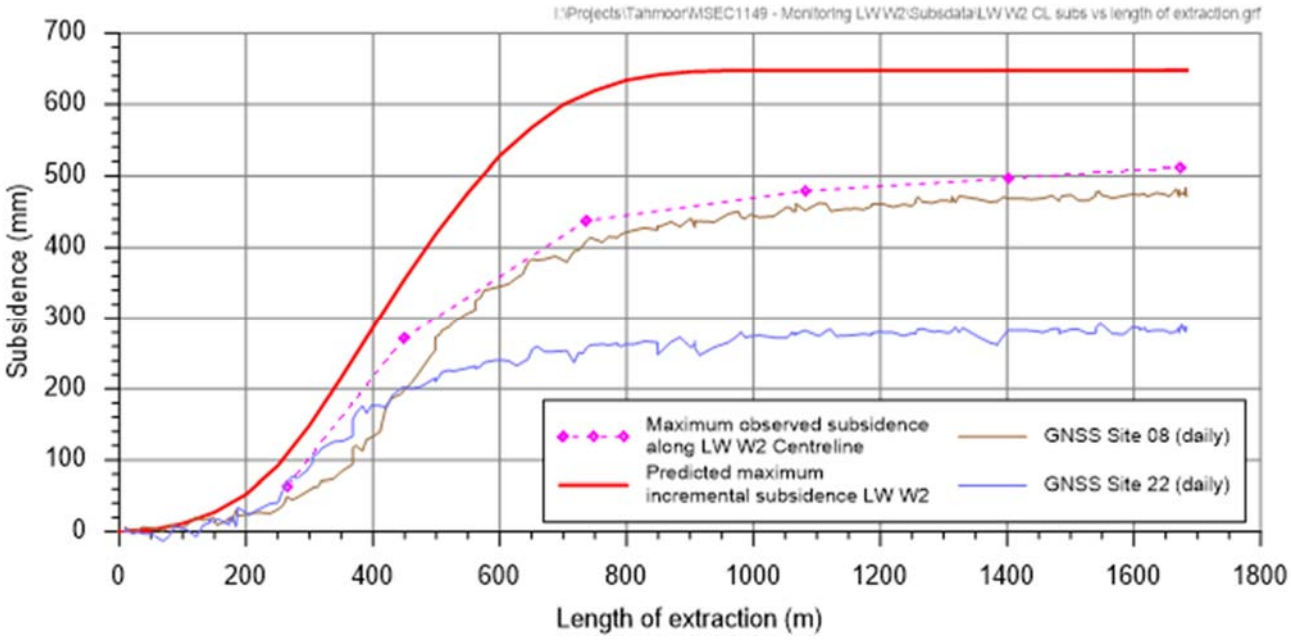


Figure 1-8 Development of subsidence along centreline of LW W2 relative to length of longwall extraction at TC

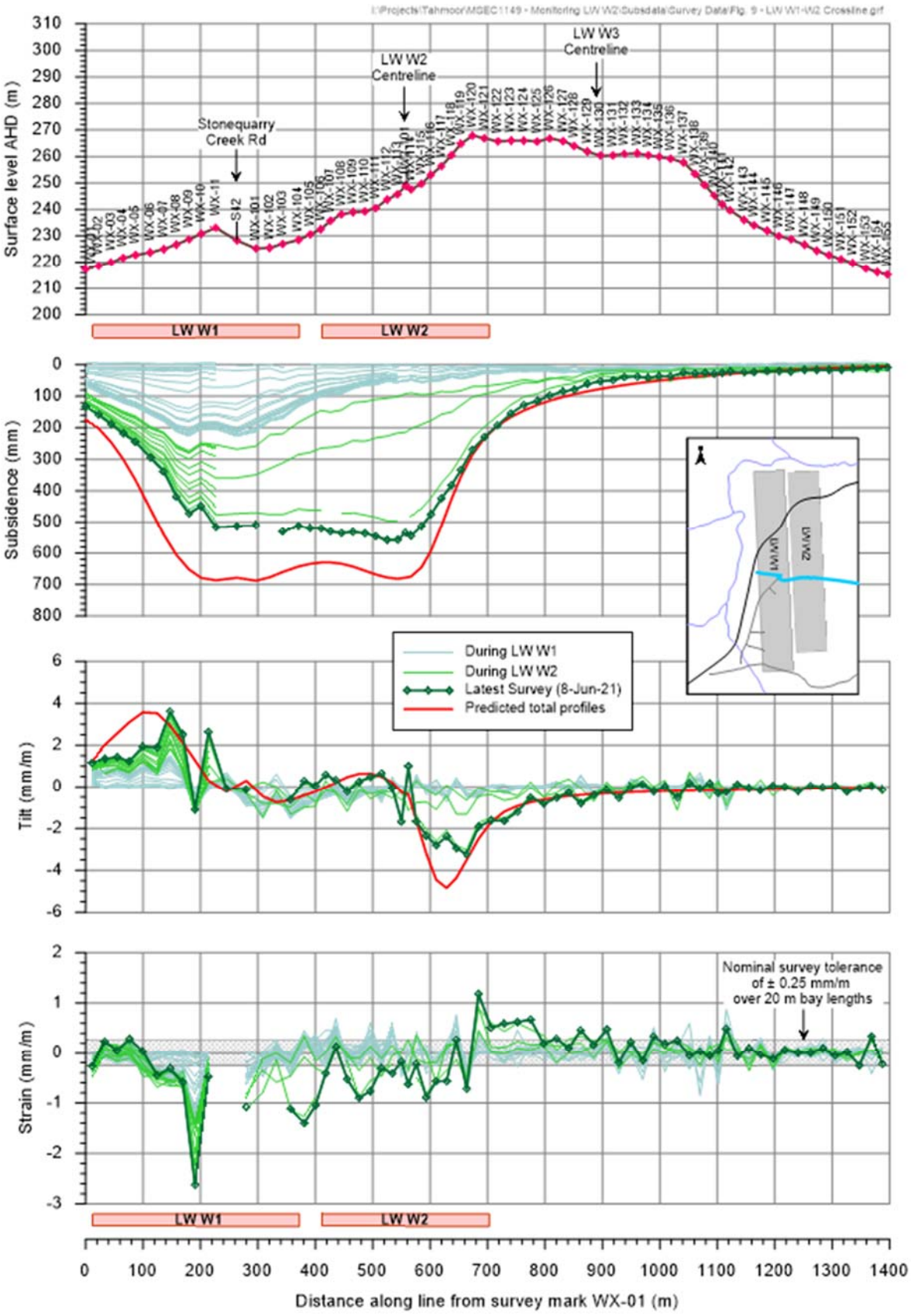


Figure 1-9 **Comparison between measured and predicted subsidence, tilt and strain profiles along LW W1-W2 crossline during the mining of LW W1-W2**

Whilst observed subsidence above LW W1 and LW W2 has been less than predicted, subsidence due to the extraction of LW W3-W4 may not follow the same pattern and return to the normal, predicted subsidence levels. Subsidence may also be greater than predicted.

It is therefore planned to monitor during the early stages of extraction of LW W3 and LW W4 to compare observations with predictions. The information will assist with managing potential impacts as described in the subsidence management plans.

2 Regulatory Requirements

2.1 Project Approval

2.1.1 Development Consent

Tahmoor Coal's operations are conducted in accordance with applicable Commonwealth and State environmental, planning, mining safety, and natural resource legislation. A register of relevant environmental legislative and regulatory requirements is maintained by Tahmoor Coal in a compliance database.

The proposed LW W3-W4 will be operating in the Tahmoor North mining area under Development Consents DA 57/93 and DA 67/93, as discussed further in **Section 3.2.1** of the Extraction Plan Main Document. Development consent was modified in 2006 (Mod 1), 2012 (Mod 2), 2018 (Mod 4) and 2020 (Mod 5).

DA 67/98 provides the conditional planning approval framework for mining activities in the Western Domain to be addressed within an Extraction Plan and supporting management plans. Conditions relevant to this Subsidence Monitoring Program from DA 67/98 are detailed in **Table 2-1**.

Table 2-1 Key Conditions from DA 67/98 regarding Subsidence Monitoring Program (October 2020)

Condition	Condition Requirement	Section Addressed
Extraction Plan		
13H(vii)(a)	Subsidence Monitoring Program which has been prepared in consultation with the Resources Regulator to:	Section 2.2, Section 3
	• describe the ongoing conventional and non-conventional subsidence monitoring program;	
	• provide data to assist with the management of risks associated with conventional and non-conventional subsidence;	
	• validate the conventional and non-conventional subsidence predictions;	
	• analyse the relationship between the predicted and resulting conventional and non-conventional subsidence effects and predicted and resulting impacts under the plan and any ensuring environmental consequences; and	
	• inform the adaptive management process;	
13H(vii)(i)	Contingency Plan that expressly provides for:	Section 3 Subsidence Monitoring Program can be used to collect data to support future Extraction Plans.
	• adaptive management where monitoring indicates that there has been an exceedance of any performance measure in Table 1 and Table 2, or where any such exceedance appears likely; and	
	• an assessment of remediation measures that may be required if exceedances occur and the capacity to implement those measures; and	
	• includes a program to collect sufficient baseline data for future Extraction Plans.	

2.1.2 Adaptive Management Report Conditions of Consent

Tahmoor Coal completed a review of observations of subsidence impacts and environmental consequences as a result of mining the first 1,000 m of LW W1 to determine whether additional setback for the commencing end of LW W2 was likely to further reduce the potential for subsidence impacts on Stonequarry Creek. The review found that there had been no exceedances of the subsidence impact performance measures, and a modification of the starting position of LW W2 was not proposed.

DPIE confirmed on 7 September 2020 that, based on the Adaptive Management Report, there was no reason to impose a further setback distance of LW W2 from nearby creek lines. However, to provide additional safeguards, DPIE requested the following amendments to monitoring frequencies during the extraction of LW W2:

- Pool MR45 – increased frequency of data download of automated pool water level and visual inspection of natural drainage behaviour from monthly to fortnightly, during active subsidence period;
- P12 – increased frequency of download from monthly to fortnightly, during mining; and
- TNC036 – increased frequency of data download from monthly to fortnightly, during mining.

These additional requests were incorporated into the LW W1-W2 Subsidence Monitoring Program, and will continue during the mining of LW W3 as listed in **Table 3-1.**

2.1.3 Extraction Plan Guideline

This Subsidence Monitoring Program has been prepared in accordance with the DPIE *Draft Guidelines for the Preparation of Extraction Plans V5* (DPE, 2015), as illustrated in **Table 2-2**.

Table 2-2 Extraction Plan Guideline Requirements for Subsidence Monitoring Program

Extraction Plan Guideline Content Requirements	Section(s) Addressed
The Subsidence Effects Monitoring Program must provide sufficient information on subsidence effects to fully support implementation of the Extraction Plan. It should have clearly stated objective(s) and address the following:	Section 3
• Proposed subsidence monitoring activities (individually specified);	Section 3
• Information on subsidence parameters to be obtained from each monitoring activity;	Section 3
• Proposed locations and/or extents where each monitoring activity will be undertaken, in particular, the proposed layout and/or locations of instrumentation, monitoring points or inspections (including graphical plans);	Section 3, Appendix A
• Proposed timing, frequency and duration of each monitoring activity;	Section 3
• Proposed monitoring method, technologies, industry standards (e.g. ICSM Standards SP1) Version 2.0) or Cods of Practice to be applied in undertaking each monitoring activity;	Appendix B, Appendix C
• Proposed measures and procedures for quality assurance and competence of personnel undertaking monitoring activities;	Section 3.2, Appendix B, Appendix C
• Proposed procedures to record monitoring results;	Section 3.3, Appendix B, Appendix C

Extraction Plan Guideline Content Requirements	Section(s) Addressed
• Proposed reporting monitoring results, including the frequency of reporting; and	Section 3.3, Appendix B, Appendix C
• Capacity of the program to detect early warning of deviations from the defined performance measures and associated performance indicators.	Section 3.5
The Subsidence Effects Monitoring Program must summarise and consolidate the various monitoring programs presented in each of the key component plans, including the Built Features and Public Safety Management Plans.	Section 3

2.2 Consultation

The NSW Department of Planning, Industry and Environment – Resources Regulator (Resources Regulator) have been consulted with during the preparation of this Extraction Plan and Subsidence Monitoring Program. A summary of consultation undertaken to date is provided in **Section 2.1.2** of the Extraction Plan Main Document, and a copy of the incoming correspondence is also provided in **Appendix C** of the Extraction Plan Main Document.

3 Subsidence Monitoring Program

3.1 Layout of Monitoring Points

The layout of monitoring points is provided in **Drawing No. MSEC1173-00-01**, which is included in **Appendix A**. Due to the density of survey marks, detailed layouts of monitoring points for key items of railway infrastructure associated with the Picton-Mittagong Loop Line (PMLL) and Stonequarry Estate Wastewater Treatment Plant.

3.2 Monitoring Methods and Accuracy

With the exception of surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Specifications for Subsidence Monitoring Lines for LW W3-W4* by SMEC. This specification is appended to this Subsidence Monitoring Program in **Appendix B**.

With respect to surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the reports entitled *Loop Line- Survey Monitoring Plan for LW W3-W4, Main South Line- Survey Monitoring Plan for LW W3-W4 and Far Field Structures- Survey Monitoring Plan for LW W3-W4* by Southern Rail Surveys. These specifications are appended to this Subsidence Monitoring Program in **Appendix C**.

Occasionally survey pegs become disturbed or lost. Tahmoor Coal will replace the lost pegs unless approval for not replacing the pegs is provided by the NSW Department of Planning and Environment, Resources Regulator, Mine Safety Operations (DPE, 2017).

Tahmoor Coal will conduct monitoring in accordance with the Tahmoor Coal Environmental Management Strategy Framework, which is aligned with ISO 14001 Environmental Management System.

Monitoring will be supervised by the Tahmoor Coal Environment and Community Team, the members of which are professional and competent scientists and engineers.

3.3 Recording and Reporting of Monitoring Results

The recording and reporting of monitoring results is described in the report entitled *Subsidence Monitoring Lines for LW W3-W4* by SMEC and in the reports entitled *Loop Line- Survey Monitoring Plan for LW W3-W4, Main South Line- Survey Monitoring Plan for LW W3-W4 and Far Field Structures- Survey Monitoring plan for LW W3-W4* by Southern Rail Surveys. These specifications are appended to this Subsidence Monitoring Program in **Appendix B** and **Appendix C**.

3.4 Inspection Regimes, Parameters to be Measured, Timing and Frequencies of Surveys and Inspections

The inspection regimes, parameters to be measured, timing and frequencies of surveys and inspections are outlined in **Table 3-1**. The information is sorted by features that are being monitored.

To clarify, where the timing of the monitoring or inspection frequency is described as "*Monthly after x metres of extraction"*, or *"Every 200 metres of extraction after x metres of extraction*", this means that the first survey will commence within one week of the longwall face passing "*x metres of extraction".*

3.5 Centreline and Crossline Surveys for LW W3-W4

A survey line has been installed along the centreline of LW W3, as shown in **Drawing No. MSEC1173-00-01**. A survey line has been installed along the centreline of LW W4 prior to the commencement of LW W3.

The purpose of the survey line is to establish the general magnitude and shape of surface subsidence along the centrelines of LW W3-W4. The observed subsidence movements will be used to provide early subsidence information to inform Tahmoor Coal and affected stakeholders. The information would assist Tahmoor Coal and affected stakeholders in considering whether any additional measures are required to manage potential impacts on the built features.

The information will also be used by Tahmoor Coal as part of its ongoing review of subsidence effects on natural features.

The survey line will consist of pegs spaced nominally every 20 m, where possible. Surveys will measure levels and horizontal distances between adjacent pegs.

A GNSS unit is proposed to be installed approximately 100 m inside the commencing end of LW W3 (relocated from GNSS Site 22 above the commencing end of LW W2) to monitor the development of initial subsidence, which is expected to occur after the length of extraction exceeds approximately 150 m. The GNSS unit will then be relocated to approximately 100 m inside the commencing end of LW W4 prior to the start of LW W4.

Weekly ground surveys along the centreline of LW W3 will commence after 20 mm of vertical subsidence is measured by the GNSS unit, or the length of the extraction of LW W3 exceeds 150 m, whichever occurs first. The surveys will be conducted on a weekly basis in accordance with the Stonequarry Creek Rockbar Management Plan. The survey frequency will reduce to monthly once the rates of change in subsidence at the commencing end of LW W3 reduce to low levels.

