SIMEC Mining:

Tahmoor North Western Domain Longwalls West 1 and West 2

Management Plan for Potential Impacts to Wollondilly Shire Council Infrastructure

 | REPORT NUMBER: MSEC1045-02 | REVISION B

AUTHORISATION OF MANAGEMENT PLAN

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DOCUMENT REGISTER

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Sep-19	MSEC1045-02	A	Draft for submission to Wollondilly Shire Council
Sep-19	MSEC1045-02	B	Final following consultation with Wollondilly Shire Council

References:-

	AS/NZS ISO 31000:2009 Risk Management – Principles and guidelines
GHD Geotechnics (2017)	Glencore – Tahmoor Underground – Landslide risk assessment for identified "steep slopes" – Properties affected by retreat of LW31, GHD Geotechnics, July 2017.
MSO (2017)	Managing risks of subsidence – Guide | WHS (Mines and Petroleum Sites) Legislation, NSW Department of Planning & Environment, Resources Regulator, Mine Safety Operations, February 2017.
MSEC (2019)	Tahmoor Coal - Longwalls W1 and W2 - Subsidence Predictions and Impact Assessments for Natural and Built Features due to the Extraction of the Proposed Longwalls W1 and W2 in Support of the Extraction Plan Application. (Report No. MSEC1019, Revision B, July 2019), prepared by Mine Subsidence Engineering Consultants.
Traffic Professionals (2018)	Traffic management plans for Tahmoor Coal near 700 Thirlmere Way, Picton.
Tahmoor Coal (2019)	Risk Assessment Report – Infrastructure. Tahmoor North – Western Domain, Longwalls West 1 and West 2, April 2019.

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LIST OF TABLES AND FIGURES

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Figures

Figures are prefaced by the number of the chapter or the letter of the appendix in which they are presented.

Drawings

Drawings referred to in this report are included in Appendix A at the end of this report.

Drawing No.	*Description*	*Revision*
MSEC1045-00-01	Monitoring over LW W1-W2	03
MSEC1045-00-02	Far field monitoring	01
MSEC1045-02-01	Local roads, culverts and bridges	01

1.1. Background

Tahmoor Coal is located approximately 80 km south-west of Sydney in the township of Tahmoor NSW. It is managed and operated by SIMEC Mining. Tahmoor Coal has previously mined 31 longwalls to the north and west of the mine's current location. It is currently mining Longwall 32.

Longwalls West 1 and West 2 (LW W1-W2) are the first two longwalls to be mined in the Western Domain. The longwall panels are located to the north of the current longwall series, and to the south of Cedar and Stonequarry Creeks. Infrastructure owned by Wollondilly Shire Council is located within this area.

A summary of the dimensions of LW W1-W2 are provided in Table 1.1.

Table 1.1 Longwall dimensions

Longwall	Overall void length including the installation heading (m)	Overall void width including the first workings (m)	Overall tailgate chain pillar width (m)
LW W1	1875	283	-
LW W2	1685	283	39

This Management Plan provides detailed information about how the risks associated with mining beneath the infrastructure will be managed by Tahmoor Coal and Wollondilly Shire Council.

The Management Plan is a live document that can be amended at any stage of mining, to meet the changing needs of Tahmoor Coal and Wollondilly Shire Council.

1.2. Wollondilly Shire Council assets potentially affected by LW W1-W2

A map showing the locations of Wollondilly Shire Council infrastructure in relation to LW W1-W2 is shown in Drawing No. MSEC1045-02-01.

There are a number of local roads located directly above or adjacent to LW W1-W2. The most significant roads are Thirlmere Way and Stonequarry Creek Road.

There are no bridges within the vicinity of LW W1-W2, though several bridges are predicted to experience far field movements during the mining of LW W1-W2. The majority of the bridges cross the Main Southern Railway. Risk control measures to manage potential impacts on this bridge are described in a separate management plan for the Main Southern Railway, which will be developed in consultation with the Australian Rail Track Corporation, ARTC. A copy of that management plan can be provided to Wollondilly Shire Council.

There are many road drainage culverts located above and in the vicinity of LW W1-W2. The culverts comprise concrete pipes with diameters ranging between 600 mm and 900 mm. Two culverts are located on Stonequarry Creek Road directly above LW W1 and two culverts are located within Rumker Gully to the west of LW W1 beneath Stonequarry Creek Road and Thirlmere Way.

1.3. Consultation

1.3.1. Consultation with Wollondilly Shire Council

Tahmoor Coking Coal Operations regularly consults with Wollondilly Shire Council in relation to mine subsidence effects from mining. This includes consultation during the development of Subsidence Management Plans for previous Longwalls 22 to 32, and regular reporting of subsidence movements and impacts.

Feedback was provided by Wollondilly Shire Council in relation to identification of Council owned buildings and preparation of a traffic management plan for Thirlmere Way, which was submitted to Council prior to the installation of survey marks and prior to influence of Longwall 31.

Details regarding consultation and engagement are outlined below:

- Meeting with Wollondilly Shire Council, David Talbert (Tahmoor Coal) and Fiona Robinson (Tahmoor Coal) in September 2019 to discuss the draft Subsidence Management Plan for LW W1-W2.

Tahmoor Coal will continue to consult regularly with Wollondilly Shire Council during the extraction of LW W1-W2 in relation to mine subsidence effects from mining.

1.3.2. Consultation with Government Agencies & Key Infrastructure Stakeholders

Government agencies including the NSW Department of Planning & Environment, Resources Regulator, Mine Safety Operations, Subsidence Advisory NSW and key infrastructure stakeholders including Endeavour Energy, Sydney Water, Integral, Telstra and Jemena have also been consulted as part of the Extraction Plan approval process.

1.4. Limitations

This Management Plan is based on the predictions of the effects of mining on surface infrastructure as provided in Report No. MSEC1019 by Mine Subsidence Engineering Consultants (MSEC, 2019). Predictions are based on the planned configuration of LW W1-W2 at Tahmoor Coal (as shown in Drawing No. MSEC1045-02-01), along with available geological information and data from numerous subsidence studies for longwalls previously mined in the area.

Infrastructure considered in this Plan has been identified from site visits and aerial photographs and from discussions between Tahmoor Coal representatives and Wollondilly Shire Council.

The impacts of mining on surface and sub-surface features have been assessed in detail. However, it is recognised that the prediction and assessment of subsidence can be relied upon only to a certain extent. The limitations of the prediction and assessment of mine subsidence are discussed in report MSEC1019 by Mine Subsidence Engineering Consultants.

As discussed in the report, there is a low probability that ground movements and their impacts could exceed the predictions and assessments. However, if these potentially higher impacts are considered prior to mining, they can be managed. This Management Plan will not necessarily prevent impacts from longwall mining, but will limit the impacts by establishing appropriate procedures that can be followed should evidence of increased impacts emerge.

1.5. Objectives

The objectives of this Management Plan are to establish procedures to measure, control, mitigate and repair potential impacts that might occur to roads, bridges and culverts.

The objectives of the Management Plan have been developed to:-

- Ensure the safe and serviceable operation of all surface infrastructure. Public and workplace safety is paramount. Ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence.
- Avoid disruption and inconvenience, or, if unavoidable, keep to minimal levels.
- Monitor ground movements and the condition of infrastructure during mining.
- Initiate action to mitigate or remedy potential significant impacts that are expected to occur on the surface.
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted.
- Establish a clearly defined decision-making process to ensure timely implementation of risk control measures for high consequence but low likelihood mine subsidence induced hazards that involve potential serious injury or illness to a person or persons that may require emergency evacuation, entry or access restriction or suspension of work activities.
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Coal, Wollondilly Shire Council, relevant government agencies as required, and consultants as required.
- Establish lines of communication and emergency contacts.

1.6. Scope

The Management Plan is to be used to protect and monitor the condition of the Wollondilly Shire Council infrastructure identified to be at risk due to mine subsidence and to ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence. The major items at risk are:-

- Local roads
- Bridges
- Culverts

The Management Plan only covers infrastructure that is located within the limit of subsidence, which defines the extent of land that may be affected by mine subsidence as a result of mining LW W1-W2 only. The management plan does not include other roads, bridges and culverts owned by Wollondilly Shire Council which lie outside the extent of this area.

1.7. Proposed Mining Schedule

It is planned that LW W1-W2 will extract coal working south from the northern end. This Management Plan covers longwall mining until completion of mining in LW W2 and for sufficient time thereafter to allow for completion of subsidence effects. The current schedule of mining is shown in Table 1.2.

Table 1.2 Schedule of Mining

Longwall	Start Date	Completion Date
LW W1	October 2019	August 2020
LW W2	September 2020	May 2021

Please note the above schedule is subject to change due to unforeseen impacts on mining progress. Tahmoor Coal will keep Wollondilly Shire Council informed of changes.

1.8. 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 metres in front of the longwall face to an area 450 metres behind the longwall face.

This is termed the “active subsidence zone” for the purposes of this Management Plan, where surface monitoring is generally conducted. The active subsidence zone for each longwall is defined by the area bounded by the predicted 20 mm subsidence contour for the active longwall and a distance of 150 metres in front and 450 metres behind the active longwall face, as shown by Fig. 1.1.

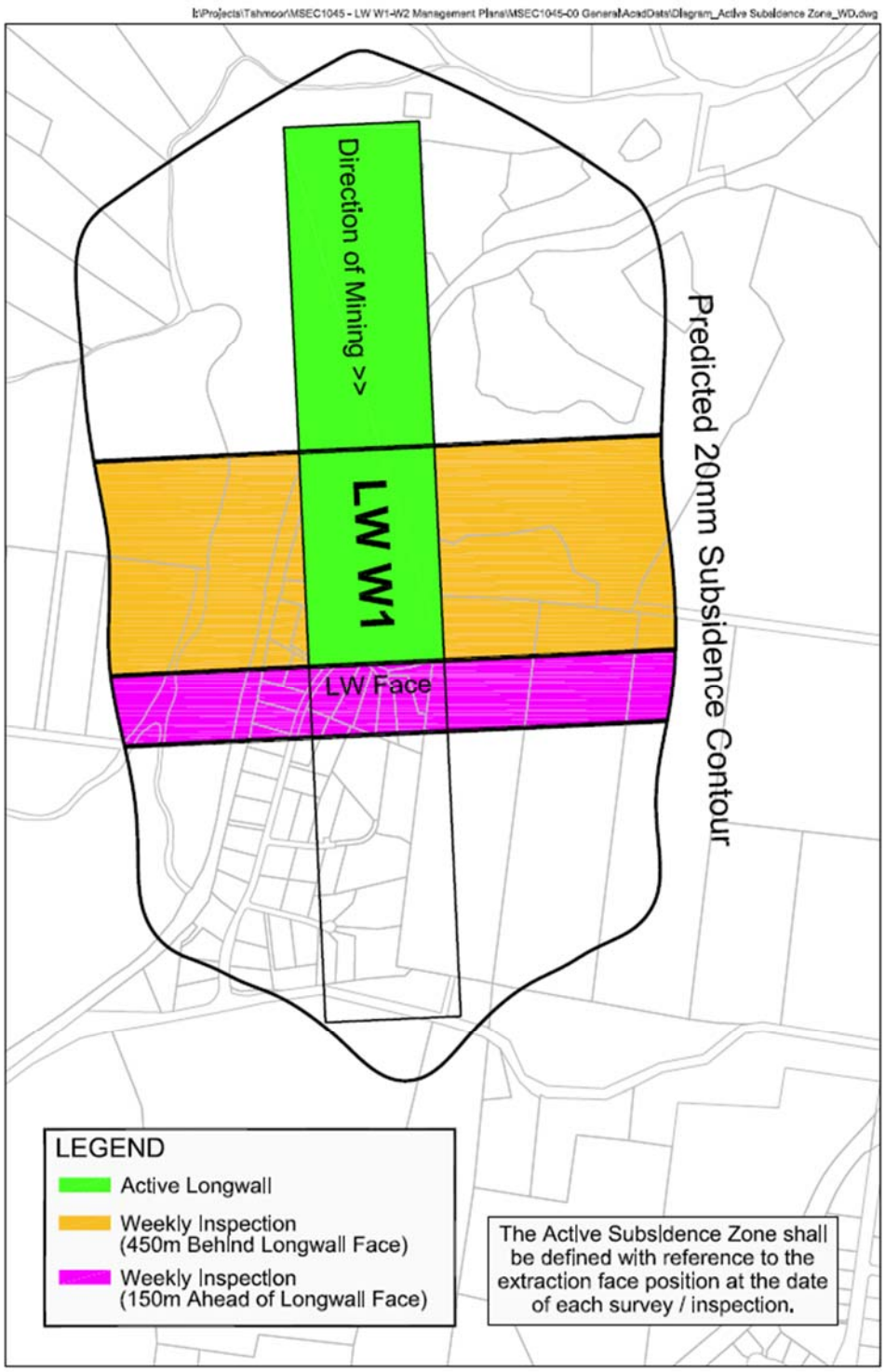

Fig. 1.1 Diagrammatic Representation of Active Subsidence Zone

1.9. Compensation

The *Coal Mine Subsidence Compensation Act 2017* (MSC Act) is administered by Subsidence Advisory NSW (Mine Subsidence Board).

Currently, under the *Coal Mine Subsidence Compensation Act 2017*, any claim for mine subsidence damage needs to be lodged with Subsidence Advisory NSW. Subsidence Advisory NSW staff will arrange for the damage to be assessed by an independent specialist assessor. If the damage is attributable to mine subsidence, a scope will be prepared and compensation will be determined. For further details please refer to *Guidelines – Process for Claiming Mine Subsidence Compensation* at www.subsideneadvisory.nsw.gov.au.

2.1. NSW Work Health & Safety Legislation

All persons conducting a business or undertaking (PCBUs), including mine operators and contractors, have a primary duty of care to ensure the health and safety of workers they engage, or whose work activities they influence or direct. The responsibilities are legislated in *Work Health and Safety Act 2011* and the *Work Health and Safety (Mines and Petroleum Sites) Act 2013* and associated Regulations (collectively referred to as the 'WHS laws').

The *Work Health and Safety (Mines and Petroleum Sites) Regulation 2014* commenced on 1 February 2015 and contains specific regulations in relation to mine subsidence.

As outlined in the Guide by the NSW Department of Trade & Investment Mine Safety:

"a PCBU must manage risks to health and safety associated with mining operations at the mine by:

- *complying with any specific requirements under the WHS laws*
- *identifying reasonably foreseeable hazards that could give rise to health and safety risks*
- *ensuring that a competent person assesses the risk*
- *eliminating risks to health and safety so far as is reasonably practicable*
- *minimising risks so far as is reasonably practicable by applying the hierarchy of control measures, any risks that it is are not reasonably practical to eliminate*
- *maintaining control measures*
- *reviewing control measures.*

The mine operator's responsibilities include developing and implementing a safety management system that is used as the primary means of ensuring, so far as is reasonably practicable:

- *the health and safety of workers at the mine, and*
- *that the health and safety of other people is not put at risk from the mine or work carried out as part of mining operations."*

Detailed guidelines have also been released by the NSW Department of Planning & Environment, Resources Regulator, Mine Safety Operations (MSO, 2017).

The risk management process has been carried out in accordance with guidelines published by the NSW Department of Planning & Environment, Resources Regulator, Mine Safety Operations (MSO, 2017). The following main steps of subsidence risk management have been and will be undertaken, in accordance with the guidelines.

1. identification and understanding of subsidence hazards
2. assessment of risks of subsidence
3. development and selection of risk control measures
4. implementation and maintenance of risk control measures, and
5. continual improvement and change management.

Each of the above steps have been or will be conducted together with the following processes.

1. consultation, co-operation and co-ordination, and
2. monitoring and review.

This Management Plan documents the risk control measures that are planned to manage risks to health and safety associated with the mining of LW W1-W2 in accordance with the WHS laws.

2.2. General

The method of assessing potential mine subsidence impacts in the Management Plan is consistent with the Australian/New Zealand Standard for Risk Management (AS/NZS ISO 31000:2009). The Standard defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of potential mine subsidence impacts. In this context:-

2.2.1. Consequence

'The outcome of an event expressed qualitatively or quantitatively, being a loss, injury, disadvantage or gain. There may be a range of possible outcomes associated with an event.' The consequences of a hazard are rated from negligible to catastrophic.

2.2.2. Likelihood

'Used as a qualitative description of probability or frequency.' The likelihood can range from rare to almost certain.

2.2.3. Hazard

'A source of potential harm or a situation with a potential to cause loss.'

2.2.4. Method of assessment of potential mine subsidence impacts

The method of assessing potential mine subsidence impacts combines the likelihood of an impact occurring with the consequence of the impact occurring. In this Management Plan, the likelihood and consequence are combined via the SIMEC Risk Matrix to determine an estimated level of risk for particular events or situations. A copy of the Risk Matrix is included in the Appendix of this Management Plan.

3.1. 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 for LW W1-W2. A summary of the maximum predicted total subsidence parameters due to the extraction of LW W1-W2 are provided in Table 3.1.

Table 3.1 Maximum predicted conventional subsidence parameters for LW W1-W2

Longwall	Maximum predicted subsidence (mm)	Maximum predicted tilt (mm/m)	Maximum predicted hogging curvature (1/km)	Maximum predicted sagging curvature (1/km)
After LW W1	475	3.0	0.03	0.06
After LW W2	750	5.5	0.06	0.11

The values provided in the above table are the maximum predicted conventional subsidence parameters which occur within the general longwall mining area.

3.2. Comparison of measured and predicted subsidence for single panels

Predictions using MSEC's Incremental Profile Method have been continually tested and refined during the mining of previous Longwalls 22 to 31, as described in Report No. MSEC1019.

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

It is therefore planned to monitor the development of subsidence during the early stages of extraction of LW W1 to compare observations with predictions. This will initially be achieved by regular surveys along the centreline of LW W1, followed by monitoring of subsidence along the Picton-Mittagong Loop Line and survey lines along local roads.

3.3. Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the average relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values.

Adopting a linear relationship between curvature and strain provides a reasonable prediction for the conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones. In the Southern Coalfield, it has been found that a factor of 15 provides a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains. At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the

normal scatters which are observed in strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The data used in an analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements, but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

3.3.1. Analysis of strains measured in survey bays

For features that are in discrete locations, such as building structures, farm dams and archaeological sites, it is appropriate to assess the frequency of the observed maximum strains for individual survey bays.

Predictions of strain above goaf

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of Longwalls 22 to 32 at Tahmoor Mine, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

A histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf at Tahmoor Mine is provided in Fig. 3.1. A number of probability distribution functions were fitted to the empirical data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data, and this is also shown in this figure.

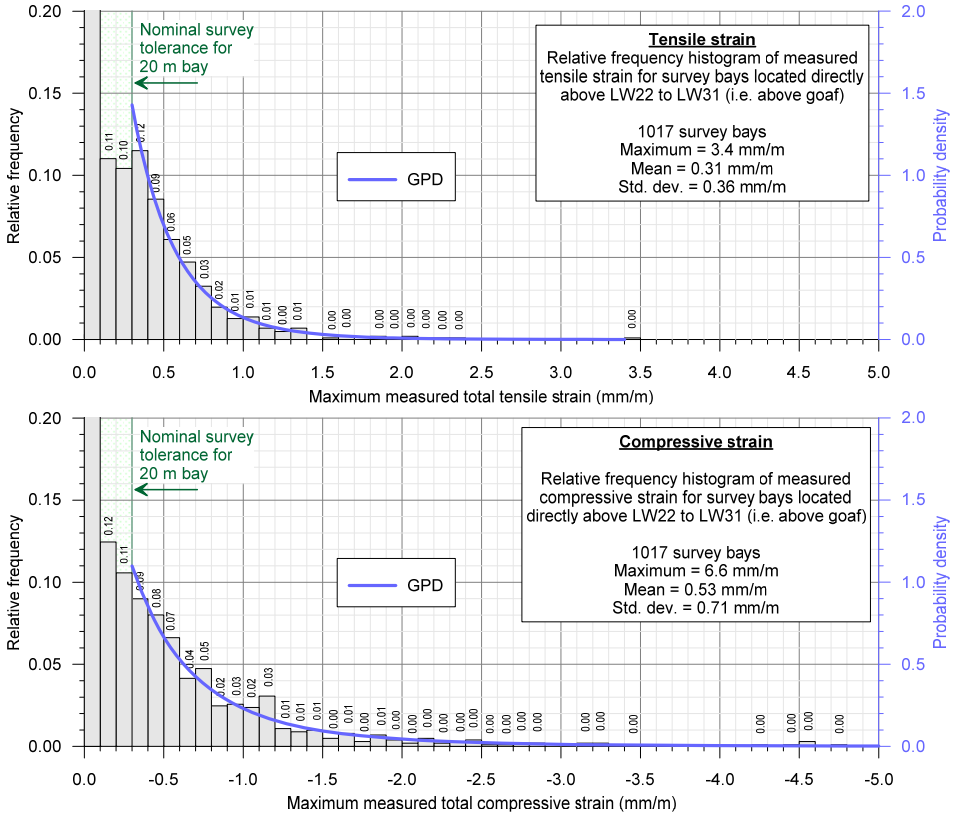

Fig. 3.1 Distributions of the maximum measured tensile and compressive strains during the Extraction of previous longwalls for survey bays located above goaf

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining were 1.0 mm/m tensile and 1.8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining are 1.6 mm/m tensile and 3.4 mm/m compressive.

