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Tahmoor Coal Pty Ltd

SUBSIDENCE MONITORING PROGRAM

Tahmoor North Western Domain
Longwalls West 1 and West 2

October 2020

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1 Introduction

1.1 Background

The 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**).

The 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 (**SIMEC**) of the GFG Alliance (**GFG**).

Tahmoor Coal has previously mined 32 longwalls to the north and west of the Tahmoor Mine's current pit top location.

Tahmoor Coal has extended underground coal mining to the north-west of the Main Southern Railway (referred to as the 'Western Domain') which will include Longwalls West 1 (**LW W1**) to West 4 (**LW W4**) at Picton and Thirlmere. The first two longwalls to be mined are LW W1 and Longwall West 2 (**LW W2**) (collectively referred to as **LW W1-W2**), which will be the focus of this Subsidence Monitoring Program.

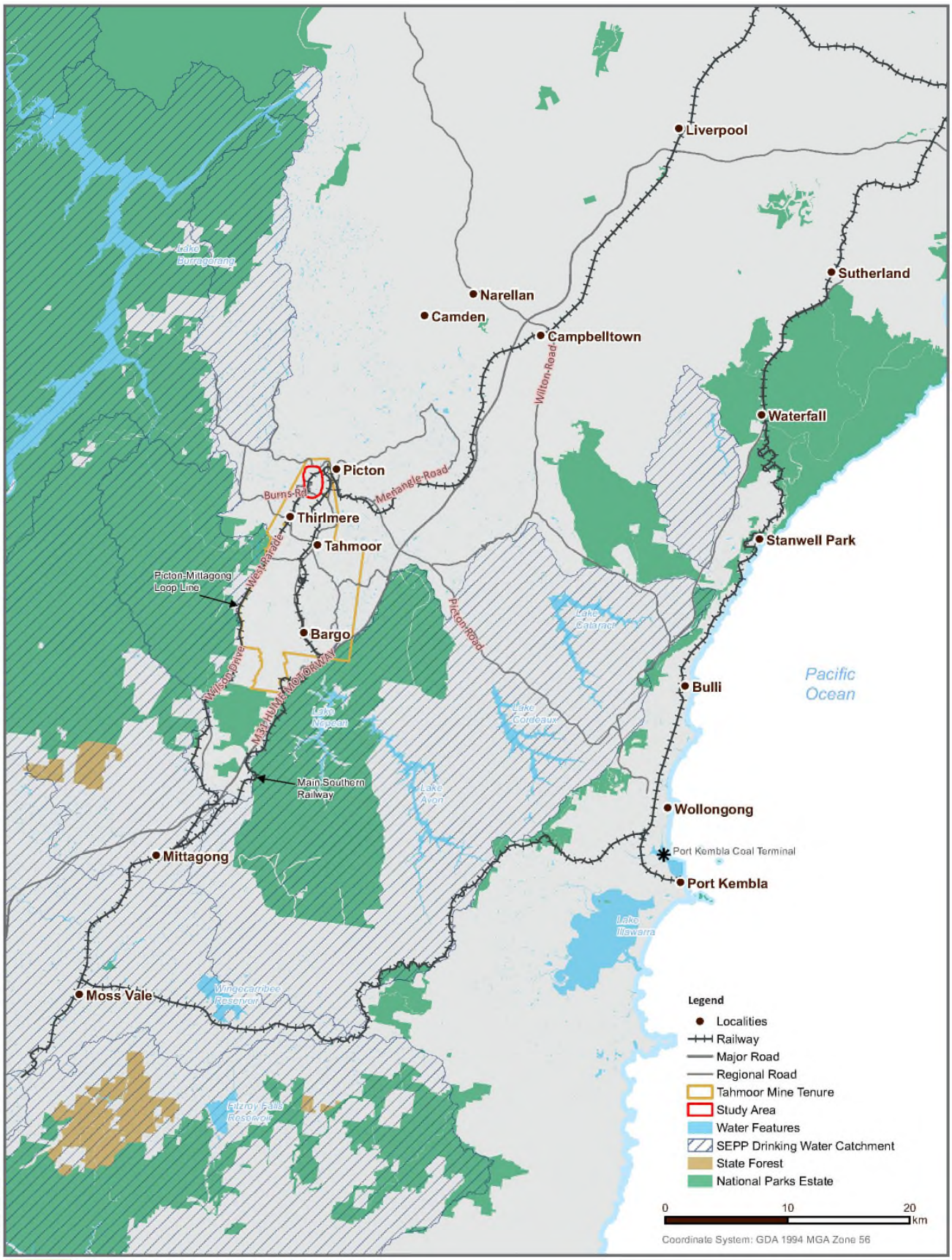
Tahmoor Coal received approval of the Extraction Plan for LW W1-W2 on 8 November 2019 and commenced extraction of LW W1 on 15 November, in accordance with Development Consents and Extraction Plan Approval.

LW W1-W2 are located to the west of the township of Picton, between Matthews, Cedar and Stonequarry Creeks, the Main Southern Railway and the currently active Tahmoor North longwall series.

LW W1-W2 are approximately 283 metres (**m**) wide (rib-to-rib). LW W1 and LW W2 are approximately 1875 m and 1685 m long, respectively. The width of the chain pillar between LW W1 and LW W2 is 39 m.

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 W1-W2. The Subsidence Monitoring Program focuses on monitoring that is planned to be conducted during the extraction of LW W2.



DOCUMENT FILE PATH

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REGIONAL CONTEXT

Tahmoor North Western Domain Longwalls West 1 and West 2
Extraction Plan

FIGURE 1-1

Date: 27/05/2019

Data Sources:
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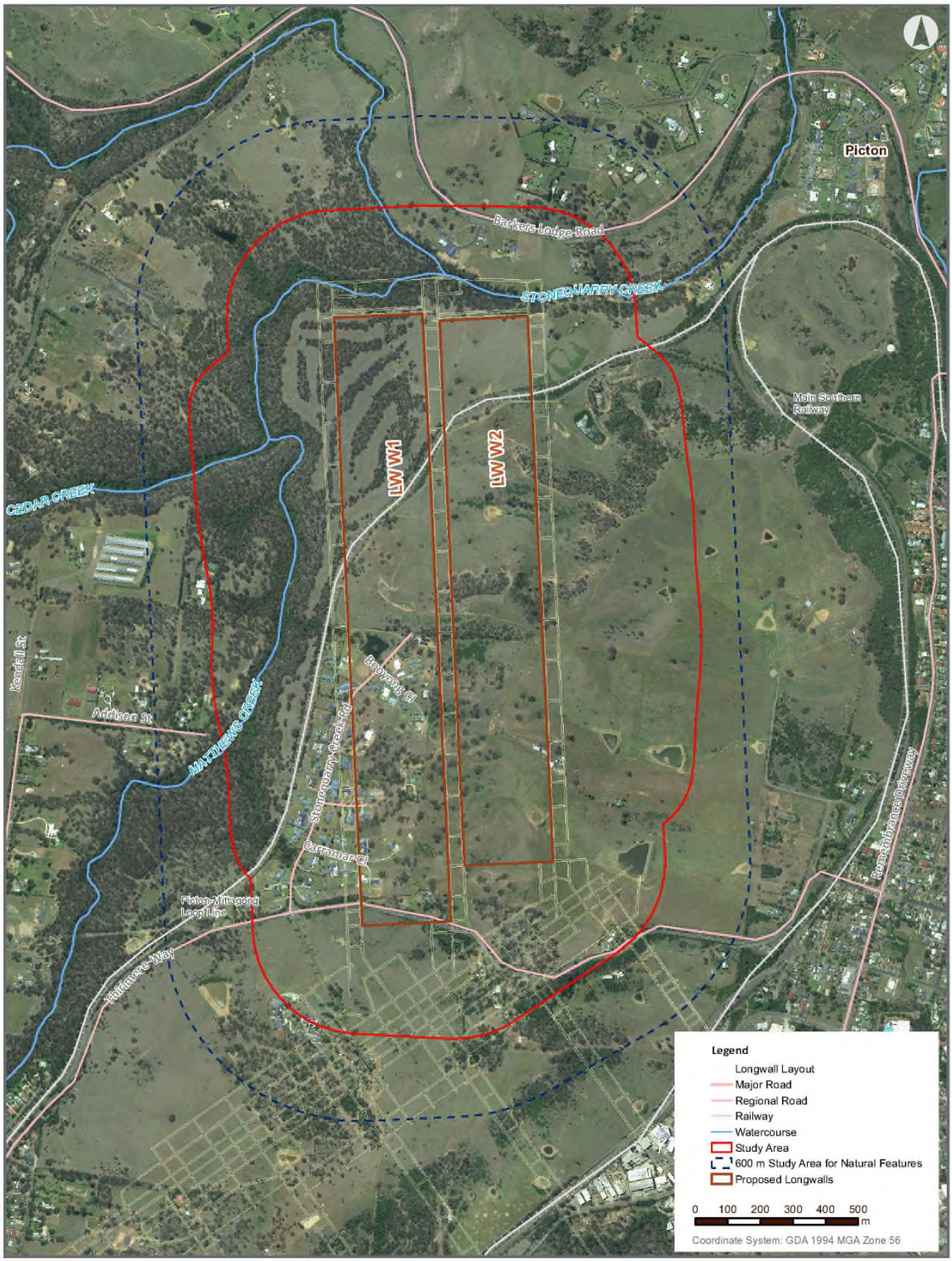

EXTRACTION PLAN STUDY AREA

Tahmoor North Western Domain Longwalls West 1 and West 2
Extraction Plan

FIGURE 1-2

Date: 4/07/2019

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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 W1-W2:

- Tahmoor Coal – Water Management Plan for LW W1-W2, 2020;
- Tahmoor Coal – Land Management Plan for LW W1-W2, 2019;
- Tahmoor Coal – Biodiversity Management Plan for LW W1-W2, 2019;
- Tahmoor Coal – Heritage Management Plan for LW W1-W2, 2019;
- Tahmoor Coal – Built Features Management Plan for LW W1-W2, 2019; and
- Tahmoor Coal – Public Safety Management Plan for LW W1-W2, 2019.

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 W1-W2 Management Plan for Potential Impacts to Wollondilly Shire Council Infrastructure, Report No. MSEC1045-02, 2019;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Sydney Water Potable Water Infrastructure, Report No. MSEC1045-03, 2019;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Stonequarry Wastewater Treatment Plant, Report No. MSEC1045-04, 2020;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Jemena Gas Infrastructure, Report No. MSEC1045-05, 2019;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Endeavour Energy Infrastructure, Report No. MSEC1045-06, 2019;
- Tahmoor Coal –Management Plan (LW W1 & W2) beneath Telstra Plant at Picton, Comms Network Solutions, 2019;
- Tahmoor Coal – LW W1-W2 Management Plan for NBN Co Infrastructure, Comms Network Solutions, 2019.
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Built Structures, Report No. MSEC1045-12, 2019;
- Tahmoor Coal – LW W1-W2 Property Subsidence Management Plan for potential mine subsidence impacts on Queen Victoria Memorial Home, Report No. MSEC1045-13-01, 2020;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to No. 675 Thirlmere Way (Mill Hill), Report No. MSEC1045-13-02, 2020;
- Tahmoor Coal – LW W1-W2 Management Plan for Potential Impacts to Roads and Maritime Services Infrastructure, Report No. MSEC1045-18, 2019.
- Tahmoor Coal – LW W1-W2 Management Plan for extraction of LW W1-W2 beneath the Picton-Mittagong Loop Line, Report No. MSEC1036, 2019; and
- Tahmoor Coal – LW W1-W2 Management Plan for extraction of LW W1-W2 adjacent to the Main Southern Railway, Report No. MSEC1058, 2019.

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.

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**.

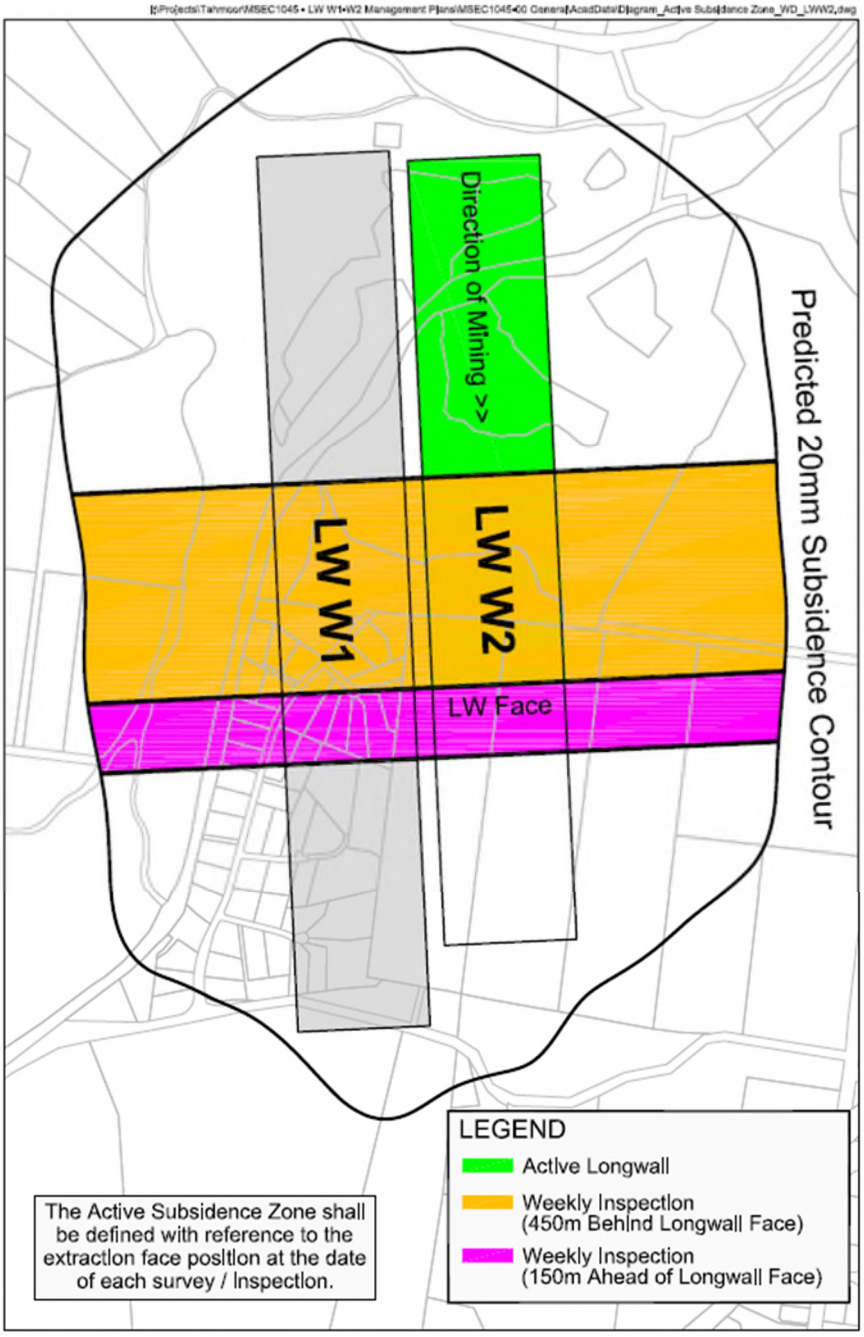


Figure 1-3 Diagrammatic Representation of Active Subsidence Zone

1.3 Maximum Predicted Conventional Subsidence Parameters

Predicted mining-induced conventional subsidence movements were provided in Report No. MSEC1019, which was prepared in support of Tahmoor Coal's Extraction Plan Application for LW W1-W2. A summary of the maximum predicted incremental subsidence parameters due to the extraction of LW W1-W2 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 W1	475	3.0	0.03	0.06
LW W2	650	5.0	0.06	0.11

A summary of the maximum predicted total subsidence parameters due to the extraction of LW W1-W2 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 W1	475	3.0	0.03	0.06
LW W2	750	5.5	0.06	0.11

1.4 Comparison of Measured and Predicted Subsidence for LW W1

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. MSEC1019**.