A survey line has also been installed along a cross line that follows a property boundary that is approximately square to the proposed longwall panels. Access has been granted to install the survey marks along this line, part of which is on privately owned land. The survey line extends to Star Street, just east of the LW W4.

3.6 Surveys along Local Roads and Main Services Infrastructure

Survey lines have been installed along Barkers Lodge Road, Thirlmere Way, Stonequarry Creek Road, Carramar Close, Attunga Close and Booyong Close, as shown in **Drawing No. MSEC1173-00-01**.

Additional survey lines have also been installed along Connellan Crescent and along Telstra and NBN Co. optical fibre cables.

The survey lines along the local roads and optical fibre cables follow the alignments of Wollondilly Shire Council infrastructure, and services infrastructure including Sydney Water potable water and sewerage pipelines, Stonequarry Estate sewerage infrastructure, Jemena gas pipelines, Endeavour Energy electrical infrastructure, and telecommunications infrastructure (Telstra and NBN).

The survey lines consist of pegs spaced nominally every 20 m. Surveys will measure levels and horizontal distances between adjacent pegs.

Visual inspections will also be conducted along the local roads during the proposed extraction of LW W3-W4.

3.7 Monitoring of Structures

Survey lines have been installed along Barkers Lodge Road, Thirlmere Way, Stonequarry Creek Road, Carramar Close, Attunga Close and Booyong Close, as shown in **Drawing No. MSEC1173-00-01**. Additional survey lines have been installed along Connellan Crescent and along Telstra and NBN Co. optical fibre cables.

The survey lines along the local roads pass the majority of the residential structures. The survey lines consist of pegs spaced nominally every 20 m. Surveys will measure levels and horizontal distances between adjacent pegs.

Visual inspections will also be conducted along the local roads during the proposed extraction of LW W3-W4.

In accordance with the Built Structures Management Plan, the following surveys and inspections will be conducted as required:

- Specific ground surveys for selected properties, where recommended by the geotechnical engineer or structural engineer due to their proximity to steep slopes or pre-existing condition, or where requested by landowners. This includes two dam walls above the southern end of LW W3;
- Visual inspections of residential structures that are either located on or adjacent to steep slopes, are in poor existing condition (based on the hazard identification inspections), have previously reported impacts, or where recommended by the Structures Response Group;
- Visual inspections of pool fences and gates;
- Visual inspections of commercial, industrial and business establishments, public amenities and public utilities; and
- Visual inspection of farm dams monthly during periods of active subsidence for each dam from the extraction of LW W3-W4.

The properties where landowners have requested or agreed with Tahmoor Coal to install survey pegs are shown in **Drawing No. MSEC1173-00-01**. Survey pegs have been installed at these properties.

3.8 Monitoring along the Picton-Mittagong Loop Line

The PMLL is located directly above the northern commencing end of LW W3. It is part of the former alignment of the Main South Line and was built in 1867. The PMLL was bypassed in 1919 following the construction of a new double track deviation, which is the current alignment of the MSR.

Transport Heritage NSW, as the operator of the Trainworks Railway Museum at Thirlmere, holds a licence to use the track. The majority of tourist trains run between Thirlmere and Buxton to the south of the Study Area. Approximately 4 to 5 trains typically travel through the Study Area per week as part of tours or arriving or leaving the museum for maintenance.

The PMLL is a single line jointed track, which is defined by Australian Rail Track Corporation as rails that can move through the rail/sleeper fastenings and which have standard joints with a 6 mm gap installed at neutral temperature. The rails are generally fixed to steel or timber sleepers (but not concrete).

The PMLL passes over an embankment and culverts at 87.850 km directly above LW W3.

A description of planned monitoring and inspections along the PMLL is provided in the following sub-sections. Further information is provided in Tahmoor Coal's management plan for the PMLL (PMLL Management Plan).

3.8.1 Ground Surveys along Rail Corridor

A survey line has been established along the PMLL from 87.100 km (junction of the PMLL and MSR) to 90.000 km, as shown in **Drawing No. MSEC1173-00-01.**

The survey line consists of pegs spaced nominally 20 m apart along the line. The survey pegs will be measured in absolute 3D on a monthly basis and 2D (levels and horizontal distances between adjacent pegs) on a weekly basis within the zone of active subsidence. The extent of the survey will follow the zone of active subsidence as it migrates down each longwall panel.

3.8.2 Ground Surveys at Culverts and Embankments

Surveys will be conducted at PMLL culverts and embankments, in addition to standard surveys along the track. The surveys include:

- Absolute 3D surveys and relative 3D surveys of the embankments along monitoring lines at the crests and toes on both sides at 87.850 km, 88.400 km, 88.980 km and 89.629 km, as shown in **Drawings Nos. MSEC1168-05** to **MSEC1168-08**; and
- Absolute 3D and relative 3D surveys along the sandstone or brick arch culverts at 87.630 km, 87.850 km, 88.400 km, 88.980 km and 89.629 km. Survey marks are located at the spring point on both sides at the outlet, midpoint and inlet of the culvert (six survey marks in total per culvert).

3.8.3 Ground Surveys at Railway Cuttings

Surveys will be conducted at PMLL cuttings, in addition to standard surveys along the track. The surveys will include an absolute 3D surveys and relative 3D surveys of the cuttings along the main railway corridor and pairs of survey pegs that are located every 20 m along the crest of the cuttings on both sides of the track.

3.8.4 GNSS Monitoring

GNSS units have been placed along the PMLL corridor above the culverts at 87.850 km, 88.980 km and 89.629 km, and above the centrelines of LW W1 and LW W2. GNSS Site 22 will be relocated to the centreline of LW W3 and will labelled as Site 23.

3.8.5 Track Geometry Monitoring

The track geometry along the PMLL will be monitored by a track recording trolley on a weekly basis during the period of active subsidence. Further details are provided in the PMLL Management Plan.

3.8.6 Visual Inspections

Visual inspections will be conducted along the PMLL by a Track Certifier on a weekly basis along the railway corridor within the zone of active subsidence.

An additional visual inspection will be conducted by the Track Certifier prior to train movement. The inspection will be conducted within 24 hours of planned train movements, with the inspection targeted to occur on the morning prior to the planned train movement. The purpose of this inspection is to inspect the track and to immediately stop or slow trains in the event that the condition of the track is considered unsafe for trains to pass through the site.

Detailed visual inspections of culverts, embankments and cuttings will be conducted by a geotechnical engineer when each site is located within the zone of active subsidence.

Further details are provided in the PMLL Management Plan.

3.9 Monitoring along the Main Southern Railway

The closest distance of proposed LW W3 to the MSR is approximately 290 metres at 88.33 km. The closest distance of proposed LW W4 to the MSR is approximately 245 metres at 89.32 km near the Thirlmere Way Underbridge.

Whilst the likelihoods are assessed to be very low, potential impacts could occur to railway infrastructure during the extraction of LW W3-W4. Monitoring will be conducted along the railway track and at major railway structures during the extraction of LW W3-W4 as part of the risk control procedures, as documented in the MSR Management Plan (MSEC1163).

3.9.1 Ground Surveys along Rail Corridor

A survey line has been established along the MSR from 87.0 km (junction of the PMLL and MSR) to 90.0 km.

The survey line consists of pegs spaced nominally 20 m apart along the line. The survey pegs will be measured in absolute 3D on a monthly basis and 2D (levels and horizontal distances between adjacent pegs) on a weekly basis within the zone of active subsidence. The extent of the survey will follow the zone of active subsidence as it migrates down each longwall panel.

3.9.2 Track Geometry Monitoring

The track geometry along the MSR will be monitored by a track recording trolley on a weekly basis during the period of active subsidence. Further details are provided in the MSR Management Plan.

3.9.3 Rail stress monitoring

Rail stress and temperature gauges have been installed on one rail for each track, spaced every 120 metres along the MSR from 87.200 km (junction of the PMLL and MSR) to 88.040 km prior to the start of LW W3. The rail stress monitoring system will be extended to 89.600 km prior to the start of LW W4. Two gauging sites are located within the Picton Tunnel.

3.9.4 Visual Inspections

Visual inspections will be conducted along the MSR by a Track Certifier on a daily basis along the railway corridor within the zone of active subsidence.

Detailed visual inspections of culverts, embankments and cuttings will be conducted by a geotechnical engineer when each site is located within the zone of active subsidence.

Further details are provided in the MSR Management Plan.

3.9.5 Monitoring of railway embankments

In addition to the measures described above, additional ground survey lines have been established along the MSR embankments prior to the start of LW W3.

Automated, continuous extensometers have been placed across the crests of the embankments where the embankment heights are highest at 87.331 km, 88.091 km and 88.496 km. Extensometers will be installed at 89.216 km, 89.300 km and 89.350 km prior to the last 400 metres of extraction of LW W3.

The embankments will also be inspected by a geotechnical engineer on a monthly basis during and after mining. Additional inspections can be conducted if adverse changes are observed from daily inspections by Track Certifier, weekly surveys along the rail corridor or continuous readings from extensometers.

Further details are provided in the MSR Management Plan.

3.9.6 Railway structures

Tahmoor Mine will continue to monitor movements at key items of railway infrastructure along the MSR in accordance with the MSR Management Plan.

Monitoring includes a combination of absolute 3D ground surveys, local 3D surveys of structures and automated, continuous monitoring of specific elements of key structures. The majority of the monitoring measures have been installed and were used to monitor changes during the mining of LW W2.

Further details are described below.

Bridge Street Overbridge

- Absolute 3D survey of the position of the Bridge (installed); and
- Absolute 3D survey of marks on the bridge deck, abutments, bridge approaches and on the cutting on both sides of the Overbridge (installed).

Thirlmere Way Underbridge

- Absolute 3D survey of the position of the Bridge (installed);
- Local 3D survey of survey marks at the base of the brick arch on both sides, base of the abutment walls and at the ends of the wingwalls (installed);
- Laser distancemeters across and along the base of the brick arch, and across the diagonals (installed); and
- Visual inspections

Connellan Crescent Overbridge

- Absolute 3D survey of the position of the Bridge (installed);
- Local 3D surveys of survey marks at the base of the concrete arch on both sides, on the brick spandrel walls, bridge approaches, parapet walls and marks in the ground adjacent to the bridge abutments and at the base of the cutting supporting the bridge (installed);
- Measurement of changes to existing cracks with crack gauges; and
- Visual inspections

Ballast Top Subway at 88.133 km

- Absolute 3D survey of the position of the Subway (installed); and
- Local 3D surveys of survey marks at the top and base of the abutment walls, on the ends of the concrete ballast top and at the ends of wingwalls (installed); and
- Visual inspection if measurements exceed trigger level.

Picton Tunnel

- Absolute 3D survey of the position above the Tunnel (installed during LW31);
- Continuous, automated GNSS monitoring above the Tunnel (installed during LW31);
- Absolute 3D and Relative 3D surveys of prisms every 20 metres inside the Tunnel with a 9 prism array covering the base, mid-height of concrete wall, spring points and crown (installed prior to commencement of LW W1), and sleeper on each track inside the Tunnel (installed post LW W2);
- Absolute 3D and 2D surveys of ground lines along rail corridor leading into the Tunnel at both ends (installed);
- Continuous automated laser distancemeters every 20 metres across the base and spring point of the Tunnel (installed during the mining of LW W1);
- Vertical inclinometer borehole to the side of the Tunnel (installed prior to the commencement of LW W2);
- Track centre and track clearance surveys along the Tunnel;
- Rail stress monitoring within the Tunnel (installed prior to LW W3); and
- Visual inspection

Mushroom Tunnel

- Local 3D surveys of new marks every 20 metres inside the Tunnel on both sides (installed); and
- Visual inspection.

Ballast Top Underbridge at 86.838 km

- Absolute 3D survey of the position of the Subway (installed);
- Local 3D surveys of survey marks at the top and base of the abutment walls, on the ends of the concrete ballast top and at the ends of wingwalls (installed); and
- Visual inspection if measurements exceed trigger level.

Argyle Street Underbridge

- Absolute 3D survey of the position of the Bridge (installed);
- Local 3D survey of survey marks at the base of the brick arch on both sides, along the tops of the spandrel walls at the approaches and above the arch, and at the base of the abutment walls (installed);
- Laser distancemeters across and along the base of the brick arch, and across the diagonals (installed); and
- Visual inspection if measurements exceed trigger level.

Pedestrian Overbridges at 85.846 km and 86.100 km

- Local 3D surveys of survey marks on the abutments and gaps between the ends of the bridge decks and approach slabs (installed); and
- Visual inspection if measurements exceed trigger level.

Picton Viaduct

- Absolute 3D survey of the position of each end of the Viaduct (installed during LW31);
- Continuous, automated GNSS monitoring at each end of the Viaduct (installed during LW31);
- Local 3D surveys of prisms mounted at the base of the intermediate piers and abutments and along the tops of the piers below the low height parapet walls (installed during LW31 and LW W1), and additional marks above the mid-span of the arches (installed post LW W2);
- Local 3D surveys of ground survey pegs along a monitoring line that is located upstream and downstream of the Viaduct (new marks installed prior to LW W3);
- 2D horizontal distance surveys between two marks that are located in stable ground at both ends and sides of the Viaduct (installed prior to LW W1 with additional marks installed prior to LW W3);
- Rail stress monitoring above the Viaduct (installed prior to LW W3);
- Three inclinometer boreholes in the ground adjacent to the Viaduct (installed prior to LW W3);
- Track geometry trolley survey along Viaduct;
- Laser distancemeters across the spans of the arches (installed prior to LW W3).

- Detailed visual inspections using UAV technology, including measurement of crack gauges (baseline completed); and
- Visual inspection by Track Certifier.

Prince Street Overbridge

- Absolute 3D survey of the position of the Bridge (installed);
- Local 3D surveys of the prisms at the base of the brick piers, on the bridge deck above the piers and at the approaches, and at the top of the piers (installed);
- Visual inspection if measurements exceed trigger level.

Retaining wall at 84.867 km

- Local 3D surveys of prisms at three cross-sections along the brick wall (installed);
- 2D horizontal distance survey between two marks located at the wall across the tops of the valley sides (installed); and
- Visual inspection if measurements exceed trigger level.

Matthews Lane Overbridge

- Absolute 3D survey of the position of the bridge (installed);
- Local 3D surveys of prisms at the bridge abutments and on the bridge deck above the piers and at the base of the piers (installed); and
- Visual inspection if measurements exceed trigger level.

3.10 Monitoring along Optical Fibre Cables

A network of optical fibre cables owned by Telstra and NBN Co. are located directly above and adjacent to the proposed LW W3-W4.

In addition to ground surveys and visual inspections along the local roads, a ground survey line has been installed along the Telstra / NBN Co. optical fibre cables beyond the southern ends of LW W2-W4, including where they cross the creeks.

Optical Time Domain Reflectometer (OTDR) monitoring will also be conducted on potentially affected optical fibre cables during the extraction of proposed LW W3-W4. OTDR monitoring has been used extensively by Tahmoor Coal's telecommunications consultant Comms Network Solutions during the mining of previously extracted longwalls. Baseline monitoring has been conducted prior to mining and it is planned to monitor potentially affected optical fibre cables on a weekly basis during periods of active subsidence. The losses in attenuation can be identified early and located by the OTDR monitoring system to a sufficient accuracy to allow the affected cable(s) to be locally exposed by excavation and relieved of deformations.

3.11 Monitoring of Electrical Infrastructure

A network of overhead and buried electrical infrastructure owned by Endeavour Energy is located directly above and adjacent to proposed LW W3-W4.

An inspection of power poles located directly above and adjacent to LW W1-W2 was conducted by Endeavour Energy on 9 May 2019. The accompanying report concluded that the electricity infrastructure is generally in a good state of repair and in serviceable order. The poles are generally vertical and there are no concerns currently present regarding clearances to the ground or structures. Experience has shown that power poles have remained safe and serviceable during and after mining.

In addition to ground surveys and visual inspections along local roads, Endeavour Energy has recommended six power poles for monthly monitoring by survey when each pole is experiencing active subsidence.

The locations of the identified six critical poles are shown in **Drawing No. MSEC1173-00-01**.

Tahmoor Coal has consulted with Endeavour Energy to complete a risk assessment for LW W3-W4. No additional critical poles are required to be surveyed during the mining of LW W3-W4.