Predictions of strain above solid coal

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of Longwalls 22 to 32 at Tahmoor Mine, for survey bays that were located outside and within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

A histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal at Tahmoor Mine is provided in Fig. 3.2. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

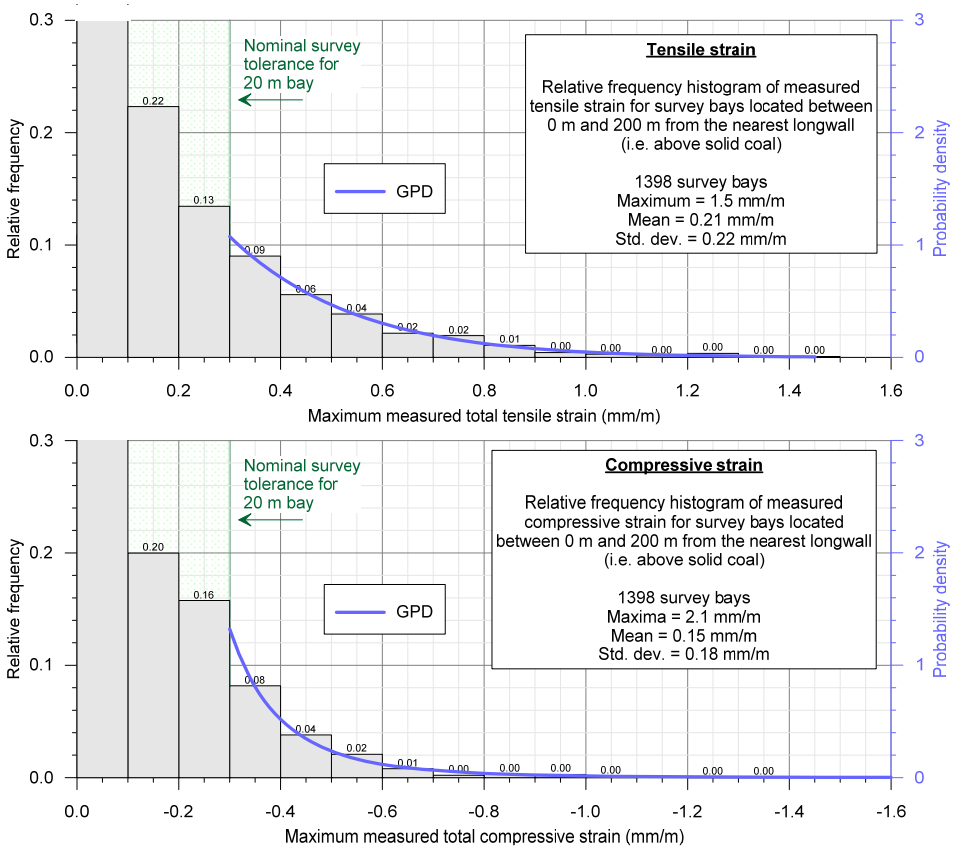

Fig. 3.2 Distributions of the maximum measured tensile and compressive strains during the extraction of previous longwalls for survey bays located above solid coal

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining were 0.7 mm/m tensile and 0.5 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining are 1.0 mm/m tensile and 0.8 mm/m compressive.

3.3.2. Analysis of strains measured along whole monitoring lines

For linear features such as roads, cables and pipelines, it is more appropriate to assess the frequency of the maximum observed strains along whole monitoring lines, rather than for individual survey bays. That is, an analysis of the maximum strains measured anywhere along the monitoring lines, regardless of where the strain actually occurs.

A histogram of maximum measured total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls at the mine, is provided in Fig. 3.3.

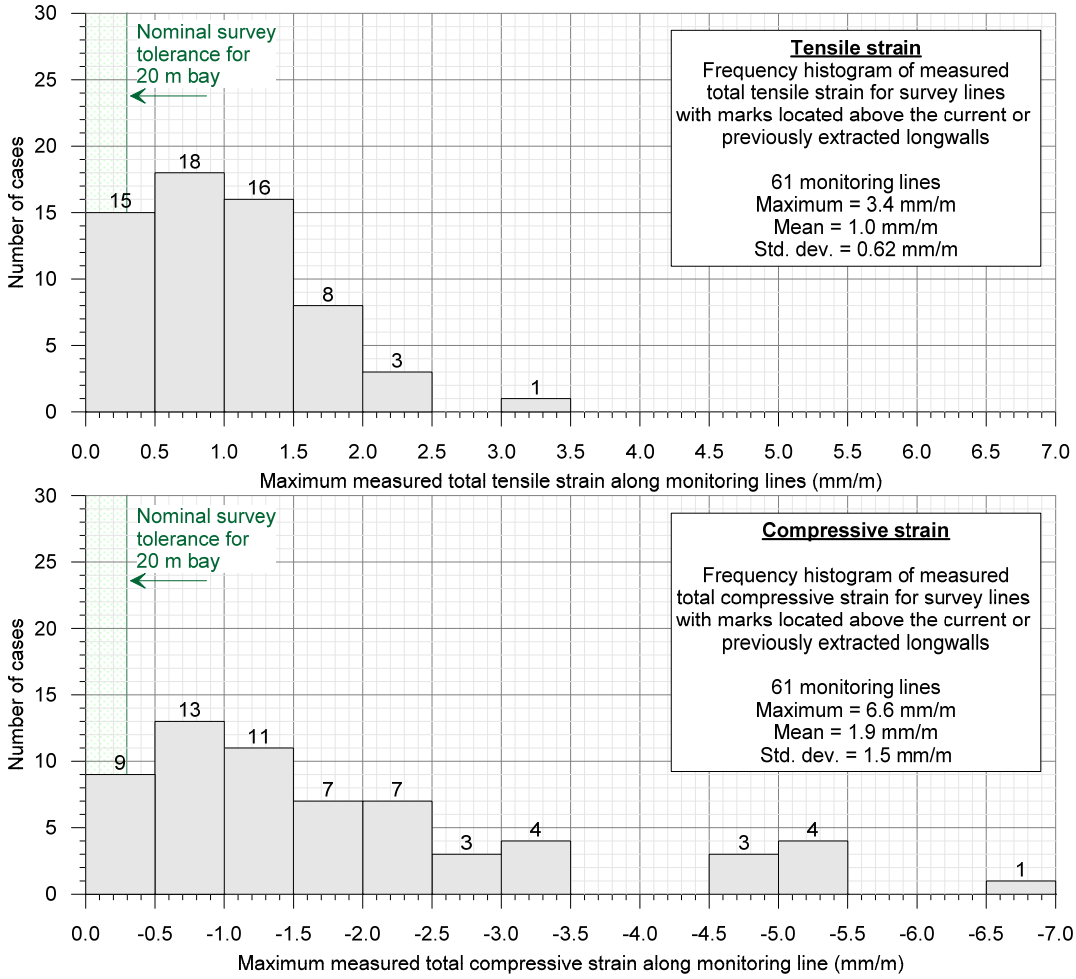

Fig. 3.3 Distributions of maximum measured tensile and compressive strains along monitoring lines during the extraction of previous longwalls at the mine

It can be seen from the above figure, that 33 of the 61 monitoring lines (i.e. 54 %) had recorded maximum total tensile strains of 1.0 mm/m, or less, and that 57 monitoring lines (i.e. 93 %) had recorded maximum total tensile strains of 2.0 mm/m, or less. It can also be seen, that 40 of the 61 monitoring lines (i.e. 66 %) had recorded maximum compressive strains of 2.0 mm/m, or less, and that 54 of the monitoring lines (i.e. 89 %) had recorded maximum compressive strains of 4.0 mm/m, or less.

3.4. Managing Public Safety

The primary risk associated with mining beneath Wollondilly Shire Council infrastructure is public safety. Tahmoor Coal has previously directly mined beneath or adjacent to more than 1900 houses and civil structures, commercial and retail properties, the Main Southern Railway and local roads and bridges. It has implemented extensive measures prior to, during and after mining to ensure that the health and safety of people have not been put at risk due to mine subsidence. People have not been exposed to immediate and sudden safety hazards as a result of impacts that have occurred due to mine subsidence movements.

Emphasis is placed on the words “immediate and sudden” as in rare cases, some structures have experienced severe impacts, but the impacts did not present an immediate risk to public safety as they developed gradually with ample time to repair the structure.

In the case of this Subsidence Management Plan, the potential for impacts on public safety has been assessed on a case by case basis. The assessments include a geotechnical engineer for steep slopes.

3.4.1. Subsidence Impact Management Process for Infrastructure

Tahmoor Coal has developed and acted in accordance with a subsidence management plan to manage potential impacts during the mining of Longwalls 22 to 32. The management strategy has been reviewed and updated based on experiences gained during the mining of Longwalls 22 to 32 and the strategy for LW W1-W2 includes the following process:

1. Regular consultation with Wollondilly Shire Council before, during and after mining.
2. Site-specific investigations.
3. Implementation of mitigation measures following inspections by a structural engineer, a mine subsidence engineer, and, if required, a geotechnical engineer or other specialist engineer.
4. Surveys and inspections during mining within the active subsidence area:
   - Detailed visual inspections and vehicle-based inspections along the streets
   - Ground surveys along streets
   - Specific ground surveys and visual inspections, where recommended by an engineer based on the inspections and assessments.

A flowchart illustrating the subsidence impact management process prior to, during and after Wollondilly Shire Council infrastructure experiences mine subsidence movements is shown in Fig. 3.4.

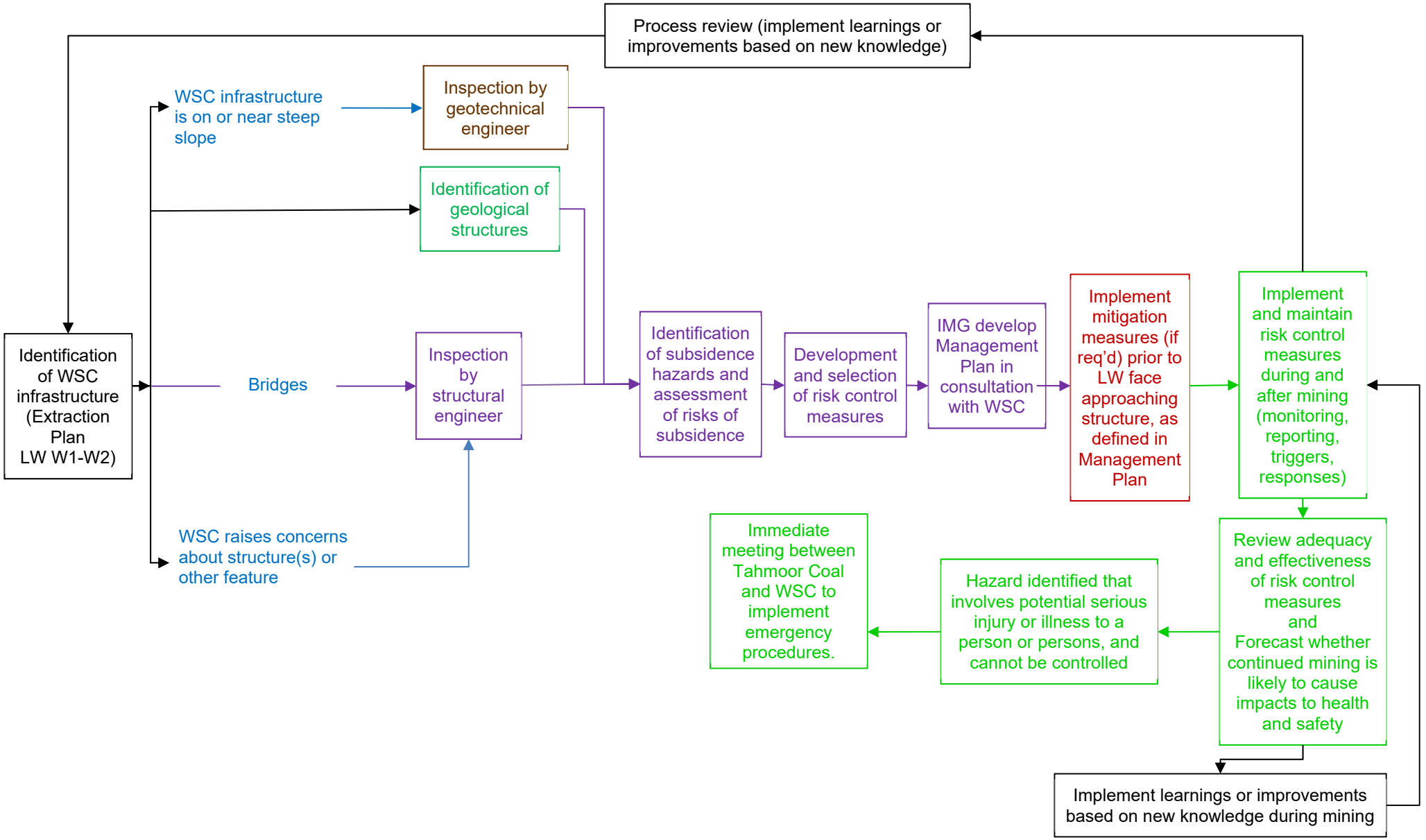

Fig. 3.4 Flowchart for Subsidence Impact Management Process

3.5. Summary of Potential Impacts

A summary of potential impacts on Wollondilly Shire Council infrastructure is provided in Table 3.2. The summary is consistent with the risk assessment undertaken by Tahmoor Coal (2019). The results of the risk assessment are included in the Appendix.

Table 3.2 Summary of Potential Mine Subsidence Impacts

Risk	Likelihood	Consequence	Level of Potential Impact
Local Roads			
Minor cracking or heaving of pavement, kerbs and gutters	LIKELY	MINOR	MEDIUM
Major cracking or heaving of pavement, kerbs and gutters	UNLIKELY	MODERATE	MEDIUM
Thirlmere Way			
Slope instability causing loss of support to road resulting in tension cracking in road surface	UNLIKELY	MINOR	LOW
Culverts and stormwater drain			
Cracking or spalling of pipework	UNLIKELY	MINOR	LOW

Additional information on each potential impact is provided below.

3.6. Identification of subsidence hazards that could give rise to risks to health and safety

Clause 34 of the Work Health and Safety Regulation (2017) requires that the duty holder (in this case Tahmoor Coking Coal Operations), in managing risks to health and safety, must identify reasonably foreseeable hazards that could give rise to risks to health and safety.

This section of the Management Plan summarises hazards that have been identified in Chapter 3, which could give rise to risks to health and safety of people on Council infrastructure.

Using the processes described in Section 3.4 of this Management Plan, mine subsidence hazards have been identified, investigated and analysed in a systematic manner by examining each aspect of infrastructure, as described in Sections 3.7 to 3.9 of this Management Plan. Each of the aspects below could potentially experience mine subsidence movements that give rise to risks to the health and safety of people.

- Local roads
- Bridges
- Road drainage culverts.

The following mine subsidence hazards were identified that could give rise to risks to health and safety on Council infrastructure due to the extraction of LW W1-W2.

- Potential major mine subsidence damage to local roads, particularly the main roads where vehicles travel at a higher speed (refer Section 3.7);
- Potential slope instability beneath Thirlmere Way (refer Section 3.7.3); and
- Potential damage or loss of services to culverts (refer Section 3.8).

The identification and risk assessment process took into account the location of infrastructure relative to LW W1-W2 and the associated timing and duration of the subsidence event, as described in Section 1.8 of this Management Plan.

Whilst mine subsidence predictions and extensive past experiences from previous mining at Tahmoor Mine were taken into account, the identification and risk assessment process recognised that there are uncertainties in relation to predicting subsidence movements, and uncertainties in how mine subsidence movements may adversely impact Council infrastructure, as discussed in Section 1.4 and Chapter 3 of this Management Plan. In this case, creeks have been mapped that intersect local roads, and Thirlmere Way is situated on top of a ridgeline.

Tahmoor Coal has considered the outcomes of the hazard identification and risk assessment process when developing measures to manage potential impacts on the health and safety of people, and potential impacts on Council property in general. These are described in Chapter 4 of this Management Plan.

3.7. Local roads

There are a number of local roads that are located directly above or adjacent to LW W1-W2, as shown in Drawing No. MSEC1045-02-01.

- Thirlmere Way
  One of the main roads linking the townships of Thirlmere and Picton. The finishing end of LW W1 is located directly beneath a short section of Thirlmere Way.
- Stonequarry Creek Road
  The main road within the Stonequarry Estate to the north of Thirlmere Way. The northern end of the road is located directly above LW W1.
- Carramar Close, Attunga Close and Booyong Close
  These streets are located directly above and adjacent to LW W1-W2.
- Barkers Lodge Road
  A small section is located within the Study Area and may experience minor subsidence movements during the extraction of W W1-W2.

3.7.1. Predicted subsidence movements

The local roads are spread across LW W1 and, therefore, they will collectively experience the full range of predicted subsidence movements, as described in Section 3.1. A discussion on the expected range of tensile and compressive strains during the mining of LW W1-W2 is provided in Section 3.3.

The predicted profiles of conventional subsidence, tilt and curvature along Thirlmere Way and Stonequarry Creek Road are shown in Fig. 3.5 and Fig. 3.6, respectively.

A summary of the maximum predicted conventional subsidence, tilt and curvature for Thirlmere Way and Stonequarry Creek Road, is provided in Table 3.3 and Table 3.4, respectively. The values are the maximum predicted parameters anywhere along the sections of roads located within the predicted limit of vertical subsidence for LW W1-W2.

Table 3.3 Maximum predicted total conventional subsidence, tilt and curvature for Thirlmere Way

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)
After LW W1	80	< 0.5	0.01	< 0.01
After LW W2	100	< 0.5	0.02	< 0.01

Table 3.4 Maximum predicted total conventional subsidence, tilt and curvature for Stoneqaurry Creek Road

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)
After LW W1	425	2.0	0.02	0.05
After LW W2	700	3.0	0.03	0.05

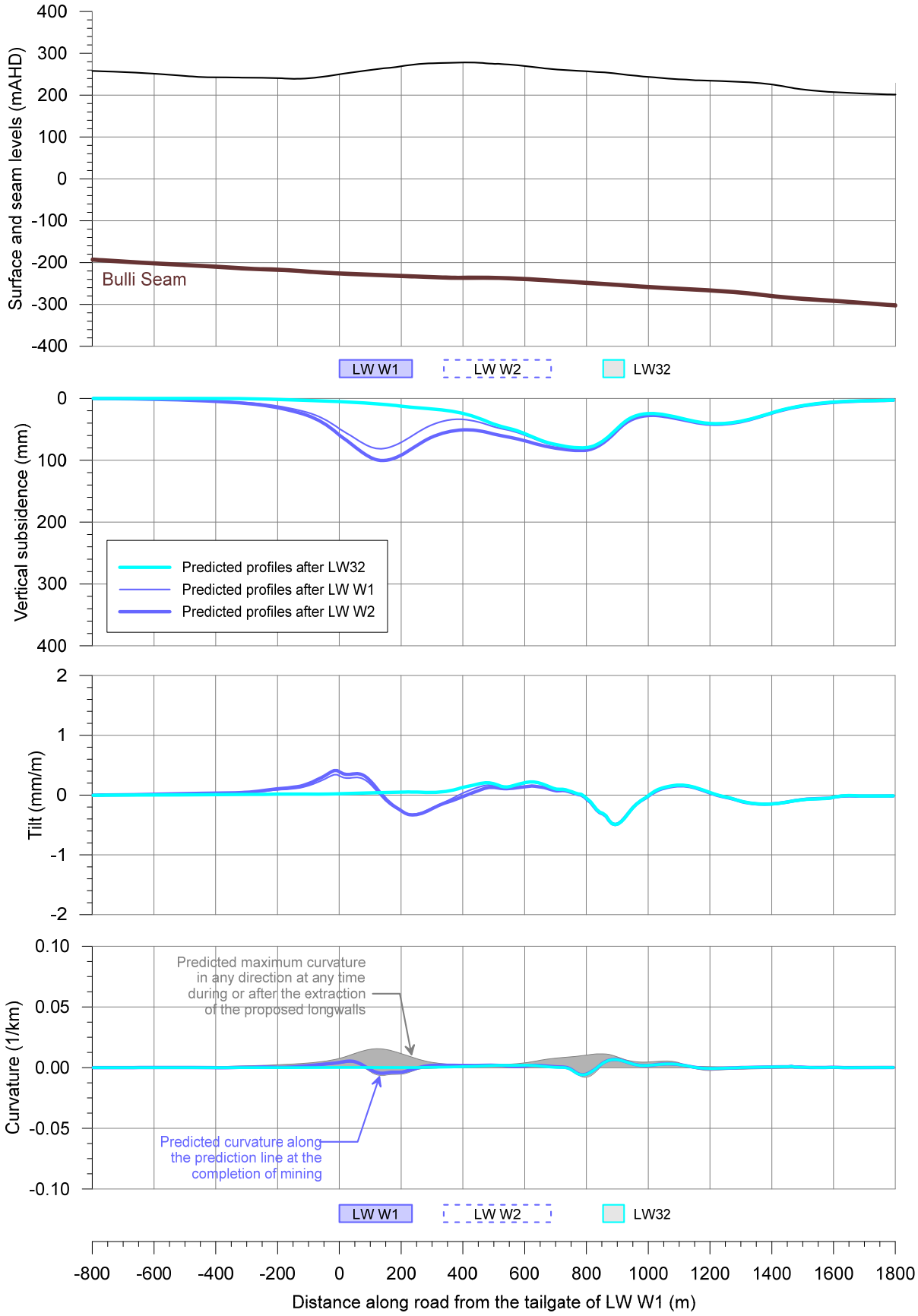

Fig. 3.5 Predicted profiles of total subsidence, tilt and curvature along Thirlmere Way after the mining of LW W1-W2