In this case, LW W1-W2 will be extracting in a new longwall series, which is located to the north of completed LW 32.

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. MSEC1019**.

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.

Observed subsidence above LW W1 has been less than predicted. An example is provided in **Figure 1-4**, which compares predicted and observed subsidence along the Picton to Mittagong Loop Line.

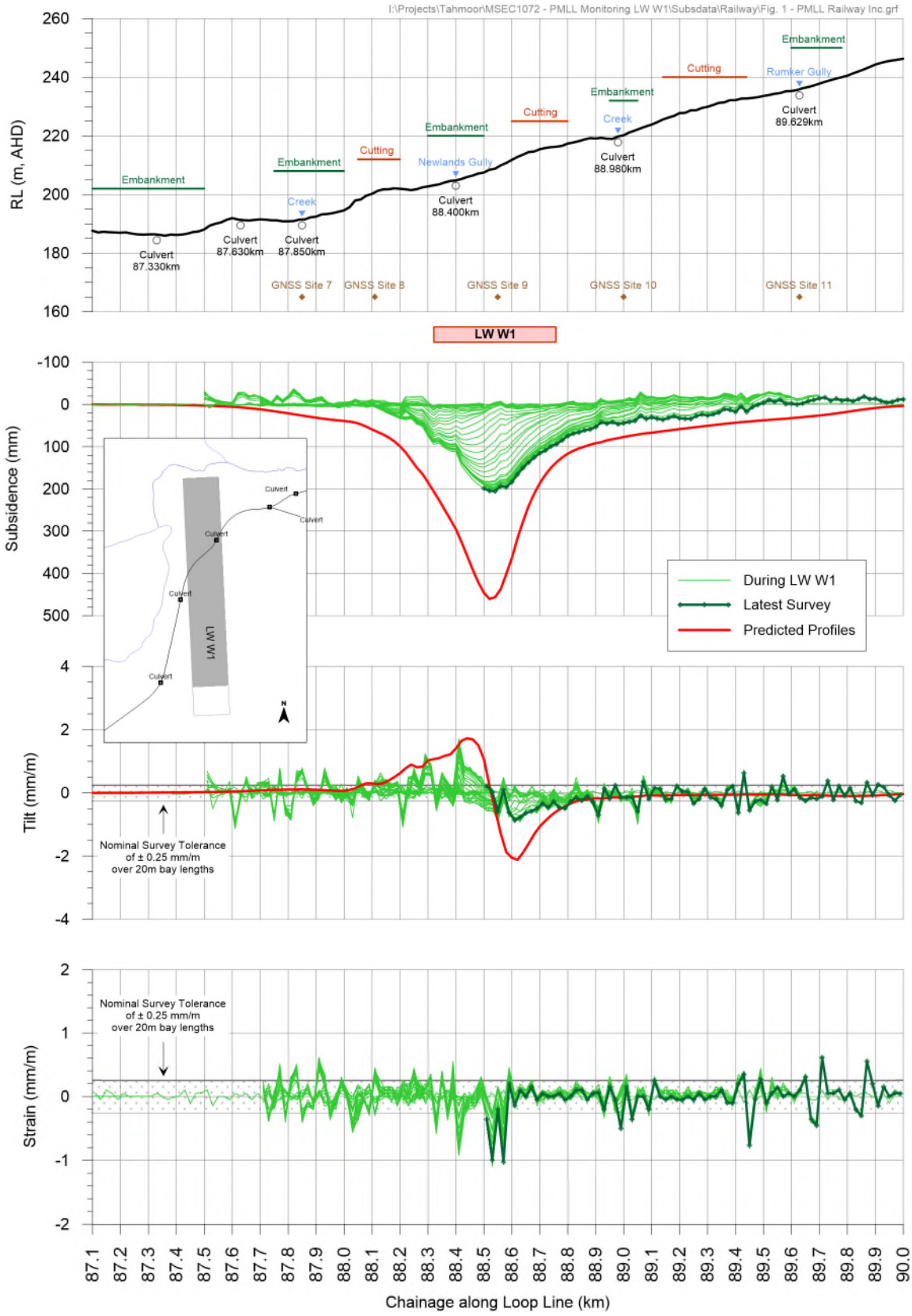


Figure 1-4 Observed subsidence along Picton to Mittagong Loop Line during the mining of LW W1

Peg 88.560 km on the Picton to 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 1-5.**

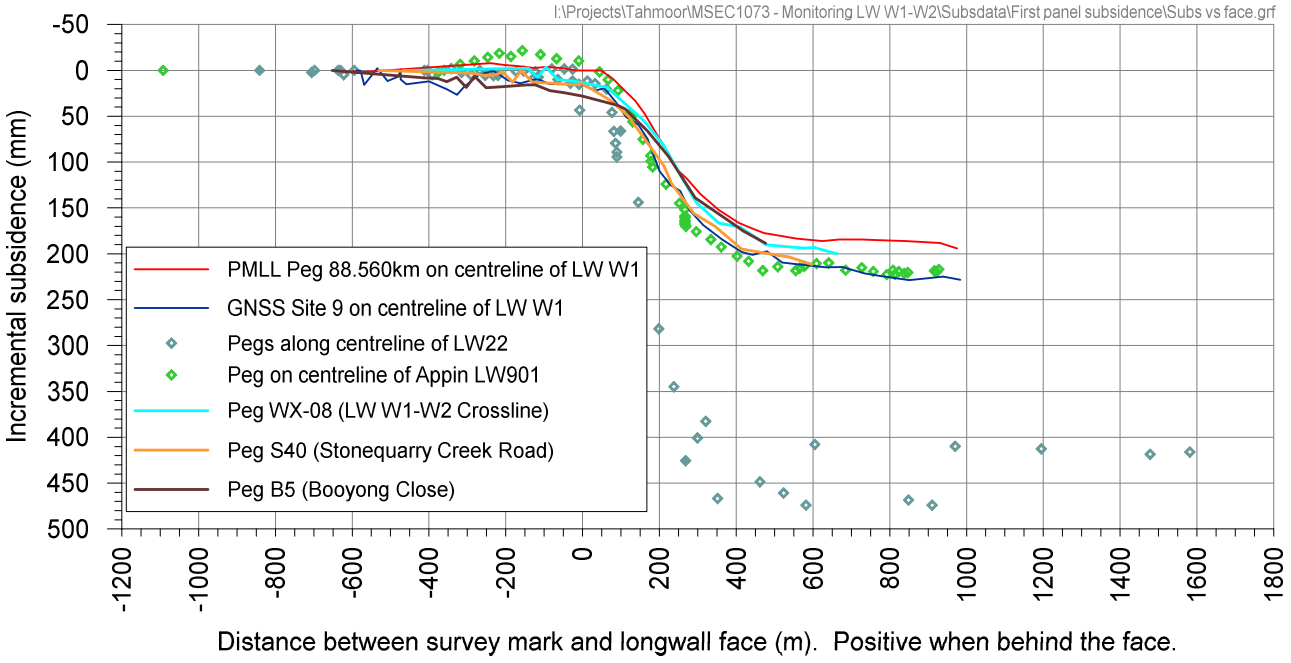


Figure 1-5 Development of subsidence along centreline of LW W1 compared to previously extracted single panels

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.

While observed subsidence have been less than predicted, it is possible that subsidence due to the extraction of LW W2 will return to higher levels.

Access was permitted on 29 September 2020 to install survey pegs along the centreline of LW W2. It is, therefore, planned that monitoring will be conducted during the early stages of extraction of LW W2 to compare observations with predictions. This will initially be achieved by regular surveys along the centreline of LW W2, followed by monitoring of subsidence along the Picton-Mittagong Loop Line (**PMLL**).

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 W1-W2 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.

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 BFMP from DA 67/98 are detailed in **Table 2-1**.

Table 2-1 Key Conditions from DA 67/98 regarding Subsidence Monitoring Program

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 have been incorporated into the LW W1-W2 Subsidence Monitoring Program, as demonstrated in **Table 3-1.**

2.1.3 Extraction Plan Guideline

This Subsidence Monitoring Program has been prepared in accordance with the *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
• Proposed reporting monitoring results, including the frequency of reporting; and	Section 3.3, Appendix B, Appendix C

Extraction Plan Guideline Content Requirements	Section(s) Addressed
• 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 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 as part of the preparation of the Extraction Plan is provided in **Section 2.1.2** of the Extraction Plan Main Document (July 2019), including a copy of the incoming correspondence in **Appendix C**.

3 Subsidence Monitoring Program

3.1 Layout of Monitoring Points

The layout of monitoring points is provided in **Drawing No. MSEC1045-00-01**, 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, and with the Queen Victoria Memorial Home and Mill Hill Homestead are also included in **Appendix A**.

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 W1-W2*, by SMEC. This specification is appended to this Subsidence Monitoring Program at **Appendix B**.

With respect to surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Loop Line- Survey Monitoring Plan for LW W1-W2* by Southern Rail Surveys. This specification is appended to this Subsidence Monitoring Program at **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 W1-W2* by SMEC and *Loop Line- Survey Monitoring Plan for LW W1-W2*, by Southern Rail Surveys. These specifications are appended to this Subsidence Monitoring Program at **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 W1-W2

A Survey line is proposed to be installed along the centreline of LW W2, as shown in **Drawing No. MSEC1045-00-01**. A survey line had also been planned to be installed along the centreline of LW W1 but the landowner had denied access. Access was granted on 29 September 2000 and it is planned to install a survey line along the centreline of LW W2.

The purpose of the survey line is to establish the general magnitude and shape of surface subsidence along the centrelines of LW W2. The observed subsidence movements will be used to provide early subsidence information to inform Tahmoor Coal and affected stakeholders prior to built surface features experiencing active subsidence, the majority of which are located at the central to southern end of LW W1-W2. 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 W2 to monitor the development of initial subsidence, which is expected to occur after the length of extraction exceeds approximately 200 m.

Monthly ground surveys along the centreline of LW W2 will commence after 20 mm of vertical subsidence is measured by the GNSS unit, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.

In addition to the above, a GNSS unit has been placed on the PMLL at the centrelines of LW W1 and LW W2 to provide general monitoring information.

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.

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. MSEC1045-00-01**.

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 pipelines, Jemena gas pipelines, Endeavour Energy electrical infrastructure, telecommunications infrastructure (Telstra and NBN) and privately operated sewerage infrastructure.

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 W1-W2.

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. MSEC1045-00-01**.

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 W1-W2.

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;
- 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 W1-W2.

The properties where landowners have requested or agreed with Tahmoor Coal to install survey pegs are shown in **Drawing No. MSEC1045-00-01**. 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 ends of LW W1 W2. 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 Main Southern Railway.

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 through a series of cuttings and over a series of embankments and culverts above and adjacent of LW W1-W2.

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 Picton-Mittagong Loop Line (PMLL Management Plan). Planning and consultation with Transport Heritage NSW for managing potential impacts on the PMLL has commenced and the PMLL Management Plan was developed prior to the influence of LW W1.

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 Main Southern Railway) to 90.000 km, as shown in **Drawing No. MSEC1045-00-01** and **Drawing No. MSEC1036-01.**

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. MSEC1036-03** to **MSEC1036-06**; 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 will be located every 20 m along the bases of the cuttings on both sides of the track.

It had previously been advised that there was insufficient room to install marks across the bases of the cuttings but the surveyor has managed to install and baseline survey the marks across the bases of the cutting at spacings between 60 m and 100 m. Following feedback provided by the mining regulator, additional marks will be installed at 20 m spacings in between the original marks.

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.

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 will be 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 will be provided in the PMLL Management Plan.

3.9 Monitoring along the Main Southern Railway

The Main Southern Railway is located 600 m east of the proposed LW W2 at its closest point to the proposed LW W1-W2. At this distance, it is unlikely that the railway track would experience adverse impacts.

Tahmoor Mine will continue to monitor movements at key items of railway infrastructure along the Main Southern Railway in accordance with the Main Southern Railway Management Plan, which is discussed in **Section 3.19**.

In addition to the far-field monitoring program, surveys were undertaken of piers and abutments of the structures during the mining of Longwall 31 and 32. With the exception of the Bridge Street Overbridge where substantial monitoring has been undertaken, the structures will be re-surveyed on a monthly basis during the mining of LW W1-W2 to monitor environmental changes and potentially detect mining-induced changes. The surveys can be conducted at greater frequencies if triggered by actual monitoring results.

Survey marks have been installed within the Picton Tunnel prior to the start of LW W1, and additional survey marks were also installed at additional railway structures by the end of December 2019.

Further details are described below.

Bridge Street Overbridge

- Local 3D survey of marks on the bridge deck, abutments, bridge approaches and on the cutting on both sides of the Overbridge.

Thirlmere Way Underbridge

- Local 3D survey of four marks at the base of the brick arch on both sides (installed).
- Local 3D surveys of additional survey marks at the ends of the wingwalls and base of the abutment walls (installed).

Connellan Crescent Overbridge

- Local 3D survey of four marks at the base of the concrete arch on both sides (installed).
- Local 3D surveys of additional survey marks 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).

Ballast Top Subway at 88.133 km

- 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 (installed).

Picton Tunnel

- Absolute 3D surveys of new prisms every 20 metres inside the Tunnel on both sides (installed and baseline surveyed prior to commencement of LW W1).

Mushroom Tunnel

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

Ballast Top Underbridge at 86.838 km

- 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 (installed).

Argyle Street Underbridge

- Local 3D survey of four marks at the base of the brick arch on both sides (installed).
- Local 3D surveys of additional survey marks along the tops of the spandrel walls at the approaches and above the arch, and at the base of the abutment walls (installed).

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).

Picton Viaduct

- Local 3D surveys of the twelve existing prisms at the base of the intermediate piers and abutments (installed near end of LW31).
- Local 3D surveys of additional survey marks along the tops of the arches below the low height parapet walls (installed).
- Local 3D survey along ground survey line upstream of the Viaduct (installed).
- 2D horizontal distance survey between two marks located downstream of the Viaduct across the tops of the valley sides (installed).

Princes Street Overbridge

- Local 3D surveys of the four prisms at the base of the brick piers (installed).
- Local 3D surveys of new marks on the bridge deck above the piers and at the approaches, and at the top of the piers (installed).

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)

Matthews Lane Overbridge

- 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).

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 W1-W2.

In addition to ground surveys and visual inspections along the local roads, Optical Time Domain Reflectometer (**OTDR**) monitoring will be conducted on potentially affected optical fibre cables during the extraction of proposed LW W1-W2. 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 W1-W2.

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. MSEC1045-00-01**.

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 Wastewater Treatment Plant (**WTP**) and associated sewerage infrastructure. It is noted that LW W1 is located more than 400 metres from the WTP boundary and LW W2 is located approximately 90 m to the west of the WTP boundary at their closest points.