Tahmoor Coal will also survey Pole No. 762531, which is located in the middle of the rockbar on Stonequarry Creek.

3.12 Monitoring of the Stonequarry Wastewater Treatment Plant and Sewerage Infrastructure

An Infrastructure Management Plan has been developed in consultation with the operator of the Stonequarry Estate sewerage infrastructure. A Wastewater Treatment Plant (WTP), Re-Use Water Storage Pond and associated pumping stations and pipework at Stonequarry Estate are located within the Study Area. The WTP and Re-Use Water Storage Pond are located directly above LW W3.

Wastewater Treatment Plan (WTP)

Survey marks have been installed around the WTP structures and along the wall and base of the Pond, as shown in **Drawing No. MSEC1173-04-02**.

Survey marks have also been placed along the PMLL, which is approximately 45 metres from the WTP at its closest point. Monitoring of the PMLL will provide information on observed subsidence near the WTP and valley closure downstream of the dam wall.

The dam is visible from the PMLL Embankment at 87.850 km, as shown by the photograph in Figure 3-1. The dam wall will be inspected visually prior to operation of trains along the PMLL as part of the PMLL Management Plan.

In the event that the dam shows signs of distress, Tahmoor Coal and the operator will consider whether additional management measures are required, which may include an increase in monitoring and reporting procedures, and lowering of the water level in the dam.

Figure 3-1 View of Stonequarry Wastewater Treatment Dam from Embankment at 87.850 km

Sewerage infrastructure

The sewerage consists of a mixture of gravity and pumped sewer mains. Drawings provided by the landowner show that sewage is transferred to the WTP via a 150 mm diameter rising main, which runs immediately adjacent to the PMLL. A 63 mm diameter MDPE potable water pipe runs alongside the rising main.

A survey line has been installed along the rail corridor, immediately adjacent to the rising main, water pipe and buried power cable. The survey line will be surveyed on a weekly basis during the periods of active subsidence. Visual inspections along the rail corridor will include an inspections of the ground surface above the rising main, looking for wet patches.

Sewage is pumped along the rising main via a Pumping Station 2 that is located adjacent to the PMLL near 89.00 km downstream of the stormwater catchment dam (Ref. PSC_019_d01). Survey marks are placed around the Pumping Station. The pumping station is fed by a gravity sewer main, which runs along publicly accessible land from the northern end of Stonequarry Creek Road. The potable water pipe connects to the Sydney Water main at the end of Stonequarry Creek Road. A survey cross line has been installed adjacent to this section of sewer main and water pipe and will be surveyed on a weekly basis during active subsidence. Visual inspections will be conducted along the natural surface above the sewer main and water pipe.

The remainder of the sewerage system will be monitored by the local street surveys and visual inspections along the local streets.

3.13 Monitoring at Matthews, Cedar and Stonequarry Creeks

Tahmoor Coal has designed the mine layout of LW W1-W4 to avoid mining directly beneath Matthews, Cedar and Stonequarry Creeks. The purpose of the design is to substantially reduce the severity and extent of impacts on surface water flows within these creeks, compared to impacts that would occur if the longwalls were extracted directly beneath them.

Tahmoor Coal has implemented a detailed monitoring program to measure and record mining-induced ground movements and impacts on the streams during the mining of LW W1. A review of these observations has been completed after the LW W1 face has mined a sufficient distance such that the majority of mining-induced movements have occurred (after approximately 1,000 m of extraction). This review concluded that, as impacts on Cedar Creek and Stonequarry Creek near the commencing end of LW W1 were not greater than anticipated and impacts on Stonequarry Creek from LW W2 were unlikely to exceed predictions, Tahmoor Coal retained the commencing position of LW W2. This was approved by DPIE (7/9/2020) with additional monitoring requirements.

A similar review was undertaken during the extraction of LW W2 to confirm the commencing position of proposed LW W3.

A description of planned monitoring and inspections at Matthews, Cedar and Stonequarry Creeks is provided in the following sub-sections. Further information is provided in LW W3-W4 Water Management Plan.

In response to feedback provided by DPIE, Tahmoor Coal has developed a Stonequarry Creek Rockbar Management Plan to manage the potential for impacts on the Aboriginal heritage value of the grinding groove site on Rockbar SR17 on Stonequarry Creek.

3.13.1 Ground Surveys

There is limited access in order to survey ground movements along and across Matthews, Cedar and Stonequarry Creeks due to the terrain and density of natural vegetation.

Valley Closure Lines

Valley closure lines have been installed across the tops of the valley sides along Matthews, Cedar and Stonequarry Creeks. The valley closure lines consist of pairs of pegs on or near the crests of the valleys, where there are adequate lines of sight available. The locations are shown in **Drawing No. MSEC1173-00-01**. Surveys of the valley closure lines will measure horizontal distances between the pairs of pegs.

Access was not permitted by the landowner prior to the commencement of LW W1 to conduct surveys on a large parcel of land that wraps around the southern bank of Stonequarry Creek, Cedar Creek to the north of the commencing end of LW W1, and along the eastern side of Cedar Creek and Matthews Creek to the west of LW W1.

As no access was available prior to the commencement of LW W1, Tahmoor Coal developed an alternative and appropriate monitoring process to monitor valley closure during the mining of LW W1 (and future LW W2) by installing survey lines within crown land across the floor of the valleys. The majority of the survey lines cross rockbars that control water levels in pools but survey lines have also been installed across the shoreline of the long pool along Stonequarry Creek. The locations of the rockbar / valley floor closure lines are shown in **Drawing No. MSEC1173-00-01.**

Access was permitted on 29 September 2020. While the extraction of LW W1 had effectively been completed, a small number of additional valley closure lines were installed across Cedar and Matthew Creeks, as shown in **Drawing No. MSEC1173-00-01.** Additional survey lines have also been installed across sections of Cedar Creek where mining-induced impacts due to LW W1 have occurred.

Unfortunately, access is not permitted to some private properties on the western side of Cedar and Matthews Creek, preventing the installation of some initially planned valley closure lines.

GNSS Monitoring

Global Navigation Satellite System (GNSS) units are fixed survey stations that continuously measure their absolute horizontal and vertical positions in real time.

As shown in **Drawing No. MSEC1173-00-01**, GNSS units were placed on both sides of Matthews, Cedar and Stonequarry Creeks to monitor the development of absolute vertical and horizontal movements. Differential movements can also be calculated between GNSS units to measure valley closure. With access permitted to the southern and eastern sides of Stonequarry, Cedar and Matthews creeks on 29 September 2020, an additional three GNSS were installed prior to the commencement of LW W2. Preferred sites are away from overhanging vegetation and require protection from damage by livestock.

The monitoring points will be measured in real time and the data will be reviewed weekly during the mining of LW W3-W4. GNSS Site 22 is currently located directly above the commencing end of LW W2. The unit provided useful monitoring information during the early stages of mining of LW W2 and will be relocated to the commencing ends of LW W3 (renamed to Site 23) and LW W4 (renamed to Site 24).

GNSS Site 12 was initially installed in clay soil due to land access restrictions. The GNSS unit recorded changes in response to changes in moisture levels, which detracted from its original purpose to detect valley closure movements across Rockbar SR17. With access permitted to the southern back of Stonequarry Creek, the unit was located to a rock outcrop and has been renamed Site 12A. Its new location is shown in **Drawing No. MSEC1173-00-01**.

3D Survey Lines along Cedar Creek and Stonequarry Creek

With access permitted to the southern and eastern banks of Stonequarry Creek and Cedar Creek on 29 September 2020, relative 3D survey lines were planned to be installed along the banks of Cedar and Stonequarry Creeks from Rockbar CR26 at the main bend in Cedar Creek to Rockbar SR22 on Stonequarry Creek.

Pegs were installed in cleared land just beyond the natural vegetation within the valleys, spaced approximately every 50 m. It was found that the surveys could be conducted to an acceptable level of accuracy in 3D due to the density of vegetation. The survey was, therefore, converted to 2D closure surveys, which are included as part of the valley closure line surveys. The locations of the monitoring lines are shown in **Drawing No. MSEC1173-00-01**.

Rockbar SR17 on Stonequarry Creek

A long pool is located on Stonequarry Creek beyond the commencing end of LW W3. Water levels are controlled at the downstream end by Rockbar SR17. A study of Aboriginal heritage sites has identified several grinding grooves on Rockbar SR17.

Tahmoor Coal has installed a ground survey grid across Rockbar SR17. The survey line follows the alignment of a public access track and includes survey marks across the rockbar, taking care to avoid the grinding groove site. The spacing of the pegs are nominally 10 m apart, in a grid formation that was determined on site.

Surveys of Rockbar SR17 will measure the absolute 3D position of survey pins over the rockbar. GNSS units are proposed to be located on both sides of the valley above Rockbar SR17.

The survey methodology has been modified to improve the resolution of the survey results. The changes include additional set ups of the total station to align with survey pegs that are located across the grinding grooves.

High Resolution Closure Lines (HRC Lines) have been installed at seven locations across Rockbar SR17 by MNC Consulting. The purpose is to accurately measure and track the development of any valley closure that develops across the rockbar. The HRC Lines consist of prisms mounted on both sides of the rockbar across the grinding groove sites. The target accuracy is approximately ± 0.5 mm.

Detailed visual inspections will be conducted during the mining of LW W3, which will include measurement of existing joints and natural fractures surrounding the grinding groove site.

3.13.2 Baseline 3D Photogrammetric Survey at Rockbar SR17

A high resolution, spatially and geometrically correct baseline 3D model has been developed of Rockbar SR17 on Stonequarry Creek.

The nominal accuracy of the surface definition is ± 10mm. The methodology uses digital photogrammetry from a combination of both airborne (drone) photography as well as terrestrial photography.

The survey was repeated after the extraction of LW W1 and LW W2. The survey will be repeated after the extraction of LW W3. Additional surveys can be conducted to identify areas of deformation if impacts are observed.

3.13.3 Surface Water Monitoring

Surface water monitoring points have been established along Matthews, Cedar and Stonequarry Creeks.

There are 8 sites on Matthews Creek, 10 sites on Cedar Creek and 5 sites on Stonequarry Creek, as shown in **Drawing No. MSEC1173-01-01**.

The monitoring sites measure changes in water level and quality.

Further details are provided in the LW W3-W4 Water Management Plan.

3.13.4 Visual Monitoring

Visual inspections will be conducted on creeks, cliffs, steep slopes and rock face features along Matthews, Cedar and Stonequarry Creeks within the Study Area during the extraction of LW W3-W4.

A baseline photographic survey was completed in 2014 by GeoTerra, and further baseline photographic surveys were completed prior to the commencement of LW W1 extraction in 2019.

3.14 Groundwater Monitoring

A groundwater monitoring plan has been developed by Tahmoor Coal and it is described in the LW W3-W4 Water Management Plan. Additional sites have been installed prior to the commencement of LW W3. The locations of groundwater monitoring sites around proposed LW W3-W4 are shown in **Drawing No. MSEC1173-01-02**. Groundwater monitoring includes monitoring of groundwater levels and quality.

3.15 Biodiversity Monitoring

A biodiversity monitoring plan has been developed by Tahmoor Coal and it is described in the LW W3-W4 Biodiversity Management Plan. The locations of riparian monitoring sites and aquatic biodiversity monitoring sites are shown in **Drawing No. MSEC1173-01-03**.

3.16 Monitoring of Aboriginal Heritage Sites

A plan has been developed to monitor changes at Aboriginal heritage sites during the extraction of proposed LW W3-W4 by Tahmoor Coal and it is described in the LW W3-W4 Heritage Management Plan.

Monitoring of ground movements at Matthews, Cedar and Stonequarry Creeks is described in **Section 3.13.1**. This includes detailed monitoring of ground movements at Rockbar SR17 on Stonequarry Creek where grinding grooves are present.

Visual inspections will be conducted at the Aboriginal heritage sites within the Study Area by an archaeologist at the completion of LW W3 and LW W4.

3.17 Far Field Monitoring Program

Tahmoor Coal has installed a far field monitoring survey network for the following structures during the extraction of LW W1-W2. Monitoring will continue during the extraction of LW W3-W4. The far field horizontal movement monitoring program will continue to investigate the potential for differential horizontal movements across the Nepean Fault for the following features:

- Thirlmere Way Rail Underbridge (89.326 km);
- Connellan Crescent Railway Overbridge (89.080 km);
- Argyle Street Rail Underbridge (86.13 km);
- Picton Viaduct (85.42 km);
- Prince Street Overbridge (85.17km);
- Picton Tunnel (87.85 km); and
- Victoria Bridge over Stonequarry Creek.

This information has been retracted
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Table 3-1 Subsidence Monitoring Program for LW W3-W4