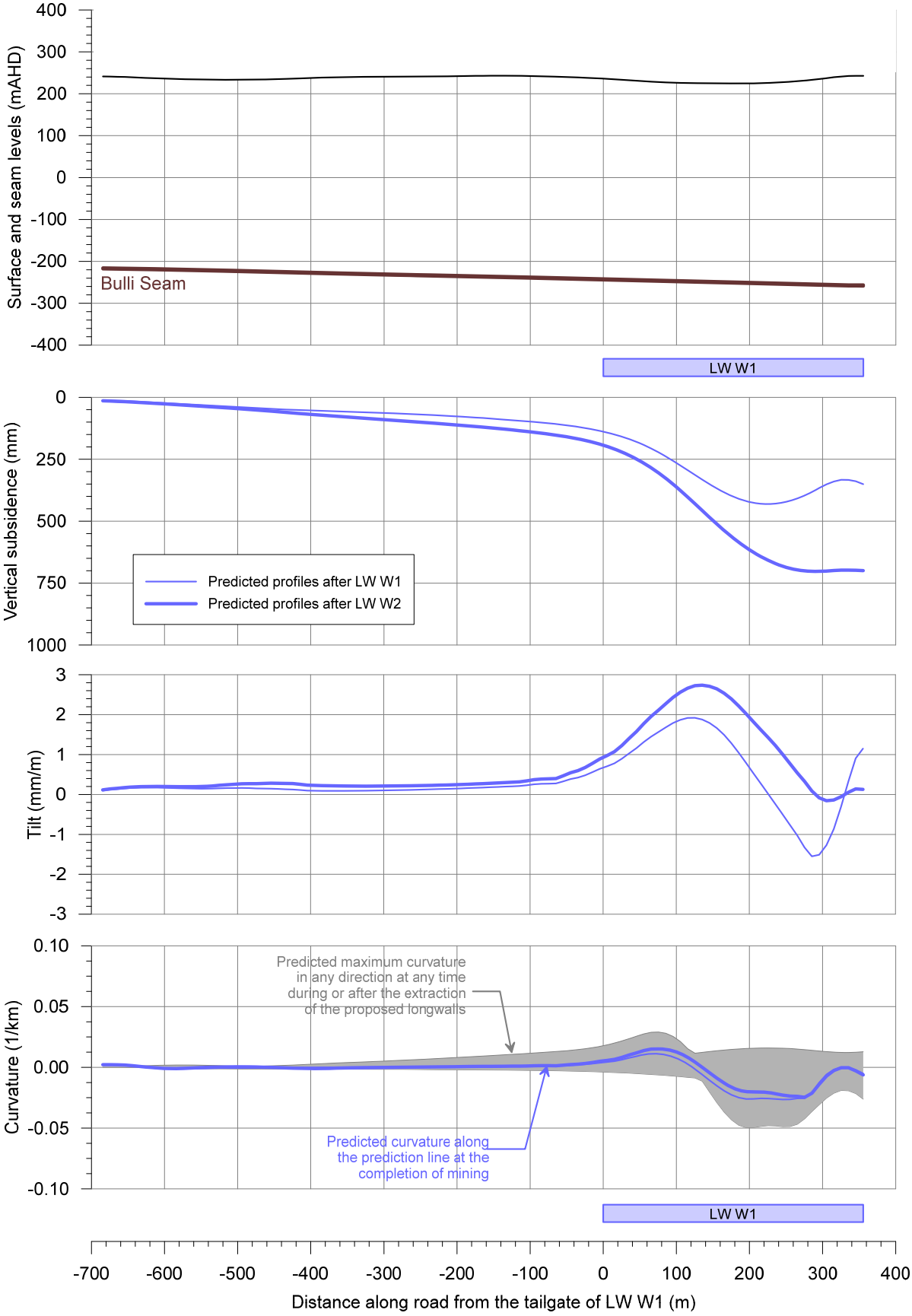

Fig. 3.6 Predicted profiles of total subsidence, tilt and curvature along Stonequarry Creek Road after the mining of LW W1-W2

3.7.2. Potential subsidence impacts on local roads

Extensive monitoring of road pavements has been undertaken during the extraction of Longwalls 22 to 32 at Tahmoor. This includes a network of ground monitoring lines and weekly visual inspections in areas that are experiencing active subsidence. Approximately 28 km of asphaltic pavement lie directly above the extracted longwalls and a total of 52 impact sites have been reported. The observed rate of impact equates to an average of one impact for every 540 m of pavement. The impacts have not presented a public safety risk, and the majority of the impacts have been minor in nature.

Impacts have also been observed to concrete kerbs, gutters and drainage pits. The impacts are most commonly focussed around driveway laybacks and involve cracking, spalling or buckling.

The most severe impacts were located where substantial non-conventional movements had developed. These impact sites were identified using visual and ground monitoring and remediation was undertaken during active subsidence to maintain the roads in safe and serviceable condition.

Traffic signs and other road infrastructure have not previously experienced impacts due to mine subsidence.

It is expected that minor impacts will occur to the local roads during the extraction of LW W1-W2, similar in frequency and severity to those experienced during the mining of Longwalls 22 to 32. As described in Sections 1.8 and 3.4, mine subsidence movements will develop gradually as mining progresses. Impacts on the asphaltic pavements will also develop gradually due to their flexible nature, as has been previously observed during the mining of Longwalls 22 to 32 at Tahmoor Mine.

Lintina Street (most severe to date)

Remembrance Drive (hump at roundabout)

Brundah Road (typical impact to pavement)

Patterson Street (typical impact to kerb)

Struan Street

Moorland Rd

Photographs courtesy of Tahmoor Coking Coal Operations and Colin Dove

Fig. 3.7 Impacts to road pavements and kerbs in Tahmoor

3.7.3. Thirlmere Way

Thirlmere Way runs along the side of a ridge near the southern (i.e. finishing) end of LW W1, with steep slopes located above and below the road. The same section of road has experienced subsidence movements during the mining of LW 31 with no impacts observed and at the time of preparing this Management Plan, the pavement will soon experience subsidence movements due to the extraction of LW 32.

It is possible that surface cracking or slippage could develop on the side of the ridge due to the extraction of LW W1 and that these may intersect with Thirlmere Way. A cross-section through Thirlmere Way and the ridgeline above the finishing end of LW W1 is provided in Fig. 3.8.

Thirlmere Way narrows in this section, with no shoulders on either side of the pavement, limiting the access for monitoring and undertaking repairs. The traffic along this section of road, therefore, will need to be managed to allow surveys and inspections to be undertaken and undertake any required remediation works.

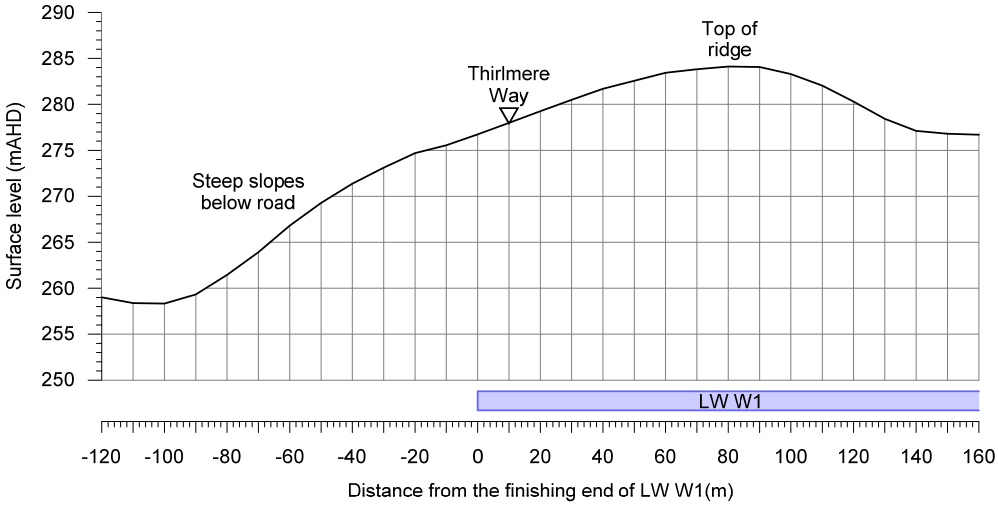

Fig. 3.8 Cross-section through Thirlmere Way and the ridgeline above LW W1

Tahmoor Coal engaged geotechnical engineer GHD Geotechnics to undertake a geotechnical assessment of the steep slopes along Thirlmere Way (GHD Geotechnics, 2017). The existing conditions along Thirlmere Way were appraised using RMS methodology (RMS Guide to Slope Risk Management, Version 4), where ARL1 is a high risk, and ARL5 is low.

- A scenario of approximately 20m^3 of rock or soil debris flowing onto the road from the cuttings was assessed as ARL3.
- A scenario of loss of embankment edge leading to step in the road pavement was assessed as assessed as ARL4.

The assessments were repeated taking into account the potential effects from subsidence. The assessments did not change from the current condition.

Prior to the influence of LW 31, survey marks T101 to T127 were installed and surveyed along Thirlmere Way where steep slopes are located above and below the road. The survey line has recently been extended to Peg T159 to monitor changes during the mining of LW32. A map showing the locations of survey pegs is provided in Fig. 3.9.

Weekly surveys are currently being conducted as the LW32 face approaches the road. The results of surveys as at 26 August 2019 are shown in Fig. 3.10. It can be seen that low level subsidence was observed during and after the mining of LW31. Additional residual subsidence has developed at survey marks T101 to T127 during the period of time between the cessation of surveys for LW31 and the recommencement of surveys for LW32. Mining-induced tilts and strains remain very small.

Six survey pegs were installed on the opposite side of Thirlmere Way from the main survey line to monitor changes in horizontal distances across the pavement. A map showing the locations of the six cross sections is provided in Fig. 3.9. The results of surveys as at 26 August 2019 are shown in Fig. 3.11. It can be seen that some changes were observed during the period of time between the cessation of surveys for LW31 and the recommencement of surveys for LW32. Minor changes have generally been observed since surveys recommenced for LW32, with minor growth in ground shortening between Pegs T116A and T117, which are oriented in a direction along the pavement.

No impacts have been observed to the pavement to date.

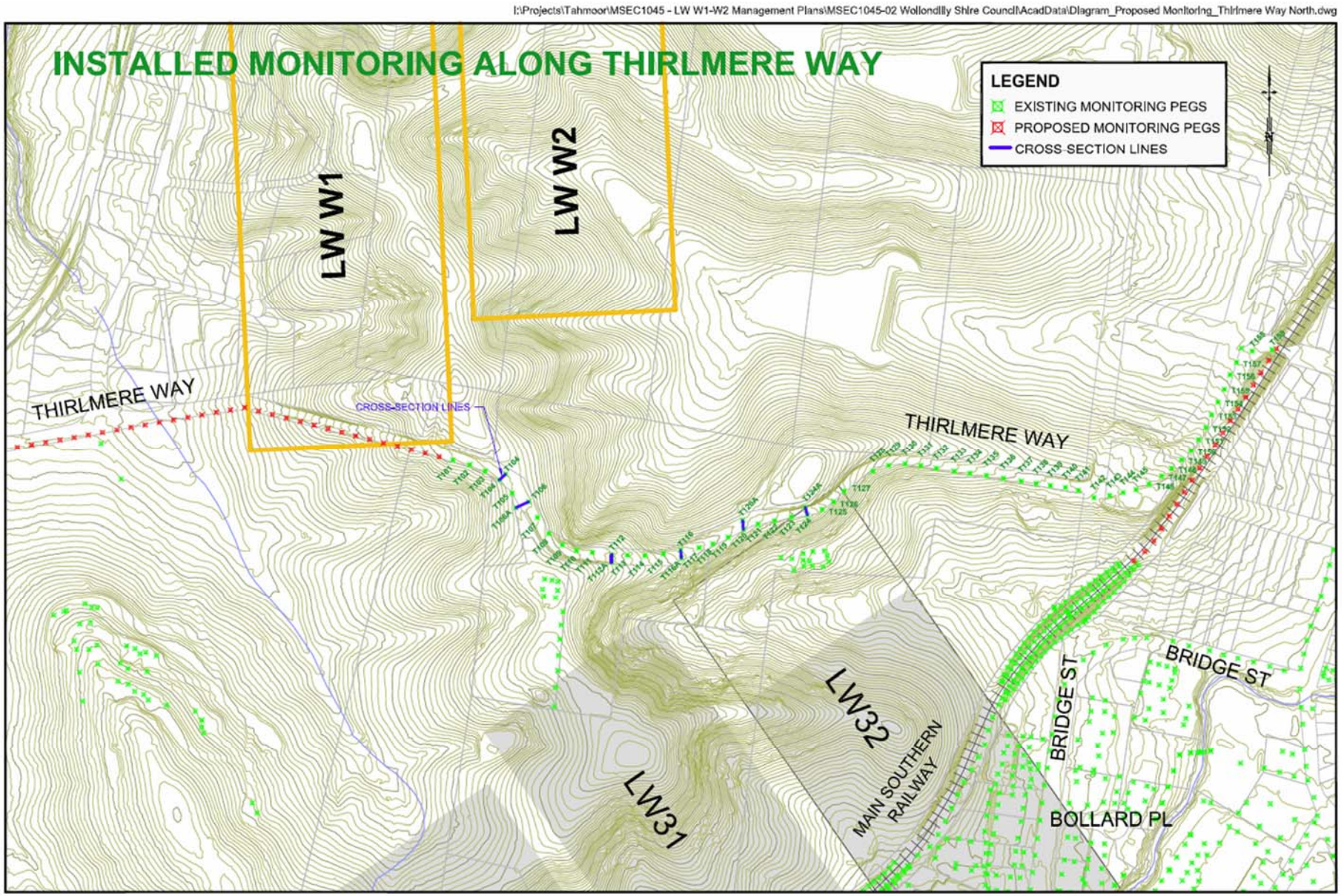

Fig. 3.9 Installed and proposed extension of survey lines along Thirlmere Way

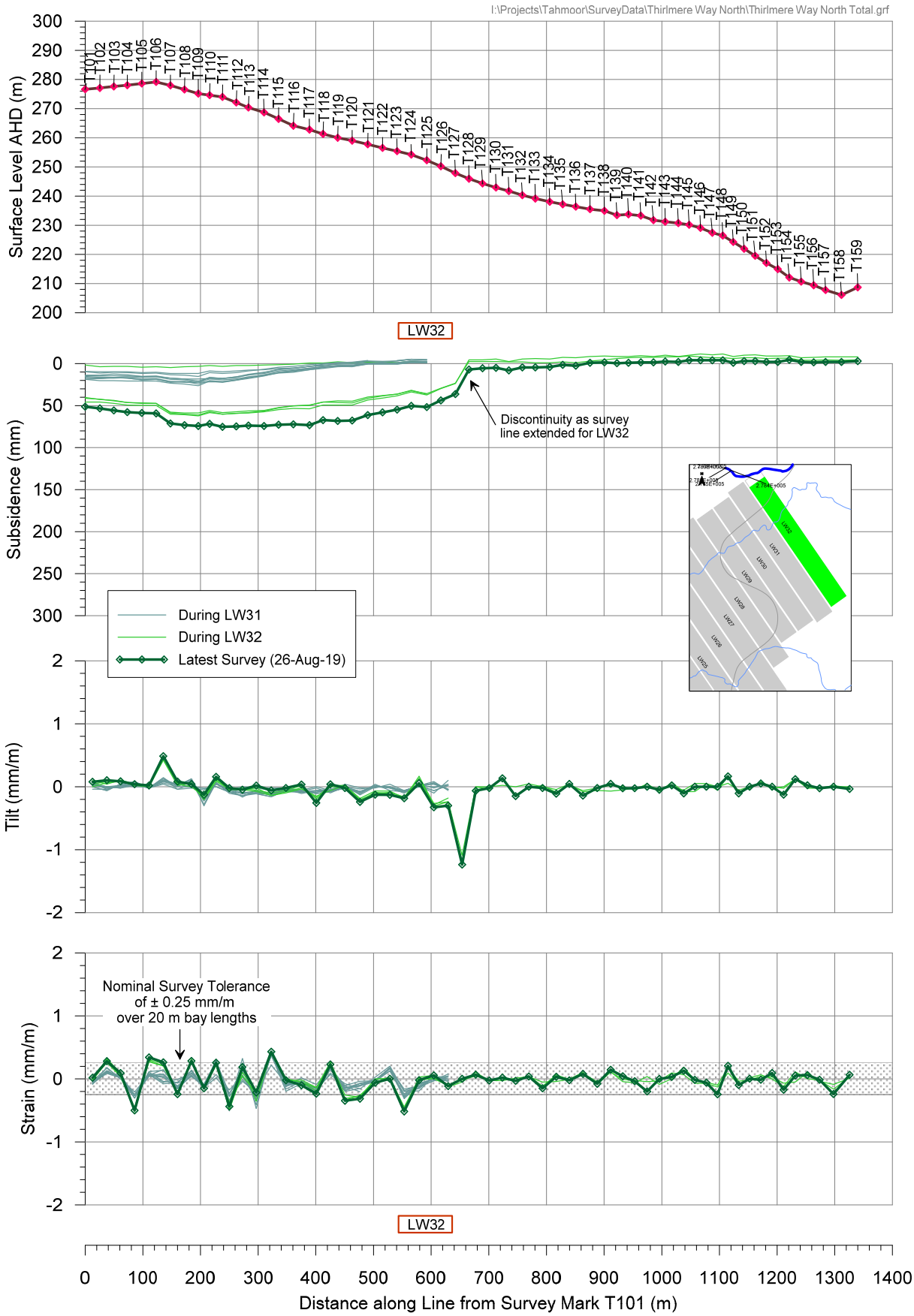

Fig. 3.10 Observed subsidence along Thirlmere Way during the mining of LWs 31 and 32 as at 26 August 2019

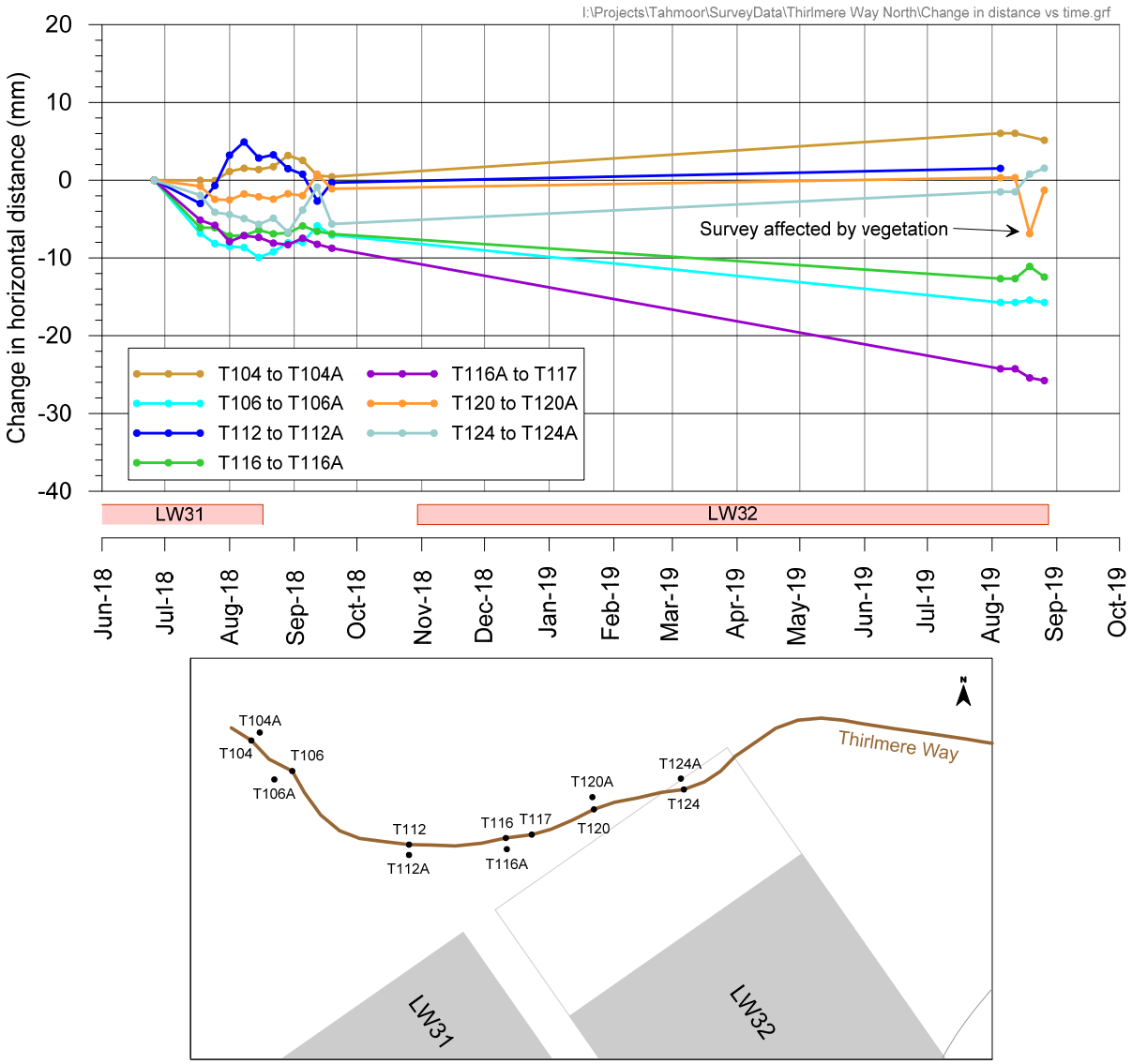

Fig. 3.11 Observed changes in distance across Thirlmere Way during the mining of LWs 31 and 32 as at 26 August 2019

Tahmoor Coal has developed and selected risk control measures in consultation, co-ordination and co-operation with Wollondilly Shire Council in accordance with WHS legislation. In this instance, there are no reasonably practicable controls which could eliminate, substitute or isolate the identified risks, nor engineering controls that could put in place a structure or item that prevents or minimises risks. Tahmoor Coal has identified controls that will manage potential issues associated with the identified risks, as described by GHD Geotechnics.