Wastewater Treatment Plan (WTP)

It is proposed to install survey marks around the WTP structures and along the wall and base of the WTP dam, as shown in **Drawing No. MSEC1045-00-00**. Access was permitted to install survey marks at the WTP on 29 September 2020.

Survey marks have been placed along the Picton-Mittagong Loop Line (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 WTP and the wastewater treatment dam (Ref. PSC_090_d01) was constructed between 2002 and 2005. The dam has been inspected by geotechnical engineer Douglas Partners (2019). A perimeter catch drain runs around the back of the dam to collect and divert overland catchment flow away from the dam. The dam has a submersible pump to control the water level, which discharges via a flexible line downslope of the embankment.

The geotechnical inspection included drilling of two investigation boreholes in the dam embankment wall. Douglas Partners advise that the dam is in good condition with relatively flat batter slopes and is performing in accordance with industry accepted expectations. No signs of instability were observed.

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, the Rail Structures Management Group and Tahmoor Coal 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 that is located adjacent to the PMLL near 89.00 km downstream of the stormwater catchment dam (Ref. PSC_019_d01). 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 Mine has designed the mine layout of LW W1-W2 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 Mine has committed to implementing 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 are not greater than anticipated and impacts on Stonequarry Creek from LW W2 are unlikely to exceed predictions, Tahmoor Coal will be retaining the commencing position of LW W2.

A similar review will be undertaken during the extraction of LW W2 prior to confirming the commencing position of future 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 Tahmoor Mine's Water Management Plan, which is included in the Extraction Plan for LW W1-W2.

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.

The following ground surveys are planned to be installed, subject to approval for access by landowners.

Valley Closure Lines

It is proposed to monitor valley closure across the tops of the valley sides along Matthews, Cedar and Stonequarry Creeks. The valley closure lines will consist of pairs of pegs on or near the crests of the valleys, where there are adequate lines of sight available. The proposed locations are shown in **Drawing No. MSEC1045-00-01**. Surveys of the valley closure lines will measure horizontal distances between the pairs of pegs.

As previously discussed for the centreline survey, 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. MSEC1045-00-01.**

Access was permitted on 29 September 2020. While the extraction of LW W1 has effectively been completed, a small number of valley closure lines will be installed across Cedar and Matthew Creeks, as shown in **Drawing No. MSEC1045-00-01.** Unfortunately access is not permitted to

some private properties on the western side of Cedar Creek 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. MSEC1045-00-01**, 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 are planned to be 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 W1-W2.

As previously discussed for the centreline survey, access was not permitted prior to the commencement of LW W1 by the landowner 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 at this stage, one of the GNSS units was transferred slightly to the PMLL corridor near 89.440 km.

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, it is proposed to establish relative 3D survey lines along the banks of Cedar and Stonequarry Creeks from Rockbar CR26 at the main bend in Cedar Creek to Rockbar SR22 on Stonequarry Creek, which is located more than 540 m from LW W2.

Pegs will be installed in cleared land just beyond the natural vegetation within the valleys, spaced approximately every 50 m. The proposed locations of the monitoring lines are shown in **Drawing No. MSEC1045-00-01**.

The locations of the pegs will be measured in 3D coordinates, with their absolute positions calculated by 3D traverse to the GNSS units.

As previously discussed for the centreline survey, access was not permitted prior to the commencement of LW W1 by the landowner 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. This has prevented the installation of the 3D survey lines until 29 September 2020, prior to the commencement of LW W2. Given the timing, the planned extent of surveys has been shortened to the section of Cedar Creek that flows in an eastward direction.

Prior to approval to access landowner property, Tahmoor Coal developed an alternative and appropriate monitoring process to monitor valley closure during the mining of LW W1 and 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. MSEC1045-00-01.**

Rockbar SR17 on Stonequarry Creek

A long pool, labelled SC2, has been identified on Stonequarry Creek beyond the commencing end of LW W2. 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 Mine has installed a ground survey line across Rockbar SR17. The survey line follows the alignment of a public access track and include 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.

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 will be repeated after the extraction of LW W1 and LW W2. 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. MSEC1045-01-01**.

The monitoring sites measure changes in water level and quality.

Further details are provided in the 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 during the extraction of LW W1-W2.

A baseline photographic survey was completed in 2014 by GeoTerra, and further baseline photographic surveys have been 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 Water Management Plan. The locations of groundwater monitoring sites around proposed LW W1-W2 are shown in **Drawing No. MSEC1045-01-02**. 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 Biodiversity Management Plan. The locations of riparian monitoring sites and aquatic biodiversity monitoring sites are shown in **Drawing No. MSEC1045-01-03**.

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 W1-W2 by Tahmoor Coal and it is described in the 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 by an archaeologist at the completion of LW W1 and LW W2.

3.17 Monitoring at Queen Victoria Memorial Home

Property Subsidence Management Plans (**PSMPs**) have previously been developed and agreed with the operators of the Queen Victoria Memorial Home during and after the mining of Longwalls 30 and 31. The identified risks from subsidence movements are predominantly damage to the buildings and structures themselves, and an associated health and safety risk from potential additional hazardous material, subsequent to subsidence damage to buildings and structures.

In consultation with Tahmoor Coal, QVMH engaged surveyors to undertake ground surveys in accordance with the PSMPs. The surveyors have installed the pegs and completed a baseline survey. The purpose of the ground surveys is to provide information to the operator, Tahmoor Coal and Subsidence Advisory NSW in the unlikely event that impacts are visually observed to built structures on the property, or to trigger additional inspections or additional management actions if required within the property, or to trigger a CCTV inspection of QVMH's sewer pipe.

A PSMP has been developed in consultation with the operators of the Queen Victoria Memorial Home prior to the influence of LW W1-W2.

The installed ground survey network is shown in **Drawing No. MSEC1045-13-01**.

Surveys of QVMH have commenced with the approach of LW W1 and will continue until the completion of LW W1 and for a sufficient time thereafter until measured changes are negligible.

Whilst the likelihood of impacts to the building structures is very rare, mine subsidence could result in new or existing cracks or joints opening up in building elements, potentially allowing existing hazardous materials, such as asbestos dust, to enter occupied spaces or be released externally. The hazard is greatest in ceiling spaces where dust containing asbestos or lead has

been identified in ceiling spaces if a mining-induced crack was large enough for material to pass through.

Tahmoor Coal has developed and implemented a monitoring and inspection program for mining-induced asbestos air dust in consultation, co-operation and co-ordination with the operators of QVMH for Longwalls 30 and 31. A similar program has been developed and implemented for LW W1. The program includes the following monitoring measures:

- Weekly ground surveys;
- Baseline asbestos air monitoring; and
- Visual inspections for structures where more than 20 mm of subsidence has been measured.

Tahmoor Coal has previously engaged hazardous materials' specialists to design and implement a monitoring program for the detection of mining-induced asbestos air dust, including associated baseline monitoring, in consultation, co-operation and co-ordination with QVMH and Tahmoor Coal.

Air monitoring locations were selected where asbestos containing dust is known to be present, and where asbestos linings are present within accessible spaces inside QVMH buildings.

Air monitors collect airborne particles in a filter over a period of time (typically half a day). The filters are collected and analysed within a NATA accredited laboratory, with results provided the following day.

Air monitoring has commenced at QVMH with the approach of LW W1. The monitoring program has been designed based on the position of the LW W1 face. Monitoring will continue until ground surveys confirm that the rates of change in subsidence have reduced to negligible levels.

The results of the asbestos air monitoring will be summarised in weekly reports, unless adverse readings are found.

3.18 Monitoring and Inspections at No. 675 Thirlmere Way (Mill Hill)

A PSMP has previously been developed in consultation, co-operation and co-ordination with the owners of Mill Hill.

The PSMP includes the following monitoring and management measures in relation to the structures at Mill Hill:

- Monthly ground surveys around the perimeter of the house, and along the south-eastern property boundary, as shown in **Drawing No. MSE1045-13-02**; and
- Monthly visual inspections of structures and dams.

The purpose of the ground surveys on the property is to provide information to the owner, Tahmoor Coal and Subsidence Advisory NSW in the unlikely event that impacts are visually observed to the structures.

Surveys have now commenced as LW W1 is approaching Mill Hill and will continue until the completion of each longwall and for a sufficient time thereafter until measured changes are negligible.

Additional surveys and inspections may be undertaken during the mining of LW W1-W2 if impacts are reported at the site or substantial differential movements are observed from the results of the ground surveys.

3.19 Far Field Monitoring Program

Tahmoor Coal has installed a far field monitoring survey network for the following structures during the proposed extraction of LW W1-W2. These include a far field horizontal movement monitoring program 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);
- Princes Street Overbridge (85.17km);
- Picton Tunnel (87.85 km); and
- Victoria Bridge over Stonequarry Creek.

The locations of the structures and far field survey marks are shown in **Drawing No. MSEC1045-00-02**. Two pegs have been installed at the Picton Viaduct and Victoria Road Bridge as these structures span the surface expression of the Nepean Fault.

3.19.1 Absolute 3D Surveys

Ground pegs have been installed at the above locations, with baseline absolute 3D surveys conducted on 19 December 2017. Photographs of the survey pegs installed above the Picton Tunnel and Picton Viaduct are shown in **Figure 3-2**.

The pegs will be surveyed in absolute 3D on a monthly basis during the extraction of LW W1-W2.

Prior to start of LW W1, Tahmoor Coal extended the far field monitoring network to provide a greater spread of monitoring data on the western side of the mapped Nepean Fault zone, plus one additional location on the eastern side.

- Subway at 88.133 km;
- Ballast top underbridge at 84.687 km; and
- Matthews Lane Overbridge at 84.551 km.

The survey marks have been installed and baseline surveys have been completed.

The Bridge Street Overbridge will also be included as part of the far field network.

Photographs courtesy Southern Rail Surveys

Figure 3-2 Ground survey pegs installed above Picton Tunnel (left) and Picton Viaduct (right)

3.19.2 Continuous GNSS Monitoring

The GNSS points are fixed survey stations that continuously measure their absolute horizontal and vertical position in real time. In addition to the absolute 3D ground survey pegs, continuous GNSS monitoring points were installed at the following four sites during the extraction of Longwall 31:

- Picton Viaduct at 85.42 km – two units;
- Picton Tunnel at 87.85 km; and
- Victoria Bridge over Stonequarry Creek.

The two units at the Picton Viaduct have been installed in the ground at each end of the Viaduct, as this structure spans the surface expression of the Nepean Fault. The locations are shown in **Drawing No. MSEC1045-00-02**.

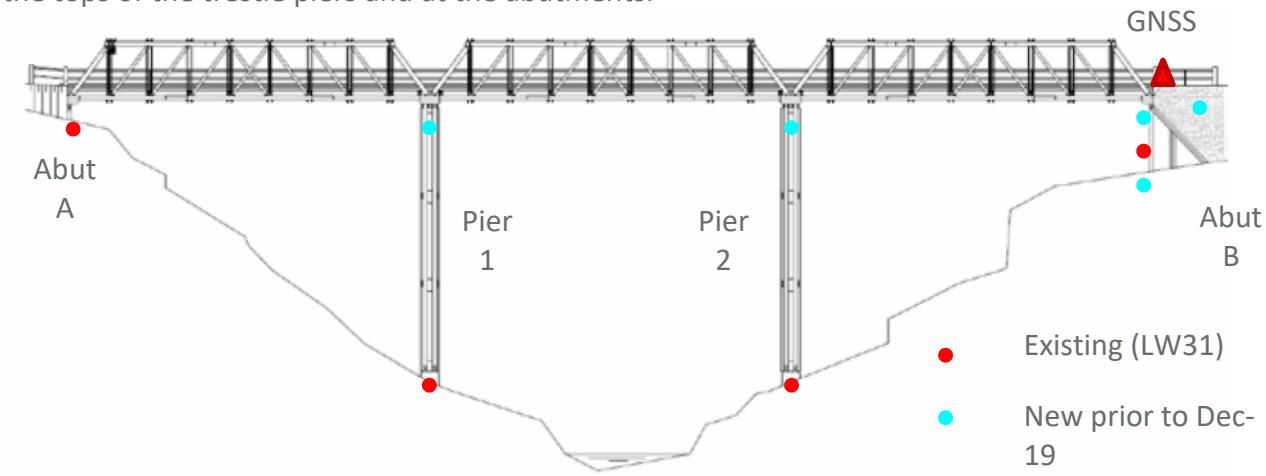
The GNSS system will record an average reading for each day and the data will be reviewed weekly during active subsidence. A more regular review of the data will be considered if significant absolute or differential movements are observed.

Monitoring will continue during the extraction of proposed LW W1-W2.

3.20 Monitoring and inspections of RMS infrastructure

3.20.1 Structure surveys

In addition to the far-field monitoring program, eight prisms were installed and surveyed on 30 July 2018 at each end of Victoria Bridge and at the base of the timber trestles, on both sides. In accordance with recommendations by Cardno (2019), additional marks have been installed at the tops of the trestle piers and at the abutments.



Note: Diagram is representative of survey marks on both sides of the Victoria Bridge

Figure 3-3 Locations of existing and new prisms on both sides of Victoria Bridge

The gap between the timber buffer board and road pavement on Abutment B has been measured, as shown in Figure 3-4. Marks will be placed on the Bridge to measure any changes across the gap during mining, including during the reconstruction works at Abutment A.

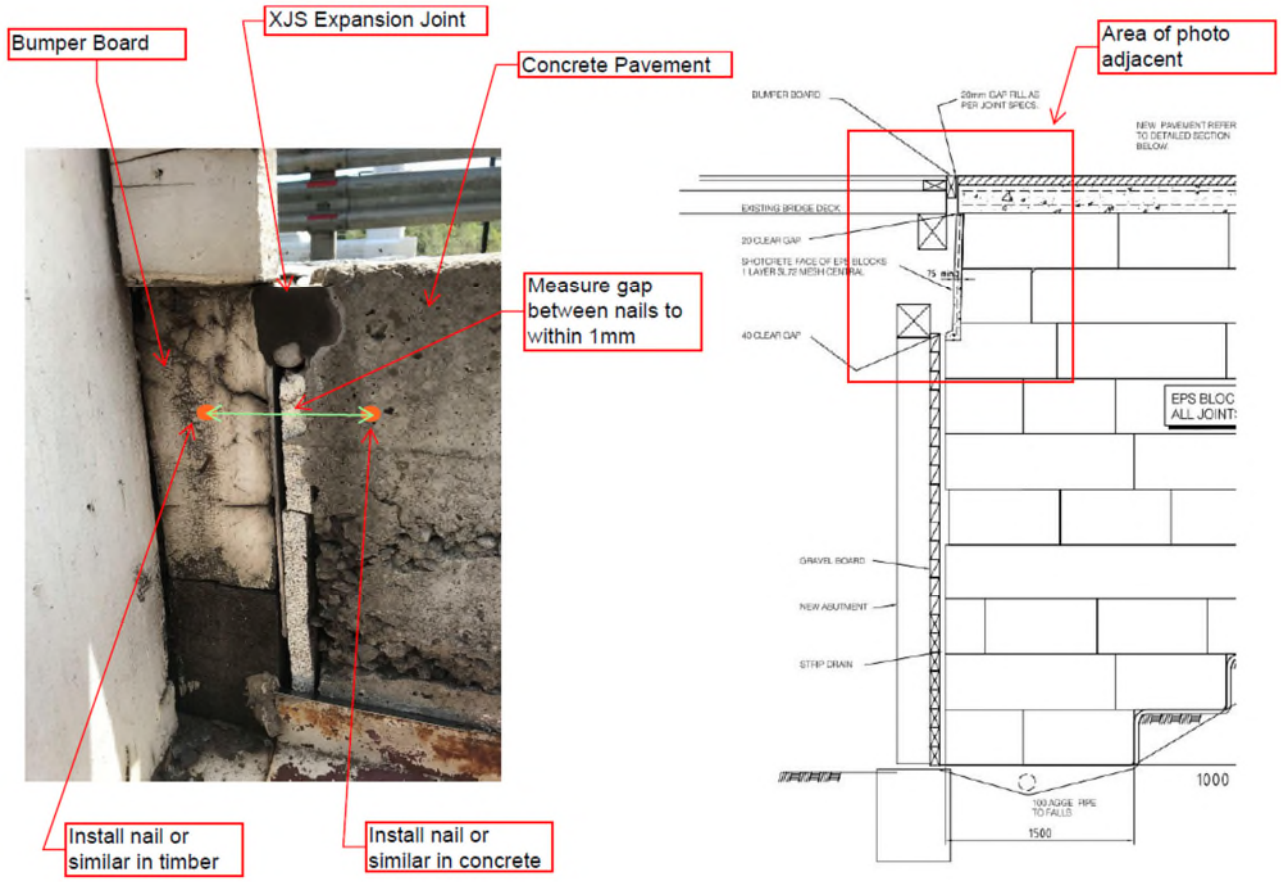


Diagram courtesy Cardno

Figure 3-4 Location of measurements of gap between buffer board and road pavement

3.20.2 Dilapidation surveys

RMS has conducted inspections of the Victoria Bridge as part of its maintenance program and reconstruction works. An additional dilapidation inspection was completed by Tahmoor Coal in October 2019.