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Centreline and cross line surveys					
Initial Goaf GNSS unit (located approximately 100 m inside the commencing end of LW W3-W4)	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Prior to commencement of LW W3-W4, relocate GNSS unit prior to the start of each LW.	• Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W3-W4.	-
Ground survey	2D survey lines along centrelines of LW W3-W4	2D subsidence and distance	• LW W3 centreline survey installed and baseline surveyed. LW W4 centreline survey installed and baseline surveyed.	• Weekly survey of LW W3 centreline after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit 23, or the length of the extraction of LW W3 exceeds 150 metres, whichever occurs first. Continue until agreed to reduce by Expert Technical Committee for Stonequarry Creek Rockbar SR17. • Monthly survey of LW W3 and LW W4 centreline for pegs located within active subsidence zone after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first.	• Full length at end of LW W3-W4.
	2D survey line across LW W1-W4	2D subsidence and distance	• Installation and baseline survey complete.	• Monthly survey during LW W3 and LW W4 during period of active subsidence and continue if ongoing adverse movements are observed.	• Full length at end of LW W3-W4.
Wollondilly Shire Council infrastructure					
Local roads	Ground surveys along streets	2D subsidence and distance Please refer **Dwg. No. MSEC1173-00-01**	• Installed and baseline surveyed	• Weekly surveys along local roads within active subsidence zone during the mining of LW W3-W4.	• Full length at end of LW W3-W4 survey for all lines.
	Visual inspections of streets	-	-	• Detailed inspection once a week within the active subsidence zone of LW W3-W4.	-
Remembrance Drive Road Bridge and Footbridge over Redbank Creek	Local 3D survey of installed survey marks on bridge abutments, bridge deck and spandrel walls	RL, Local easting and northing	• Installed and baseline surveyed prior to LW32.	-	• End of LW W3-W4.
Abbotsford Bridge on Barkers Lodge Road over Stonequarry Creek	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1.	• Monthly after 200 m extraction of LW W3-W4.	-
Sydney Water potable water and sewerage infrastructure					
Potable water infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Stonequarry Estate sewer infrastructure					
Stonequarry Estate sewerage infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Ground surveys along rising main (alongside PMLL)	2D subsidence and distance	As described for PMLL Management Plan.		
	Ground surveys along gravity sewer main (alongside 2D survey line across LW W3-W4)	2D subsidence and distance	• Installed and baseline survey complete.	• Weekly surveys along cross line during LW W3 and LW W4 during period of active subsidence and continue if ongoing adverse movements are observed.	• End of LW W3-W4.
	Ground surveys at and around Pumping Station 2, Overflow Storage Tanks and Detention Basin	RL, Local easting and northing	• Installed and baseline survey complete.	• Weekly surveys along cross line during LW W3 and LW W4 during period of active subsidence and continue if ongoing adverse movements are observed.	• End of LW W3-W4.
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		
	Visual inspection of Pumping Station 2, Overflow Storage Tanks and Detention Basin	-	-	• Weekly inspections along cross line during LW W3 and LW W4 during period of active subsidence and continue if ongoing adverse movements are observed.	-
Stonequarry Wastewater Treatment Plant	Ground surveys	RL, Local easting and northing	• Installed and baseline survey complete.	• Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. Cease weekly surveys after 800 m of extraction of LW W3 unless ongoing adverse movements are observed. • Monthly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W4, or the length of the extraction of LW W4 exceeds 200 m, whichever occurs first. Cease monthly inspections after 800 m of extraction of LW W4 unless ongoing adverse movements are observed.	• End of LW W3 and LW W4.
	Visual inspection	-	-	• Weekly inspection after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. Cease weekly surveys after 800 m of extraction of LW W3 unless ongoing adverse movements are observed. • Monthly inspection after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W4, or the length of the extraction of LW W4 exceeds 200 m, whichever occurs first. Cease monthly inspections after 800 m of extraction of LW W4 unless ongoing adverse movements are observed.	-
Gas infrastructure					
Gas infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Electrical infrastructure					
Electrical infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		
Critical power poles, as shown in **Drawing No. MSEC1173-00-01**.	Power pole surveys	Subsidence at base and vertical offset (or tilt)	• Baseline survey of poles identified for LW W1-W2 complete. • No additional poles identified for LW W3-W4	• Monthly for each pole within active subsidence zone, and for following three months thereafter.	• End of LW W3-W4 for all poles.
Pole No. 762531 in Rockbar SR17	Power pole surveys	Subsidence at base and vertical offset (or tilt)	• Baseline survey complete	• Monthly after 200m of extraction of LW W3 until length of extraction exceeds 800m and continue if adverse movements are observed.	• End of LW W3-W4.
Telecommunications infrastructure					
Telstra and NBN infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Ground survey along optical fibre cable south of LW W2-W4	2D subsidence and distance	• Install and baseline survey of prior to influence of LW W3 (complete)	• Weekly during period of active subsidence and one month after completion of LW W3-W4.	• End of LW W3-W4.
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		
	Detailed visual inspections of pits and streets	-	-	• Weekly when within active subsidence zone.	-
	OTDR monitoring of optical fibre cables	-	-	• Weekly for cables located within active subsidence zone.	-
Spatial Services					
Permanent survey marks	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
Structures					
Houses, public amenities, pools	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan.		
	Ground surveys for structures as requested by or agreed with landowners	RL, Local easting and northing	• Baseline survey of house requested for survey prior to each LW approaching within 400m of property (majority completed).	-	• End of LW W3-W4.
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		
	Visual inspections of specific structures, including pools	Varies depending on structure	Refer Built Structures Management Plan (Weekly when within active subsidence zone or as required by geotechnical or structural engineer).		
Farm dams	Visual inspection of farm dams	Dam embankment integrity and water level observation	• Monthly for at least two months immediately prior to undermining using fixed location photo points.	• Weekly during active subsidence period using fixed location photo points.	• Quarterly for a minimum of 12 months post mining using fixed location photo points.
	Ground survey across farm dams at southern end of LW W3	RL, Local easting and northing	• Baseline survey prior to LW W3 approaching within 400m of dams (FD-1 and FD-3 complete)	• Weekly during active subsidence and one month after completion of LW W3-W4.	• End of LW W3-W4.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Picton-Mittagong Loop Line					
Initial Goaf GNSS unit / Centreline (located approximately 100 m inside the commencing end of LW W3 on PMLL)	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Prior to commencement of LW W3.	• Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W3.	-
PMLL Embankment GNSS units at 87.850 km, 88.980 km and 89.629 km	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Installation and baseline surveys complete.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
Railway Track	Absolute 3D ground survey along rail corridor *Full length = 87.1 km to 90.0 km* *Initial extent for monthly survey for LW W3 = 87.100 km to 88.300 km and then extend to the south to include pegs that are at least 400 metres in front of the longwall face, up to 90.000 km.*	Absolute easting, northing and level (MGA coordinates)	• Installed full length from 87.100 km to 90.000 km and baseline survey complete.	• Monthly survey during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. • After 20 mm of vertical subsidence is measured by a GNSS unit along the railway during LW W4 and for every 20 mm of additional vertical subsidence thereafter (extent to be determined by RMG based on actual monitoring results)	• Full length at end of LW W3-W4.
	Focussed 2D ground survey along rail corridor *Full length = 87.1 km to 90.0 km* *Initial extent for weekly survey for LW W3 = 87.100 km to 88.300 km and then extend to the south to include pegs that are at least 200 metres in front of the longwall face, up to 90.000 km.*	2D subsidence and distance	• Installed full length from 87.100 km to 90.000 km and baseline survey complete.	• Focussed weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first.	• Full length at end of LW W3-W4.
	Long bay length ground surveys *Extents as per Focussed 2D ground surveys*	2D distances over bay lengths that are nominally 100 m long	• Installed full length from 87.100 km to 90.000 km and baseline survey complete.	• Focussed weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first.	• Full length at end of LW W3-W4.
	Track geometry surveys using Amber track mounted device or equivalent *Extents as per Focussed 2D ground surveys*	Superelevation (cant), twist, gauge	• Full length from 87.100 km to 90.000 km complete.	• Focussed weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first.	• Full length from 87.100 km to 90.000 km at end of LW W3-W4.
	Track inspection by qualified track certifier. *Extents as per Focussed 2D ground surveys*	The inspection will check infrastructure within the rail corridor, including the track, culverts, cuttings, embankments and fences	-	• As per track geometry surveys; and • Additional inspections prior to train movements (within 24 hours, target morning of train movement).	-
Culvert at 87.630 km	Absolute 3D survey at spring points on both sides of culvert at outlet, midpoint and inlet	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline survey complete.	• Weekly after 200 m of extraction of LW W3.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Culvert and Embankment at 87.850 km	Continuous GNSS monitoring at 87.850 km	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS unit prior to commencement of LW W1.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
	Absolute 3D and local 3D surveys along monitoring lines along crest and toe of embankment at 87.850 km on both sides of track, with prisms at spring points on both sides of the brick arch culvert at outlet, midpoint and inlet.	Absolute 3D – Absolute easting, northing and level (MGA coordinates) Local 3D – RL, Local easting and northing	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly Absolute 3D survey and Weekly Local 3D survey during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. • Absolute 3D survey after 20 mm of vertical subsidence is measured by GNSS unit at 87.850 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Crest extensometer survey	Horizontal distance	• Installed and baseline surveyed prior to commencement of LW W1.	• Weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W3, or the length of the extraction of LW W3 exceeds 200 metres, whichever occurs first. • Survey after 20 mm of vertical subsidence is measured by GNSS unit at 87.850 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
	Inclinometer survey	Tilt	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W3, or the length of the extraction of LW W3 exceeds 200 metres, whichever occurs first. • Survey after 20 mm of vertical subsidence is measured by GNSS unit at 87.850 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
	Measurement of soil suction within the embankment at depth and along the embankment batters at locations shown in Drawing No. MSEC1168-05	Negative pore pressure	• Installed and baseline surveyed prior to commencement of LW W1.	• Weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W3, or the length of the extraction of LW W3 exceeds 200 metres, whichever occurs first.	-
	Visual inspection of culvert and embankment and Stonequarry Wastewater Treatment dam by geotechnical engineer	-	-	• Weekly during LW W3 after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W3, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. • Inspection after 20 mm of vertical subsidence is measured by GNSS unit at 87.850 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Culvert and Embankment at 88.400 km	Absolute 3D and local 3D surveys along monitoring lines along crest and toe of embankment at 88.400 km on both sides of track, with prisms at spring points on both sides of the brick arch culvert at outlet, midpoint and inlet.	Absolute 3D – Absolute easting, northing and level (MGA coordinates) Local 3D – RL, Local easting and northing	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly Absolute 3D survey and Weekly Local 3D survey after length of the extraction of LW W3 exceeds 300 m. • Absolute 3D survey after 20 mm of vertical subsidence is measured by GNSS units at either 88.100 km or 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	• Absolute 3D at end of LW W3-W4.
	Crest extensometer survey	Horizontal distance	• Installed and baseline surveyed prior to commencement of LW W1.	• Weekly after length of the extraction of LW W3 exceeds 300 m. • Survey after 20 mm of vertical subsidence is measured by GNSS units at either 88.100 km or 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
	Inclinometer survey	Tilt	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly after length of the extraction of LW W3 exceeds 300 m. • Survey after 20 mm of vertical subsidence is measured by GNSS units at either 88.100 km or 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
	Measurement of soil suction within the embankment at depth and along the embankment batters at locations shown in Drawing No. MSEC1036-05	Negative pore pressure	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly after length of the extraction of LW W3 exceeds 300 m.	-
	Visual inspection of culvert and embankment by geotechnical engineer	-	-	• Weekly after length of the extraction of LW W3 exceeds 300 m. • Inspection after 20 mm of vertical subsidence is measured by GNSS units at either 88.100 km or 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Culvert and Embankment at 88.980 km	Continuous GNSS monitoring at 88.980 km	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS unit prior to commencement of LW W1.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
	Absolute 3D and local 3D surveys along monitoring lines along crest and toe of embankment at 88.980 km on both sides of track, with prisms at spring points on both sides of the brick arch culvert at outlet, midpoint and inlet.	Absolute 3D – Absolute easting, northing and level (MGA coordinates)	• Install and baseline survey complete.	• Absolute 3D survey if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 88.980 km and for every 20 mm of additional vertical subsidence thereafter.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Crest extensometer survey	Horizontal distance	• Install and baseline survey complete.	• Survey if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 88.980 km and for every 20 mm of additional vertical subsidence thereafter.	-
	Inclinometer survey	Tilt	• Install and baseline survey complete.	• Survey if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 88.980 km and for every 20 mm of additional vertical subsidence thereafter.	-
	Visual inspection of culvert and embankment and dam upstream of embankment by geotechnical engineer	-	-	• Inspection if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 88.980 km and for every 20 mm of additional vertical subsidence thereafter.	-
Culvert and Embankment at 89.629 km	Continuous GNSS monitoring at 89.629 km	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS unit prior to commencement of LW W1.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
	Absolute 3D and local 3D surveys along monitoring lines along crest and toe of embankment at 89.629 km on both sides of track, with prisms at spring points on both sides of the brick arch culvert at outlet, midpoint and inlet.	Absolute 3D – Absolute easting, northing and level (MGA coordinates)	• Install and baseline survey complete.	• Absolute 3S survey if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 89.629 km and for every 20 mm of additional vertical subsidence thereafter.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Visual inspection of culvert and embankment by geotechnical engineer	-	-	• Inspect if more than 20 mm of vertical subsidence from LW W3-W4 is measured by the GNSS unit at 89.629 km and for every 20 mm of additional vertical subsidence thereafter.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Cuttings at 88.100 km	Continuous GNSS monitoring at 88.100 km	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS unit prior to commencement of LW W1.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
	Absolute 3D and local 3D surveys along rail corridor line and pairs of pegs located every 20 m along the bases of the cuttings on both sides of the track	Absolute 3D – Absolute easting, northing and level (MGA coordinates) Local 3D – RL, Local easting and northing	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly Absolute 3D survey and Weekly Local 3D survey during LW W3 after 20 mm of vertical subsidence is measured by the GNSS unit at 88.100 km, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. • Absolute 3D survey after 20 mm of vertical subsidence is measured by GNSS unit at 88.100 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	Absolute 3D at end of LW W3-W4.
	Visual inspection of cutting by geotechnical engineer	-	-	• Weekly inspection during LW W3 after 20 mm of vertical subsidence is measured by the GNSS unit at 88.100 km, or the length of the extraction of LW W3 exceeds 200 m, whichever occurs first. • Inspection after 20 mm of vertical subsidence is measured by GNSS unit at 88.100 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
Cuttings at 88.700 km	Absolute 3D and local 3D surveys along rail corridor line and pairs of pegs located every 20 m along the bases of the cuttings on both sides of the track	Absolute 3D – Absolute easting, northing and level (MGA coordinates) Local 3D – RL, Local easting and northing	• Installed and baseline surveyed prior to commencement of LW W1.	• Monthly Absolute 3D survey during LW W3 after 20 mm of vertical subsidence is measured by the GNSS unit at 88.550 km, or the length of the extraction of LW W3 exceeds 450 m, whichever occurs first. • Absolute 3D survey after 20 mm of vertical subsidence is measured by GNSS unit at 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Visual inspection of cutting by geotechnical engineer	-	-	• Monthly inspection during LW W3 after 20 mm of vertical subsidence is measured by the GNSS unit at 88.550 km, or the length of the extraction of LW W3 exceeds 450 m, whichever occurs first. • Inspection after 20 mm of vertical subsidence is measured by GNSS unit at 88.550 km during LW W4 and for every 20 mm of additional vertical subsidence thereafter.	-
Cuttings at 89.300 km	Absolute 3D and local 3D surveys along rail corridor line and pairs of pegs located every 20 m along the bases of the cuttings on both sides of the track	Absolute 3D – Absolute easting, northing and level (MGA coordinates) Local 3D – RL, Local easting and northing	• Install and baseline survey prior to 600 m extraction of LW W1.	- (Outside Study Area)	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Visual inspection of cutting by geotechnical engineer	-	-	- (Outside Study Area)	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Main Southern Railway					
Railway track	Absolute 3D ground survey along rail corridor	Absolute easting, northing and level (MGA coordinates)	• Installed full length from 87.000 km to 90.000 km and baseline survey prior to start of LW W3.	• Monthly survey initially from 87.000 km to 88.040 km after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first, then extend to the south to include pegs that are at least 400 metres in front of the longwall face, up to 90.000 km.	Full length at end of LW W3-W4.
	Focussed 2D ground survey along rail corridor	2D subsidence and distance	• Installed full length from 87.000 km to 90.000 km and baseline survey prior to start of LW W3.	• Focussed weekly initially from 87.000 km to 88.040 km after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first, then extend to the south to include pegs that are at least 200 metres in front of the longwall face, up to 90.000 km (Stage 2).	Full length at end of LW W3-W4.
	Long bay length ground surveys *Extents as per Focussed 2D ground surveys*	2D distances over bay lengths that are nominally 100 m long	• Installed full length from 87.000 km to 90.000 km and baseline survey prior to start of LW W3.	• Focussed weekly initially from 87.000 km to 88.040 km after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first, then extend to the south to include pegs that are at least 200 metres in front of the longwall face, up to 90.000 km (Stage 2).	Full length at end of LW W3-W4.
	Automated, continuous rail stress monitoring with gauges on one rail for each track, spaced every 120 metres	Rail stress and temperature	• Installed 87.200 km to 88.040 km prior to start of LW W3. • Extend to 89.600 km prior to start of LW W4.	• Every 5 minutes.	-
	Track geometry surveys using Amber track mounted device or equivalent *Extents as per Focussed 2D ground surveys*	Superelevation (cant), twist, gauge	• Baseline survey from 87.000 km to 90.000 km complete.	• Focussed weekly initially from 87.000 km to 88.040 km after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first, then extend to the south to include pegs that are at least 200 metres in front of the longwall face, up to 90.000 km (Stage 2).	Full length from 87.100 km to 90.000 km at end of LW W1-W2.
	Track inspection by qualified track certifier. *Extents as per Focussed 2D ground surveys*	The inspection will check infrastructure within the rail corridor, including the track, culverts, cuttings, embankments and fences	• Baseline inspection from 87.000 km to 90.000 km prior to LW W3.	• Daily initially from 87.000 km to 88.040 km after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first, then extend to the south to include pegs that are at least 200 metres in front of the longwall face, up to 90.000 km (Stage 2).	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Railway culverts and embankments	Absolute 3D surveys and relative 3D surveys along monitoring lines on the crests and/or toes of the embankments on both sides and at spring points of both sides of culverts. The layout of survey marks is shown in Drawings Nos. MSEC1163-116 to 119. Absolute 3D survey of culvert at 89.785 km.	Absolute easting, northing and level (MGA coordinates) Relative easting, northing and level	• Install and baseline survey prior to start of LW W3.	• Monthly when section of track over each embankment is in Stage 2.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Automated, continuous extensometer across crests of the embankments at 87.331 km, 88.091 km, 88.496 km, 89.216 km, 89.300 km and 89.350 km	Distance	• Installed 87.331km, 88.091km, 88.496km • Install 89.216km, 89.300km and 89.350km prior to last 400m of extraction of LW W3	• Every 15 minutes.	-
	Monitor changes in crack width of existing crack in obvert of culvert at 89.216 km and headwalls	Change in crack gauge	• Install crack gauges and baseline measure prior to last 400m of extraction of LW W3	• Monthly during last 400m of extraction of LW W3	-
	Inspection by geotechnical engineer	-	• Baseline inspection prior to start of LW W3.	• Monthly when section of track over each embankment is in Stage 2 (additional inspections can be conducted if adverse changes are observed from daily inspections by Track Certifier, weekly surveys along rail corridor or continuous readings from .extensometers).	-
Railway cuttings	Absolute 3D and relative 3D surveys every 20 metres along the toe of the cutting between 88.700 km and 89.050 km and at two locations across the crests of the cutting	Absolute / relative easting, northing and level (MGA coordinates)	• Install and baseline survey prior to start of LW W3.	• Absolute 3D Monthly during LW W3-W4 when section of track is in Stage 2. • Relative 3D Weekly during LW W3-W4 when section of track is in Stage 2.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Inspection by geotechnical engineer	-	• Baseline inspection prior to start of LW W3.	• Monthly when section of track through each cutting is in Stage 2.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
GNSS network along Main Southern Railway as per Drawing No. MSEC1173-00-02	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• GNSS units installed and operating.	• Continuous readings, with data averaged over 24 hours and recorded once per day.	-
Bridge Street Overbridge (91.030km)	Absolute 3D survey of mark on both abutments	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Absolute 3D ground survey of all marks, incl ground around Bridge Street Overbridge at 91.030 km and on the bridge structures (deck, abutments and reinforced soil wall) and adjacent cutting	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	-	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
Thirlmere Way Rail Underbridge (89.326km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D survey marks at base of arch, base of the abutment walls and at the ends of the wingwalls	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4. • Weekly during last 200 m of LW W4.	• End of LW W3. • End of LW W4.
	Automated, continuous measurements across and along base of arch, including diagonals by laser distancemeters	Distance	• Installed and baseline surveyed.	• Hourly.	-
	Visual inspections	-	-	• Daily when section of track is in Stage 2 • Detailed during last 200 m of LW W4.	-
Connellan Crescent Railway Overbridge (89.080km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D survey marks at base of arch, brick spandrel walls, bridge approaches, parapet walls and marks in the ground adjacent to the bridge abutments and at the base of the cutting supporting the bridge	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4. • Weekly when section of track is in Stage 2 during LW W4.	• End of LW W3. • End of LW W4.
	Monitoring of existing cracks with crack gauges	Change in crack gauge	• Install prior to 200m extraction of LW W3.	• Monthly after 200 m extraction of LW W3-W4	-
	Visual inspections	-	-	• Daily when section of track is in Stage 2 • Detailed weekly when section of track is in Stage 2	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Ballast Top Subway (88.133 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D surveys of new marks at the top and base of the abutment walls, on the ends of the concrete ballast top and at the ends of wingwalls	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
Ballast Top Underbridge (86.838 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D surveys of new marks at the top and base of the abutment walls, on the ends of the concrete ballast top and at the ends of wingwalls	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
Argyle Street Rail Underbridge (86.13 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D survey marks at base of arch, base of the abutment walls, on the ends of the concrete ballast top and at the ends of wingwalls	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
	Automated, continuous measurements across and along base of arch, including diagonals by laser distancemeters	Distance	• Installed and baseline surveyed.	• Hourly.	-
Pedestrian Overbridges (85.846 km and 86.010 km)	Local 3D surveys of survey marks on the abutments and gaps between the ends of the bridge decks and approach slabs	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Picton Viaduct (85.42 km)	Continuous, automated GNSS monitoring at each end of the Viaduct (Sites 00 and 02)	Absolute easting, northing and level (MGA coordinates)	Installed and operating	• Continuous readings • Recorded daily	-
	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D surveys of prisms at the base of the intermediate piers and abutments, along the tops of the piers and abutments, along the centre of the arches, and along the ground survey lines upstream and downstream of the Viaduct	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4. • Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W4, or the length of the extraction of LW W4 exceeds 200 m, whichever occurs first.	• End of LW W3. • End of LW W4.
	Precision 2D horizontal distance survey between ground marks located in stable ground at both ends of the Viaduct	Horizontal distance	• Installed and baseline surveyed.	• • Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first	• End of LW W3. • End of LW W4.
	Automated, continuous measurements across base of arches by laser distancemeters	Horizontal distance	• Installed and baseline surveyed	• Hourly • Downloaded and reported weekly.	-
	Automated, continuous rail stress monitoring	Change in stress, temperature	• Installed.	• Every 5 minutes. • Downloaded and reported weekly	-
	Vertical inclinometer monitoring	Tilt	• Installed and baseline survey prior to start of LW W3.	• Monthly after 200 m extraction of LW W3-W4.	-
	Track geometry trolley survey along Viaduct	-	-	• Monthly after 200 m extraction of LW W3-W4	-
	Visual inspection	-	-	• Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first.	• End of LW W3. • End of LW W4.
	Visual inspection of viaduct stonework by UAV, including measurement of crack gauges	-	• Baseline inspection(s) prior to start of LW W3. • Crack gauges in September 2021	• Monthly after 200 m extraction of LW W3-W4.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Prince Street Overbridge (85.17km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D surveys of the four prisms at the base of the brick piers, on the bridge deck above the piers and at the approaches, and at the top of the piers	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
Picton Tunnel (87.85 km)	Continuous, automated GNSS monitoring above the Tunnel (Site 01)	Absolute easting, northing and level (MGA coordinates)	• Installed and operating	• Continuous readings • Recorded daily	-
	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Absolute 3D and Relative 3D surveys of 9 prism arrays covering the base, mid-height of concrete wall, spring points on both sides and crown and sleeper on each track every 20 metres inside the Tunnel	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Absolute 3D Monthly • Relative 3D weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Absolute 3D / 2D surveys of ground lines along rail corridor leading into the Tunnel at both ends	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed	• Absolute 3D Monthly • 2D Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first.	-
	Automated, continuous measurements across the base and spring point of the Tunnel by laser distancemeters	Horizontal distance	• Installed and baseline surveyed	• Every 15 minutes.	-
	Vertical inclinometer monitoring	Tilt	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	-
	Track centre and track clearance survey along the Tunnel	-	-	• Weekly	-
	Automated, continuous rail stress monitoring	Change in stress, temperature	• Installed.	• Every 5 minutes.	-
	Visual inspections of the Tunnel	-	-	• Daily after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W3 and LW W4, or the length of the extraction of LW W3 and LW W4 exceeds 200 m, whichever occurs first • Detailed inspection weekly	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Mushroom Tunnel	Local 3D surveys of survey marks every 20 metres inside the Tunnel on both sides	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
	Visual inspections of the Tunnel	-		• As per Picton Tunnel	•
Retaining wall (84.867 km)	Local 3D surveys of prisms at three cross-sections along the brick wall	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
Matthews Lane Overbridge (84.551 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D surveys of prisms at the bridge abutments and on the bridge deck above the piers and at the base of the piers	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
Main Southern Railway structures	Dilapidation inspections	-	• Complete.		
Transport for NSW Infrastructure					
Victoria Bridge over Stonequarry Creek	Continuous, automated GNSS monitoring at the western end of the Bridge (Site 03)	Absolute easting, northing and level (MGA coordinates)	• Installed and operating	• Continuous readings • Recorded daily	-
	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Local 3D survey of existing marks at base of piers and abutments, at the tops of piers, at the top and base of Abutment B and the top embankment at Abutment B	RL, Local easting and northing	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4. • Weekly between ground marks across top of valley (Pegs West Abut 2 Rock to East Abut 3 Rock) after 200 m of extraction of LW W3-W4.	• End of LW W3. • End of LW W4.
	Inspect gap between timber buffer board and road pavement above Abutment B and clear debris if required	-	• Complete.		
	Measure gap between timber buffer board and road pavement above Abutment B	Horizontal distance	• Installed and baseline surveyed.	• Monthly after 200 m extraction of LW W3-W4.	-
	Visual inspection	-	-	• Weekly after 200m of extraction of LW W3-W4 after completion of TfNSW engineering works	-
	Dilapidation inspection of Victoria Bridge	-	• Complete.		
Menangle Street – Picton Road between intersection at Argyle Street and Matthews Lane	Visual inspections	-	• Baseline inspection complete.	• Every 3 months during LW W3-W4.	-