- Local 2D survey of subsidence along Thirlmere Way with locations of pegs shown in Fig. 3.9. Prior to the influence of LW W1, the survey line will be extended to the north to monitor subsidence movements during and after the mining of LW W1-W2.
- Local 2D survey of changes in horizontal distance at six cross-sections across the Thirlmere Way road pavement where the steep slopes are present. The locations of the install cross-sections are shown in Fig. 3.9.
- Visual inspections along Thirlmere Way.
- Additional surveys and/or inspections, if triggered by monitoring results.
- Repair of pavement if damage is observed.
- As a last resort, temporary closure of Thirlmere Way if a hazard has been identified that involves potential serious injury or illness to a person or persons and cannot be controlled.
- Development of traffic management plan to manage traffic in the event that mining-induced damage develops along the road and requires repair.

With the implementation of the above management strategy, Tahmoor Coal will ensure that the health and safety of people along Thirlmere Way will not be put at risk due to differential mine subsidence movements due to the extraction of LW W1-W2.

A traffic management plan (Traffic Professionals, 2018) has been developed for the installation and continued monitoring of survey pegs. Visual inspections of the pavement can be undertaken whilst the surveys are conducted. The traffic management plan has been appended to this Management Plan.

3.8. Road drainage culverts

There are four road drainage culverts located above and in the vicinity of LW W1-W2. The culverts are single reinforced concrete pipes (RCP) with diameters ranging between 600 mm and 900 mm.

A summary of these culverts is provided in Table 3.5.

Table 3.5 Road drainage culverts located within the Study Area

Road	Culvert ref.	Location	Size and type
Stonequarry Creek Road	SC-C1	190 m west of LW W1	Single RCP 600 mm dia.
	SC-C2	Directly above LW W1	Single RCP 600 mm dia.
	SC-C3	Directly above LW W1	Single RCP 900 mm dia.
Thirlmere Way	TH-C2	130 m west of LW W1	Single RCP 800 mm dia.

Culvert TH-C2 is an 800 mm diameter RCP culvert located on Rumker Gully approximately 130 metres to the west of LW W1. Photographs of the culvert are shown in Fig. 3.12, where it can be seen that the inlet (top left image) is an RCP with broken masonry headwall. On the downstream (northern) side of Thirlmere Way, a broad drainage ditch collects surface water run off via a side inlet (top right image) and directs it into the culvert at a buried tee connection. An access cover is located above the main culvert, as shown in the bottom image.

The culvert then continues beneath private property before linking up with Culvert SC-C1 and discharging into Rumker Gully.

A summary of the maximum predicted conventional subsidence, tilt and curvature for road drainage culverts is provided in Table Table 3.6, respectively. The values are the maximum predicted values within 20 m of each of the culverts at any time during or after the extraction of LW W1-W2.

Table 3.6 Maximum predicted total conventional subsidence, tilt and curvature for road drainage culverts

Culvert	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})
SC-C1	40	< 0.5	< 0.01	< 0.01
SC-C2	625	3.5	0.05	0.05
SC-C3	700	2.5	0.02	0.05
TH-C2	30	< 0.5	< 0.01	< 0.01

The predicted profiles of total vertical subsidence, upsidence and closure along Rumker Gully are shown in Fig. 3.13. The locations of the road crossings are indicated in this figure.

The predicted valley related effects for Culvert TH-C2 are 50 mm upsidence and 80 mm closure. The predicted valley related effects for Culvert SC-C1 at Stonequarry Creek Road are 50 mm upsidence and closure.

The maximum predicted valley related effects for Culverts SC-C2 and SC-C3 along Stonequarry Creek Road at Carramar Close and Booyong Close are also 50 mm upsidence and closure.

Fig. 3.12 Culvert TH-C2 on Thirlmere Way west of LW W1 with inlet at top left, side inlet in top right and access cover to main culvert in bottom right

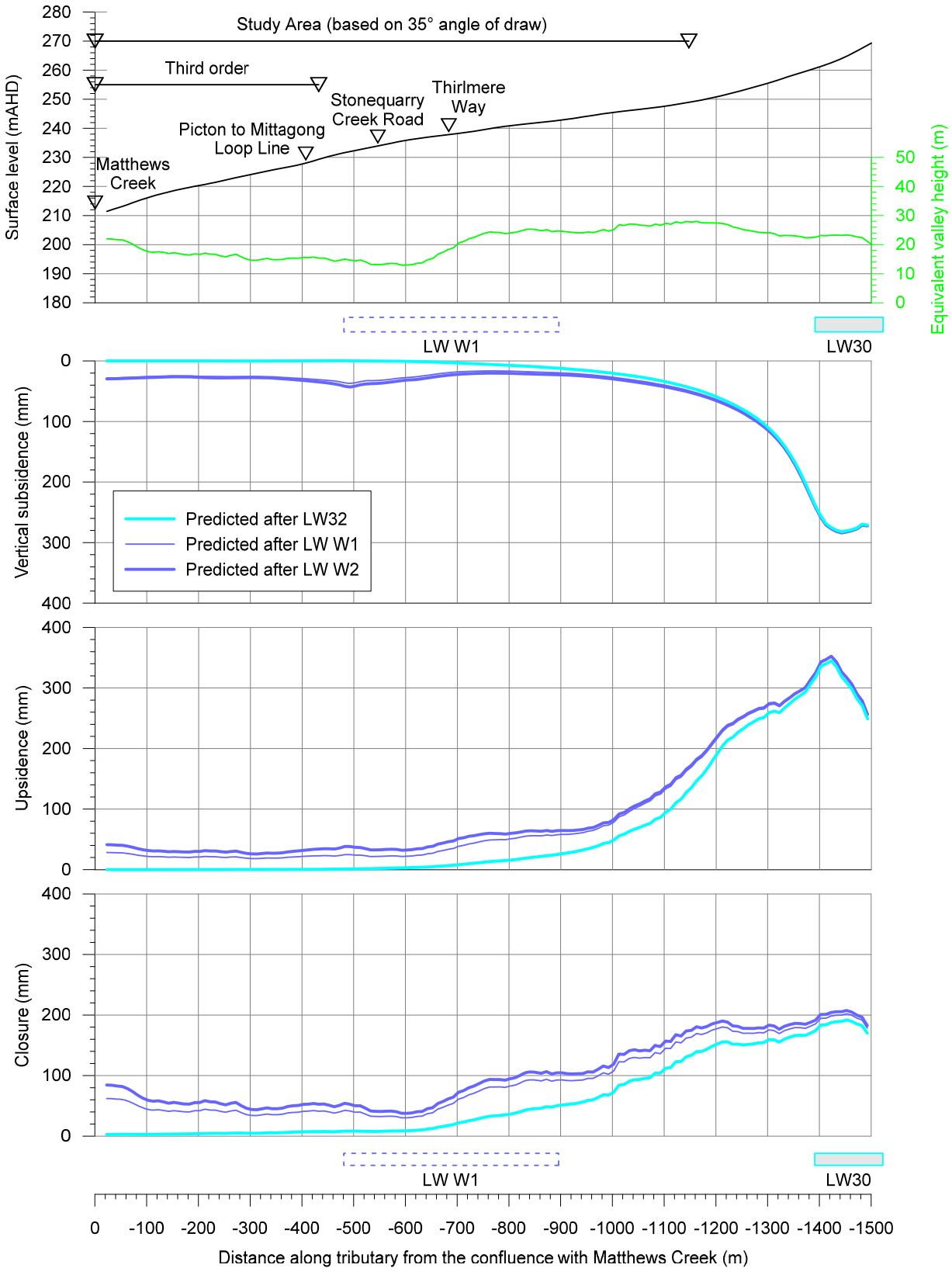

Fig. 3.13 Predicted profiles of total subsidence, upsidence and closure along Rumker Gully after the mining of LW W1-W2

3.8.1. Potential subsidence impacts on road drainage culverts

The maximum predicted tilt for Culverts SC-C1 to SC-C3 and TH-C2 is 3.5 mm/m (i.e. 0.35 %, or 1 in 285). It is unlikely that the mining-induced tilts would result in adverse impacts on the serviceability of these culverts, as the changes in grade are less than 1 %. If the flow of waters through any of the culverts were adversely affected, due to the extraction of LW W1-W2, these could be remediated by re-levelling the affected culverts.

The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the culverts or the headwalls. It is unlikely, however, that these movements would adversely impact on the stabilities or structural integrities of the culverts.

The drainage culverts are located along the tributaries and therefore could experience valley related effects. The drainage culverts are orientated along the alignments of the tributaries and, therefore, the upsidence and closure movements are orientated perpendicular the main axes of the culverts and unlikely to result in adverse impacts.

Previous experience of mining beneath culverts in the NSW coalfields, at similar depths of cover, indicates that the incidence of impacts is low. Impacts have generally been limited to cracking in the concrete headwalls which can be readily remediated. In some cases, however, cracking in the culvert pipes occurred which required the culverts to be replaced.

There have been no reports of impacts to road drainage culverts during the mining of Longwalls 22 to 32, with the exception of a culvert headwall on Bridge Street during the mining of Longwall 31. The low incidence of impacts is understandable as the culverts are typically constructed of jointed circular concrete pipes, which are able to tolerate substantial differential ground movements. While it is possible that the culverts could experience physical impacts such as cracking, the probability is considered low.

The potential impacts on the drainage culverts could be managed by visual inspection and, where required, any affected culverts can be repaired or replaced. Visual inspections of Culvert TH-C2 will be conducted by CCTV inspection and include the pipes that extend from Thirlmere Way to Culvert SC-C1 and the discharge into Rumker Gully downstream of Stonequarry Creek Road. If the stormwater pipes experience cracking due to mine subsidence movements, the pipes can be repaired in situ by inserting a liner or in the worst case, replacing the damaged pipe section.

Tahmoor Coal and Wollondilly Shire Council have developed and acted in accordance with an agreed risk management plan to manage potential impacts to roads drainage culverts during the mining of Longwalls 22 to 32. The management plans provide for visual monitoring of the culverts.

Survey lines will be installed along the local roads and monitoring data will be used to determine whether the culverts have experienced significant differential subsidence movements. If any adverse impacts were to occur as the result of mining, the affected culverts could be repaired or replaced.

3.9. Bridges

LW W1-W2 do not extract directly beneath any bridges, though some bridges are predicted to experience far field subsidence movements during the mining of LW W1-W2.

- Bridge Street Overbridge over Main Southern Railway
  This bridge has been mined directly beneath by Longwall 29 and has experienced additional subsidence movements during the extraction of Longwalls 30 to 32. This rail bridge is located 1.1 km south of the proposed LW W1. Risk control measures to manage potential impacts on this bridge are described in a separate management plan for the Main Southern Railway, which has been developed in consultation with the Australian Rail Track Corporation, ARTC. A copy of the management plan can be provided to Wollondilly Shire Council.

  Survey marks have been placed on the bridge abutments and the bridge deck on both sides. They have been regularly surveyed during the mining of Longwalls 30 to 32. The survey marks will be re-surveyed at the completion of LW W1 and LW W2.

- Thirlmere Way Rail Underbridge beneath Main Southern Railway
  This bridge is located approximately 625 metres to the eastern side of Longwall 32 and 850 metres from LW W2. It is predicted to experience less than 20 mm vertical subsidence and minor absolute and differential horizontal movements during the extraction of LW W1-W2. Risk control measures to manage potential impacts on this bridge are described in a separate management plan for the Main Southern Railway, which has been developed in consultation with ARTC. A copy of that management plan can be provided to Wollondilly Shire Council.

  Survey marks have been placed across the base of the bridge abutment on both sides. A ground survey mark has been installed adjacent to the bridge and its absolute position has been surveyed on a

monthly basis during the mining of Longwalls 31 and 32. The survey mark will continue to be surveyed on a monthly basis during the mining of LW W1 and LW W2.

- Connellan Crescent Overbridge over Main Southern Railway
  This bridge is located approximately 940 metres from Longwall 32 and 1,000 metres from LW W2. It is predicted to minor absolute and differential horizontal movements during the extraction of LW W1-W2. Risk control measures to manage potential impacts on this bridge are described in a separate management plan for the Main Southern Railway, which has been developed in consultation with ARTC. A copy of that management plan can be provided to Wollondilly Shire Council.

  Survey marks have been placed across the base of the bridge abutment on both sides. A ground survey mark has been installed adjacent to the bridge and its absolute position has been surveyed on a monthly basis during the mining of Longwalls 31 and 32. The survey mark will continue to be surveyed on a monthly basis during the mining of LW W1 and LW W2.

- Argyle Street Underbridge beneath Main Southern Railway
  This bridge is located approximately 1,980 metres to the eastern side of Longwall 32 and 1,250 metres from LW W2. It is predicted to minor absolute and differential horizontal movements during the extraction of LW W1-W2. Risk control measures to manage potential impacts on this bridge are described in a separate management plan for the Main Southern Railway, which has been developed in consultation with ARTC. A copy of that management plan can be provided to Wollondilly Shire Council.

  Survey marks have been placed across the base of the bridge abutment. A ground survey mark has been installed adjacent to the bridge and its absolute position has been surveyed on a monthly basis during the mining of Longwalls 31 and 32. The survey mark will continue to be surveyed on a monthly basis during the mining of LW W1 and LW W2.

- Victoria Road Bridge over Stonequarry Creek
  The bridge is owned by the Roads and Maritime Services (RMS) and is located approximately 1.25 km away from Longwall 32 and approximately 1.4 km away from LW W1-W2. Whilst it is extremely unlikely that the Bridge will experience mining-induced movements, it is located over a section of Stonequarry Creek that runs along the alignment of the Nepean Fault and may, therefore, experience minor absolute and differential horizontal movements during the extraction of LW W1-W2.

  Survey marks have been placed at the ends of the Bridge and at the base of the intermediate trussed piers on both sides. Ground survey marks have been installed at each end of the Bridge and their absolute position has been surveyed on a monthly basis during the mining of Longwalls 31 and 32. The absolute position of the Bridge is continuously monitored by a GNSS unit that is mounted near the eastern abutment. Monitoring will continue during the mining of LW W1 and LW W2.

- Remembrance Drive Road Bridge and Footbridge over Redbank Creek
  These bridges are located approximately 350 metres to the eastern side of Longwall 32 and is located 1,050 metres from LW W2. The road bridge is a two lane, reinforced precast concrete arch structure, of BEBO arch design, with precast concrete spandrel walls (JMA, 2018). The bridge is a clear single span of approximately 9 metres. The bridge surface is sealed with asphalt, and there is a steel guardrail crash barrier on each side.

  The adjacent footbridge over Redbank Creek is a separate structure, which has a single span of approximately 10 metres. The bridge is formed from reinforced pretensioned double T concrete bridge girders, supported on reinforced concrete plinths on rock (JMA, 2018). The balustrades are built from proprietary steel fence sections.

  Prior to the influence of Longwall 32, survey marks were installed at the base of the road bridge arch above the water line on both sides and on top of the bridge deck on both sides at mid-span, and along the top of the spandrel walls on both sides of the bridge at abutments and mid-span.

  The survey marks will be re-surveyed at the completion of LW W1 and LW W2. The bridges can be repaired in the unlikely event that impacts are observed.

- Abbotsford Bridge on Barkers Lodge Road over Stonequarry Creek
  The bridge is located approximately 1.1 km from LW W2. The road bridge is a two lane, reinforced concrete bridge. Whilst it is extremely unlikely that the Bridge will experience mining-induced movements, it is located over a section of Stonequarry Creek that runs along the alignment of geological structures associated with the Nepean Fault and may, therefore, experience minor absolute and differential horizontal movements during the extraction of LW W1-W2.

  Survey marks will be placed at the ends of the Bridge and at the base of the intermediate piers on both sides. A ground survey mark will be installed at the Bridge and its absolute position will be surveyed on a monthly basis during the mining of LW W1 and LW W2.

4.1. Infrastructure Management Group (IMG)

The Infrastructure Management Group (IMG) is responsible for taking the necessary actions required to manage the risks that are identified from monitoring the infrastructure and to ensure that the health and safety of people who may be present on public property or Wollondilly Shire Council property are not put at risk due to mine subsidence. The IMG develops and reviews this management plan, collects and analyses monitoring results, determines potential impacts and provides advice regarding appropriate actions. The members of the IMG are highlighted in Chapter 8.

4.2. Development and selection of risk control measures

Tahmoor Coal has developed and selected risk control measures in consultation, co-ordination and co-operation with the infrastructure owner in accordance with WHS legislation. In accordance with Clauses 35 and 36 in Part 3.1 of the Work Health and Safety regulation (2017) and the guidelines (MSO, 2017), a hierarchy of control measures has been considered and selected where reasonably practicable, using the following process:

1. Eliminate risks to health and safety so far as is reasonably practicable, and
2. If it is not reasonably practicable to eliminate risks to health and safety – minimise those risks so far as is reasonably practicable, by doing one or more of the following:
   (a) substituting (wholly or partly) the hazard giving rise to the risk with something that gives rise to a lesser risk
   (b) isolating the hazard from any person exposed to it,
   (c) implementing engineering controls.
3. If a risk then remains, minimise the remaining risk, so far as is reasonably practicable, by implementing administrative controls.
4. If a risk then remains, the duty holder must minimise the remaining risk, so far as is reasonably practicable, by ensuring the provision and use of suitable personal protective equipment.

A combination of the controls set out in this clause may be used to minimise risks, so far as is reasonably practicable, if a single control is not sufficient for the purpose.

There are primarily two different methods to control the risks of subsidence, namely:

- Method A – Selection of risk control measures to be implemented prior to the development of subsidence, (Items 1 and 2 above), and
- Method B – Selection of risk control measures to be implemented during the development of subsidence (Items 3 and 4 above).

Method A and B risk control measures are described in Section 4.3 to Section 4.6. Prior to selecting Method B risk control measures, Tahmoor Coking Coal Operations has investigated and confirmed that the measures are feasible and effective for the site-specific conditions during the extraction of LW W1-W2.

4.3. Selection of risk control measures for council infrastructure

Based on its own assessments, and the assessments by the structural engineer, and the geotechnical engineer, Tahmoor Coal considered Method A and Method B risk control measures, in accordance with the process described in Section 4.2.

Elimination

In this instance, no reasonably practicable controls could be identified that would eliminate the identified risks.

Substitution

In this instance, no reasonably practicable controls could be identified that will change the environment so the hazards could be substituted for hazards with a lesser risk.

Isolation

In this instance, no reasonably practicable controls could be identified to isolate a hazard from any person exposed to it.

Engineering Controls

In this instance, no reasonably practicable engineering controls could be identified to put in place a structure or item that prevents or minimises risks.

Administrative Controls

The following Administrative Controls were identified and selected that will put in place procedures on site to minimise the potential of impacts on the safety of people in relation to mining-induced damage to Wollondilly Shire Council infrastructure.