3.20.3 Visual inspections of Menangle Street – Picton Road

RMS conducts routine vehicle-based visual inspections of the condition of Menangle Street – Picton Road. The last inspection was conducted in March 2018.

Tahmoor Coal has conducted a baseline visual inspection of Menangle Street – Picton Road from Argyle Street to the intersection with Matthews Road. Inspections will continue during mining.

Table 3-1 Subsidence Monitoring Program for LW W1-W2

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 W1-W2)	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Prior to commencement of LW W2, relocate GNSS unit above LW W2 if access is permitted by landowner.	• Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W1. • Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W2.	-
Ground survey	2D survey lines along centrelines of LW W1-W2	2D subsidence and distance	• Install and baseline survey above LW W2 for at least 600 m of extraction prior to commencement of LW W2. Install and baseline survey remaining pegs prior to LW W2 approaching within 400 m of pegs.	• Monthly survey 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 W1 and LW W2 exceeds 200 m, whichever occurs first.	• Full length at end of LW W1-W2.
	2D survey line across LW W1-W2	2D subsidence and distance	• Install and baseline survey prior to 500 m of extraction of LW W1 (completed).	• Monthly survey during LW W1 and LW W2 between 800 m and 1450 m of extraction and continue if ongoing adverse movements are observed.	• Full length at end of LW W1-W2.
Wollondilly Shire Council Infrastructure					
Local roads	Ground surveys along streets	2D subsidence and distance Please refer **Dwg. No. MSEC1045-00-01**	• Install and baseline survey along Barkers Lodge Road prior to start of LW W1 (completed). • Install and baseline survey Stonequarry Creek Road, Booyong Close prior to 500m of extraction of LW W1 (completed). • Install and baseline survey Attunga Close, Carramar Close, Thirlmere Way prior to 1000m of extraction of LW W1 (completed).	• Weekly surveys along Stonequarry Creek Road during LW W1 and LW W2 after 800 m of extraction until one month after completion of each LW, extending to the south to include pegs within the active subsidence zone. Reduce extent from the north for pegs beyond active subsidence zone unless ongoing adverse movements are observed. • Weekly surveys along Booyong Close during LW W1 and LW W2 between 950 m and 1600 m of extraction and continue if ongoing adverse movements are observed. • Weekly surveys along Attunga Close during LW W1 and LW W2 after 1300 m of extraction until one month after completion of each LW and continue if ongoing adverse movements are observed. • Weekly surveys along Carramar Close during LW W1 and LW W2 after 1450 m of extraction until one month after completion of each LW and continue if ongoing adverse movements are observed. • Weekly surveys along Thirlmere Way during LW W1 and LW W2 after 1650 m of extraction until one month after completion of each LW and continue if ongoing adverse movements are observed.	• Full length at end of LW W1-W2 survey for all lines.
	Visual inspections of streets	-	-	• Detailed inspection once a week within the active subsidence zone, commencing after 800 m of extraction of LW W1 and LW W2 until one month after completion of each LW.	-

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
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 (completed)	-	• End of LW W1-W2
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 (completed)	• Monthly after 200 m extraction of LW W1-W2.	-
Potable Water 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.		
Stonequarry sewer Infrastructure					
Sewer 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 Picton-Mittagong Loop Line		
	Ground surveys along gravity sewer main (alongside 2D survey line across LW W1-W2)	2D subsidence and distance	• Install and baseline survey prior to 500m of extraction of LW W1 (completed).	• Weekly surveys along cross line during LW W1 and LW W2 between 800 m and 1450 m of extraction and continue if ongoing adverse movements are observed.	• End of LW W2
	Visual inspections of streets	-	As described for Wollondilly Shire Council Management Plan.		
Stonequarry Wastewater Treatment Plant	Ground surveys	RL, Local easting and northing	• Install and baseline survey prior to start of LW W2, as per the Stonequarry Wastewater Management Plan.	• Weekly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first. Cease weekly surveys after 800 m of extraction of LW W2 unless ongoing adverse movements are observed.	• End of LW W2.
	Visual inspection	-	-	• Weekly between 200 m and 800 m of extraction of LW W2 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.		
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. MSEC1045-00-01**.	Power pole surveys	Subsidence at base and vertical offset (or tilt)	• Baseline survey of Pole No. 631136 prior to start of LW W1 (completed). • Baseline survey of other poles prior to LW W1 approaching within 400m of each pole (completed).	• Monthly for each pole within active subsidence zone, and for following three months thereafter.	• End of LW W1-W2 for all poles.

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
Telecommunications Infrastructure					
Telstra and NBN 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.		
	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 and PMLL	2D subsidence and distance	As described for Wollondilly Shire Council Management Plan and PMLL 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 on Barkers Lodge Road (completed). • Baseline survey prior to LW W1 approaching within 400 m of property.	-	• End of LW W2
	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.	• 3-monthly for a minimum of 12 months post mining using fixed location photo points.
Picton-Mittagong Loop Line					
Initial Goaf GNSS unit (located approximately 100 m inside the commencing end of LW W2)	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Prior to commencement of LW W2.	• Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W1. • Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W2.	-
PMLL LW Centreline GNSS unit	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS unit on PMLL above centreline of LW W1 and LW W2 prior to commencement of LW W1 (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W1. • Continuous readings, with data averaged over 24 hours and recorded once per day until end of LW W2.	-
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)	• Installed GNSS units prior to commencement of LW W1 (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W1-W2.	-

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 Track	Absolute 3D ground survey along rail corridor *Initial extent for monthly survey for LW W1 = 87.700 km to 88.500 km and then extend to the north to include pegs that are at least 400 m in front of the longwall face, up to 90.000 km.* *Initial extent for monthly survey for LW W2 = 87.500 km to 88.500 km and then extend to the north to include pegs that are at least 400 m 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 surveyed prior to start of LW W1 (completed).	• Monthly survey after start of LW W1 • Monthly survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Full length from 87.100 km to 90.000 km at end of LW W1-W2.
	Focussed 2D ground survey along rail corridor *Initial extent for weekly survey for LW W1 = 87.700 km to 88.300 km and then extend to the north to include pegs that are at least 200 m in front of the longwall face, up to 90.000 km.* *Initial extent for weekly survey for LW W2 = 87.500 km to 88.300 km and then extend to the north to include pegs that are at least 200 m in front of the longwall face, up to 89.700 km.*	2D subsidence and distance	• Installed full length from 87.100 km to 90.000 km and baseline survey prior to start of LW W1 (completed).	• Focussed weekly after start of LW W1 • Focussed weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Full length from 87.100 km to 90.000 km at end of LW W1-W2.
	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 prior to start of LW W1 (completed).	• Focussed weekly after start of LW W1 • Focussed weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Full length from 87.100 km to 90.000 km at end of LW W1-W2.
	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 prior to start of LW W1 (completed).	• Weekly after start of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first. .	• 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	-	• Weekly after start of LW W1 • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first. • Additional inspections prior to train movements (within 24 hours, target morning of train movement).	-

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 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 surveyed prior to commencement of LW W1 (completed).	• Monthly Absolute 3D survey after 200 m of extraction of LW W2.	• Absolute 3D at end of LW W1. • Absolute 3D at end of LW W2.
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 (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W1-W2.	-
	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 (completed).	• Absolute 3D Monthly survey after 20 mm of vertical subsidence is measured by the GNSS unit at 87.850 km, or the length of the extraction of LW W1 exceeds 200 m, whichever occurs first. • Monthly Absolute 3D survey and Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Absolute 3D at end of LW W1. • Absolute 3D at end of LW W2.
	Crest extensometer survey	Horizontal distance	• Installed and baseline surveyed prior to commencement of LW W1 (completed).	• Monthly after 20 mm of vertical subsidence is measured by the GNSS unit at 87.850 km, or the length of the extraction of LW W1 exceeds 200 metres, whichever occurs first. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W2, or the length of the extraction of LW W2 exceeds 200 metres, whichever occurs first.	-
	Inclinometer survey	Tilt	• Installed and baseline surveyed prior to commencement of LW W1 (completed).	• Monthly during LW W1 and LW W2.	-
	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 (completed).	• Weekly after start of LW W1 and LW W2.	-
	Visual inspection of culvert and embankment and Stonequarry Wastewater Treatment dam by geotechnical engineer	-	-	• Monthly after 20 mm of vertical subsidence is measured by the GNSS unit at 87.850 km, or the length of the extraction of LW W1 exceeds 200 m, whichever occurs first. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit above LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	-
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 (completed).	• Monthly Absolute 3D survey after start of LW W1 and Weekly Local 3D survey after start of LW W1. • Monthly Absolute 3D survey and Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Absolute 3D at end of LW W1-W2.

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
	Crest extensometer survey	Horizontal distance	• Installed and baseline surveyed prior to commencement of LW W1 (completed).	• Weekly after start of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 metres, whichever occurs first.	-
	Inclinometer survey	Tilt	• Installed and baseline surveyed prior to commencement of LW W1 (completed).	• Monthly during LW W1 and LW W2.	-
	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 (completed).	• Weekly after start of LW W1 and LW W2.	-
	Visual inspection of culvert and embankment by geotechnical engineer	-	-	• Weekly after start of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W1 and LW W2 exceeds 200 m, whichever occurs first.	-
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 (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W1-W2.	-
	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) Local 3D – RL, Local easting and northing	• Install and baseline survey prior to 500 m of extraction of LW W1 (completed).	• Monthly Absolute 3D survey after 600 m of extraction of LW W1. • Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the GNSS unit at 88.980 km, or the length of the extraction of LW W1 exceeds 800 m, whichever occurs first. • Absolute 3D survey if more than 20 mm of incremental vertical subsidence from LW W2 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 W1. • Absolute 3D at end of LW W2.
	Crest extensometer survey	Horizontal distance	• Install and baseline survey prior to 500 m of extraction of LW W1 (completed).	• Monthly Absolute 3D survey after 600 m of extraction of LW W1. • Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the GNSS unit at 88.980 km, or the length of the extraction of LW W1 exceeds 800 metres, whichever occurs first. • Monthly after 20 mm of incremental vertical subsidence from LW W2 is measured by the GNSS unit at 88.980 km, or the length of the extraction of LW W2 exceeds 600 metres, whichever occurs first.	-
	Inclinometer survey	Tilt	• Install and baseline survey prior to 500 m of extraction of LW W1 (completed).	• Monthly after 600 m of extraction of LW W1 and LW W2.	-

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
	Visual inspection of culvert and embankment and dam upstream of embankment by geotechnical engineer	-	-	• Monthly after 600 m of extraction of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the GNSS unit at 88.980 km, or the length of the extraction of LW W1 exceeds 800 m, whichever occurs first. • Monthly after 20 mm of incremental vertical subsidence from LW W2 is measured by the GNSS unit at 88.980 km, or the length of the extraction of LW W2 exceeds 600 m, whichever occurs first.	-
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 (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W1-W2.	-
	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) Local 3D – RL, Local easting and northing	• Install and baseline survey prior to 1100 m of extraction of LW W1 (completed).	• Monthly Absolute 3D survey after 1200 m of extraction of LW W1. • Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the GNSS unit at 89.629 km, or the length of the extraction of LW W1 exceeds 1400 m, whichever occurs first. • Absolute 3D survey if more than 20 mm of incremental vertical subsidence from LW W2 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 W1. • Absolute 3D at end of LW W2.
	Visual inspection of culvert and embankment by geotechnical engineer	-	-	• Monthly after 1200 m of extraction of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the GNSS unit at 89.629 km, or the length of the extraction of LW W1 exceeds 1400 m, whichever occurs first. • Inspection if more than 20 mm of incremental vertical subsidence from LW W2 is measured by the GNSS unit at 89.629 km and for every 20 mm of additional vertical subsidence thereafter.	-
Cuttings at 88.100 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 (completed).	• Monthly Absolute 3D survey and Weekly Local 3D survey after start of LW W1. • Monthly Absolute 3D survey and Weekly Local 3D survey after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	• Absolute 3D at end of LW W1-W2.
	Visual inspection of cutting by geotechnical engineer	-	-	• Weekly after start of LW W1. • Weekly after 20 mm of vertical subsidence is measured by the Initial Goaf GNSS unit for LW W2, or the length of the extraction of LW W2 exceeds 200 m, whichever occurs first.	-
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 (completed).	• Monthly Absolute 3D survey after 300 m of extraction of LW W1. • Weekly Local 3D survey after 550 m of extraction of LW W1. • Monthly Absolute 3D survey after 300 m extraction of LW W2.	• Absolute 3D at end of LW W1. • Absolute 3D at end of LW W2.