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Matthews, Cedar and Stonequarry Creeks					
GNSS units along Matthews, Cedar and Stonequarry Creeks, as shown in **Drawing No. MSEC1173-00-01**.	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W3-W4.	-
Valley closure monitoring lines, as shown in **Drawing No. MSEC1173-00-01**.	2D horizontal distance measurement of pegs on or near the crests of the valleys, where there are adequate lines of sight available.	Horizontal distance	• Installed and baseline surveyed.	• Weekly for lines across Stonequarry Creek (SQ104 to SQ120) and Cedar Creek (C102 to C106) after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit 23, or the length of the extraction of LW W3 exceeds 150 metres, whichever occurs first. Continue until agreed to reduce by Expert Technical Committee for Stonequarry Creek Rockbar SR17. • Monthly for valley closure lines within active subsidence zone after 200 m extraction of LW W3-W4. Cease after 1000 m of extraction of LW W3-W4 for lines that are located behind the active subsidence zone unless adverse changes are observed.	• End of LW W3. • End of LW W4.
Rockbar / Valley floor closure lines, as shown in **Drawing No. MSEC1173-00-01**.	2D horizontal distance measurement of pegs across rockbar or valley floor (incl. across long pool SC2 on Stonequarry Creek)	Horizontal distance	• Installed and baseline surveyed.	• Weekly for lines across Stonequarry Creek (SQ01 to SQ13) after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit 23, or the length of the extraction of LW W3 exceeds 150 metres, whichever occurs first. Continue until agreed to reduce by Expert Technical Committee for Stonequarry Creek Rockbar SR17. • Monthly for rockbar / valley floor closure lines within active subsidence zone after 200 m extraction of LW W3-W4. Cease after 1,000 m of extraction of LW W3-W4 for lines that are located behind the active subsidence zone unless adverse changes are observed.	• End of LW W3. • End of LW W4.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Rockbar SR17	Absolute 3D and relative 3D survey of survey marks across Rockbar SR17 spaced nominally every 10 m	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed.	• Absolute 3D Monthly from start of LW W3 • Relative 3D weekly after start of LW W3. Continue until agreed to reduce by Expert Technical Committee for Stonequarry Creek Rockbar SR17. • Absolute 3D between 200 m and 1,000 m of extraction of LW W4 and continue if ongoing adverse movements are observed.	• Absolute 3D at end of LW W3. • Absolute 3D at end of LW W4.
	Baseline 3D photogrammetric survey of Rockbar SR17	-	• Complete.	-	• End of LW W3 • End of LW W4.
	Seven (7) High resolution closure lines HRC-A to HRC-G inclusive	Horizontal distance	• Install and baseline survey prior to start of LW W3	• Weekly after start of LW W3 • Twice weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit 23, or the length of the extraction of LW W3 exceeds 150 metres, whichever occurs first • Continue until agreed to reduce by Expert Technical Committee.	• End of LW W3 • End of LW W4
	Detailed visual inspections, including measurement of existing joints and fractures and water level of pool upstream of Rockbar SR17	Changes in width of joints and cracks	• Baseline survey prior to start of LW W3	• As per High Resolution Surveys	-
Surface water monitoring, as shown in **Drawing No. MSEC1173-01-01**	Continuous water level monitoring	Water level relative to Cease to Flow level for subject pool	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.	• Continuous readings, downloaded fortnightly at sites CC1A, CA, CB and MG, and monthly for all other monitoring locations. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly for 12 months following completion of LW W4. Refer Water Management Plan for further details.
	Manual water level monitoring	Water level relative to Cease to Flow level for subject pool	• Monthly. Refer Water Management Plan for further details.	• Fortnightly for MR45 and MR46, monthly for all other monitoring locations. Refer Water Management Plan for further details.	• Monthly for 12 months following completion of LW W4. Refer Water Management Plan for further details.
	Flow rate in Stonequarry Creek	Flow rate	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly for 12 months following completion of LW W4. Refer Water Management Plan for further details.
	Water quality sampling	Refer Water Management Plan	• Monthly. Refer Water Management Plan for further details.	• Monthly. Refer Water Management Plan for further details.	• Monthly for 12 months following completion of LW W4. Refer Water Management Plan for further details.
Visual inspections of creeks	Baseline photographic survey of pools and rockbars	-	Complete.		
	Visual inspections of creeks	-	• Completed in November 2019 prior to LW W1 extraction.	• Fortnightly for CB10-CR24, MR45 and MR46, and monthly for all other sites within active subsidence zone after 200 m extraction of LW W3-W4. Reduce frequency of observations to 2-monthly after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless continuing adverse changes are observed.	• Quarterly for 12 months following the completion of LW W4. Refer Water Management Plan for further details.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Cliffs, Steep Slopes and Rock Face Features					
Cliffs, steep slopes and rock face features	Visual inspections	-	• One month before active subsidence period by geotechnical engineer.	• Monthly during active subsidence period by geotechnical engineer.	• Quarterly for 12 months following active subsidence period by geotechnical engineer.
Agricultural Land					
Agricultural lands	Visual inspection	-	• One month before active subsidence period.	• Monthly during active subsidence period.	• Quarterly for 12 months following active subsidence period.
Groundwater monitoring					
Groundwater monitoring, as shown in **Drawing No. MSEC1173-01-02**	Continuous groundwater level monitoring at piezometers P9, P12 – P17	Water level in borehole (RL)	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.	• Continuous readings, downloaded fortnightly for P12 and monthly for all other bores. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.
	Continuous groundwater pressure monitoring at VWPs, TNC036, TNC040 and TNC043	Water pressure	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.	• Continuous readings, downloaded fortnightly for TNC036 and monthly for all other bores. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly. Refer Water Management Plan for further details.
	Groundwater quality sampling	Refer Water Management Plan	• Monthly. Refer Water Management Plan for further details.	• Monthly. Refer Water Management Plan for further details.	• Monthly. Refer Water Management Plan for further details.
Biodiversity monitoring					
Riparian vegetation monitoring, as shown in **Drawing No. MSEC1173-01-03**	Riparian vegetation health at monitoring and control sites	Refer Biodiversity Management Plan	• Six monthly. Refer Biodiversity Management Plan for further details.	• Six monthly. Refer Biodiversity Management Plan for further details.	• Six monthly. Refer Biodiversity Management Plan for further details.
Amphibian monitoring, as shown in **Drawing No. MSEC1173-01-03**	Frog surveys at monitoring and control sites	Refer Biodiversity Management Plan	• Bi-annually. Refer Biodiversity Management Plan for further details.	• Bi-annually (Spring and Summer). Refer Biodiversity Management Plan for further details.	• Bi-annually (Spring and Summer). Refer Biodiversity Management Plan for further details.
Aquatic sites, as shown in **Drawing No. MSEC1173-01-03**	Aquatic habitat assessment, macroinvertebrate sampling, water quality sampling, fish sampling at monitoring sites and control sites	Refer Biodiversity Management Plan	• Six monthly. Refer Biodiversity Management Plan for further details.	• Six monthly. Refer Biodiversity Management Plan for further details.	• Six monthly. Refer Biodiversity Management Plan for further details.

Feature	Survey or inspection regime	Parameters to be measured	Timing and Frequency (may be increased if triggered by monitoring results)		
			Prior to Mining	During Mining	Post Mining
Aboriginal heritage monitoring					
Scarred tree	Visual inspection and condition assessment by archaeologist	-	• Baseline inspection completed. • Monitoring at the completion of LW W1-W2 and prior to the commencement of LW W3.	-	• End of LW W3-W4.
Grinding grooves	Ground surveys and baseline photogrammetry of Rockbar SR17	-	Refer Rockbar SR17 monitoring.		
	Visual inspection and condition assessment by archaeologist	-	• Baseline inspection completed.	-	• End of LW W3-W4.
Items of Heritage Significance					
Railway sites	Refer PMLL and MSR sites				
Weatherboard Cottage	Ground survey of pegs around house	RL, Local easting and northing	• Install prior to influence of LW W4.	• Monthly during last 200 m of extraction of LW W4 and continue for one month after completion of longwalls.	• End of LW W3-W4.
	Visual inspection	-	• Baseline inspection prior to influence of LW W4.	• Monthly during last 200 m of extraction of LW W4 and continue for one month after completion of longwalls.	• End of LW W3-W4.
	Visual inspections of structures by heritage consultant	-	• New baseline inspection prior to influence of LW W4.	-	• End of LW W3-W4.

4 Document Information

4.1 References

NSW Department of Planning and Environment (DPE) (2015), Draft Guidelines for the Preparation of Extraction Plans V5.

NSW Department of Planning & Environment (2017), Resources Regulator, Mine Safety Operations.

4.2 Glossary of Terms

The Extraction Plan Main Document provides a compiles Glossary of Terms in **Section 8.3**.

4.3 Abbreviations

Abbreviations used in this document are provided below in **Table 6-1**.