- Implementation of a Monitoring Plan and Trigger Action Response Plan (TARP)
  As described in the Management Plan, Tahmoor Coal and Wollondilly Shire Council has developed and implemented a management strategy of detecting early the development of potential adverse subsidence movements in the ground, so that contingency response measures can be implemented before impacts on the safety and serviceability develop. The TARP includes the following:
    - Local 2D surveys along local roads as shown in Drawing No. MSEC1045-00-01. These include Barkers Lodge Road, Thirlmere Way, Stonequarry Creek Road, Carramar Close, Attunga Close and Booyong Close.
    - Local 2D survey of changes in horizontal distance at six cross-sections across the Thirlmere Way road pavement where the steep slopes are present.
    - Visual inspections along streets within the active subsidence zone.
    - Surveys of road bridges as part of the far field monitoring network.
    - Baseline CCTV inspection of stormwater pipes along the alignment of Rumker Gully from Culvert TH-C2 to Culvert SC-C1.
    - Additional surveys and/or inspections, if triggered by monitoring results.
    - Repair of pavement, culverts or bridges if damage is observed.
    - Development of a traffic management plan for Thirlmere Way to manage traffic in the event that mining-induced damage develops along the road and requires repair.
    - As a last resort, temporary closure of Thirlmere Way if a hazard has been identified that involves potential serious injury or illness to a person or persons and cannot be controlled.

4.4. Monitoring measures

A number of monitoring measures will be undertaken during mining.

4.4.1. Ground Surveys along streets and centrelines of LW W1-W2

Survey lines will be installed along the centrelines of LW W1-W2, as shown in Drawing No. MSEC1045-00-01, subject to approval for access by landowners.

The purpose of the survey lines is to establish the general magnitude and shape of surface subsidence along the centrelines of LW W1-W2. The observed subsidence movements will be used to provide early subsidence information to inform Tahmoor Mine 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 will assist Tahmoor Mine 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 Mine as part of its ongoing review of subsidence effects on natural features.

The survey lines will consist of pegs spaced nominally every 20 metres, where access is available, noting that the centrelines pass through private property and building structures. Surveys will measure levels and horizontal distances between adjacent pegs.

Survey lines will be 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 pegs will be surveyed during the period of active subsidence of these features during the extraction of LW W1-W2.

The surveys measure changes in height and changes in horizontal distances between adjacent pegs

4.4.2. Far-field Surveys

Tahmoor Coal has installed a far-field monitoring survey network to investigate the potential for differential horizontal movements across the Nepean Fault.

- 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)
- Victoria Road 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 each of the Picton Viaduct and Victoria Road Bridge as these structures span the surface expression of the Nepean Fault.

An additional survey mark will be installed at Abbotsford Bridge on Barkers Lodge Road over Stonequarry Creek prior to the commencement of LW W1.

Absolute 3D surveys

Ground pegs have been installed at the above locations, with baseline absolute 3D surveys conducted on 19 December 2017. The pegs, including the new survey mark at Abbotsford Bridge will be surveyed in absolute 3D on a monthly basis during the extraction of LW W1 and LW W2.

Continuous GNSS monitoring

Global Navigation Satellite System (GNSS) units are fixed survey stations that continuously measure their absolute horizontal and vertical positions 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
- Victoria Road 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.

Baseline structure surveys

In addition to the far field monitoring program, baseline surveys were undertaken of piers and abutments of the structures during the mining of Longwall 31. Further details are described below. Additional surveys will be undertaken if absolute 3D surveys measure more than 25 mm of horizontal movement.

Thirlmere Way Underbridge

- 2D horizontal distance measurement from across the base of the abutments on both sides.

Connellan Crescent Overbridge

- 2D horizontal distance measurement from across the base of the abutments on both sides.

Argyle Street Underbridge

- 2D horizontal distance measurement from across the base of the abutments on both sides.

Picton Viaduct

- 2D horizontal distance measurement from end to end of the Picton Viaduct on both sides.
- Local 3D survey of survey marks located within line of sight from each end of the Viaduct to the base of the intermediate arches, on both sides.

Princes Street Overbridge

- 2D horizontal distance measurement from across the base of the abutments on both sides.

Victoria Road Bridge

- 2D horizontal distance measurement from end to end of the Bridge on both sides.
- Local 3D survey of survey marks located within line of sight from each end of the Bridge to the base of the intermediate trussed piers, on both sides.

4.4.3. Visual Inspections

Visual inspections will be undertaken during the period of active subsidence by an experienced inspector appointed by Tahmoor Coal who is familiar with mine subsidence impacts. The inspector will undertake the following:

- Visual inspections along streets within the active subsidence zone.
- Visual inspections of culverts.

4.4.4. CCTV inspection of culverts and stormwater pipes

A baseline CCTV inspection will be conducted of stormwater pipes along the alignment of Rumker Gully from Culvert TH-C2 to Culvert SC-C1, prior to the influence of LW W1. A follow up CCTV inspection will be conducted at the completion of LW W1 and LW W2.

Additional CCTV inspections can be undertaken if required based on observations of irregular movements in the area, or visual observations of impacts to the inlet and outlet points or structures overlying the pipework.

4.4.5. Structural Inspections

Structural inspections will be undertaken by John Matheson if required by the IMG.

4.4.6. Changes to Monitoring Frequencies

Monitoring frequencies will continue while Wollondilly Shire Council infrastructure is experiencing active subsidence due to the extraction of LW W1-W2. As a general guide, monitoring is likely to continue until the longwall has moved away from the property by a distance of approximately 450 metres. Monitoring, however, may continue if ongoing adverse impacts are observed.

4.5. Triggers and Responses

Trigger levels have been developed by Tahmoor Coal based on engineering assessments and consultation with Wollondilly Shire Council.

Trigger levels for each monitoring parameter are described in the risk control procedures in Table 4.1.

Immediate responses, if triggered by monitoring results, may include:

- Increase in survey and inspection frequencies if required by the IMG.
- Additional surveys and inspections.
- Repair of impacts that create a serious public safety hazard.
- In the worst case, restriction on entry, or access to, Wollondilly Shire Council infrastructure. This will be conducted in accordance with the Traffic Management Plan in consultation with Wollondilly Shire Council.

The risk control measures described in this Management Plan have been developed to ensure that the health and safety of people in the vicinity of council infrastructure are not put at risk due to mine subsidence. It is also an objective to avoid disruption to services, or if unavoidable, keep disruption and inconvenience to minimal levels.

With respect to the extraction of LW W1-W2, no potential hazards have been identified that could reasonably give rise to the need for an emergency response. Of the potential hazards identified in Section 3.6, only a bump in the road or a steep slope on Thirlmere Way could possibly result in severe impacts that could give rise to the need for an emergency response. The likelihood is considered extremely remote and would require substantial differential subsidence movements to develop before such an event occurs.

As discussed in Section 3.1, mine subsidence movements will develop gradually and there will be ample time to identify the development of potentially adverse differential subsidence movements early, consider

whether any additional management measures are required, and repair or adjust affected surface features, in close consultation with Wollondilly Shire Council.

As documented in Section 4.6, Tahmoor Coal and the IMG will review and assess monitoring reports and consider whether any additional management measures are required on a weekly basis. If potentially adverse differential subsidence movements are detected, it is anticipated that a focussed inspection will be undertaken in the affected area, and a decision will likely be made to increase the frequency of surveys and/or inspections. Additional management measures may also be implemented. It is therefore expected that, as a potential adverse situation escalates, Tahmoor Coal will be present on site on a more frequent basis to survey or inspect the affected site, and that Wollondilly Shire Council will be consulted on a more frequent basis.

Notwithstanding the above, if a hazard has been identified that involves potential serious injury or illness to a person or persons on public property or council infrastructure, and cannot be controlled, the immediate response is to remove people from the hazard. If such a situation is observed or is forecast to occur by either Tahmoor Coal or by people on public property, Tahmoor Coal and Wollondilly Shire Council will immediately meet and implement emergency procedures as detailed in the Traffic Management Plan.

4.6. Subsidence Impact Management Procedures

The procedures for the management of potential impacts to Wollondilly Shire Council infrastructure are provided in Table 4.1.

Table 4.1 Risk Control Procedures during the extraction of Tahmoor Coal LW W1-W2

INFRASTRUCTURE	HAZARD / IMPACT	RISK	TRIGGER	CONTROL PROCEDURE/S	FREQUENCY	BY WHOM?
Local roads	Cracking, heaving or stepping of the pavements or unsealed surfaces	Medium / Low	None	Conduct geotechnical assessment of slopes along Thirlmere Way	Complete	GHD Geotechnics
				Prepare traffic management plan for installation and measurement of survey pegs on Thirlmere Way to satisfaction of WSC	Complete	Tahmoor Coking Coal Operations
				Prepare traffic management plan for repair of pavements along Thirlmere Way to satisfaction of WSC	Complete	Tahmoor Coking Coal Operations
				2D survey lines along centrelines of LW W1-W2	Install and baseline survey above LW W1 prior to commencement of LW W1. Install and baseline survey above LW W2 prior to commencement of LW W2. Monthly survey for pegs located within active subsidence zone after the length of the extraction of LW W1 and LW W2 exceeds 200 metres. Full length at end of LW W1-W2	Tahmoor Coal (SMEC)
				Conduct baseline survey along Barkers Lodge Road	Install and baseline survey along Barkers Lodge Road prior to start of LW W1 End of LW W1 and LW W2.	Tahmoor Coal (SMEC)
				Conduct surveys along Stonequarry Creek Road *Survey extending to the south to include pegs within the active subsidence zone, then reducing extent to the north beyond active subsidence zone unless ongoing adverse movements are observed*	Install and baseline survey prior to 500m of extraction of LW W1. Weekly after 800 m of extraction of LWW1 and LW W2 until one month after completion of each LW unless ongoing adverse movements are observed	Tahmoor Coal (SMEC)
				Conduct surveys along Booyong Close	Install and baseline survey prior to 500m of extraction of LW W1. Weekly between 950 m of extraction and 1600 m of extraction of LW W1 and LW W2, unless ongoing adverse movements are observed	Tahmoor Coal (SMEC)
				Conduct surveys along Attunga Close	Install and baseline survey prior to 1000m of extraction of LW W1. Weekly after 1300 m of extraction until one month after completion of LW W1 and LW W2, unless ongoing adverse movements are observed	Tahmoor Coal (SMEC)
				Conduct surveys along Carramar Close	Install and baseline survey prior to 1000m of extraction of LW W1. Weekly after 1450 m of extraction until one month after completion of LW W1 and LW W2, unless ongoing adverse movements are observed	Tahmoor Coal (SMEC)
				Conduct ground monitoring and visual inspection of Thirlmere Way, verges and the steep slope adjacent longwall finishing end. Survey includes local 2D survey along Thirlmere Way and local 2D survey of changes in horizontal distance at six cross-sections across the Thirlmere Way road pavement.	Install and baseline survey new pegs prior to 1000m of extraction of LW W1. Weekly after 1650 m of extraction until one month after completion of LW W1 and LW W2 until one month after completion of each LW, unless ongoing adverse movements are observed	Tahmoor Coal (SMEC)
				Conduct visual inspections for surface deformations along local roads within active subsidence zone	Weekly within active subsidence zone, commencing after 800 m of extraction, until one month after completion of LW W1-W2	Tahmoor Coal
				Analyse and report results to IMG	Monthly from start of LW W1 and LW W2 Weekly after 800 m of extraction of LWW1 and LW W2 until one month after completion of each LW, unless ongoing adverse movements are observed	Tahmoor Coal
				IMG discuss results and consider whether any additional management measures are required	Monthly from start of LW W1 and LW W2 Weekly after 800 m of extraction of LWW1 and LW W2 until one month after completion of each LW, unless ongoing adverse movements are observed	Tahmoor Coal

INFRASTRUCTURE	HAZARD / IMPACT	RISK	TRIGGER	CONTROL PROCEDURE/S	FREQUENCY	BY WHOM?
Local roads	Cracking, heaving or stepping of the pavements or unsealed surfaces	Medium / Low	Impacts occur to pavement	Notify all stakeholders, including WSC, Tahmoor Coal, Subsidence Advisory NSW and Resources Regulator	Within one week	Tahmoor Coal / WSC
				IMG, Tahmoor Coal and WSC meet to decide whether any additional management measures are required, including: - increase in frequency of surveys and visual inspections - increase in monitoring reporting - repair pavement in accordance with Traffic Management Plans	As required (target within 48 hours)	Tahmoor Coal / WSC
				Repair road in consultation with WSC	As required	Tahmoor Coal
			A hazard has been identified that involves potential serious injury or illness to a person or persons on public property or, or WSC property and cannot be controlled	IMG, Tahmoor Coal and WSC meet to decide whether any additional management measures are required, including: - emergency evacuation of hazardous area - demarcation to prevent people entering hazardous area, including diversion of traffic	Immediately	Tahmoor Coal / WSC
				Notify SRG of trigger exceedence and any management decisions undertaken (incl Subsidence Advisory NSW, Resources Regulator)	Within 24 hours of decision	Tahmoor Coal
Drainage culverts	Cracking or spalling	Low	None	Conduct ground surveys along streets, which cross over the culverts	Refer local roads section	Tahmoor Coal (SMEC)
				CCTV inspection of culverts and stormwater pipes along the alignment of Rumker Gully from Culvert TH-C2 to Culvert SC-C1	Baseline prior to 1000m of extraction of LW W1 End of LW W1 and LW W2	Tahmoor Coal
				Conduct visual inspection for impacts	Visual inspection once a week of culverts within the active subsidence zone	Tahmoor Coal
			Impacts occur	Notify all stakeholders, including WSC, Tahmoor Coal, Subsidence Advisory NSW and Resources Regulator	Within one week	Tahmoor Coal / WSC
				Repair culvert in consultation with WSC	As required	Tahmoor Coal

INFRASTRUCTURE	HAZARD / IMPACT	RISK	TRIGGER	CONTROL PROCEDURE/S	FREQUENCY	BY WHOM?
Bridges	Damage to Bridges	Low	None	GNSS network on Main Southern Railway and Victoria Road Bridge over Stonequarry Creek	Continuous readings, with data averaged over 24 hours and recorded once per day	Tahmoor Coal
				Surveys at Thirlmere Way Rail Underbridge (89.326km)	Baseline measurement across abutments complete Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Surveys at Connellan Crescent Railway Overbridge (89.080km)	Baseline measurement across abutments complete Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Surveys at Argyle Street Rail Underbridge (86.13 km)	Baseline measurement across abutments complete Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Surveys at Princes Street Overbridge (85.17km)	Baseline measurement across abutments complete Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Surveys at Victoria Road Bridge over Stonequarry Creek	Baseline measurement of 2D horizontal distance from end to end of the Bridge complete Baseline local 3D survey of survey marks located at each end of the Bridge to the base of the intermediate trussed piers complete Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Surveys at Bridge Street Overbridge (91.000km)	Absolute 3D survey of installed surveys marks on bridge abutments and bridge deck End of LW W1 and LW W2	Tahmoor Coal
				Surveys at Remembrance Drive Road Bridge and Footbridge over Redbank Creek	Local 3D survey of installed survey marks on bridge abutments, bridge deck and spandrel walls End of LW W1 and LW W2	Tahmoor Coal
				Surveys at Abbotsford Bridge on Barkers Lodge Road over Stonequarry Creek	Install ground survey mark adjacent to bridge prior to start of LW W1 Monthly Absolute 3D survey during LW W1-W2	Tahmoor Coal
				Manage potential impacts on railway bridges in accordance with Railway Management Plan	-	Tahmoor Coal
			Impacts occur to WSC managed bridges	Notify all stakeholders, including Wollondilly Shire Council, Tahmoor Coking Coal Operations, Subsidence Advisory NSW (Mine Subsidence Board) and DRE	Within one week	Tahmoor Coking Coal Operations / WSC
				Conduct structural inspection	Within 48 hours	Tahmoor Coking Coal Operations
				Tahmoor Coking Coal Operations and WSC meet to decide whether any additional management measures are required, including: - increase in frequency of surveys and visual inspections - increase in monitoring reporting - repair bridge	As required (target within 48 hours)	Tahmoor Coking Coal Operations / WSC
				Repair bridges, pavement approaches, and/or footpath approaches in consultation with WSC	As required	Tahmoor Coal

5.1. Consultation, Co-operation and Co-ordination

Substantial consultation, co-operation and co-ordination has taken place between Tahmoor Coal and Wollondilly Shire Council prior to the development of this Management Plan, as detailed in Section 1.3.1.

The following procedures will be implemented during and after active subsidence of the property to ensure the continued effective consultation, co-operation and co-ordination of action with respect to subsidence between Tahmoor Coal and Wollondilly Shire Council.

- Reporting of observed impacts to Tahmoor Coal either during the weekly visual inspection or at any time directly to Tahmoor Coal.
- Distribution of monitoring reports, which will provide the following information on a weekly basis during active subsidence:
    - Position of longwall
    - Summary of management actions since last report;
    - Summary of consultation with Wollondilly Shire Council since last report;
    - Summary of observed or reported impacts, incidents, service difficulties, complaints;
    - Summary of subsidence development;
    - Summary of adequacy, quality and effectiveness of management process;
    - Any additional and/or outstanding management actions; and
    - Forecast whether there will be any subsidence impacts to the health and safety of people due to the continued extraction of LW W1-W2.
- Convening of meetings between Tahmoor Coal and Wollondilly Shire Council at any time as required, as discussed in Section 5.2.
- Arrangements to facilitate timely repairs, if required.
- Immediate contact between Tahmoor Coal and Wollondilly Shire Council if a mine subsidence induced hazard has been identified that involves potential serious injury or illness to a person or persons on public property or Wollondilly Shire Council property and may require emergency evacuation, entry restriction or suspension of work activities.

5.2. IMG Meetings

The IMG undertakes reviews and, as necessary, revises and improves the risk control measures to manage risks to health and safety, and potential impacts to infrastructure.

The reviews are undertaken weekly during the period of active subsidence based on the results of the weekly surveys and visual inspections and summarised in the monitoring reports, as described in Section 5.1.

The purpose of the reviews are to:

- Detect changes, including the early detection of potential impacts on health and safety and impacts to council infrastructure;
- Verify the risk assessments previously conducted;
- Ensure the effectiveness and reliability of risk control measures; and
- Support continual improvement and change management.

IMG meetings may be held between Tahmoor Coal and Wollondilly Shire Council for discussion and resolution of issues raised in the operation of the Management Plan. The frequency of IMG Meetings will be as agreed between Tahmoor Coal and Wollondilly Shire Council.

IMG Meetings will discuss any incidents reported in relation to the relevant infrastructure, the progress of mining, the degree of mine subsidence that has occurred, and comparisons between observed and predicted ground movements.

It will be the responsibility of the meeting representatives to determine whether the incidents reported are due to the impacts of mine subsidence, and what action will be taken in response.

In the event that a significant mine subsidence impact is observed, any party may call an emergency IMG Meeting, with one day's notice, to discuss proposed actions and to keep other parties informed of developments in the monitoring of the infrastructure.

6.0 AUDIT AND REVIEW

This Management Plan has been agreed between parties and can be reviewed and updated to continually improve the risk management systems based on audit, review and learnings from the development of subsidence during mining and manage changes in the nature, likelihood and consequence of subsidence hazards.

The review process will be conducted to achieve the following outcomes:

- Gain an improved understanding of subsidence hazards based on ongoing subsidence monitoring and reviews, additional investigations and assessments as necessary, ongoing verification of risk assessments previously conducted, ongoing verification of assumptions used during the subsidence hazard identification and risk assessment process, ongoing understanding of subsidence movements and identified geological structures at the mine.
- Revise risk control measures in response to an improved understanding of subsidence hazards.
- Gain feedback from stakeholders in relation to managing risks, including regular input from business or property owners.
- Ensure on-going detection of early warnings of changes from the results of risk assessments to facilitate corrective or proactive management actions or the commencement of emergency procedures in a timely manner.
- Ensure timely implementation of a contingency plan in the event that the implemented risk control measures are not effective.

Some examples where review may be applied include:

- Observation of greater impacts on surface features due to mine subsidence than was previously expected.
- Observation of fewer impacts or no impacts on surface features due to mine subsidence than was previously expected.
- Observation of significant variation between observed and predicted subsidence.

Should an audit of the Management Plan be required during that period, an auditor shall be appointed by Tahmoor Coal to review the operation of the Management Plan and report at the next scheduled Plan Review Meeting. The Management Plan shall be audited for compliance with ISO 31000, or alternative standard agreed with Wollondilly Shire Council.

7.0 RECORD KEEPING

Tahmoor Coal will keep and distribute minutes of any IMG Meeting.