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
	Visual inspection of cutting by geotechnical engineer	-	-	• Monthly after 300 m and weekly after 550 m extraction of LW W1. • Monthly after 300 m extraction of LW W2.	-
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 (completed).	• Monthly Absolute 3D survey after 700 m of extraction of LW W1. • Weekly Local 3D survey after 950 m of extraction of LW W1. • Monthly Absolute 3D survey after 700 m extraction of LW W2.	• Absolute 3D at end of LW W1. • Absolute 3D at end of LW W2.
	Visual inspection of cutting by geotechnical engineer	-	-	• Monthly after 700 m and weekly after 950 m extraction of LW W1. • Monthly after 700 m extraction of LW W2.	-
Far field monitoring program, Main Southern Railway and Roads and Maritime Infrastructure					
GNSS network on Main Southern Railway at Picton Viaduct (85.42 km), Picton Tunnel (87.85 km) and Victoria Bridge over Stonequarry Creek	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• GNSS units installed and operating (completed).	• Continuous readings, with data averaged over 24 hours and recorded once per day.	-
Bridge Street Overbridge (90.030km)	Absolute 3D survey of mark on both abutments	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	Absolute 3D ground survey of all marks, incl ground around Bridge Street Overbridge at 90.030 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 (completed).	-	• Absolute 3D at end of LW W1. • Absolute 3D at end of LW W2.
Thirlmere Way Rail Underbridge (89.326km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	-	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D survey marks at base of arch	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after 200 m extraction of LW W1-W2	-
	Local 3D survey of additional survey marks at the ends of the wingwalls and base of the abutment walls	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Connellan Crescent Railway Overbridge (89.080km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	-	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D survey marks at base of arch	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-

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
	Local 3D surveys of additional survey marks 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	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Ballast Top Subway (88.133 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	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	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Ballast Top Underbridge (86.838 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	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	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Argyle Street Rail Underbridge (86.13 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	-	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D survey marks at base of arch	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after 200 m extraction of LW W1-W2.	
	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	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	
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		• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	
Picton Viaduct (85.42 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	-	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D surveys of the twelve existing prisms at the base of the intermediate piers and abutments	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-

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
	Local 3D surveys of additional survey marks along the tops of the arches below the low height parapet walls	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	
	Local 3D survey along ground survey line upstream of the Viaduct	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	
	2D horizontal distance survey between two marks located downstream of the Viaduct across the tops of the valley sides	Horizontal distance	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	
Princes Street Overbridge (85.17km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	-	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D surveys of the four prisms at the base of the brick piers	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
	Local 3D surveys of new marks on the bridge deck above the piers and at the approaches, and at the top of the piers	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Picton Tunnel (87.85 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed during LW31 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	Absolute 3D surveys of new prisms every 20 metres inside the Tunnel on both sides	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2	-
Mushroom Tunnel	Local 3D surveys of survey marks every 20 metres inside the Tunnel on both sides	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Retaining wall (84.867 km)	Local 3D surveys of prisms at three cross-sections along the brick wall	RL, Local easting and northing	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Matthews Lane Overbridge (84.551 km)	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	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	• Install and baseline survey prior to end of December 2019 (completed).	• Monthly after end of December 2019. • Monthly after 200 m extraction of LW W2.	-
Main Southern Railway structures	Dilapidation inspections	-	• Complete for Thirlmere Way Underbridge, Connellan Crescent Overbridge, Picton Viaduct, Picton Tunnel, Ballast Top Subway at 88.133 km and Ballast Top Underbridge at 86.838 km, Argyle Street Underbridge, Pedestrian Overbridges, Princes Street Overbridge and Matthews Lane Overbridge (completed). • Prior to end of December 2019 for Mushroom Tunnel and Retaining wall at 84.867 km (completed).		

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
Victoria Bridge over Stonequarry Creek	Absolute 3D survey	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D survey of existing marks at base of piers and abutments	RL, Local easting and northing	• Installed and baseline surveyed during LW31 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	Local 3D survey of additional survey marks 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 prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2	-
	Inspect gap between timber buffer board and road pavement above Abutment B and clear debris if required	-	• Completed		
	Measure gap between timber buffer board and road pavement above Abutment B	Horizontal distance	• Installed and baseline surveyed prior to start of LW W1 (completed).	• Monthly after 200 m extraction of LW W1-W2.	-
	Dilapidation inspection of Victoria Bridge	-	• Completed		
Menangle Street – Picton Road between intersection at Argyle Street and Matthews Lane	Visual inspections	-	• Baseline inspection (completed).	• Every 3 months during LW W1-W2.	-
Matthews, Cedar and Stonequarry Creeks					
GNSS units along Matthews, Cedar and Stonequarry Creeks, as shown in **Drawing No. MSEC1045-00-01**.	Continuous GNSS monitoring	Absolute easting, northing and level (MGA coordinates)	• Installed GNSS units prior to commencement of LW W1, where access was permitted. • Install outstanding GNSS units prior to commencement of LW W2.	• Continuous readings, with data averaged over 24 hours and recorded once per day during extraction of LW W1-W2.	-
Valley closure monitoring lines, as shown in **Drawing No. MSEC1045-00-01**.	2D horizontal distance measurement of pegs on or near the crests of the valleys, where there are adequate lines of sight available.	Horizontal distance	• Install across Matthews Creek where access has been permitted. • Install outstanding sites prior to commencement of LW W2.	• Where access is permitted, Monthly for valley closure lines within active subsidence zone after 200 m extraction of LW W1-W2. Cease after 1000 m of extraction of LW W1-W2 for lines that are located behind the active subsidence zone unless adverse changes are observed.	-
Rockbar / Valley floor closure lines	2D horizontal distance measurement of pegs across rockbar or valley floor (incl. across long pool SC2 on Stonequarry Creek)	Horizontal distance	• Installed prior to commencement of LW W1 (completed).	• Monthly for rockbar / valley floor closure lines within active subsidence zone after 200 m extraction of LW W1-W2. Cease after 1000 m of extraction of LW W1-W2 for lines that are located behind the active subsidence zone unless adverse changes are observed.	-
3D survey lines along Cedar and Stonequarry Creeks, as shown in **Drawing No. MSEC1045-00-01**.	Absolute 3D surveys of pegs spaced nominally every 50 m	Absolute easting, northing and level (MGA coordinates)	• Install prior to commencement of LW W2.	• Where access is permitted, monthly between 200 m and 1000 m of extraction of LW W1-W2 and continue if ongoing adverse movements are observed.	-

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 survey of survey marks across Rockbar SR17 spaced nominally every 10 m	Absolute easting, northing and level (MGA coordinates)	• Installed and baseline surveyed prior to commencement of LW W1 (completed).	• Monthly between 200 m and 1000 m of extraction of LW W1-W2 and continue if ongoing adverse movements are observed.	-
	Baseline 3D photogrammetric survey of Rockbar SR17	-	• Completed prior to commencement of LW W1 (completed).	-	• End of LW W1-W2.
Surface water monitoring, as shown in **Drawing No. MSEC1045-01-01**	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 site MG45 and monthly for all other monitoring locations. Refer Water Management Plan for further details.	• Continuous readings, downloaded monthly. 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. 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. Refer Water Management Plan for further details.
Visual inspections of creeks	Baseline photographic survey of pools and rockbars	-	Completed.		
	Visual inspections of creeks	-	-	• Monthly within active subsidence zone after 200 m extraction of LW W1-W2. Cease after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless adverse changes are observed.	-
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.	• Fortnightly for Pool MR45 and monthly for all other pools within active subsidence zone after 200 m extraction of LW W1-W2. Cease after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless adverse changes are observed.	• 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. MSEC1045-01-02**	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.

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
Biodiversity monitoring					
Riparian vegetation monitoring, as shown in **Drawing No. MSEC1045-01-03**	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. MSEC1045-01-03**	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. MSEC1045-01-03**	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.
Aboriginal heritage monitoring					
Scarred tree	Visual inspection and condition assessment by archaeologist	-	• Prior to start of LW W1 (completed).	-	• End of LW W1-W2.
Grinding grooves	Ground surveys and baseline photogrammetry of Rockbar SR17	-	Refer Rockbar SR17 monitoring.		
	Visual inspection and condition assessment by archaeologist	-	• Prior to start of LW W1 (completed).	-	• End of LW W1-W2.
Rockshelters	Visual inspection and condition assessment by archaeologist	-	• Prior to start of LW W1 (completed).	-	• End of LW W1-W2.
	Visual inspection of rockshelters along Matthews, Cedar and Stonequarry Creeks from safe location	-	-	• Monthly within active subsidence zone after 200 m extraction of LW W1-W2. Cease after 1000 m of extraction of LW W1-W2 for sections of valleys that are located behind the active subsidence zone unless adverse changes are observed.	-
Items of Heritage Significance					
Queen Victoria Memorial Home	Local 3D ground survey of all pegs on QVMH land, as shown in **Drawings No. MSEC1045-13-01**	RL, Local easting and northing	• Survey pegs installed. • New baseline survey prior to 1000 m of extraction of LW W1 (completed).	• Weekly after 1600 m of extraction until end of LW W1 and continue until negligible changes observed.	-
	Visual inspections by structural engineer to identify whether there has been any additional risk to the structure or whether there has been new or existing cracks or joints opening up in building elements, with increased risk of potentially allowing existing hazardous materials, such as asbestos dust, to enter occupied spaces or be released externally	-	• New baseline inspection prior to 1000 m of extraction of LW W1 (completed).	• Reinspection of building(s) if more than 20 mm of subsidence is measured and continue for every 20 mm of additional vertical subsidence thereafter.	• End of LW W1-W2.

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
	Asbestos air monitoring devices at locations described in QVMH Property Subsidence Management Plan	Asbestos fibres	-	• Monitoring program at frequencies that increase as LW face approaches the finishing end of LW W1 and then reduces in frequency after completion of LW W1. Refer QVMH Property Subsidence Management Plan.	-
Mill Hill	Ground survey of pegs around house	RL, Local easting and northing	• Survey pegs installed. • New baseline survey prior to 1000 m of extraction of LW W1 (completed).	• Weekly ground surveys after 1700 m of extraction of LW W1-W2 until completion of LW W1-W2, unless adverse impacts observed.	-
	Visual inspections of structures and dams	-	• New baseline inspection prior to 1000 m of extraction of LW W1 (completed).	• Monthly visual inspections after 1700 m of extraction of LW W1-W2 until completion of LW W1-W2, unless adverse impacts observed.	• End of LW W1-W2.

4 Document Information

4.1 References

NSW Department of Planning and Environment (DPE) (2015), 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 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
GFG	GFG Alliance
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
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
QVMH	Queen Victoria Memorial Home
ROM	run of mine
SIMEC	SIMEC Mining Division
SMP	Subsidence Management Plan
Tahmoor Mine	Tahmoor Coal Mine

Abbreviation	Definition
TCCO	Tahmoor Coking Coal Operations
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	July 2019	Ron Bush	New document.
2.0	November 2019	David Talbert	Updates in light of land access issues.
3.0	October 2020	Zina Ainsworth	Updates to include additional monitoring requirements for LW W2 as required by Adaptive Management Plan approval conditions.

Appendix A – Drawings

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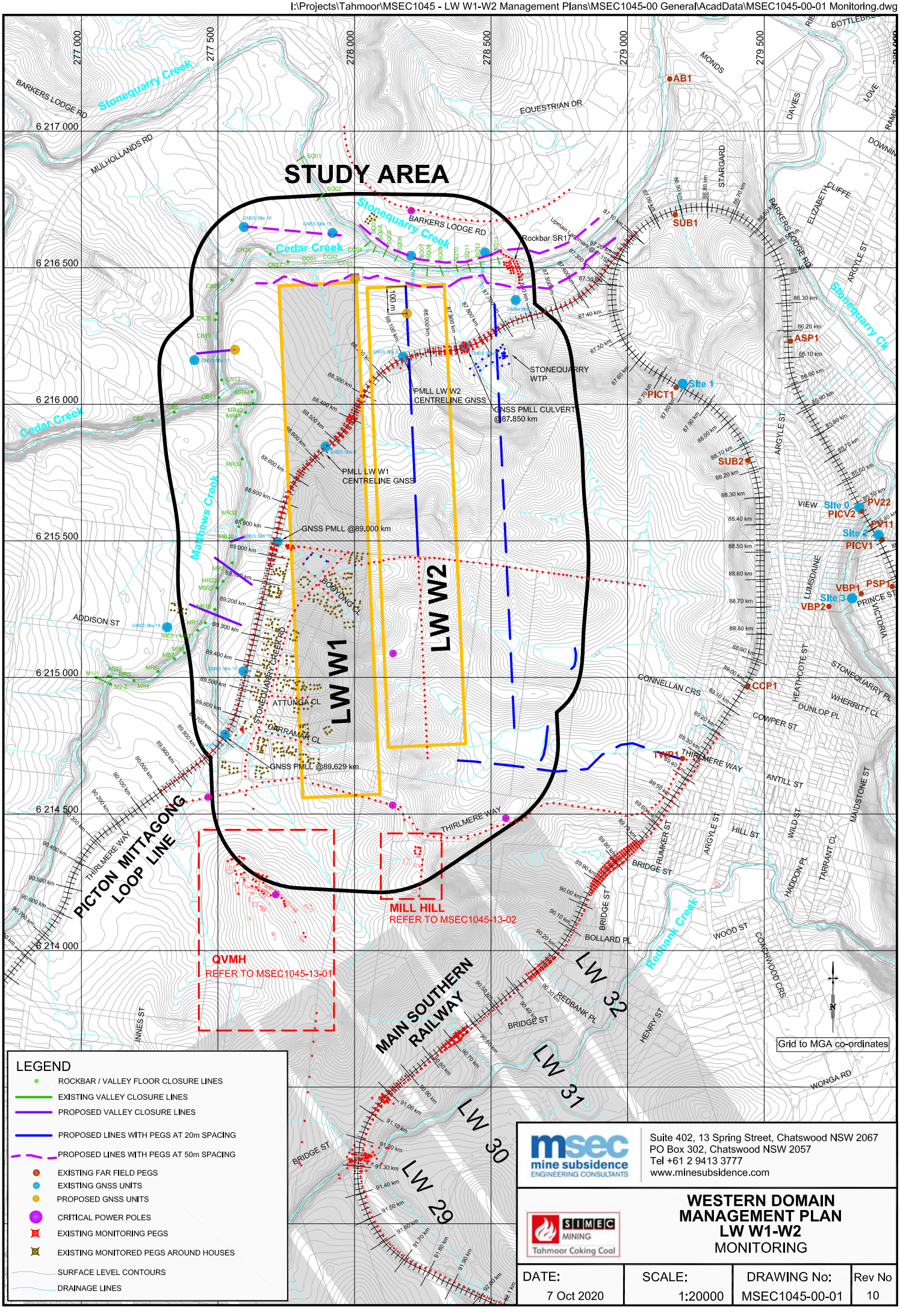

LEGEND

- ROCKBAR / VALLEY FLOOR CLOSURE LINES
- EXISTING VALLEY CLOSURE LINES
- PROPOSED VALLEY CLOSURE LINES
- PROPOSED LINES WITH PEGS AT 20m SPACING
- PROPOSED LINES WITH PEGS AT 50m 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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WESTERN DOMAIN MANAGEMENT PLAN LW W1-W2 MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
7 Oct 2020	1:20000	MSEC1045-00-01	10