Table 4-1 Abbreviations

Abbreviation	Definition
DPE	NSW Department of Planning and Environment (former) Now known as NSW Department of Planning, Industry and Environment (DPIE)
DPIE	NSW Department of Planning, Industry and Environment
GNSS	Global Navigation Satellite System
km	Kilometre/s
LW	Longwall
LW W1	Longwall West 1
LW W1-W2	Longwalls West 1 to West 2
LW W2	Longwall West 2
LW W3-W4	Longwalls West 3 to West 4
LW W4	Longwall West 4
m	Metre/s
mm	Millimetre/s
ML	Mining Lease
MSEC	Mine Subsidence Engineering Consultants
MSR	Main Southern Railway
NSW	New South Wales
OTDR	Optical Time Domain Reflectometer
PCBU	Persons conducting a business or undertaking
PMLL	Picton-Mittagong Loop Line
PSMP	Property Subsidence Management Plan
Resources Regulator	NSW Department of Planning, Industry and Environment – Resources Regulator
ROM	run of mine

Abbreviation	Definition
SMP	LW W3-W4 Subsidence Management Plan
Tahmoor Coal	Tahmoor Coal Pty Ltd
Tahmoor Mine	Tahmoor Coal Mine
TfNSW	Transport for NSW
THNSW	Transport Heritage NSW
uPVC	Unplasticised polyvinyl chloride
WTP	Wastewater Treatment Plant

4.4 Change Information

Table 4-2 provides the details of document history of this Subsidence Monitoring Program.

Table 4-2 Document History

Version	Date Reviewed	Reviewed By	Change Summary
1.0	April 2021	April Hudson, David Talbert, Zina Ainsworth	New document.
2.0	August 2021	April Hudson, Ross Barber, Zina Ainsworth	Updated prior to start of LW W3.

Appendix A – Drawings

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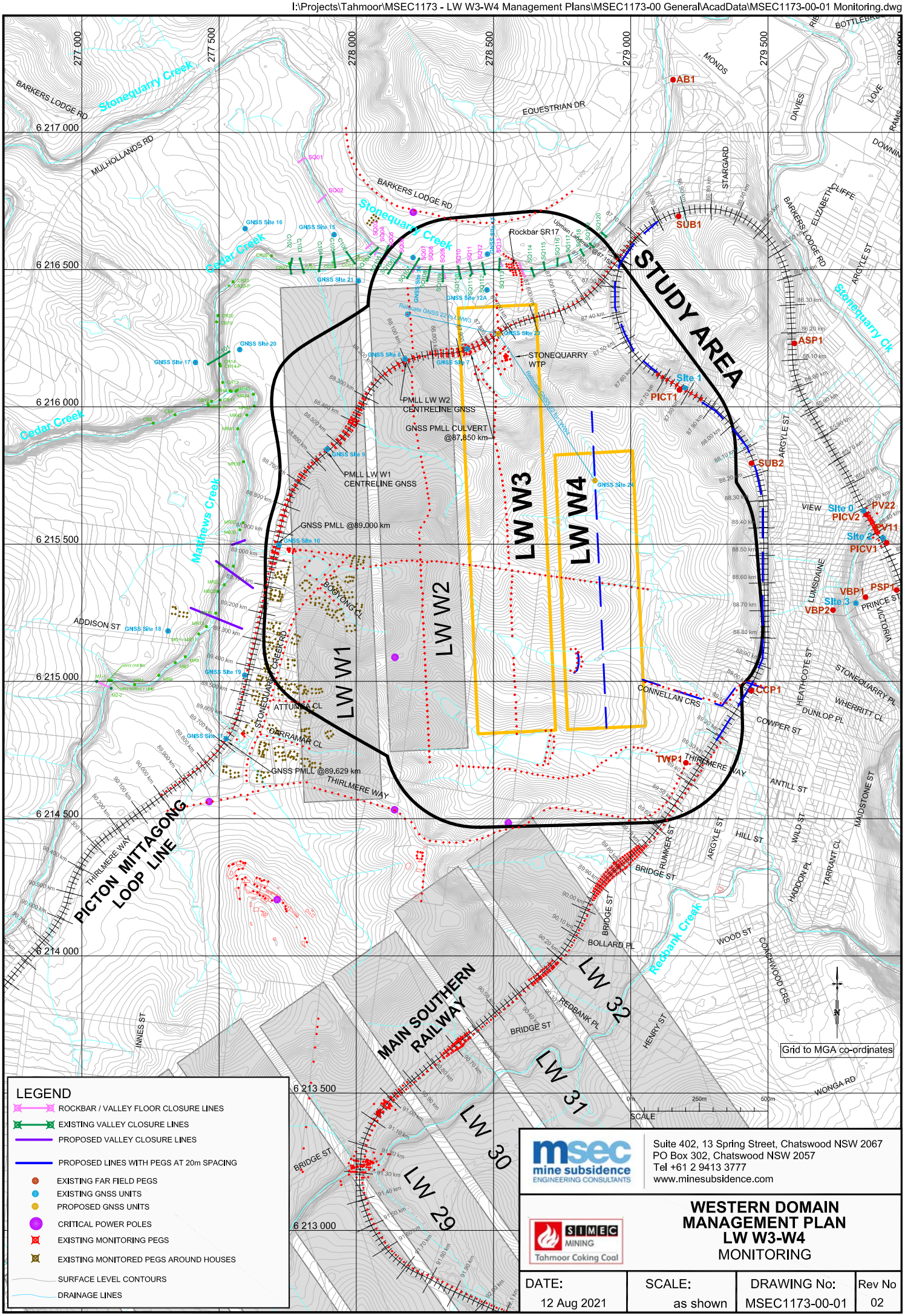

LEGEND

- ROCKBAR / VALLEY FLOOR CLOSURE LINES
- EXISTING VALLEY CLOSURE LINES
- PROPOSED VALLEY CLOSURE LINES
- PROPOSED LINES WITH PEGS AT 20m SPACING
- EXISTING FAR FIELD PEGS
- EXISTING GNSS UNITS
- PROPOSED GNSS UNITS
- CRITICAL POWER POLES
- EXISTING MONITORING PEGS
- EXISTING MONITORED PEGS AROUND HOUSES
- SURFACE LEVEL CONTOURS
- DRAINAGE LINES

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SIMEC MINING
Tahmoor Coking Coal

WESTERN DOMAIN MANAGEMENT PLAN LW W3-W4 MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
12 Aug 2021	as shown	MSEC1173-00-01	02

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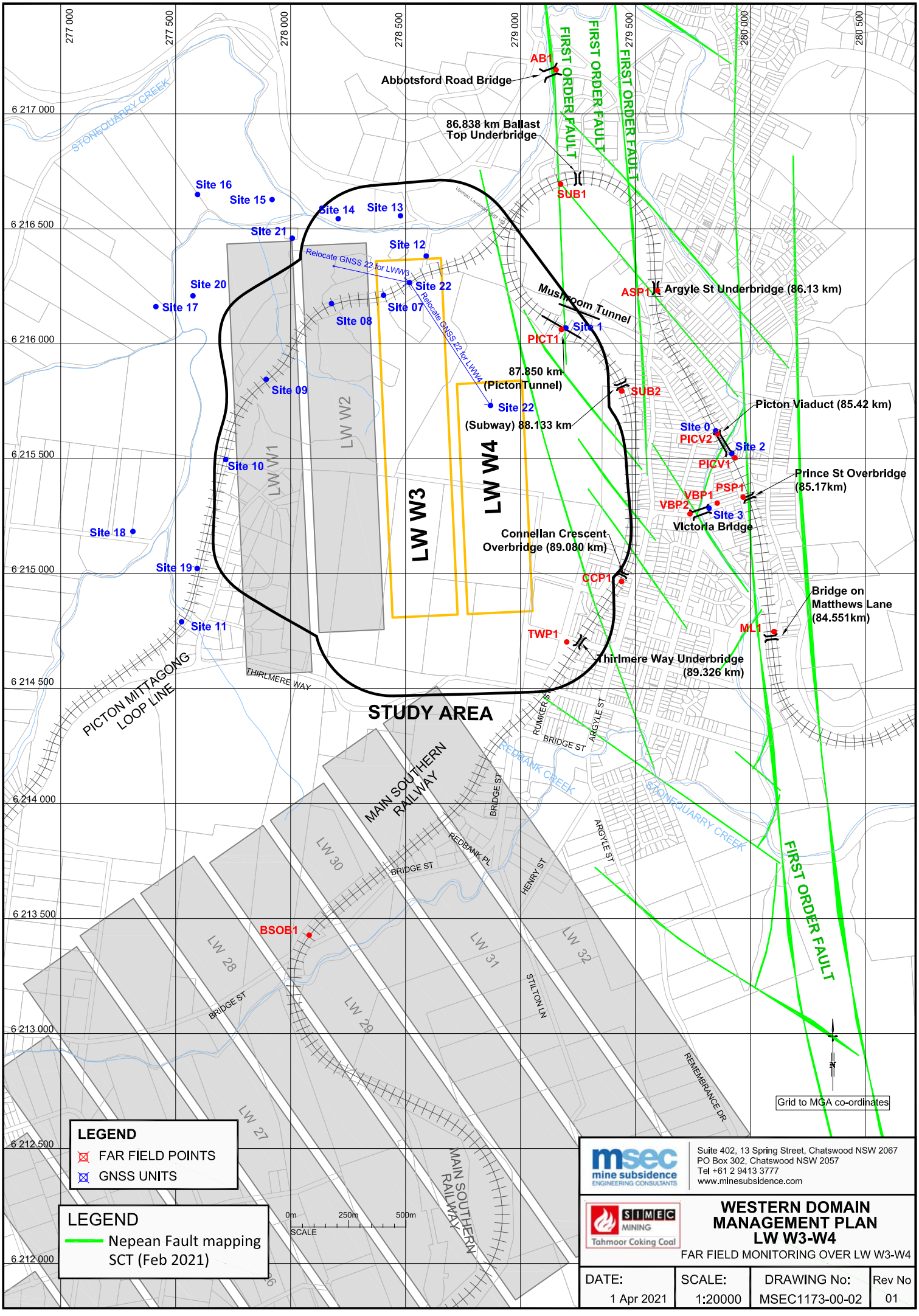

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WESTERN DOMAIN MANAGEMENT PLAN LW W3-W4

FAR FIELD MONITORING OVER LW W3-W4

DATE:	SCALE:	DRAWING No:	Rev No
1 Apr 2021	1:20000	MSEC1173-00-02	01

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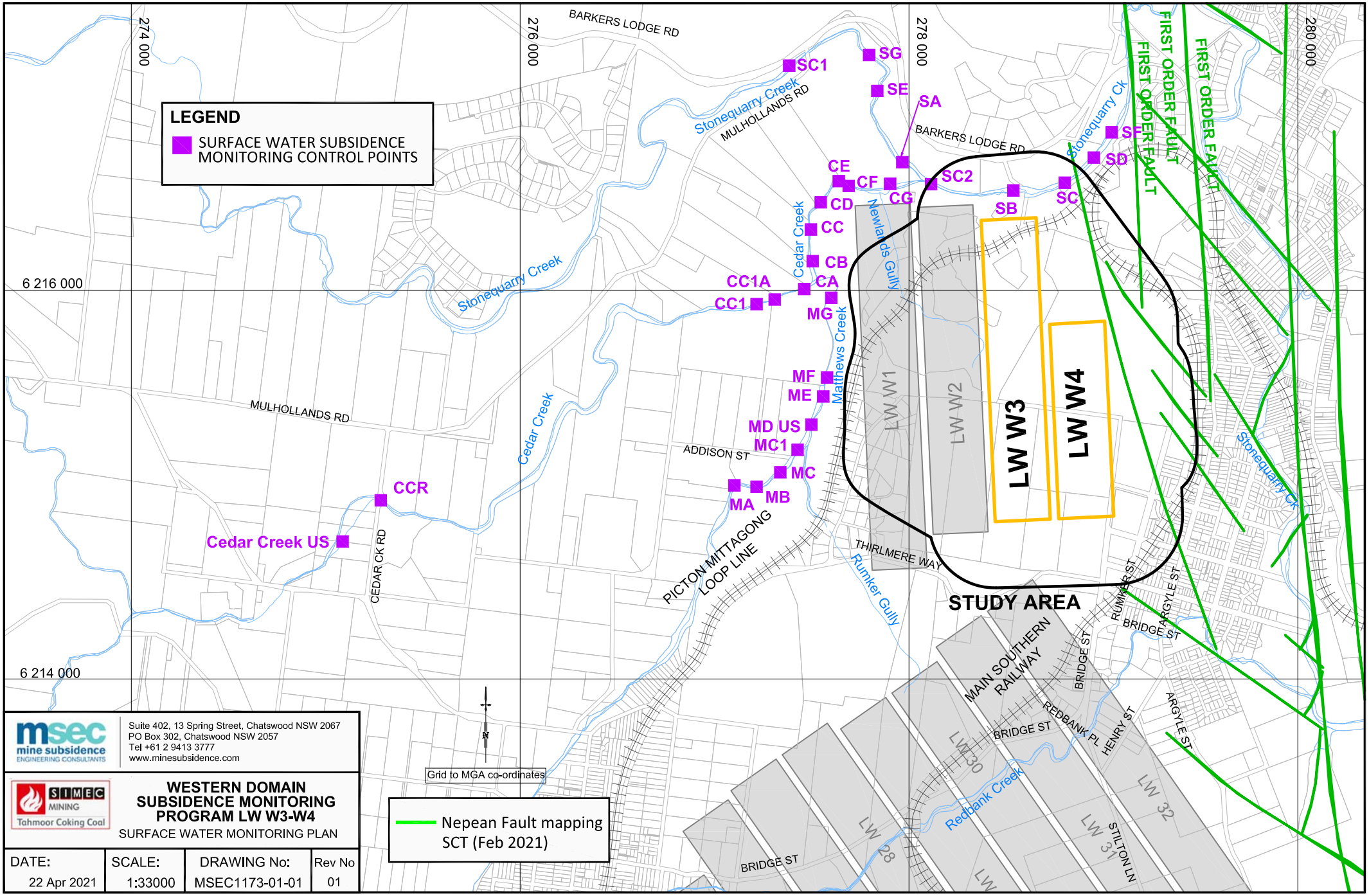

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WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W3-W4

SURFACE WATER MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
22 Apr 2021	1:33000	MSEC1173-01-01	01

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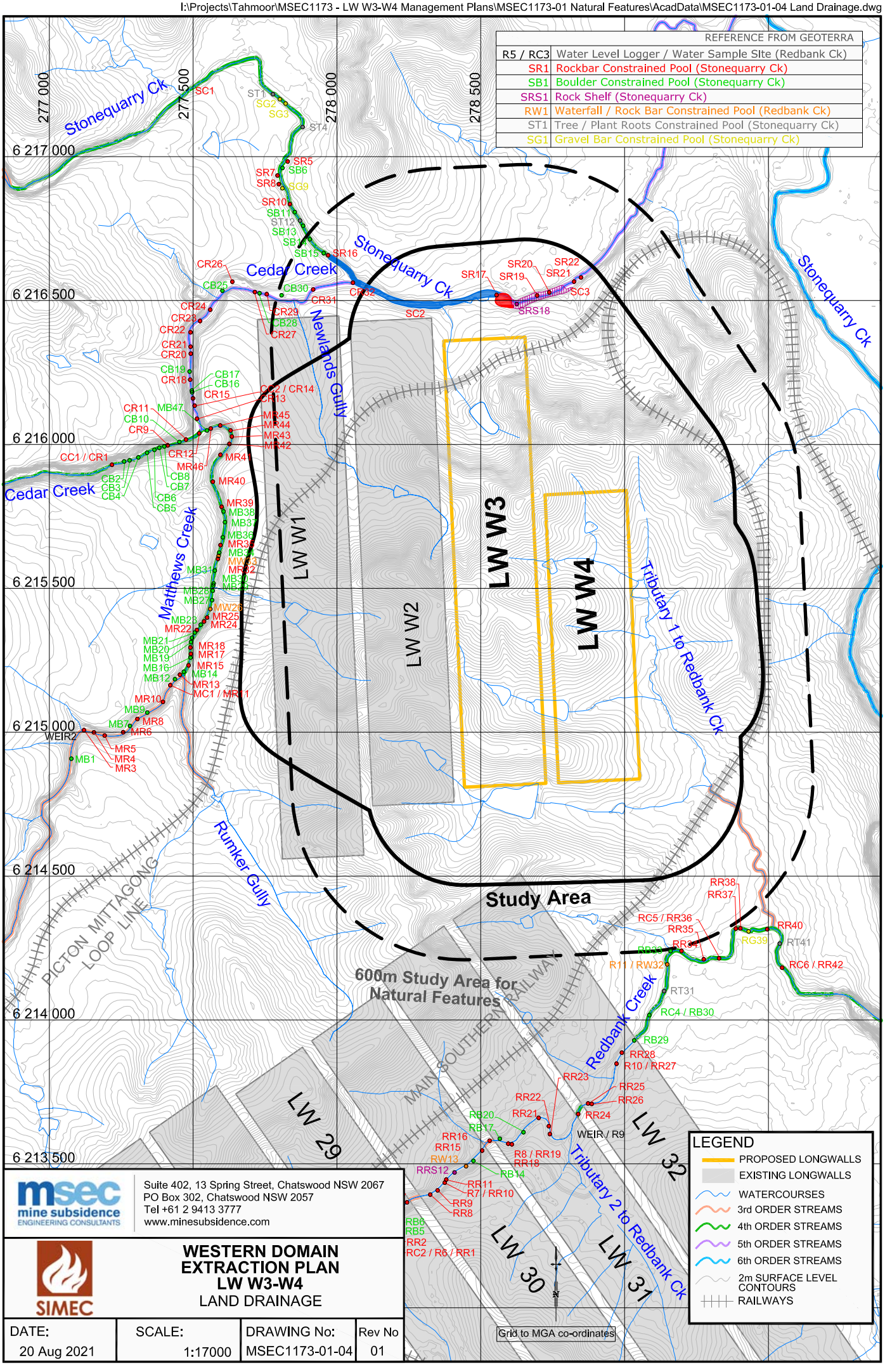