8.0 CONTACT LIST

Organisation	Contact	Phone	Email / Mail
NSW Department of Planning and Environment – Resources Regulator	Phil Steuart	(02) 4063 6484	phil.steuart@planning.nsw.gov.au
	Gang Li	(02) 4063 6429 0409 227 986	gang.li@planning.nsw.gov.au
	Ray Ramage	(02) 4063 6485 0442 551 293	ray.ramage@planning.nsw.gov.au
Subsidence Advisory NSW	Matthew Montgomery	(02) 4677 1967 0425 275 564	Matthew.Montgomery@customerservice.nsw.gov.au
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777 0416 191 304	daryl@minesubsidence.com
SIMEC Mining Tahmoor Coal Acting Environment and Community Manager	David Talbert*	(02) 4640 0028 0414 905 565	David.Talbert@simecgfg.com
SIMEC Mining Tahmoor Coal Approvals Coordinator	April Hudson*	(02) 4640 0022 0466 380 992	April.Hudson@simecgfg.com
Wollondilly Shire Council Manager - Asset Management Coordinator	Nafizul Akash	(02) 4677 9651 (02) 4677 1100**	nafizul.akash@wollondilly.nsw.gov.au
Wollondilly Shire Council Manager – Infrastructure, Strategy and Planning	Mike Nelson*	(02) 4677 1180	mike.nelson@wollondilly.nsw.gov.au

* denotes member of Infrastructure Management Group

** denotes emergency number for Wollondilly Shire Council switchboard (available 24/7)

APPENDIX A. Drawings and Supporting Documentation

The following supporting documentation is provided in Appendix A.

Drawings

Drawing No.	*Description*	*Revision*
MSEC1045-00-01	Monitoring over LW W1-W2	03
MSEC945-00-02	Far field monitoring over Longwall 32	01
MSEC1045-02-01	Local roads, culverts and bridges	01

Supporting Documentation

Traffic Professionals (2018) Traffic management plans for Tahmoor Coal near 700 Thirlmere Way, Picton.

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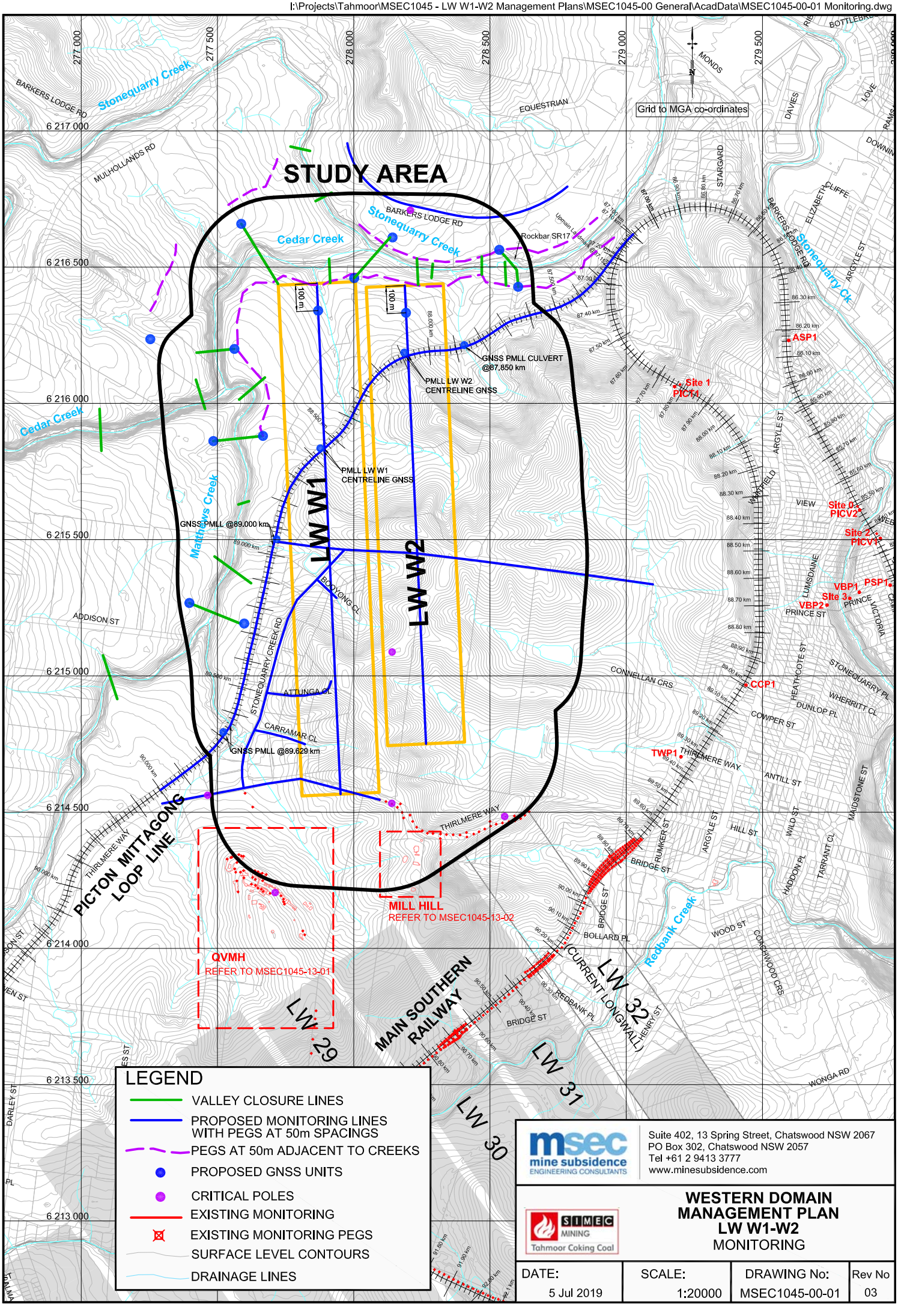

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SIMEC MINING Tahmoor Coking Coal

WESTERN DOMAIN MANAGEMENT PLAN LW W1-W2 MONITORING

DATE:	SCALE:	DRAWING No:	Rev No
5 Jul 2019	1:20000	MSEC1045-00-01	03

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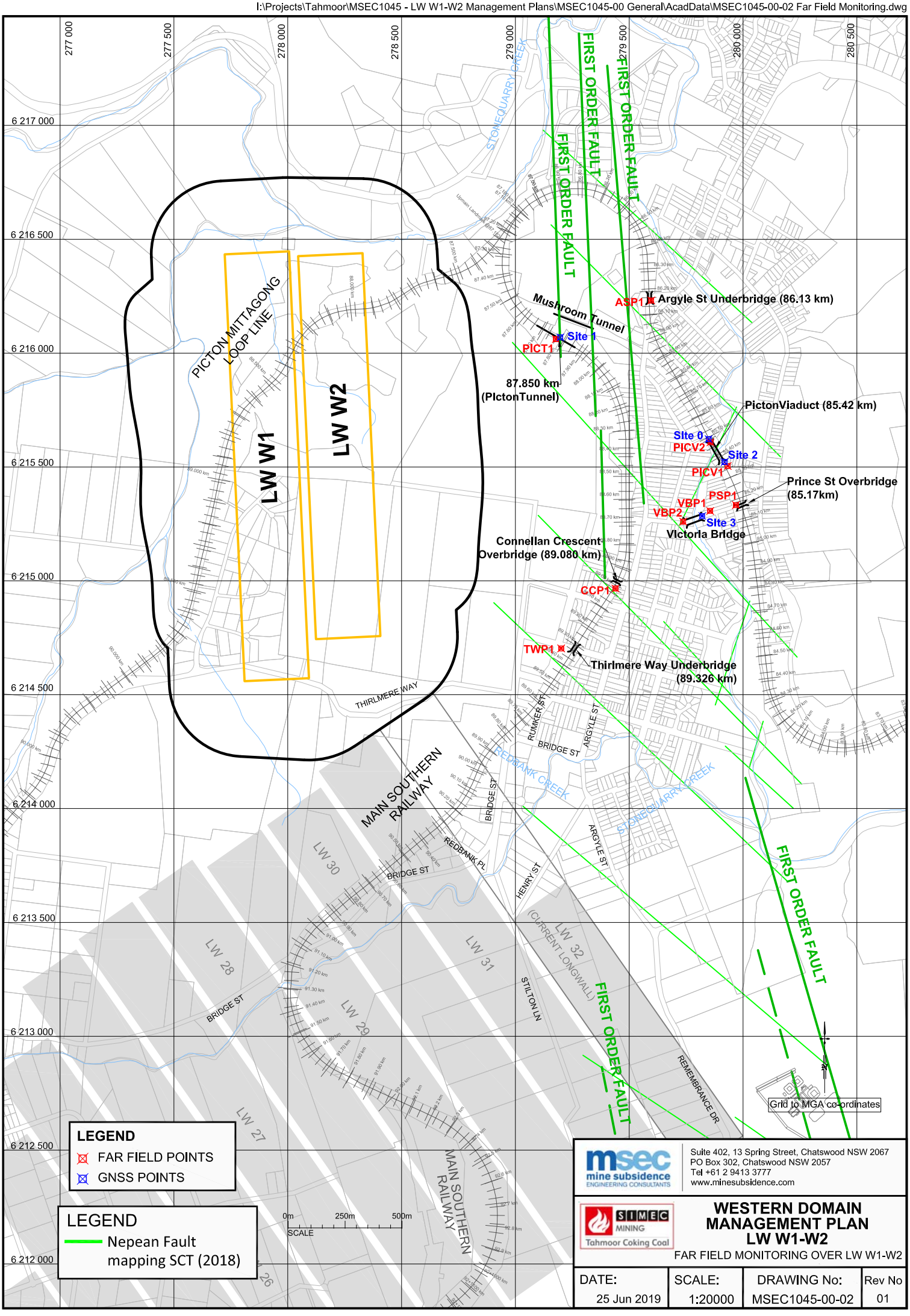

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SIMEC MINING Tahmoor Coking Coal

WESTERN DOMAIN MANAGEMENT PLAN LW W1-W2

FAR FIELD MONITORING OVER LW W1-W2

DATE:	SCALE:	DRAWING No:	Rev No
25 Jun 2019	1:20000	MSEC1045-00-02	01

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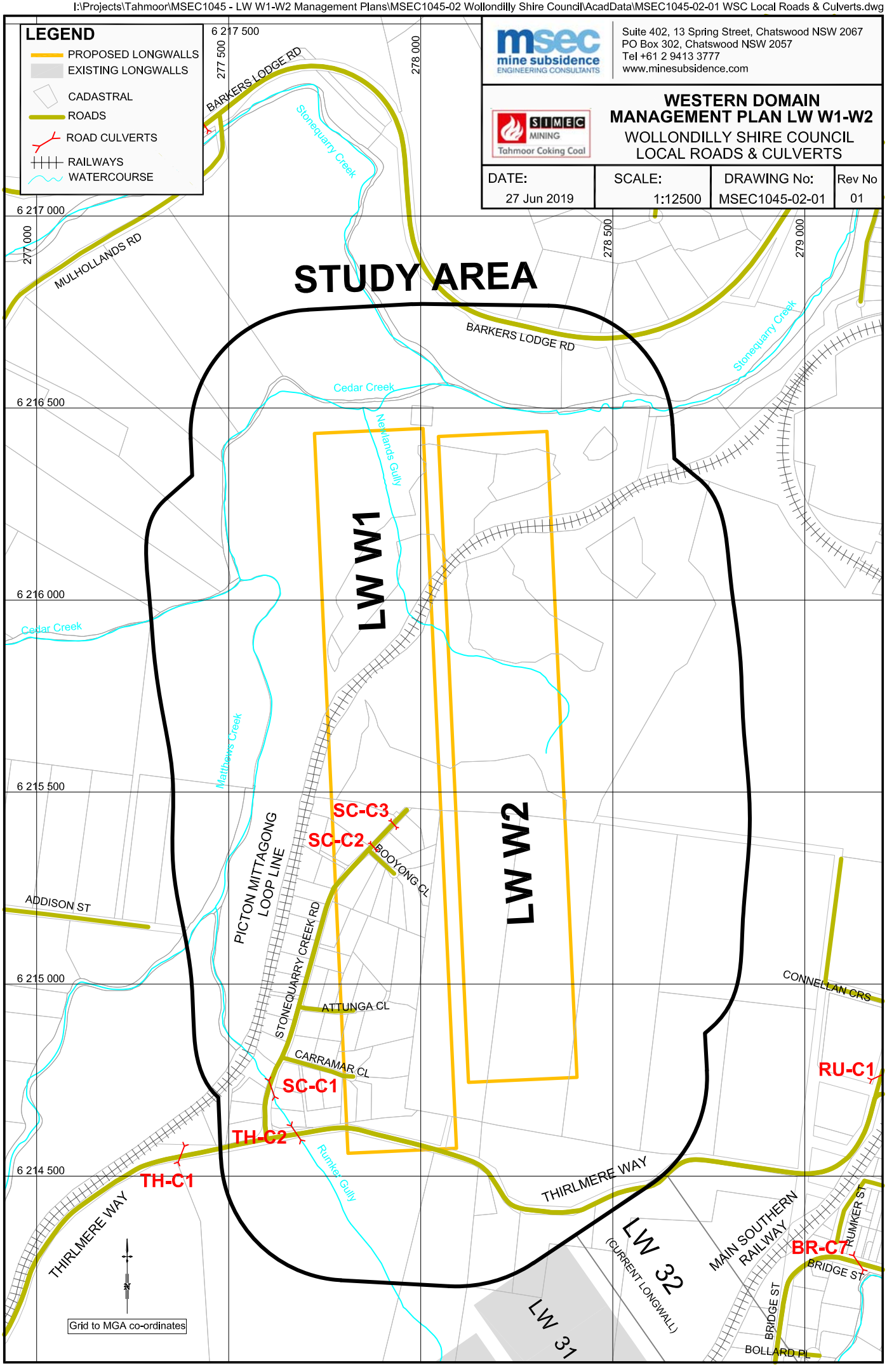

SIMEC

MEMBER OF GFG ALLIANCE

Tahmoor Coal Pty Ltd

RISK ASSESSMENT REPORT - INFRASTRUCTURE

Tahmoor North – Western Domain
Longwalls West 1 and West 2

Date Held: 26 March 2019

April 2019

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Document Control

DOCUMENT TITLE:	Tahmoor North – Western Domain LW W1-W2 – Infrastructure Risk Assessment
PUBLICATION DATE:	April 2019
DOCUMENT STATUS:	Final (Version 1)
PREPARED BY:	April Hudson Approvals Coordinator Tahmoor Coking Coal Operations – SIMEC Mining
APPROVED BY:	Ron Bush Environment and Community Manager Tahmoor Coking Coal Operations – SIMEC Mining

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1 Introduction

1.1 Background

Tahmoor Coal is located approximately 80 kilometres south-west of Sydney in the township of Tahmoor NSW. It is managed and operated by SIMEC Mining. Tahmoor Coal has previously mined 31 longwalls to the north and west of the mine's current pit top location. It is currently mining Longwall 32, in accordance with current Development Consent (DA 67/98) and Subsidence Management Plan Approval for the extraction of Longwall 32.

Tahmoor Coal proposes to extend underground coal mining to the north-west of the Main Southern Railway, which will include Longwalls West 1 to West 4 (**LW W1-W4**) at Picton (refer to **Figure 1-1**). Mining of Longwalls West 1 and West 2 (**LW W1-W2**) is expected to commence in November 2019, and first workings of development headings for LW W1 have commenced.

Under Condition 13H of the Development Consent (DA 67/980, as modified, an Extraction Plan is required for all second workings from LW W1 and subsequent longwalls. The first Extraction Plan to be prepared will cover LW W1-W1, which are located in the Tahmoor North Lease area. The Extraction Plans will be required to be approved by the NSW Department of Planning and Environment (**DPE**), and relevant Infrastructure Management Plans are required to be approved by the relevant infrastructure owners.

The Extraction Plan shall address the Study Area for LW W1-W2, which is comprised of both the predicted 20 mm Total Subsidence Contour and the 35° Angle of Draw Line (refer to **Figure 1-1**).

The Extraction Plan will provide detailed information on how the risks associated with mining under the Study Area will be managed by Tahmoor Coal during and following the extraction of LW W1-W2.

A Risk Assessment Workshop was held at the Administration Building at the Tahmoor Coking Coal Operations (**TCCO**) site on 26 March 2019 to determine the major infrastructure risks associated with LW W1-W2 that may impact on achieving timely approval for the commencement of LW W1-W2 extraction, as well as the completion of extraction of LW W1-W2.

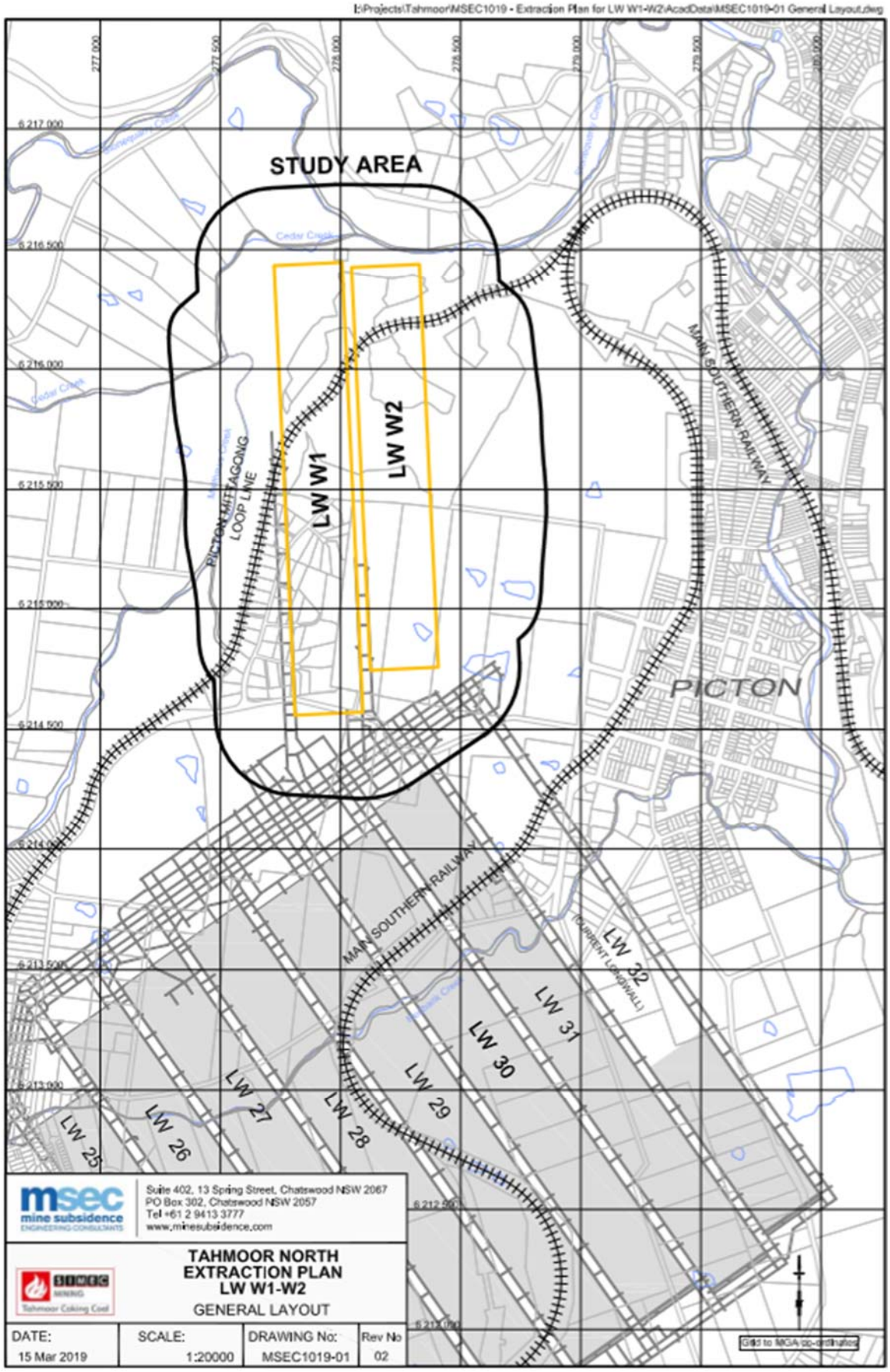


Figure 1-1 Study Area for LW W1-W2

1.2 Methodology

This risk assessment was completed using the Workplace Risk Assessment and Control methodology (**WRAC**).

It was compiled by a team of specialist personnel including:

- Compliance Officer and Risk Assessment Facilitator, Tahmoor Coal: Diana Harris;
- Environment and Community Manager, Tahmoor Coal: Ron Bush;
- Approvals Coordinator, Tahmoor Coal: April Hudson;
- Subsidence Engineer, MSEC: Daryl Kay;
- Structural Engineer, JMA Solutions: John Matheson; and
- Building Inspector, Building Inspection Services: Adam Walker.

The 12 step Risk Management process which forms part of the Tahmoor Coking Coal Operations Risk Management Standard has been adhered to in this risk assessment.