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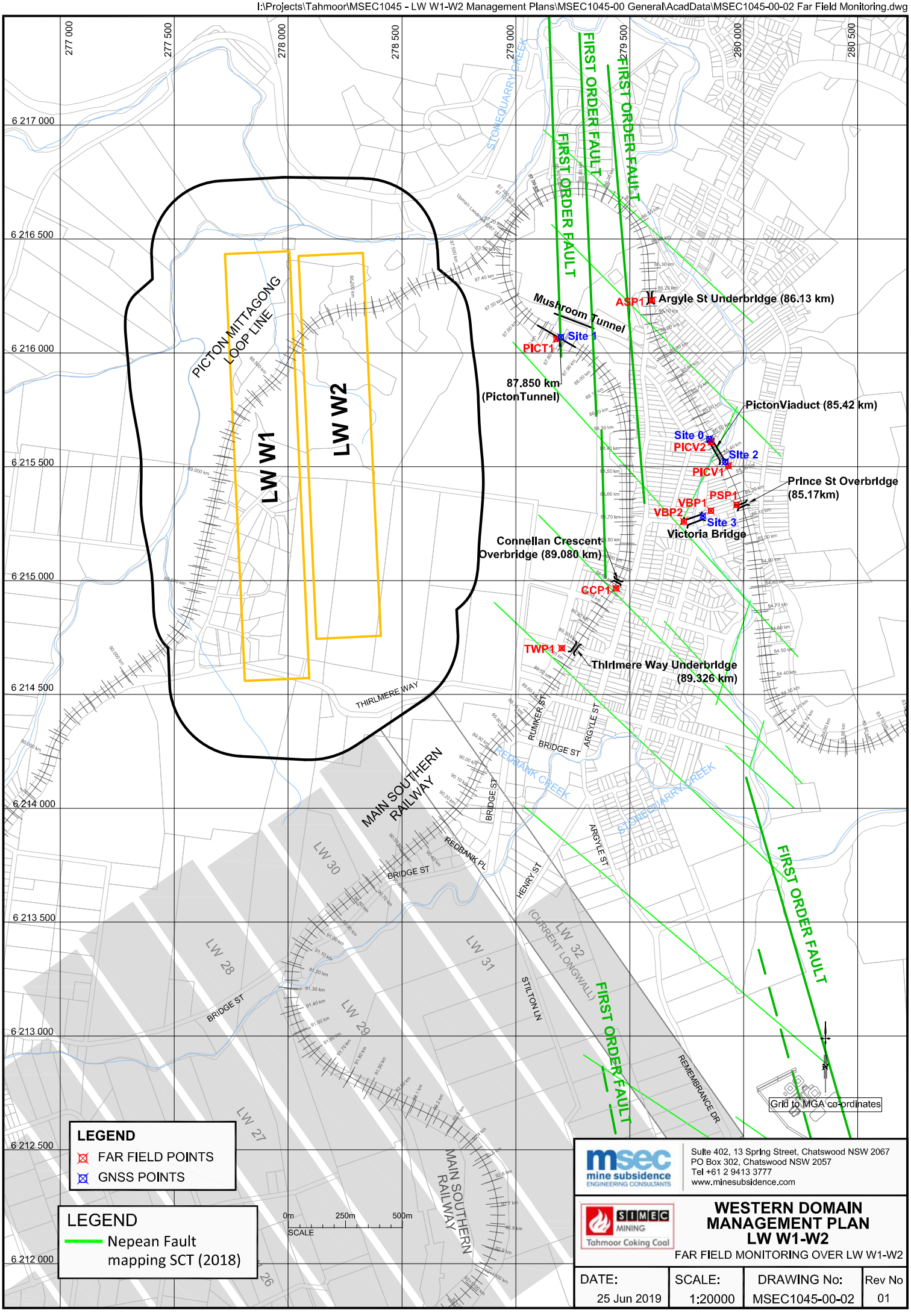

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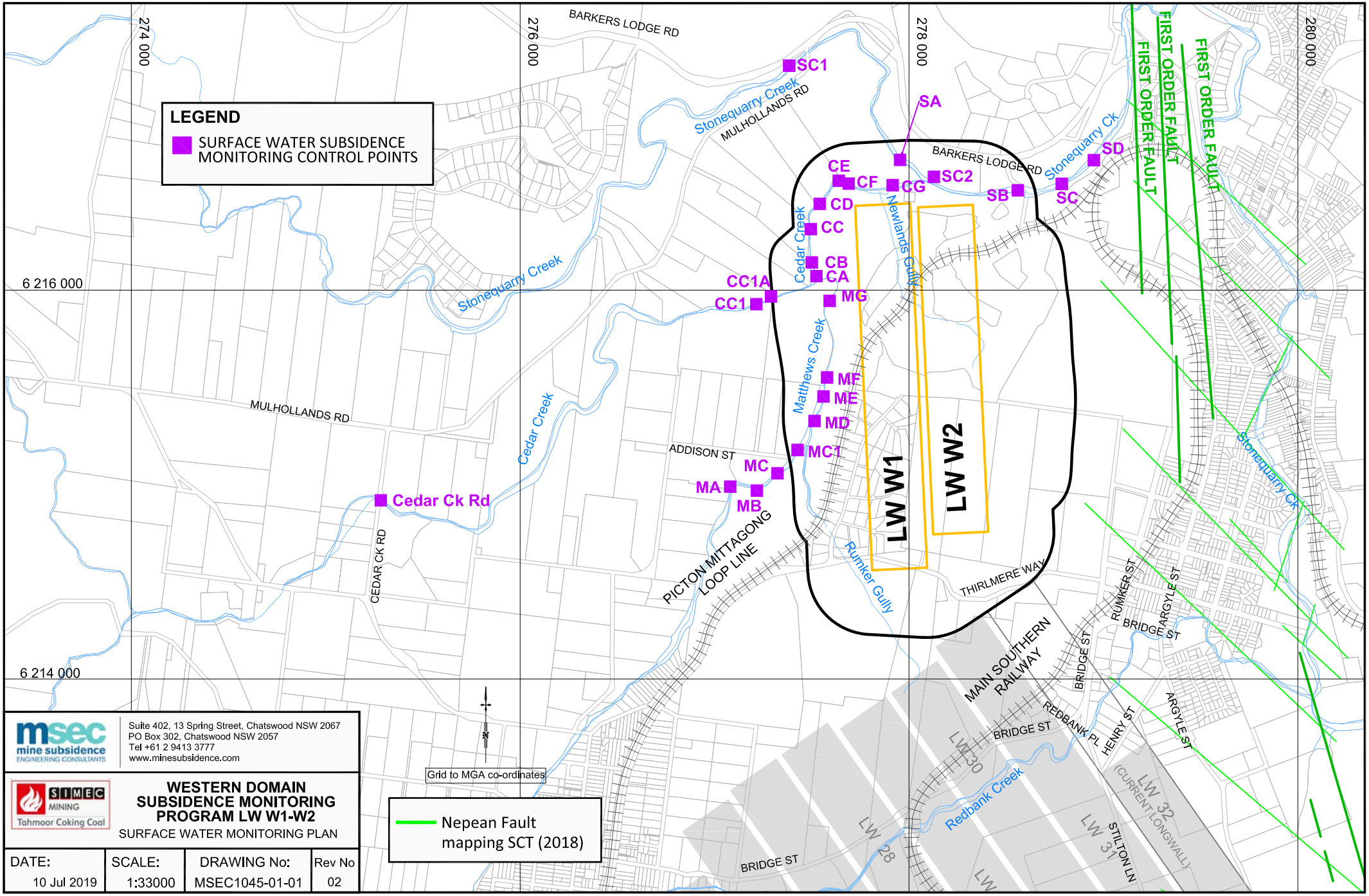

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WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W1-W2

SURFACE WATER MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
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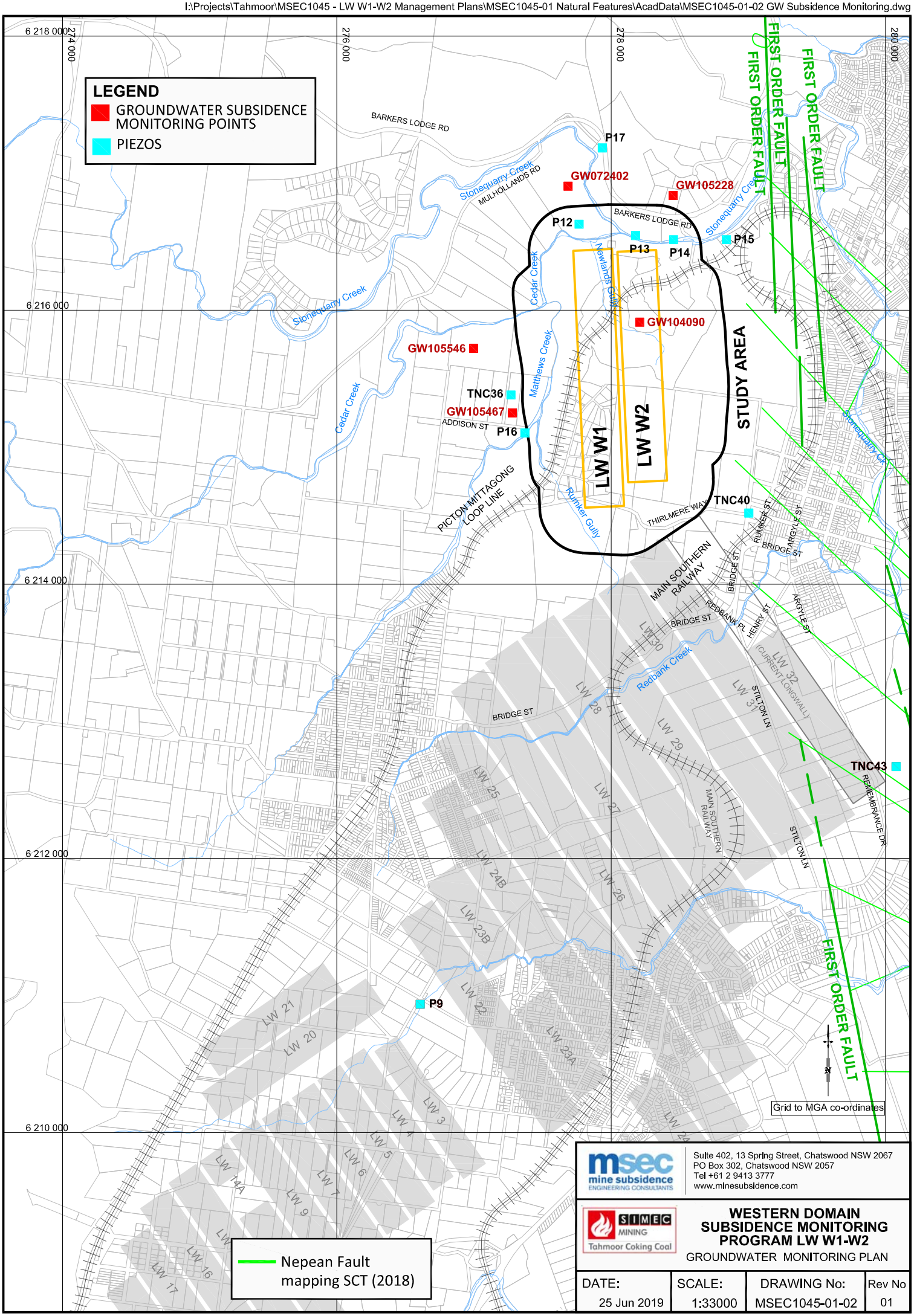

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WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W1-W2

GROUNDWATER MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
25 Jun 2019	1:33000	MSEC1045-01-02	01

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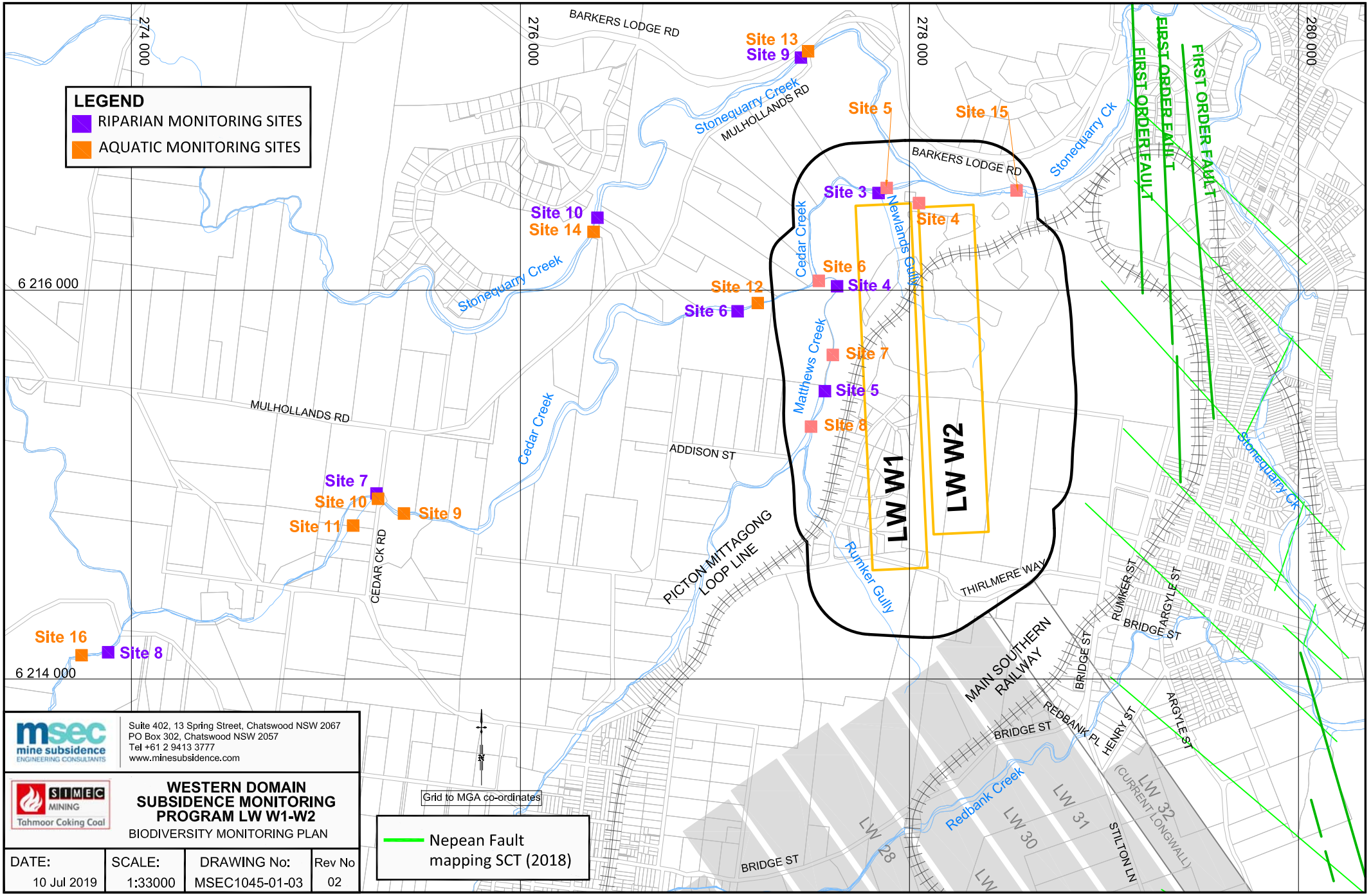