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WESTERN DOMAIN EXTRACTION PLAN LW W3-W4 LAND DRAINAGE

DATE:	SCALE:	DRAWING No:	Rev No
20 Aug 2021	1:17000	MSEC1173-01-04	01

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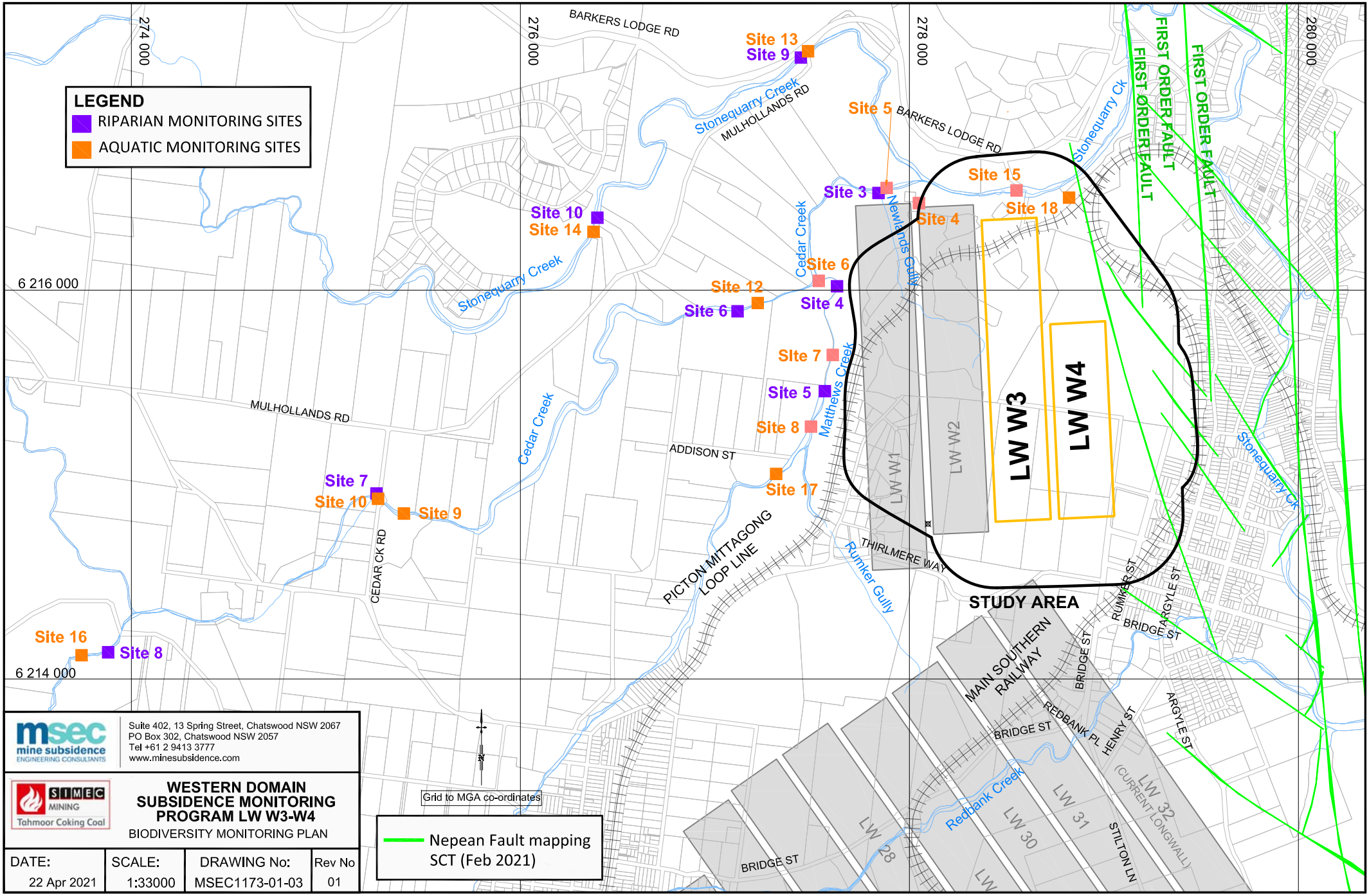

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WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W3-W4

BIODIVERSITY MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
22 Apr 2021	1:33000	MSEC1173-01-03	01

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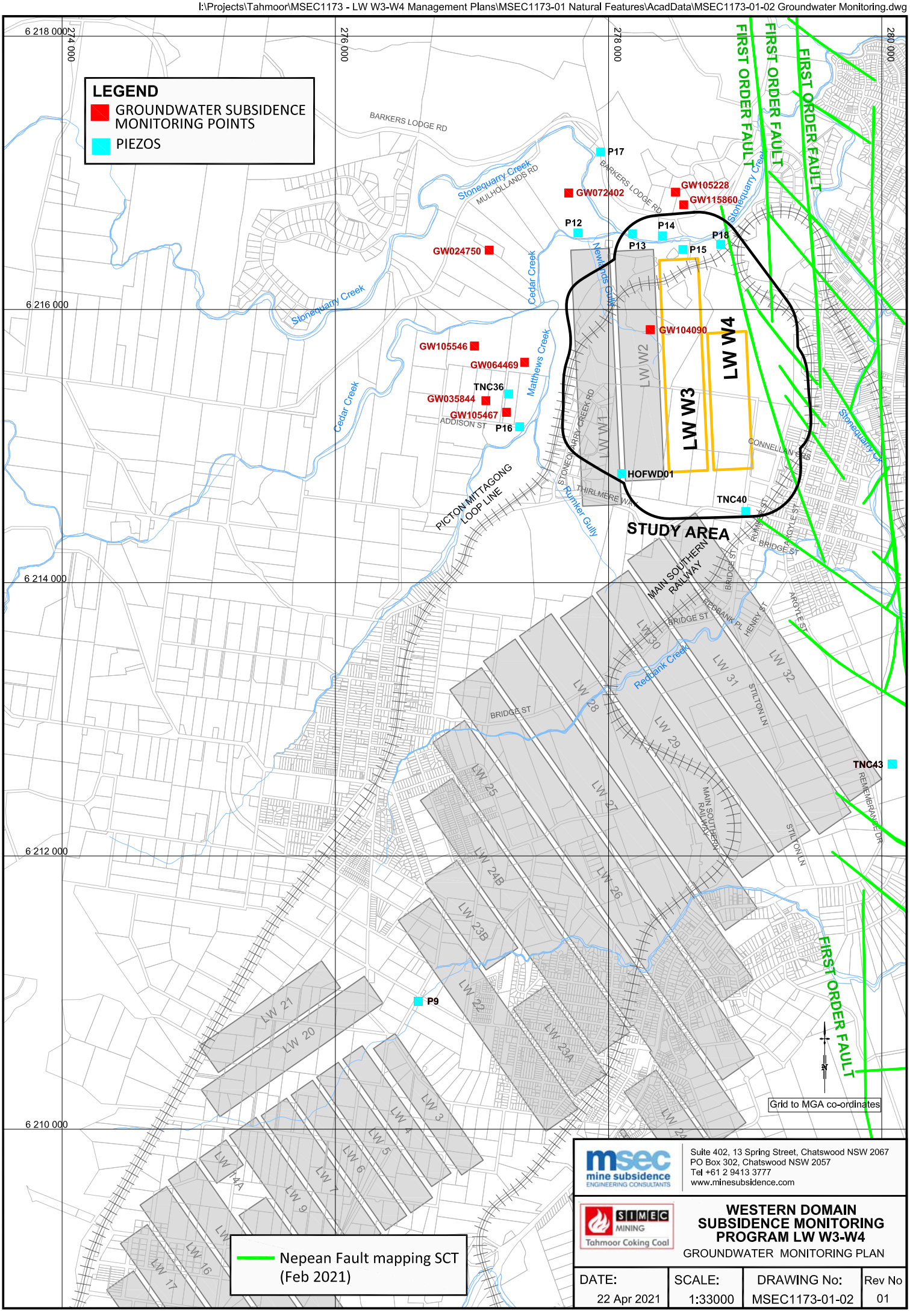

msec mine subsidence ENGINEERING CONSULTANTS
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Tel +61 2 9413 3777
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SIMEC MINING Tahmoor Coking Coal

WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W3-W4

GROUNDWATER MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
22 Apr 2021	1:33000	MSEC1173-01-02	01

This information has been retracted
- For more information contact Tahmoor Coal

SIMEC
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Appendix B – Survey Specification by SMEC

SPECIFICATIONS FOR SUBSIDENCE MONITORING LINES FOR LONGWALLS W3-W4

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2015 (NSW - Mines)* in particular *Section 3. (Survey Standards and Procedures)* will be complied with (see.www.resourcesandgeoscience.nsw.gov.au and use search).

2. Required Surveys

   2.1. Levels to Australian Height datum (AHD) on each station of the subsidence line. (In order to obtain subsidence.)
   2.2. Measured distance between each station of the subsidence line. (In order to obtain strains.)
   2.3. Relative co-ordinates of subsidence line stations where required. (In order to obtain relative horizontal movement).

3. Establishment

   3.1. Each line will be established and initial readings taken prior to the influence of mine subsidence affecting the subsidence line; a minimum distance of 1000m from longwall extraction may be used as a guide. This timeframe will be nominated by Tahmoor Coal and installation time frames agreed.
   3.2. Care is to be taken that bench marks and GNSS control stations will be unaffected by ground movement (subsidence & horizontal movement) from future mining or current Longwall extraction. The location of these bench marks and control stations should be confirmed with Tahmoor Coal before use.

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 “Standard for the Australian Survey Control Network” (see https://www.icsm.gov.au/publications/standard-australian-survey-control-network-special-publication-1-sp1)

   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily EDM survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.

   4.3. EDM Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing

      4.3.1. Conventional Theodolite/EDM levelling traverse for measuring subsidence & strain.
      4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Theodolite/EDM traverse adjusted between GPS Baseline(s).
      4.3.3. Height Datum to be carried through traverse by height levelling.
      4.3.4. Maximum traverse line length 150 metres.
      4.3.5. Maximum intermediate line length 80 metres.
      4.3.6. Target at each subsidence station to generally be either a handheld miniprism or prism & fixed pole with dual-support for stability.

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4.4. Conventional Subsidence Method.

4.4.1. Distances between stations (In order to obtain strains.) measured by a standardised steel band with corrections made for sag and temperature.
4.4.2. Alternatively, particularly in steep terrain or where there are objects on ground between stations that prevent steel band measurement. Distances between stations (In order to obtain strains.) measured by EDM.
4.4.3. Subsidence will be measured to the target accuracy and will start and finish on datum unaffected by ground movement (subsidence).
4.4.4. Levels will be measured with a digital level, lengths of back sights and foresights are to be equal and no more than 50m.
4.4.5. The digital level will be tested to prove it is in adjustment immediately prior to use.

4.5. GNSS Survey Control for Absolute Three Dimensional Survey of Subsidence Lines:

4.5.1. Connection of absolute three dimensional surveys, where applicable, to GNSS coordinates resolved using Network RTK methods. Coordinates to be resolved in the current nominated Map Grid of Australia Datum.
4.5.2. Surveyed coordinates for each GNSS position by this method are to be observed in sets using an average of a minimum of three 2 minute occupations measured once and the whole set repeated again at least 30 minutes apart. *Refer to table 13 "Technical Specifications for NSW Secondary Control Surveys" NSW Spatial Services (January 2021).*
4.5.3. Some historically surveyed GNSS monitoring baselines are to be surveyed using previously established Site GNSS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.5.4. Site GNSS Base Stations are to be monitored periodically if required by connection to an established stable 'outer' network of GNSS Stations.
4.5.5. GNSS Baselines are to be surveyed relative to a Site GNSS Base Station. Baselines are then used for the adjustment of Theodlite/EDM traverse lines locating subsidence marks in three dimensions (MGA~AHD).

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys shall be as follows:
Differential Levelling (Digital Level) - 1.5mm per kilometre of double run.
Differential Levelling (Theodolite) to an accuracy of ±5mm.
5.1.1. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse & to an accuracy of ±2.5mm (Strain 0.13mm/m over a 20 m bay) for measurement by steel band.
5.1.2. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.
5.1.3. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 20mm or better (Relative two dimensional accuracy of ± 5mm).

6. Subsidence Station Placement

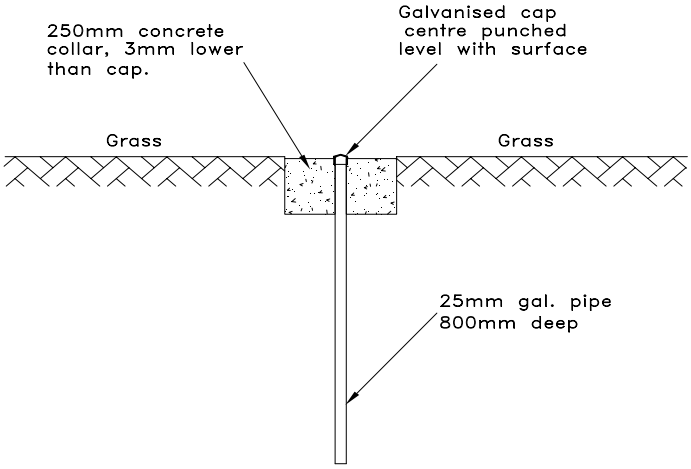
6.1. Installation. Marks are typically either fixed monitoring prisms or standard ground mark subsidence stations. Fixed prisms are either bolted to rock or a solid structure or fixed to a stable star picket. Standard ground mark subsidence marks are to be installed level or below the ground and in such a way so as not to become a danger or hazard (to the public, railway employees, livestock or other persons).
6.2. Location. Subsidence stations are to be installed in locations that will not be damaged or run over by vehicles. Where subsidence stations are located in a position near where vehicles or other

equipment may access, the location of the subsidence station should be clearly indicated with an adjacent stake or other warning marker.

6.3. Spacing. All subsidence stations are to be placed at nominal 20 metre intervals and in a straight line where possible.

6.4. Line length. The subsidence line will cover the area affected by mining and shall be specified by Tahmoor Coal.

6.5. Station type. The standard ground mark subsidence stations are generally to be 20mm diameter galvanised pipe, approximately 800mm length, driven into the ground, capped and centre punched (or rivet placed), together with a concrete collar (as shown below).
Where an area of bitumen or concrete needs to be crossed marks may be installed as a galvanized iron nail, ramset nail, rivet or drill hole.



6.6. Placement in footpaths and locations of Utility/Service providers. Utilities and services are not to be damaged by the subsidence stations.