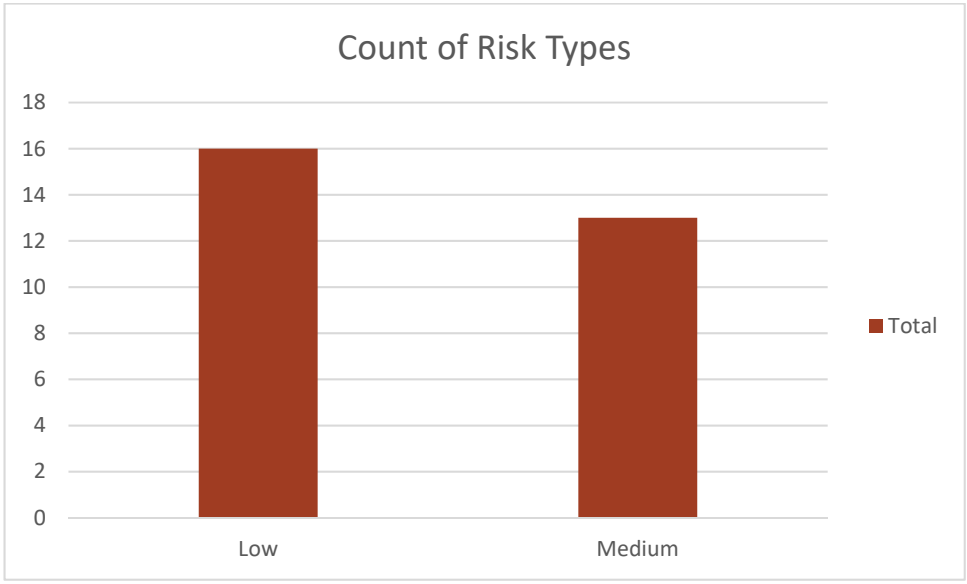
The risk matrix has been used to prioritise risk treatments.

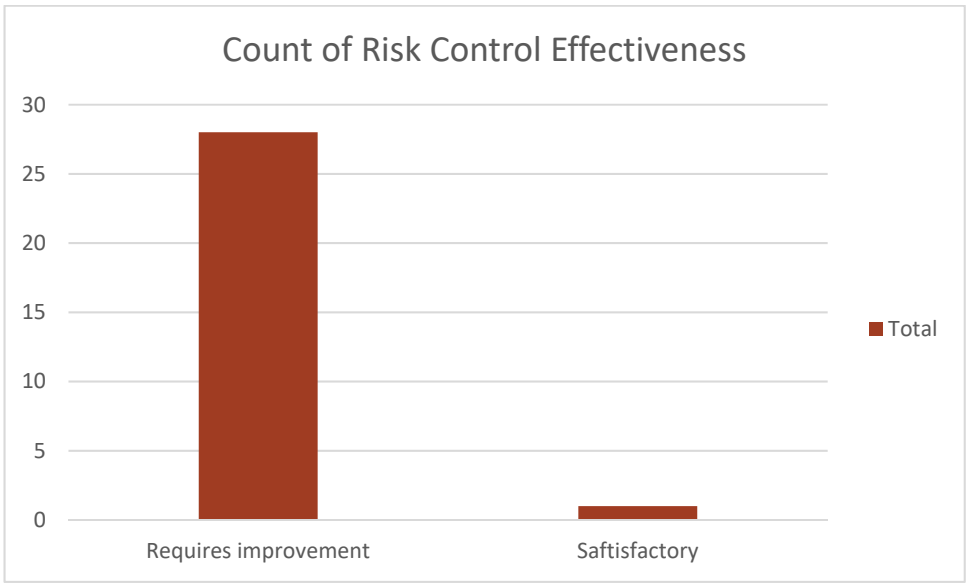
Prior to this risk assessment any previous risk assessments, safety alerts and High Potential Risk incidents have been sourced and put forward for consideration within the risk assessment workshop.

1.3 Outcome

This risk assessment identified a total of 29 risks / hazards (refer to **Figure 1-2**), which included:

- 13 medium risks and 16 low risks;
- One risk that was satisfactory and did not require any further risk control, and 28 risks that required further improvement;
- Risk consequences included:
    - Two risks with environmental impact consequences;
    - Seven risks with health and safety consequences; and
    - 20 risks with property damage consequences.





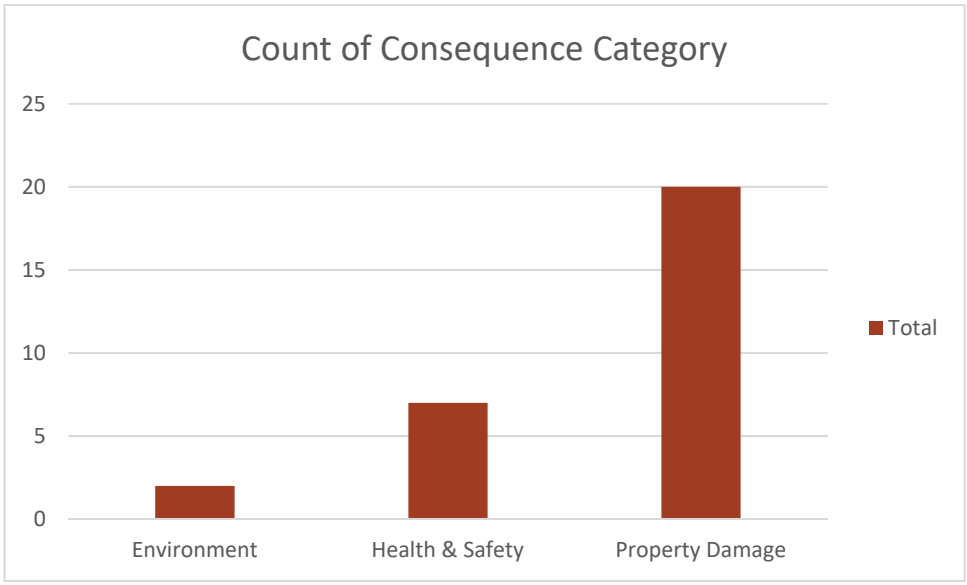


Figure 1-2 Graphs of Risk Type, Risk Control Effectiveness and Consequence Category

1.4 Further Actions

Further actions as identified in the Risk Assessment are identified in **Table 1-1**.

Table 1-1 Table of Further Actions

Treatment plans/tasks	Task Owner	Due Date
Develop Endeavour Energy Management Plan including TARP	April Hudson	10-Oct-2019
Endeavour Energy to complete Critical Poles Audit	April Hudson	10-Oct-2019
SMEC to complete survey of critical poles	April Hudson	10-Oct-2019
Building Inspection Services to complete baseline tilt measurement of poles	April Hudson	10-Oct-2019
Develop Sydney Water Potable Water Management Plan including TARP	April Hudson	10-Oct-2019
Develop Stonequarry Creek Estate Water Management Plan including TARP	April Hudson	10-Oct-2019
Develop Jemena Management Plan including TARP and contact details for Jemena	April Hudson	10-Oct-2019
Complete baseline gas detection survey (Macarthur Gas)	April Hudson	10-Oct-2019
Develop Telecommunications Management Plan including TARP	April Hudson	10-Oct-2019
Develop Wollondilly Shire Council Management Plan including TARP	April Hudson	10-Oct-2019
Develop traffic control plan for emergency repairs	April Hudson	10-Oct-2019
Develop Spatial Services Management Plan including TARP	April Hudson	10-Oct-2019
Notify Spatial Services via POSI application of predicted subsidence movements of the permanent survey control marks	Ron Bush	10-Oct-2019
Ongoing monitoring and review of far field monitoring network, including GNSS network	April Hudson	10-Oct-2019
Develop Built Structures Management Plan including TARP for emergency evacuation procedures	April Hudson	10-Oct-2019
Prepare QVMH Management Plan including TARP	April Hudson	10-Oct-2019
Consultation plan to be developed	Samantha Beresford	10-Oct-2019
Prepare Mill Hill Management Plan including TARP	April Hudson	10-Oct-2019

2 Objective

The purpose of the Risk Assessment was to:

- Ensure the required infrastructure management plans for the proposed longwalls are approved and in place in a timely manner to manage infrastructure impacts during mining;
- Ensure the safe and serviceable operation of all surface infrastructure and structures in the Study Area;
- Ensure that the health and safety of people who may be present in the Study Area are not put at risk due to mine subsidence; and
- Assist in the establishment of procedures to measure, monitor, control, mitigate and repair infrastructure in the Study Area.

The Risk Assessment will also be used to:

- Develop, review and improve the treatment plans / tasks identified as a result of the identified risks;
- Provide a basis to determine whether the identified risk management measures are sufficient to address the identified risks;
- Meet the statutory requirements of legislation and regulation that relate to impacts to infrastructure; and
- Identify those processes requiring a more detailed level of risk assessment due to the Potential Maximum Consequence (**PMC**) level of risk.

3 Context

3.1 Scope

The risk assessment considered the areas below:

- Management of infrastructure owned by Endeavour Energy (electrical), Sydney Water (potable water only), Stonequarry Creek Estate Sewerage Plant (sewer), Jemena (gas), Telstra (telecommunications), NBN (telecommunications), Wollondilly Shire Council (roads, culverts and bridges), Spatial Services (survey control marks);
- Impacts to rural properties and structures such as built structures, pools, septic tanks, and farm dams; and
- Historical heritage buildings including Queen Victoria Memorial Home and Mill Hill.

3.2 Internal Context

This risk assessment was conducted for the Environment and Community Department of Tahmoor Coal to help identify the risks to infrastructure associated with LW W1-W2.

The risk assessment was conducted in accordance with the Risk Management Standard, utilising a cross-section of site personnel, relevant civil works experts, and an internal facilitator.

3.3 External Context

The risk assessment process is completed to satisfy Tahmoor Coking Coals requirements in relation to WHS and in compliance to Mining regulations and conditions and is completed in consultation with key stakeholders.

Key Stakeholders include:

- Tahmoor Coking Coal management;
- NSW Department of Planning and Environment (Planning, Resources and Geoscience);
- Resources Regulator (Subsidence, Environment);
- NSW Office of Environment and Heritage;
- Subsidence Advisory NSW;
- NSW Environment Protection Authority;
- NSW Department of Primary Industries (Agriculture);
- Dam Safety Committee;
- Crown Lands Division;
- NSW Roads and Maritime Services;
- WaterNSW;
- NSW State Emergency Services;
- Wollondilly Shire Council;
- Other utility providers including Endeavour Energy (electrical), Sydney Water (potable water only), Stonequarry Creek Estate Sewerage Plant (sewer), Jemena (gas), Telstra (telecommunications), NBN (telecommunications), Wollondilly Shire Council (roads, culverts and bridges), Spatial Service (survey control marks);
- Heritage stakeholders; and
- Landowners.

The external context for this Risk Management Process included consideration of:

- NSW Department of Planning and Environment as the approver of the Extraction Plan;
- NSW *Work Health and Safety (Mines and Petroleum Sites) Regulations 2014*;
- AS/NZS ISO 31000:2009 Risk Management - Principles and Guidelines; and
- Risk Management Handbook for the Mining Industry (MDG1010).

3.4 Exclusions / Assumptions

The participants in the risk assessment agreed to the following exclusions:

- Community effects will be managed as per Tahmoor Coal procedures and EMS (dust, lighting and noise);
- A detailed risk assessment for rail operational risks associated with LW W1-W2 will be conducted separately; and
- A broad risk assessment focusing on approvals, environmental and general infrastructure risks has been completed for LW W1-W2 on 12 February 2019 (CMO ID 201902202). Consideration of infrastructure risks addressed in this previously completed risk assessment were excluded. These considerations included:
    - Infrastructure Owner do not approve Infrastructure Management Plan;
    - Failure to implement Infrastructure Management Plan actions;
    - Greater than predicted subsidence in Study Area;
    - Stress to landowner/business owner;
    - Formation of Community Action Group; and
    - Land owners do not sign Land Access Agreements.

The participants in the risk assessment agreed to the following assumptions:

- All plant and equipment is fit for purpose;
- Personnel are competent and authorised;
- Inspection systems are in place and effective;
- People (employees, contractors) do present themselves fit for work;
- The appropriate PPE is utilised where required; and
- Observations and learnings from Longwall 32.

4 Issue / Reason for Review

The risk assessment was completed to identify significant implications relating to approval, environmental and infrastructure risks, and to identify the controls necessary to effectively manage these risks.

5 Risk Analysis Method

5.1 Risk Management Standard

All risk assessments are conducted in accordance with Tahmoor Coking Coal Operations Risk Management Standard.

The Tahmoor Coking Coal Operations Risk Management Standard is based on the ***ISO31000:2009 Risk Management – Principles and Guidelines International Standard.***

5.2 Risk Management Process

The risk management process is set out in the 12 Steps Risk Management Process (refer to **Figure 5-1**).

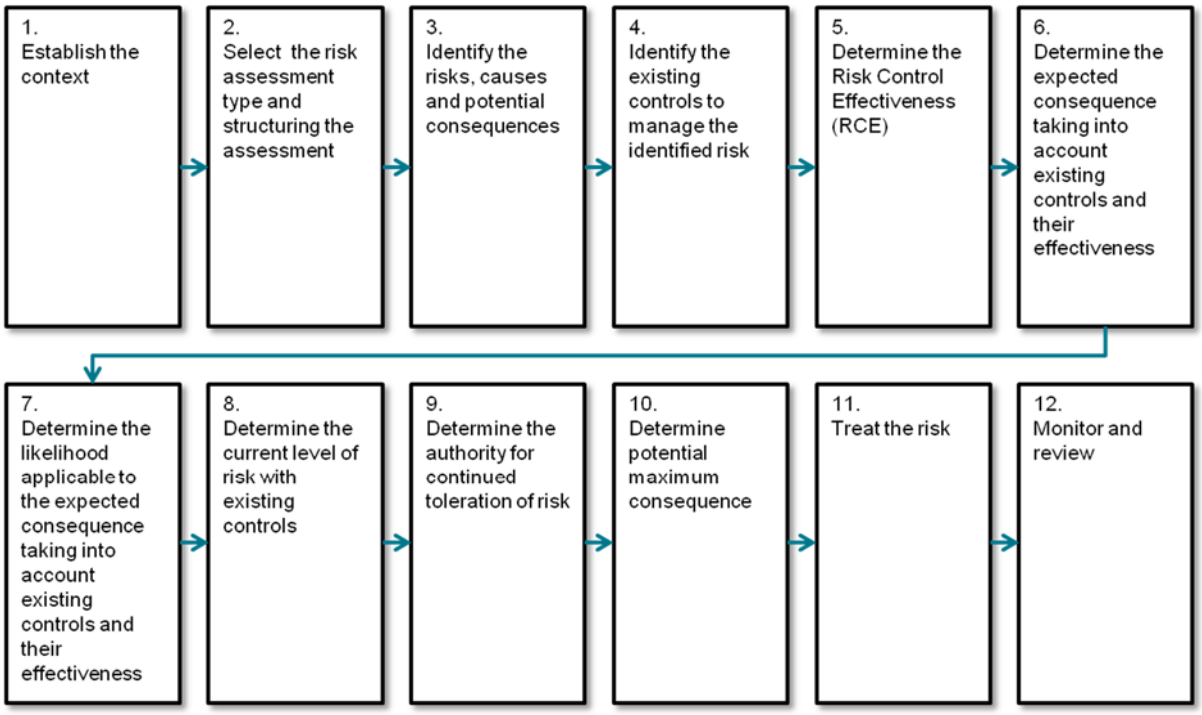


Figure 5-1 The 12 Steps Risk Management Process

5.3 Risk Matrix

The analyses of the risks identified in the workshop have undergone categorisation by the use of the risk matrix outlined within the Tahmoor Coking Coal Operations Risk Management Standard.

A copy of the risk matrix from Tahmoor Coking Coal Operations Risk Management Standard is provided in **Appendix A.**

5.4 Hierarchy of Controls

During the risk management process additional treatments and controls have been categorised using the hierarchy of controls table (refer to **Figure 5-2**).

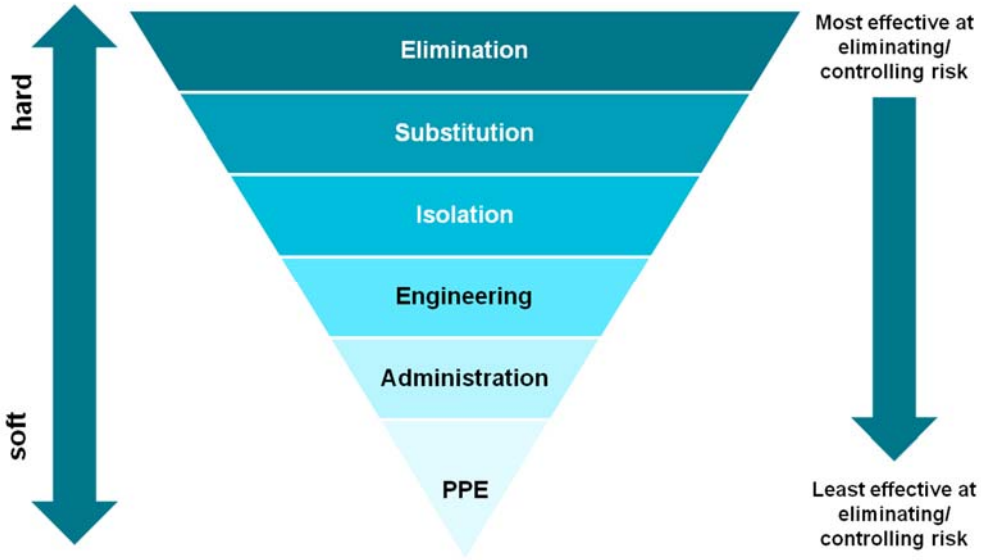


Figure 5-2 Hierarchy of Controls

5.5 Risk Assessment Team Members

Participating risk assessment team members are listed in **Table 5-1.**

Table 5-1 Participating Risk Assessment Team Members

Name	Position	Organisation	Qualifications	Related Experience
Ron Bush	Environment & Community Manager	SIMEC	BSc (Geol), GCEng, GD GW, MPlan, MProDev, MEng	30yrs
Diana Harris	Facilitator – Compliance Officer	SIMEC	Cert IV OH&S, G3 Risk Management	4yrs
April Hudson	Approvals Coordinator	SIMEC	B Env Sci (Hons)	9yrs
John Matheson	Structural Engineer	JMA Solutions	BE Struct (Hons)	20yrs
Daryl Kay	Subsidence Engineer	MSEC	BE, LLB	16yrs
Adam Walker	Building Inspector	Building Inspection Services	Cert IV Building	30yrs

A copy of the signed attendance sheet is attached in **Appendix B**.

6 Risk Assessment Register

The Risk Assessment Register is attached within **Appendix C**.

7 Treatment Plan

A treatment plan is provided in **Section 1.4.1**.

8 Risk Assessment Review Period

A review period for the risk assessment has not been identified.