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WESTERN DOMAIN SUBSIDENCE MONITORING PROGRAM LW W1-W2

BIODIVERSITY MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
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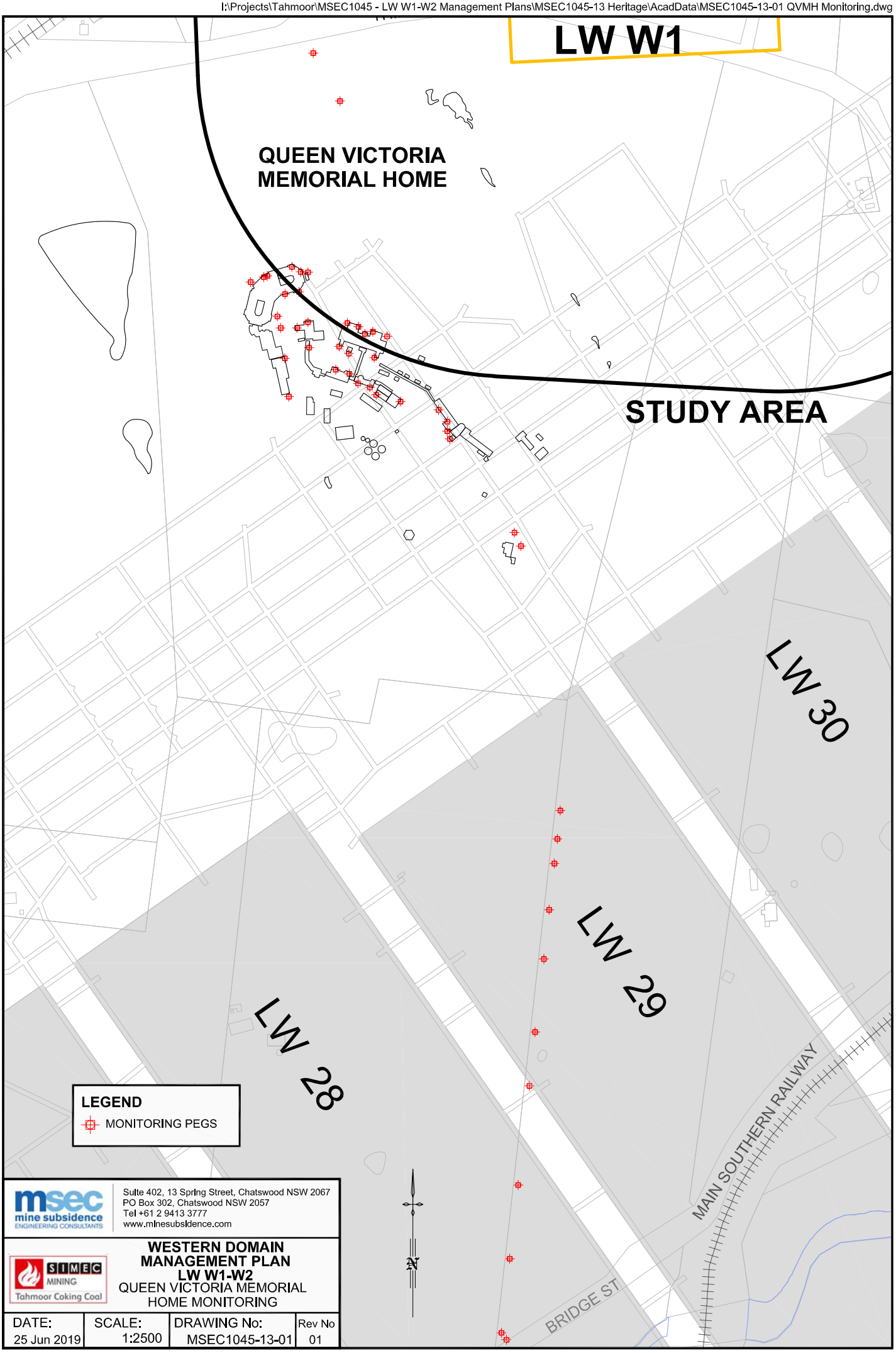

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WESTERN DOMAIN MANAGEMENT PLAN
LW W1-W2
QUEEN VICTORIA MEMORIAL HOME MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
25 Jun 2019	1:2500	MSEC1045-13-01	01

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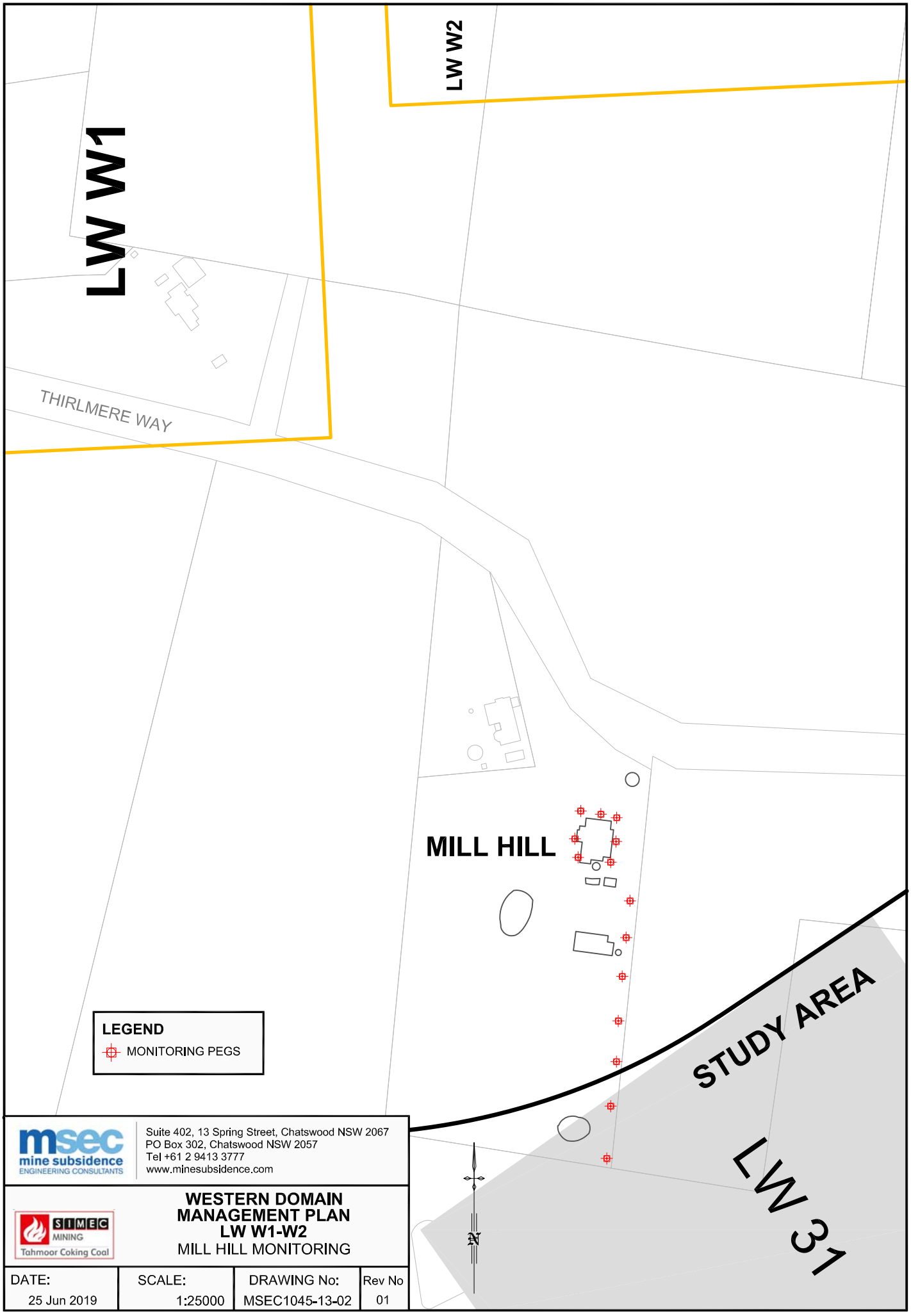

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WESTERN DOMAIN MANAGEMENT PLAN LW W1-W2

MILL HILL MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
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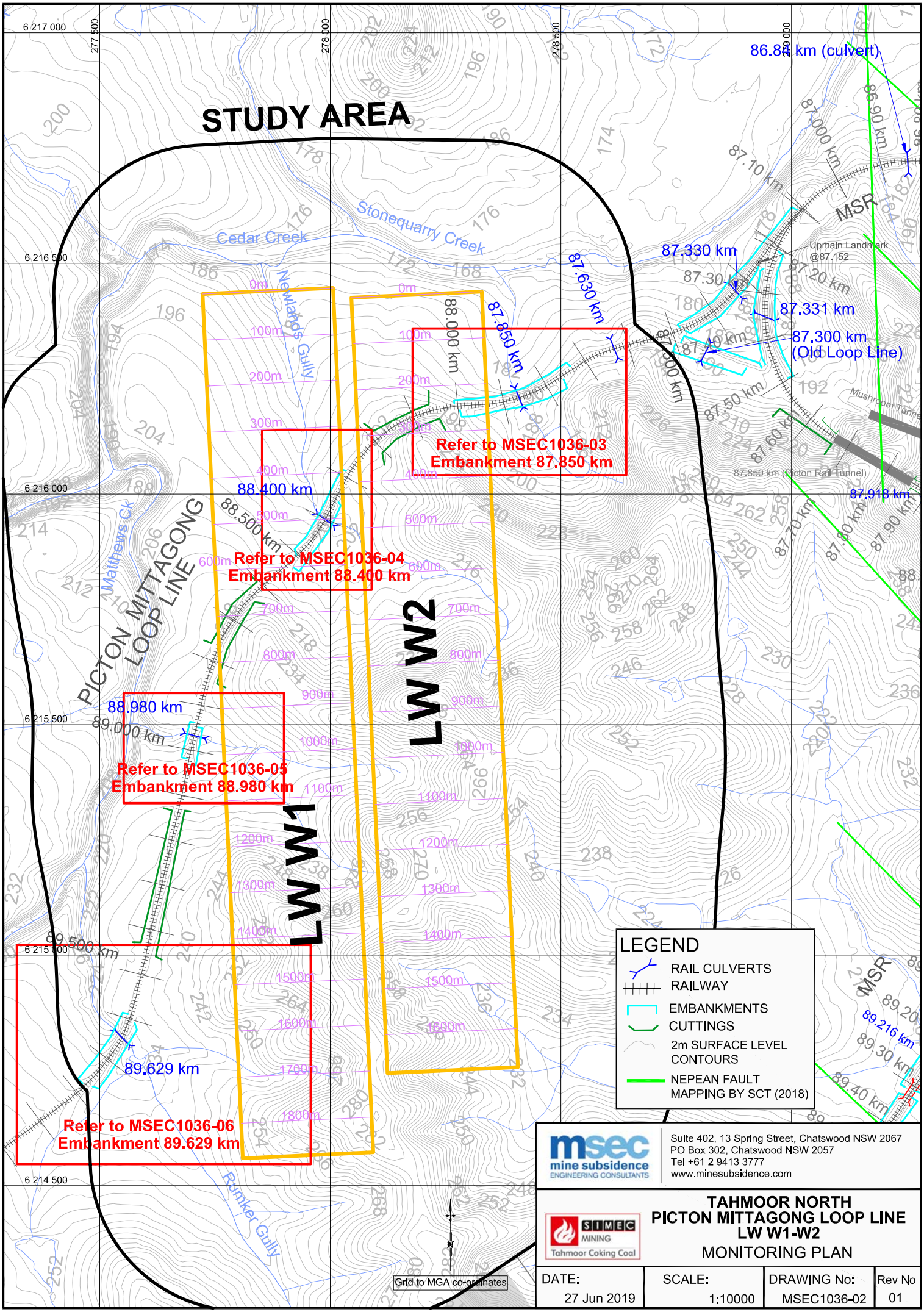

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TAHMOOR NORTH
PICTON MITTAGONG LOOP LINE
LW W1-W2
MONITORING PLAN

DATE:	SCALE:	DRAWING No:	Rev No
27 Jun 2019	1:10000	MSEC1036-02	01

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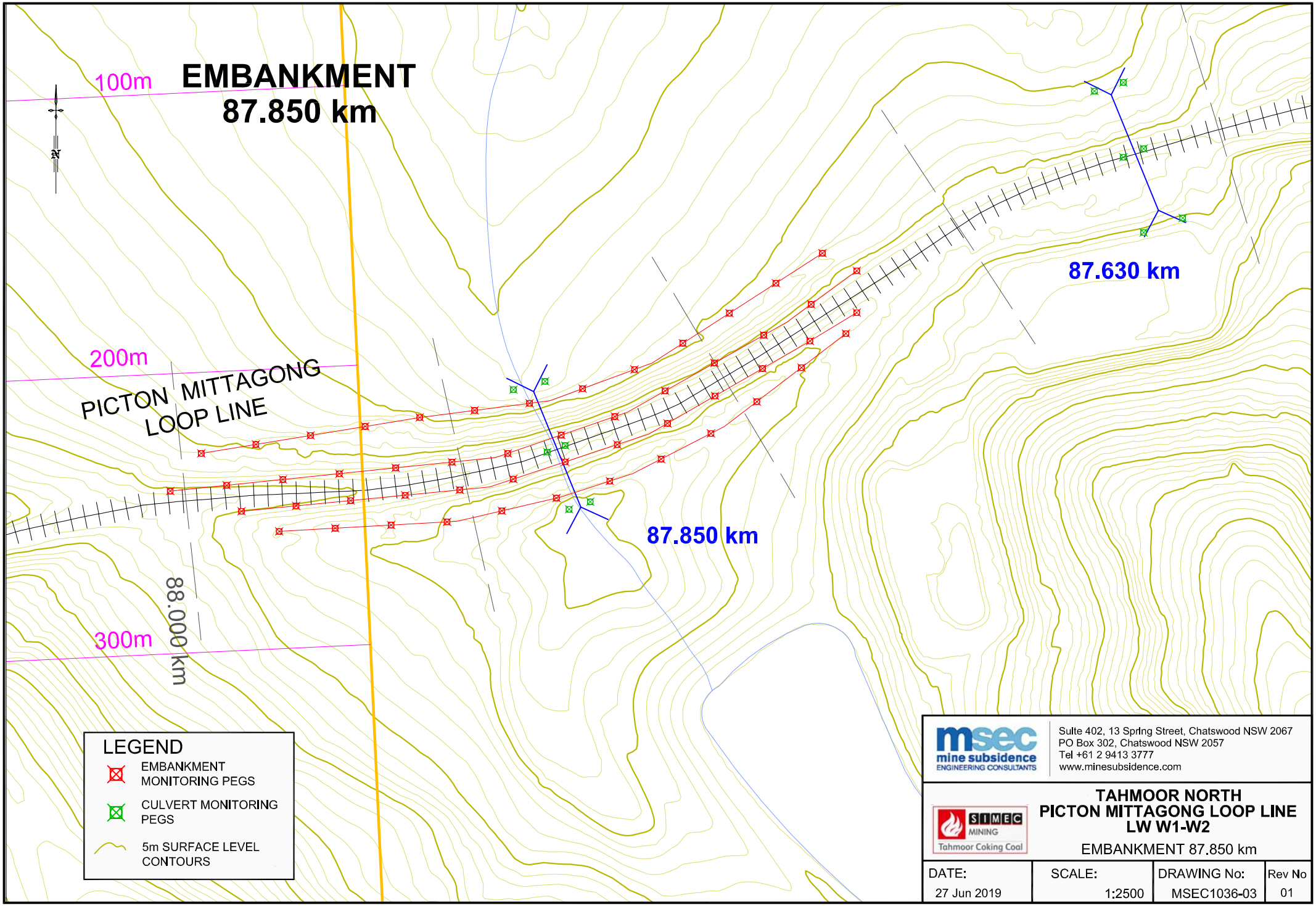

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TAHMOOR NORTH
PICTON MITTAGONG LOOP LINE
LW W1-W2
EMBANKMENT 87.850 km