6.6.1. Railway Corridor. The location of utilities and services needs to be ascertained from the appropriate rail authority and confirmed prior to installation of the subsidence survey line.

7. Monitoring frequency

The lines will be established and surveyed initially before subsidence affects the line.

Various timing for resurvey frequency may be requested by the Tahmoor Coal based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.

A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.

Please refer to Tahmoor Coal Subsidence Management Plans for survey frequencies.

8. Reports

The following information shall be included in the report:

8.1. Date of survey.
8.2. Name, location and RL of bench mark and or GPS Base station used.
8.3. When requested a summary stating maximum values of subsidence, tensile(+ve) strain, compressive(-ve) strain and horizontal movement of the current survey. Reports can also state if any visual subsidence impacts were observed.
8.4. Excel table and XML file showing subsidence results of current survey. This is to be supplied electronically.
8.5. Single graph showing subsidence of all resurveys. This is to be supplied as a digital Excel file.
8.6. Single graph showing strain of all resurveys. This is to be supplied as a digital Excel file.
8.7. Any other relevant information required by the Surveyor.

9. Additional Information

Tahmoor Coal will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Coal will provide an Excel & XML files to be used as a template.

Yours faithfully,
SMEC Australia Pty Ltd
per .. **Gary Warren**
Registered Surveyor
Survey Team Leader
Level 2, 6-8 Regent Street
Wollongong NSW 2500
Ph: 02 9900 7128
Gus.Warren@smec.com

Tahmoor Coal Contacts:

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Registered Mine Surveyor
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Amanda Fitzgerald
Environment & Community Clerk
Tahmoor Coal
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Appendix C – Survey Specifications by Southern Rail Surveys

Southern Rail Surveys Pty Ltd

PO Box 990

Wollongong, NSW, 2500

Loop Line- Survey Monitoring Plan for LW W3-W4

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2020, i*n particular *Section 3. (Survey Procedures)* will be complied with. (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

   2.1. Levels to Australian Height datum (AHD) on each station of the subsidence line. (In order to obtain subsidence.)
   2.2. Measured distance between each station of the subsidence line. (In order to obtain strains.)
   2.3. MGA Co-ordinates of each station of subsidence lines where possible. (In order to obtain horizontal movement).

3. Establishment

   3.1. Each line will be established and initial readings taken prior to the influence of mine subsidence affecting the subsidence line; a minimum distance of 1000m from longwall extraction may be used as a guide. This timeframe will be nominated by Tahmoor Colliery and installation time frames agreed.
   3.2. Care is to be taken that bench marks and control stations (GPS base stations) will be unaffected by ground movement (subsidence & horizontal movement) from future mining or current Longwall extraction. The location of these bench marks and control stations should be confirmed with Tahmoor Colliery before use.

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys".
   (see http://www.icsm.gov.au/icsm/publications/sp1/sp1v2.2)

   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily Total Station survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.

   4.3. Total Station Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing

      4.3.1. Conventional Totalstation traverse for measuring subsidence & strain.
      4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Totalstation traverse adjusted between GNSS Baseline(s).
      4.3.3. Height Datum to be carried through traverse by height traversing.
      4.3.4. Maximum traverse line length nominally 150 metres.
      4.3.5. Maximum intermediate line length nominally 80 metres.
      4.3.6. Target at each subsidence station to generally be a fixed miniprism.

4.4. GNSS Survey Control for Three Dimensional Survey of Subsidence Lines:

4.4.1. Use of NSW CORSnet GNSS Base Stations. This is a NSW wide system of continuously operating GNSS receivers. Procedures in accordance with Surveyor Generals Direction No. 12 (Sect 10)

4.4.2. CORSnet GNSS Base Stations are monitored daily by the Spatial Services Department of the NSW Government.

4.4.3. GNSS Baselines are to be surveyed relative to NSW CORSnet GNSS Base Stations. Baselines are then used for the adjustment of Total Station traverse lines locating subsidence marks in three dimensions (MGA~AHD).

4.5. Culvert pipe joints:

4.5.1. Culvert pipe joints will be measured by calliper.

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys by total station shall be as follows:
- 1.0 second angular resolution
- ±2mm and 2 ppm distance

5.2. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse.

5.3. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.

5.4. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 10mm or better (Relative two dimensional accuracy of ± 5mm).

5.5. Rail creep surveys shall be measured to an accuracy of ±3mm

5.6. Long bay surveys shall be measured to an accuracy of ±3mm

5.7. 2D Bridge surveys across the arches shall be measured to an accuracy of ±3mm

6. Survey Instrument Calibration

6.1. In accordance with the Surveyor Generals Direction No. 5 the survey instruments associated with this project will be calibrated annually.

6.2. A calibration certificate will be supplied to Tahmoor Colliery.

7. Subsidence Station Placement

7.1. Survey marks in the ground are a combination of galvanized pipe/star picket flush with the ground or raised star picket (driven at least 800 mm's into ground) with fixed prism or steel spigot.

7.2. The culvert survey marks are fixed prisms anchored to structure.

7.3. The overbridge survey marks are fixed prisms attached to the concrete bridge elements as required.

7.4. The base and bench survey marks with cutting are steel rod, drilled and epoxy anchored with a fixed prism.

Proposed track kilometrage range and monitoring frequencies are defined in the Tahmoor LW W3-W4 Railway Subsidence Management Plan.

Southern Rail Surveys Pty Ltd

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Wollongong, NSW, 2500

8. Monitoring frequency

The lines will be established and surveyed initially before subsidence affects the line.
Various timing for resurvey frequency may be requested by the Tahmoor Colliery based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.
A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.
Please refer to Tahmoor LW W3-W4 Railway Subsidence Management Plan for survey frequencies.

9. Reports

The following information shall be included in the report:

9.1. Date of survey.
9.2. Name, location and RL of bench mark and or GNSS Base station used.
9.3. When requested a summary stating maximum values of subsidence, tensile(+ve) strain, compressive(-ve) strain and horizontal movement of the current survey. Reports can also state if any visual subsidence impacts were observed.
9.4. Excel table and XML file showing subsidence results of current survey. This is to be supplied electronically.
9.5. Any other relevant information required by the Surveyor.

Survey results will nominally be reported within 24 hours of the completion of survey. Results will be forwarded electronically in Excel spreadsheets (.xls and .xml files) to relevant parties.

10. Additional Information
Tahmoor Colliery will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Colliery will provide an Excel & XML files be used as a template.

John Rolles
Registered Surveyor
Southern Rail Surveys Pty Ltd
30 March 2021

Tahmoor Colliery Contacts:

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Rail Contracts Manager
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Southern Rail Surveys Pty Ltd

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Wollongong, NSW, 2500

Main South Line- Survey Monitoring Plan for LW W3-W4

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2020, in* particular *Section 3. (Survey Procedures)* will be complied with. (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

   2.1. Levels to Australian Height datum (AHD) on each station of the subsidence line. (In order to obtain subsidence.)
   2.2. Measured distance between each station of the subsidence line. (In order to obtain strains.)
   2.3. MGA Co-ordinates of each station of subsidence lines where possible. (In order to obtain horizontal movement).

3. Establishment

   3.1. Each line will be established and initial readings taken prior to the influence of mine subsidence affecting the subsidence line; a minimum distance of 1000m from longwall extraction may be used as a guide. This timeframe will be nominated by Tahmoor Colliery and installation time frames agreed.
   3.2. Care is to be taken that bench marks and control stations (GPS base stations) will be unaffected by ground movement (subsidence & horizontal movement) from future mining or current Longwall extraction. The location of these bench marks and control stations should be confirmed with Tahmoor Colliery before use.

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys".
   (see http://www.icsm.gov.au/icsm/publications/sp1/sp1v2.2)

   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily Total Station survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.

   4.3. Total Station Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing

      4.3.1. Conventional Totalstation traverse for measuring subsidence & strain.
      4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Totalstation traverse adjusted between GNSS Baseline(s).
      4.3.3. Height Datum to be carried through traverse by height traversing.
      4.3.4. Maximum traverse line length nominally 150 metres.
      4.3.5. Maximum intermediate line length nominally 80 metres.
      4.3.6. Target at each subsidence station to generally be a fixed miniprism.

4.4. GNSS Survey Control for Three Dimensional Survey of Subsidence Lines:

4.4.1. Use of NSW CORSnet GNSS Base Stations. This is a NSW wide system of continuously operating GNSS receivers. Procedures in accordance with Surveyor Generals Direction No. 12 (Sect 10)

4.4.2. CORSnet GNSS Base Stations are monitored daily by the Spatial Services Department of the NSW Government.

4.4.3. GNSS Baselines are to be surveyed relative to NSW CORSnet GNSS Base Stations. Baselines are then used for the adjustment of Total Station traverse lines locating subsidence marks in three dimensions (MGA~AHD).

4.5. Culvert pipe joints:

4.5.1. Culvert pipe joints will be measured by calliper.

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys by total station shall be as follows:
- 1.0 second angular resolution
- ±2mm and 2 ppm distance

5.2. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse.

5.3. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.

5.4. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 10mm or better (Relative two dimensional accuracy of ± 5mm).

5.5. Rail creep surveys shall be measured to an accuracy of ±3mm

5.6. Long bay surveys shall be measured to an accuracy of ±3mm

5.7. Relative 3D surveys at structures shall be measured to an accuracy of ±3mm

6. Survey Instrument Calibration

6.1. In accordance with the Surveyor Generals Direction No. 5 the survey instruments associated with this project will be calibrated annually.

6.2. A calibration certificate will be supplied to Tahmoor Colliery.

7. Subsidence Station Placement

7.1. Survey marks in the ground are a combination of galvanized pipe/star picket flush with the ground or raised star picket (driven at least 800 mm's into ground) with fixed prism or steel spigot.

7.2. The culvert survey marks are fixed prisms anchored to structure.

7.3. The overbridge survey marks are fixed prisms attached to the concrete bridge elements as required.

7.4. The base and bench survey marks with cutting are steel rod, drilled and epoxy anchored with a fixed prism.

Proposed track kilometrage range and monitoring frequencies are defined in the Tahmoor LW W3-W4 Railway Subsidence Management Plan.

Southern Rail Surveys Pty Ltd

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Wollongong, NSW, 2500

8. Monitoring frequency

The lines will be established and surveyed initially before subsidence affects the line.
Various timing for resurvey frequency may be requested by the Tahmoor Colliery based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.
A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.
Please refer to Tahmoor LW W3-W4 Railway Subsidence Management Plan for survey frequencies.

9. Reports

The following information shall be included in the report:

9.1. Date of survey.
9.2. Name, location and RL of bench mark and or GNSS Base station used.
9.3. When requested a summary stating maximum values of subsidence, tensile(+ve) strain, compressive(-ve) strain and horizontal movement of the current survey. Reports can also state if any visual subsidence impacts were observed.
9.4. Excel table and XML file showing subsidence results of current survey. This is to be supplied electronically.
9.5. Any other relevant information required by the Surveyor.

Survey results will nominally be reported within 24 hours of the completion of survey. Results will be forwarded electronically in Excel spreadsheets (.xls and .xml files) to relevant parties.

10. Additional Information
Tahmoor Colliery will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Colliery will provide an Excel & XML files be used as a template.

John Rolles
Registered Surveyor
Southern Rail Surveys Pty Ltd
9 July 2021

Tahmoor Colliery Contacts:

Ross Barber
Rail Contracts Manager
Tahmoor Colliery
Tel 02 4640 0028
Ross.Barber@simecgfg.com

Southern Rail Surveys Pty Ltd

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Wollongong, NSW, 2500

Far Field Structures- Survey Monitoring Plan for LW W3-W4

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2020, in* particular *Section 3. (Survey Procedures)* will be complied with. (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

   2.1. Levels to Australian Height datum (AHD) on each monitoring mark at structures. (In order to obtain subsidence.) Local height datum for relative 3D Structures.
   2.2. MGA/Local Co-ordinates for each monitoring mark at structures. (In order to obtain horizontal movement)

3. Establishment

   3.1. Each monitoring mark will be established and initial readings taken prior to the influence of mine subsidence affecting the subsidence line; a minimum distance of 1000m from longwall extraction may be used as a guide. This timeframe will be nominated by Tahmoor Colliery and installation time frames agreed.
   3.2. Care is to be taken that bench marks and control stations (GPS base stations) will be unaffected by ground movement (subsidence & horizontal movement) from future mining or current Longwall extraction. The location of these bench marks and control stations should be confirmed with Tahmoor Colliery before use.

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys".
   (see http://www.icsm.gov.au/icsm/publications/sp1/sp1v2.2)

   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily Total Station survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.

   4.3. Total Station Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing

      4.3.1. Conventional Totalstation traverse for measuring subsidence & strain.
      4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Totalstation traverse adjusted between GNSS Baseline(s).
      4.3.3. Height Datum to be carried through traverse by height traversing.
      4.3.4. Maximum traverse line length nominally 150 metres.
      4.3.5. Maximum intermediate line length nominally 80 metres.
      4.3.6. Target at each subsidence station to generally be a fixed miniprism.

4.4. GNSS Survey Control for Three Dimensional Survey of Subsidence Lines:

4.4.1. Use of NSW CORSnet GNSS Base Stations. This is a NSW wide system of continuously operating GNSS receivers. Procedures in accordance with Surveyor Generals Direction No. 12 (Sect 10)

4.4.2. CORSnet GNSS Base Stations are monitored daily by the Spatial Services Department of the NSW Government.

4.4.3. GNSS Baselines are to be surveyed relative to NSW CORSnet GNSS Base Stations. Baselines are then used for the adjustment of Total Station traverse lines locating subsidence marks in three dimensions (MGA~AHD).

4.5. Culvert pipe joints:

4.5.1. Culvert pipe joints will be measured by calliper.

5. Target Accuracies

5.1. Target Accuracies for monitoring surveys by total station shall be as follows:

- 1.0 second angular resolution
- ±2mm and 2 ppm distance

5.2. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse.

5.3. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.

5.4. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 10mm or better (Relative two dimensional accuracy of ± 5mm).

5.5. Rail creep surveys shall be measured to an accuracy of ±3mm

5.6. Long bay surveys shall be measured to an accuracy of ±3mm

5.7. Relative 3D surveys at structures shall be measured to an accuracy of ±3mm

6. Survey Instrument Calibration

6.1. In accordance with the Surveyor Generals Direction No. 5 the survey instruments associated with this project will be calibrated annually.

6.2. A calibration certificate will be supplied to Tahmoor Colliery.

7. Subsidence Station Placement

7.1. Survey marks in the ground are a combination of galvanized pipe/star picket flush with the ground or raised star picket (driven at least 800 mm's into ground) with fixed prism or steel spigot.

7.2. The tunnel/culvert survey marks are fixed prisms anchored to structure.

7.3. The overbridge/underbridge survey marks are fixed prisms attached to the bridge elements as required.

7.4. The base and bench survey marks within cuttings are steel rod, drilled and epoxy anchored with a fixed prism.

Proposed track kilometrage range and monitoring frequencies are defined in the Tahmoor LW W3-W4 Railway Subsidence Management Plan.

Southern Rail Surveys Pty Ltd

PO Box 990

Wollongong, NSW, 2500

8. Monitoring frequency

The lines will be established and surveyed initially before subsidence affects the line.
Various timing for resurvey frequency may be requested by the Tahmoor Colliery based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.
A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.
Please refer to Tahmoor LW W3-W4 Railway Subsidence Management Plan for survey frequencies.

9. Reports

The following information shall be included in the report:

9.1. Date of survey.
9.2. Name, location and RL of bench mark and or GNSS Base station used.
9.3. When requested a summary stating maximum values of subsidence, tensile(+ve) strain, compressive(-ve) strain and horizontal movement of the current survey. Reports can also state if any visual subsidence impacts were observed.
9.4. Excel table and XML file showing subsidence results of current survey. This is to be supplied electronically.
9.5. Any other relevant information required by the Surveyor.

Survey results will nominally be reported within 24 hours of the completion of survey. Results will be forwarded electronically in Excel spreadsheets (.xls and .xml files) to relevant parties.

10. Additional Information
Tahmoor Colliery will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Colliery will provide an Excel & XML files be used as a template.

John Rolles
Registered Surveyor
Southern Rail Surveys Pty Ltd
9 July 2021

Tahmoor Colliery Contacts:

Ross Barber
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Tel 02 4640 0028
Ross.Barber@simecgfg.com