Appendix A – Risk Matrix

RISK MATRIX

CONSEQUENCE [potential foreseeable outcome of the event]

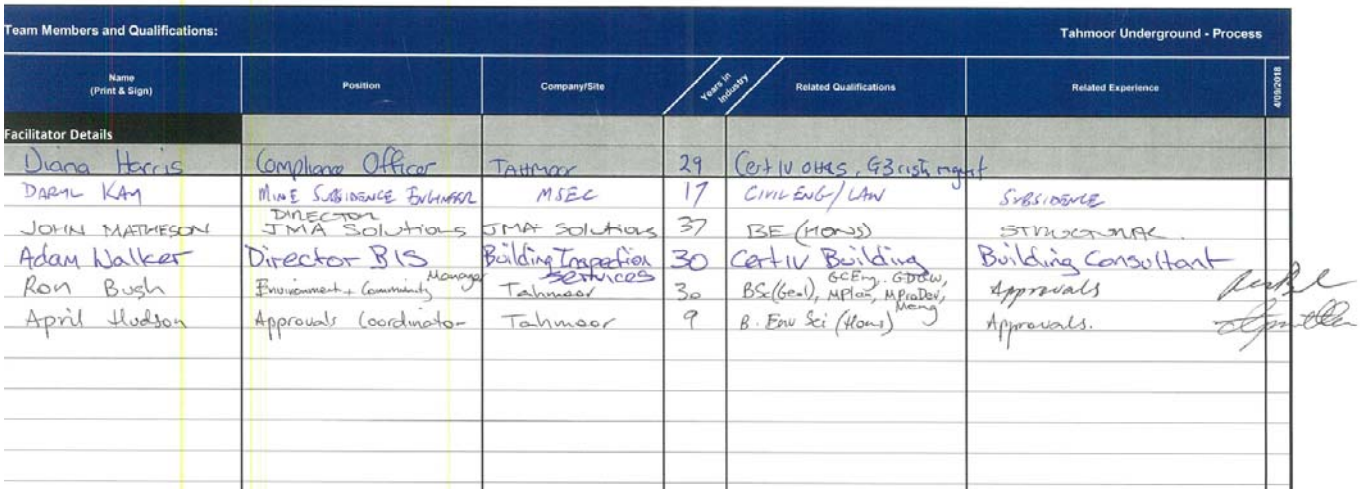
	Health & Safety	Environment	Financial Impact	Image & Reputation / Community	Legal & Compliance
5 Catastrophic	• Multiple fatalities (5 or more fatalities in a single incident) • Multiple cases (5 or more) of Permanent Damage Injuries or Diseases that result in permanent disabilities in a single incident	• Unconfined and widespread • Environmental damage or effect (permanent; >10 years) • Requires major remediation	• >$600M investment return • >$100M operating profit • >$20M property damage	• Loss of multiple major customers or large proportion of sales contracts • Sustained campaign by one or more international NGOs resulting in physical impact on the assets or loss of ability to operate • Security incident resulting in multiple fatalities or major equipment damage • Formal expression of significant dissatisfaction by government • Grievance from internal or external stakeholder alleging human rights violation resulting in multiple fatalities	• Major litigation / prosecution at SIMEC corporate level • Nationalisation / loss of licence to operate
4 Major	• Single incident resulting in: Less than 5 Fatalities • Permanent Damage Injury or Disease that results in a permanent disability- less than 5 cases in a single incident	• Long-term (2 to 10 years) impact • Requires significant remediation	• $60-600M investment return • $20-100M operating profit • $2-20M property damage	• Security/ stakeholder incident resulting in single loss of life or equipment damage • Grievance from internal or external stakeholder alleging human rights violation resulting in single fatality or serious injuries • Topic of broad societal concern and criticism • Negative media coverage at international level resulting in a Corporate statement within 24 hours • Investigation from government and/ or international (or high-profile) NGOs • Complaints from multiple "final" customers • Loss of major customer • Negative impact on share price	• Major litigation / prosecution at Department level
3 Moderate	• Lost Time Injury (LTI) • Lost Time Disease (LTD) • Permanent Disabling Injury (PDI) • Permanent Disabling Disease (PDD) • Single incident that results in multiple medical treatments	• Medium-term (<2 years) impact (typically within a year) • Requires moderate remediation	• $6-60M investment return • $2-20M operating profit • $200K-2M property damage	• Negative media coverage at national level over more than one day • Complaint from a "final" customer • Off-spec product • Local Stakeholder action resulting in national societal scrutiny	• Major litigation / prosecution at Operation level
2 Minor	• Medical Treatment Injury (MTI) • Medical Treatment Disease (MTD) • Restricted Work Injury (RWI) • Restricted Work Disease (RWD)	• Near source • Short-term impact (typically <week) • Requires minor remediation	• $600K-6M investment return • $200K-2M operating profit • $10-200K property damage	• Negative local/ regional media coverage • Complaint received from an internal or external stakeholder	• Regulation breaches resulting in fine or litigation
1 Negligible	• First Aid Injury (FAI) or illness (not considered disease or disorder)	• Near source and confined • No lasting environmental damage or effect (typically <day) • Requires minor or no remediation	• <$600K investment return • <$200K operating profit • <$10K property damage	• Negligible media interest	• Regulation breaches without fine or litigation

LIKELIHOOD [of the event occurring <u>with that consequence</u>]

Basis of Rating	E - Rare	D - Unlikely	C - Possible	B - Likely	A – Almost Certain
LIFETIME OR PROJECT OR TRIAL OR FIXED TIME PERIOD OR NEW PROCESS / PLANT / R&D	Unlikely to occur during a lifetime OR Very unlikely to occur OR No known occurrences in broader worldwide industry	Could occur about once during a lifetime OR More likely <u>NOT</u> to occur than to occur OR Has occurred at least once in broader worldwide industry	Could occur more than once during a lifetime OR As likely to occur as not to occur OR Has occurred at least once in the mining / commodities trading industries	May occur about once per year OR More likely to occur than not occur OR Has occurred at least once within Tahmoor Mine	May occur several times per year OR Expected to occur OR Has occurred several times within Tahmoor Mine
5 Catastrophic	**15 (M)**	**19 (H)**	**22 (H)**	**24 (H)**	**25 (H)**
4 Major	**10 (M)**	**14 (M)**	**18 (H)**	**21 (H)**	**23 (H)**
3 Moderate	**6 (L)**	**9 (M)**	**13 (M)**	**17 (H)**	**20 (H)**
2 Minor	**3 (L)**	**5 (L)**	**8 (M)**	**12 (M)**	**16 (M)**
1 Negligible	**1 (L)**	**2 (L)**	**4 (L)**	**7 (M)**	**11 (M)**

Consequence Category	Consequence Type	Ownership	Action
Cat. 5	**Catastrophic Hazard**	Department / Functional / Operational / Asset Leadership	• Quantitative or semi-quantitative risk assessment required. • Capital expenditure will be justified to achieve ALARP ('As Low As Reasonably Practicable'). • Catastrophic Hazard Management Plans (CHMP) must be implemented where practical, Crisis Management Plans (CMP) tested and Catastrophic Event Recovery Plans (CERP) developed.
Cat. 4 (Health & Safety consequence)	**Fatal Hazard**	Department / Functional / Operational / Asset Leadership	• Fatal Hazard Protocols or appropriate management plans must be applied. • Capital expenditure will be justified to achieve ALARP.
Risk Rank	**Risk Rating**	**Ownership**	**Action**
17 to 25	**High Risk**	Department / Functional / Operational / Asset Leadership	• Install additional HARD and SOFT controls to achieve ALARP. • Capital expenditure will be justified to achieve ALARP.
7 to 16	**Medium Risk**	Operational / Asset Leadership	• install additional HARD and SOFT controls if necessary to achieve ALARP. • Capital expenditure may be justified.
1 to 6	**Low Risk**	Operational / Asset Leadership	• Install additional controls if necessary to achieve ALARP. • Capital expenditure is not usually justified.

Appendix B – Risk Assessment Attendance Sheet



Team Members and Qualifications: Tahmoor Underground - Process

Name (Print & Sign)	Position	Company/Site	Years in Industry	Related Qualifications	Related Experience	4/05/2018
Facilitator Details						
Diana Harris	Compliance Officer	Tahmoor	29	Cert IV OHES, G3 risk mgmt		
DARYL KAM	MINE SUBSIDENCE ENGINEER	MSEC	17	CIVIL ENG/LAW	SUBSIDENCE	
JOHN MATHESON	DIRECTOR JMA Solutions	JMA Solutions	37	BE (Mons)	STRUCTURAL	
Adam Walker	Director BIS	Building Inspection Services	30	Cert IV Building	Building Consultant	
Ron Bush	Environment + Community Manager	Tahmoor	30	BSc(Geol), GCEng. GDCW, MPlan, MPraDev, Mang	Approvals	
April Hudson	Approvals Coordinator	Tahmoor	9	B. Env Sci (Hons)	Approvals.	

Appendix C – Risk Assessment Register

Environmental Risk Assessment: Tahmoor Underground - Extraction Plan LW W1-W2 - Infrastructure

	Step 2: Assess Type; Key Elements-These change depending on TYPE of Risk Assessment			Step 3: Identify the risks, causes and potential consequences				Step 4: Identify the existing controls to manage the identified risks			Step 5: Determine RCE	Steps 6, 7 & 8: Determine the Expected Consequence / Likelihood applicable to the Expected Consequence / Current level of risk				Step 10: PMC		Step 11: Treat the Risks			
☑ Appendix B Site	Type of Risk Assessment	Key Element (CURA Context/Categ ory)	Sub Key Element (If applicable)	Risk Description - Something happens.....	Consequence - resulting in:	Causes - Caused by	Risk Owner	Existing Control Description	Control Owner (Contact)	Fatal Hazard Protocol (as applicable)	Risk Control Effectiveness	Expected Consequence Category	Expected Risk Consequence	Risk Likelihood	Current Risk Rating	Potential Maximum Consequence	Potential Maximum Category	Treatment plans/tasks (Description)	Task Owner	Due Date	Comments
Tahmoor Underground	Environmental		Council Infrastructure	Minor cracking or heaving of pavement, kerbs and gutters	Slight damage to road, requiring repair. Reduced maintenance life	Subsidence		Wollondilly Shire Council Management Plan for LW W1-W2 to be prepared and will contain the following controls to manage subsidence (as per previous Management Plans for LW32) (AC): * Ground survey along streets * Visual inspection - weekly * TARP including repair of road, traffic control if required * Analysis and reporting * Consultation, coordination and cooperation with Wollondilly Shire Council			2	Property Damage	2	B	12	2	Property Damage	Develop Wollondilly Shire Council Management Plan including TARP	April Hudson	10-Oct-19	
Tahmoor Underground	Environmental		Council Infrastructure	Major cracking or heaving of pavement, kerbs and gutters	Extensive damage to road, requiring emergency repair and extension rehabilitation	Subsidence		Wollondilly Shire Council Management Plan for LW W1-W2 to be prepared and will contain the following controls to manage subsidence (as per previous Management Plans for LW32) (AC): * Ground survey along streets * Visual inspection - weekly * TARP including repair of road, traffic control if required * Analysis and reporting * Consultation, coordination and cooperation with Wollondilly Shire Council			2	Property Damage	3	D	9	3	Property Damage	Develop Wollondilly Shire Council Management Plan including TARP	April Hudson	10-Oct-19	
Tahmoor Underground	Environmental		Council Infrastructure	Slope instability causing loss of support to road	Tension cracking in road surface requiring repair or damage to roadway barriers (Tension to cables)	Subsidence		Geotechnical assessment conducted for LW 32 (EC) Traffic management plan for any work on Thirlmere Way to satisfaction of WSC (AC) Wollondilly Shire Council Management Plan for LW W1-W2 to be prepared and will contain the following controls to manage subsidence (as per previous Management Plans for LW32) (AC): * Ground survey along streets * Visual inspection - weekly * TARP including repair of road, traffic control if required * Analysis and reporting * Consultation, coordination and cooperation with Wollondilly Shire Council			2	Health & Safety	2	D	5	2	Health & Safety	Develop Wollondilly Shire Council Management Plan including TARP	April Hudson	10-Oct-19	
Tahmoor Underground	Environmental		Council Infrastructure	Damage to bridges	Not deemed a risk as no bridges in study area																
Tahmoor Underground	Environmental		Council Infrastructure	Damage to culverts and stormwater infrastructure	Reduced maintenance life; sealing / localised repair or loss of serviceability requiring emergency repair and/or replacement of culverts	Subsidence		Wollondilly Shire Council Management Plan for LW W1-W2 to be prepared and will contain the following controls to manage subsidence (as per previous Management Plans for LW32) (AC): * Ground survey along streets * Visual inspection - weekly * TARP including repair of road, traffic control if required * Analysis and reporting * Consultation, coordination and cooperation with Wollondilly Shire Council			2	Property Damage	2	D	5	2	Property Damage	Develop Wollondilly Shire Council Management Plan including TARP	April Hudson	10-Oct-19	
	5			5	5	Subtotal CountA (ignoring hidden values)					4				4	4					
Tahmoor Underground	Broad Brush														#N/A						
Tahmoor Underground	Life of Mine														#N/A						
Tahmoor Underground	Business																				
Tahmoor Underground	Major Project														#N/A						
Tahmoor Underground	Environmental/Health/Process														#N/A						
Tahmoor Underground	Equipment														#N/A						

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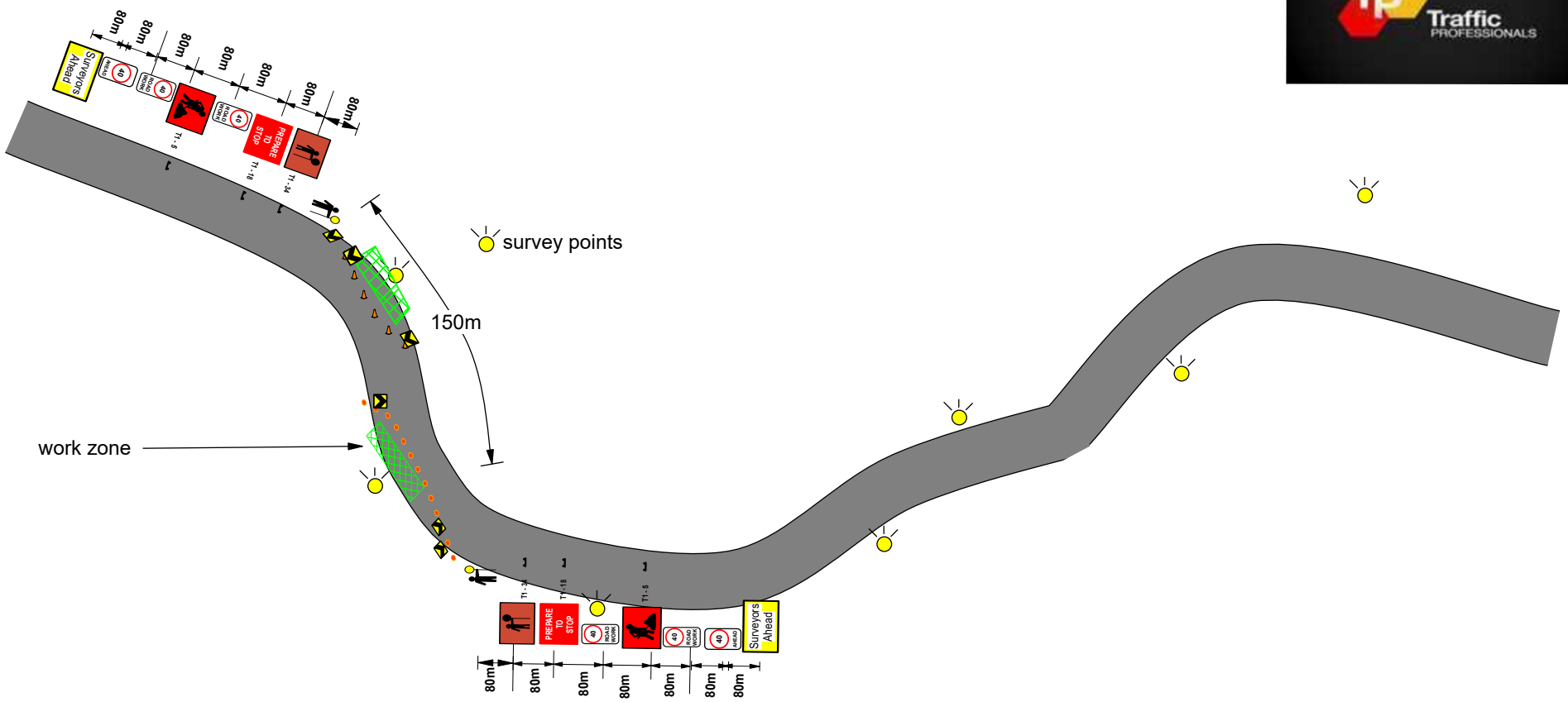

Date: 26.02.18 **Author:** David Del Tufo #36366734 EXP 29/11/19 **Project:** Tahmoor Coal - 700 Thirlmere Way, Picton

Comments:

2 Lane - 2 way- Closure of one lane - Short Term . Modified TCP 83

TCP compliant with RMS TCAWS 2010 and AS 1742.3. Sign size A & B. Delineation of traffic cones is 3m Taper and 10m workzone.

1. Existing speed at 60 and 80km/hr. Work zone approx 300m.
2. See Traffic Control at Work Sites, Section 3.2.1, Duplication of signs. Workers within 1.2m of live traffic.
3. Works are for marking survey points, installing survey pegs and maintenance of survey pegs.
3. Multiple sites to set up. Sign setups are not to scale.

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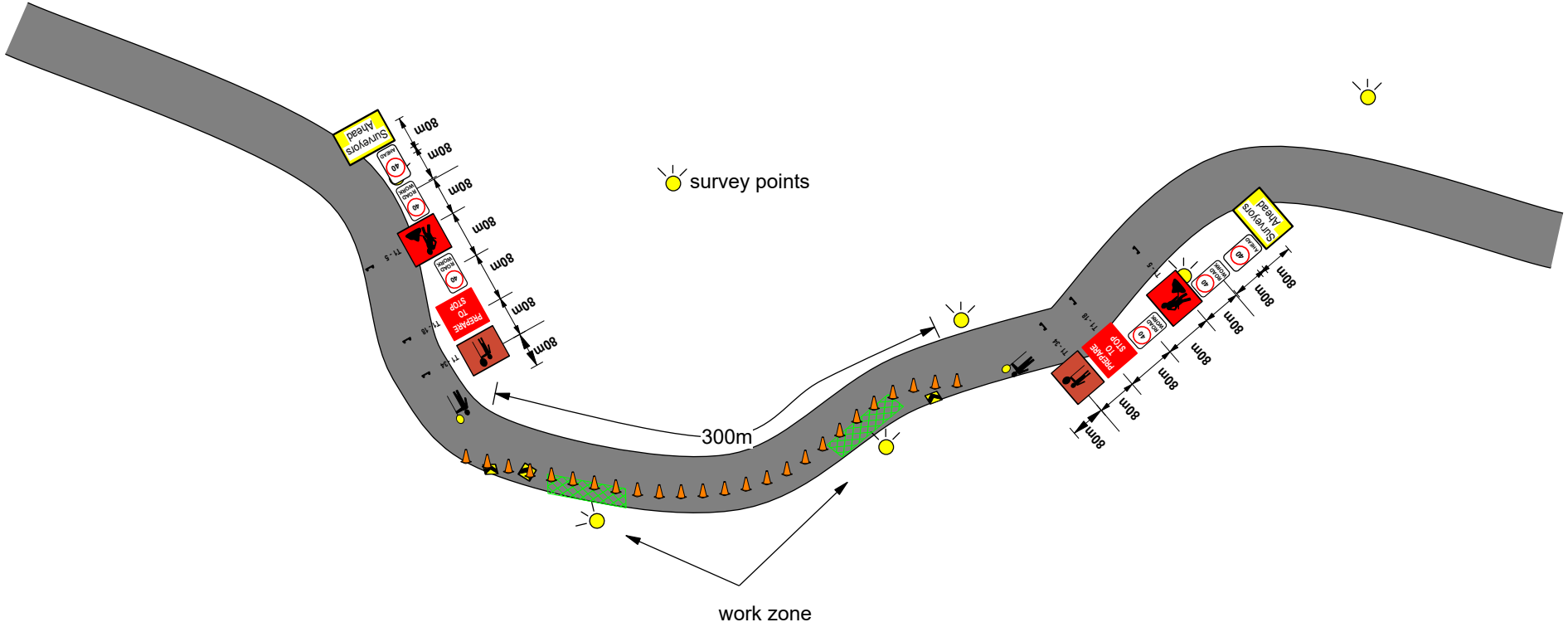

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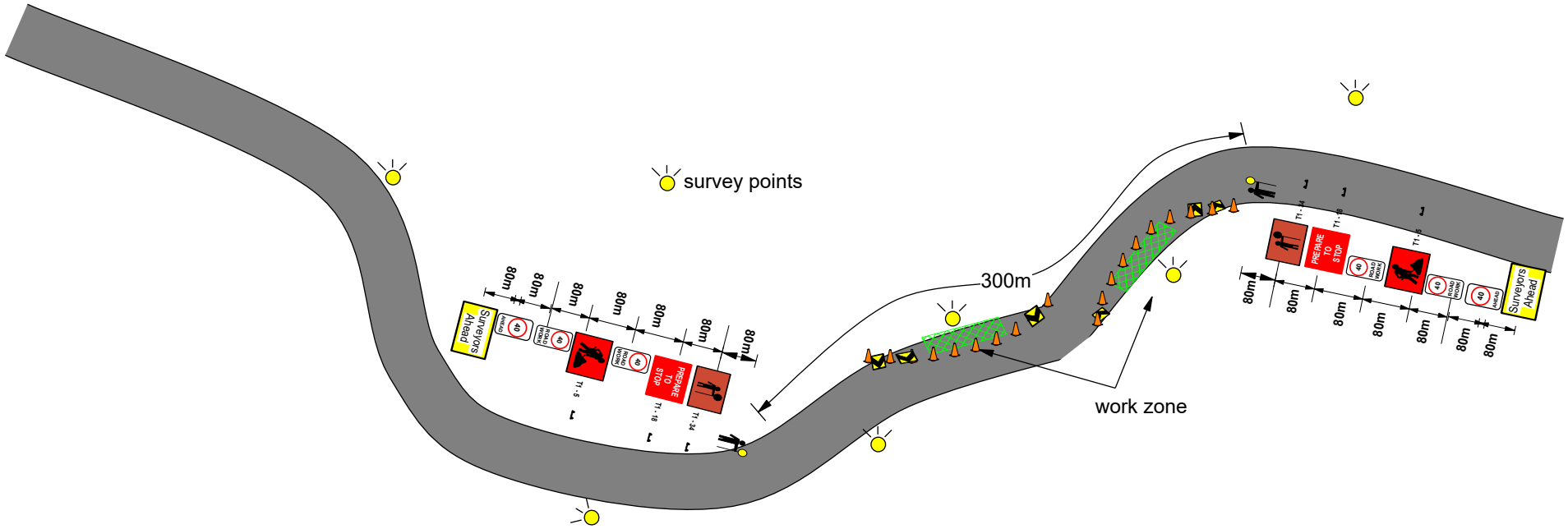

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