DATE:	SCALE:	DRAWING No:	Rev No
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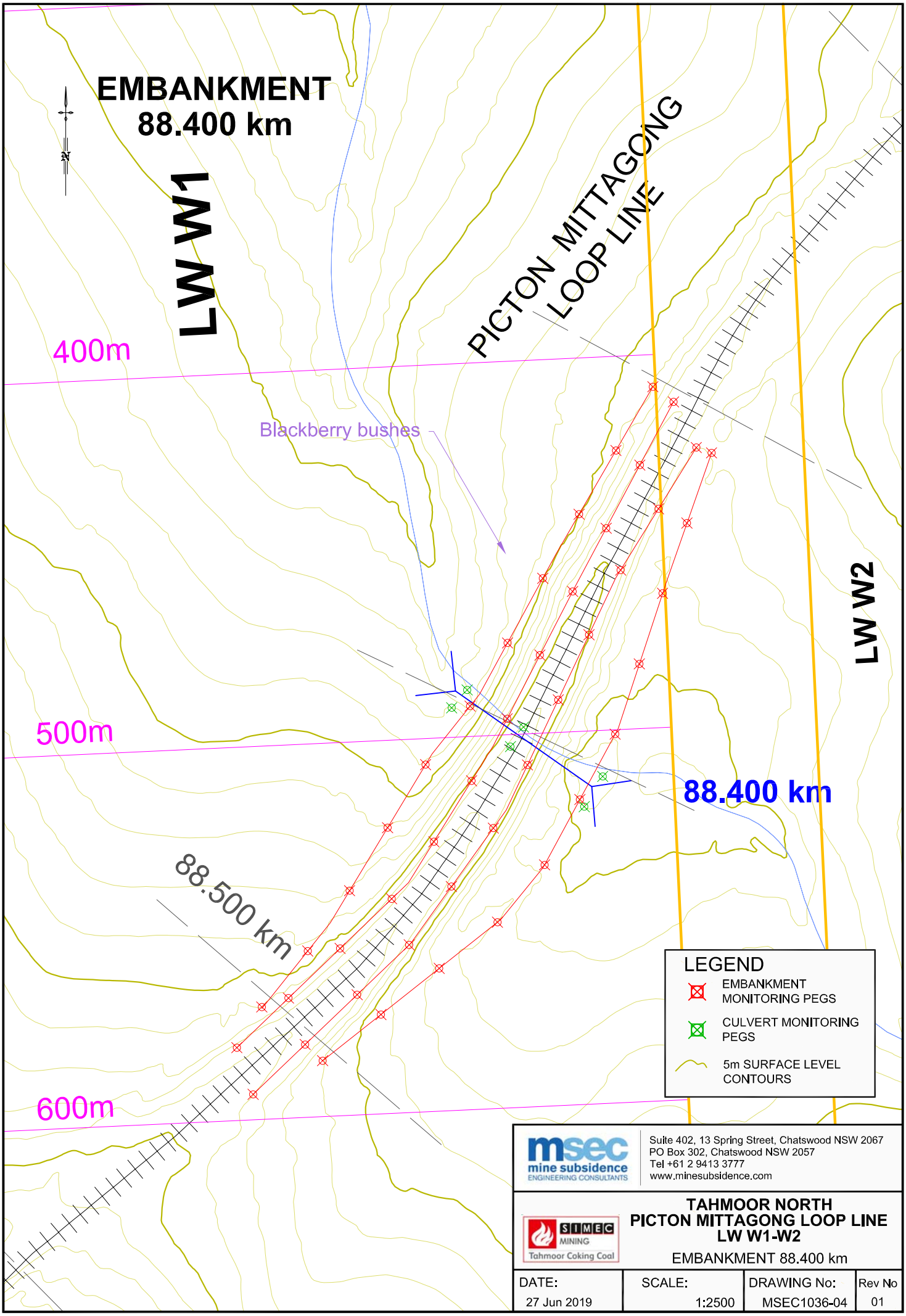

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TAHMOOR NORTH
PICTON MITTAGONG LOOP LINE
LW W1-W2
EMBANKMENT 88.400 km

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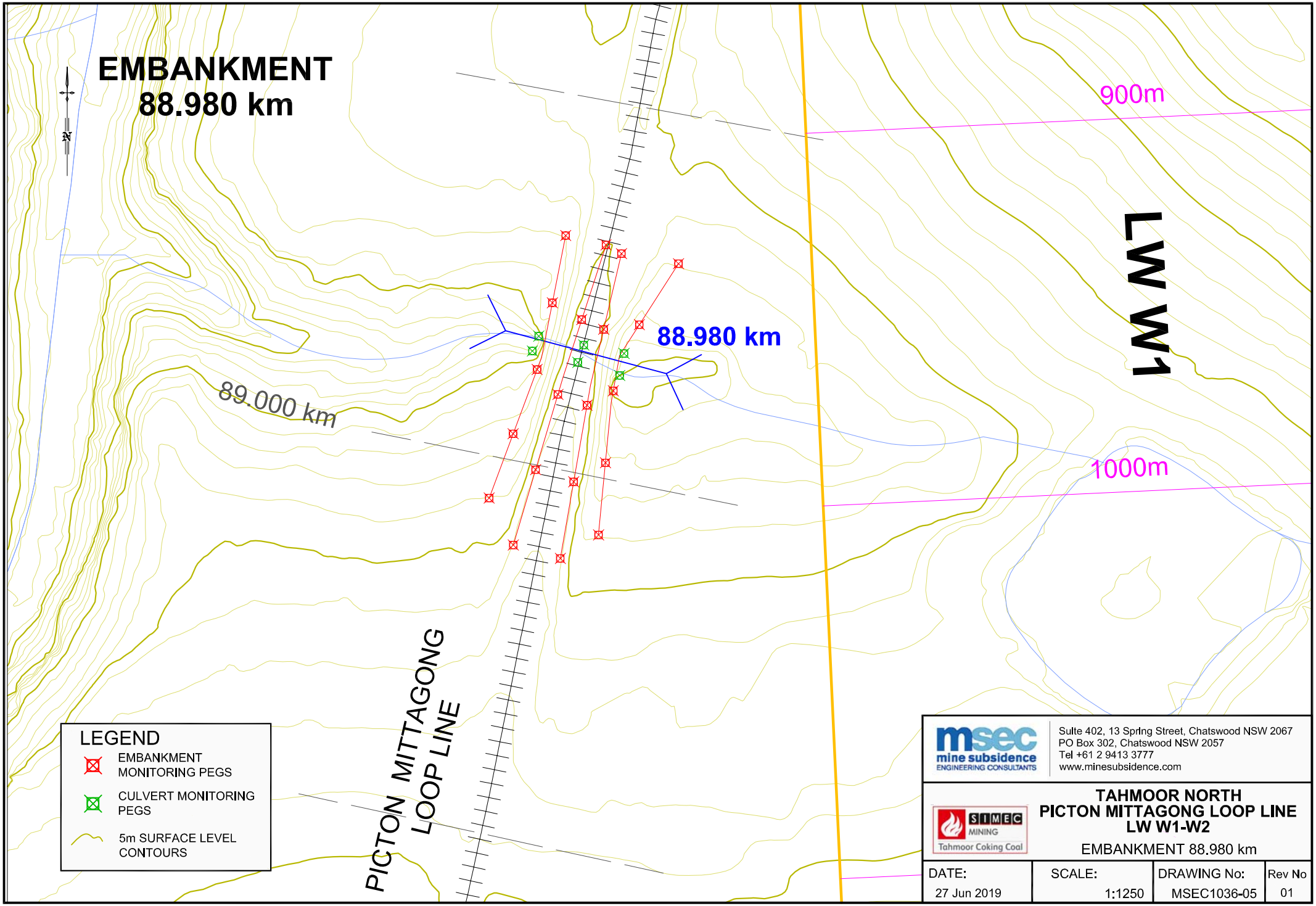

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TAHMOOR NORTH
PICTON MITTAGONG LOOP LINE
LW W1-W2
EMBANKMENT 88.980 km

DATE:	SCALE:	DRAWING No:	Rev No
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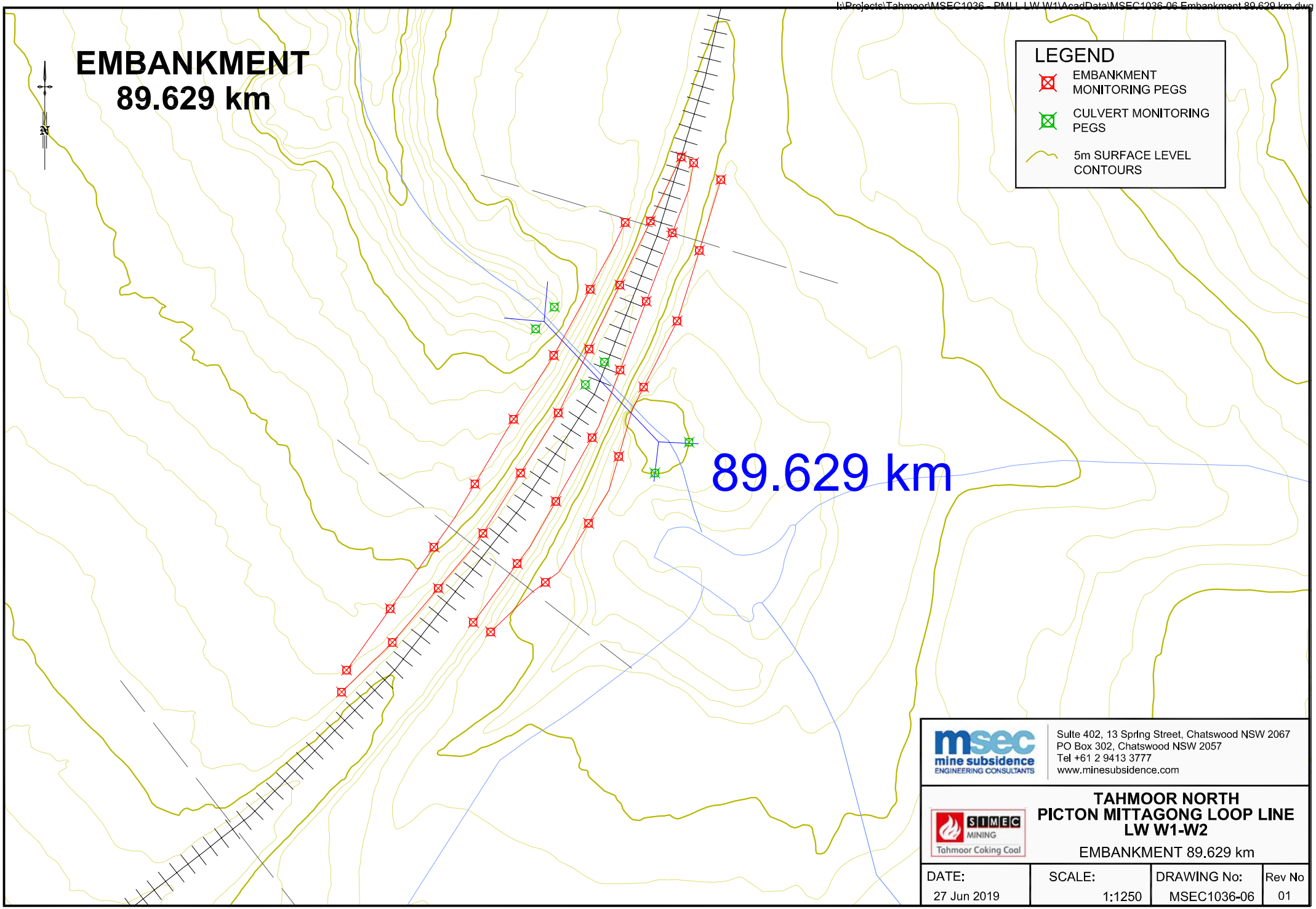
EMBANKMENT
89.629 km



LEGEND

- EMBANKMENT MONITORING PEGS
- CULVERT MONITORING PEGS
- 5m SURFACE LEVEL CONTOURS

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TAHMOOR NORTH
PICTON MITTAGONG LOOP LINE
LW W1-W2

EMBANKMENT 89.629 km

DATE:	SCALE:	DRAWING No:	Rev No
27 Jun 2019	1:1250	MSEC1036-06	01

Appendix B – Survey Specification by SMEC

SIMEC MINING
Tahmoor Coking Coal

SMEC
Member of the Surbana Jurong Group

SPECIFICATIONS FOR SUBSIDENCE MONITORING LINES FOR LONGWALLS W1-W2

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Coal 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 GPS 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 traversing.
      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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Campbelltown NSW 2560
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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. GPS Survey Control for Three Dimensional Survey of Subsidence Lines:

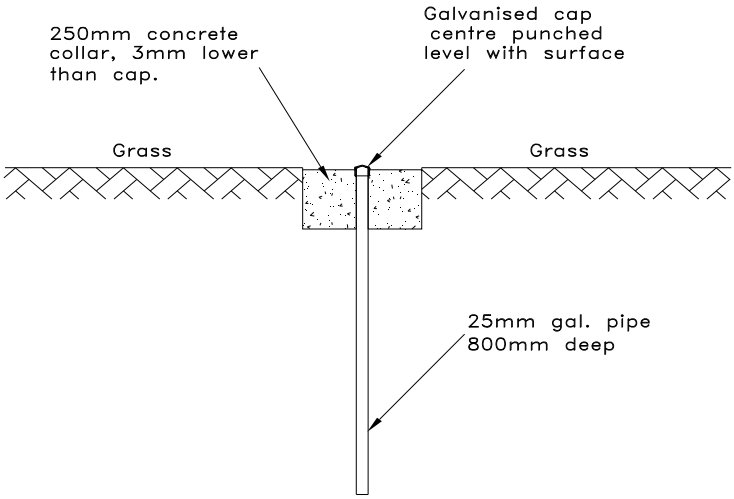
4.5.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.5.2. Site GPS Base Stations are to be monitored periodically if required by connection to an established stable 'outer' network of GPS Stations.
4.5.3. GPS Baselines are to be surveyed relative to a Site GPS 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. Subsidence stations 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 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 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 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.

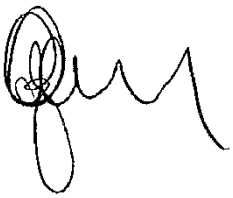
8. Reports

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**
Senior Registered Surveyor
PO Box 232
Campbelltown NSW 2560
Ph: 02 9900 7128
Gus.Warren@smec.com



Tahmoor Coal Contacts:

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Appendix C – Survey Specification by Southern Rail Surveys

Southern Rail Surveys Pty Ltd

PO Box 990

Wollongong, NSW, 2500

Loop Line- Survey Monitoring Plan for LW W1-W2

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Coal Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2007(NSW Coal)* 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 Coal 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 Coal 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/sp1v1-7.pdf)

   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily Totalstation 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. Totalstation 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 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.

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Wollongong, NSW, 2500

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.
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 Theodolite/EDM 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:
- 2.0 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 Surveying and Spatial Information Regulation 2012 the survey instruments associated with this project will be calibrated annually.
6.2. A calibration certificate will be supplied to Tahmoor Coal.

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 Mine LW W1-W2 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 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 Mine LW W1-W2 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 Coal will provide an AutoCAD file of the Mine Workings if required.
Tahmoor Coal will provide an Excel & XML files be used as a template.

John Rolles
Registered Surveyor
Southern Rail Surveys Pty Ltd
31 May 2019

Tahmoor Coal Contacts:

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