mine subsidence ENGINEERING CONSULTANTS

TAHMOOR UNDERGROUND
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GLENCORE:

Tahmoor Colliery - Longwalls 28 to 30

Management Plan for Potential Impacts to Built Structures

AUTHORISATION OF MANAGEMENT PLAN

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Date:	8 April 2014

DOCUMENT REGISTER

Date	Report No.	Rev	Comments
Mar-06	MSEC286-10	A	Draft for SMP Application
Aug-06	MSEC286-10	B	Complete for LW24B
May-08	MSEC286-10	C	Amended to include additional management measures for LW24A
Sep-08	MSEC286-10	D	Amended to include additional management measures for LW25 and LW26 Combined with public amenities and commercial establishments
Feb-11	MSEC446-12	A	Updated for LW26
Sep-12	MSEC567-12	A	Updated for LW27
Nov-12	MSEC567-12	B	Updated to include farm dams
Nov-12	MSEC567-12	C	Updated draft following feedback from DTIRIS
Nov-12	MSEC567-12	D	Final for Longwall 27
Mar-14	MSEC646-12	A	Updated for Longwalls 28 to 30

References:-

AS/NZS 4360:1999 Risk Management

MSEC, (2009). *Tahmoor Colliery Longwalls 27 to 30 - The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Items of Surface Infrastructure due to mining Longwalls 27 to 30 at Tahmoor Colliery in support of the SMP Application.* Mine Subsidence Engineering Consultants, Report No. MSEC355, Revision B, July 2009.

MSEC, (2013). *Tahmoor Colliery Longwalls 29 and 30 – The Effects of the Proposed Modified Commencing Ends of Longwalls 29 and 30 at Tahmoor Colliery on the Subsidence Predictions and Impact Assessments.* Mine Subsidence Engineering Consultants, Report No. MSEC645, 2013.

Gale, W. and Sheppard, I. (2011). *Investigation into Abnormal Increased Subsidence above Longwall Panels at Tahmoor Colliery*. Mine Subsidence Technological Society, Proceedings of the 8th Triennial Conference on Mine Subsidence, May 2011.

JMA (2014). Review of LW28-LW30 Subsidence Management. John Matheson & Associates, Report No. R0234, Rev 1, March 2014.

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Drawings

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

1.1. Introduction

Tahmoor Colliery is located approximately 80 kilometres south west of Sydney in the township of Tahmoor NSW. It is managed and operated by Glencore. Tahmoor Colliery has previously mined 26 longwalls to the north and west of the mine's current location. It is currently mining Longwall 27.

Longwalls 28 to 30 are a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panels are located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north.

A portion of Longwall 28 is located beneath the urban area of Tahmoor. Structures are directly above the commencing end of Longwall 28. A small number of structures are located directly above Longwalls 29 and 30.

Tahmoor Colliery's mine plan has changed since the Management Plan for Longwall 27 was prepared, in that Longwalls 29 and 30 have been shortened by approximately 250 metres. This represents a significant change for a small number of structures near the commencing ends of Longwalls 29 and 30, as subsidence has been substantially reduced.

The location of Longwalls 28 to 30 relative to structures is shown in Drawing No. MSEC646-12-01. A summary of the dimensions of these longwalls is provided in Table 1.1.

Table 1.1 Longwall Dimensions

Longwall	Overall Void Length Including Installation Heading (m)	Overall Void Width Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
Longwall 28	2630	283	39
Longwall 29	2321	283	39
Longwall 30	2321	283	39

As at March 2014, a total of 1542 houses, public amenities and commercial and business establishments have experienced subsidence movements during the mining of Longwalls 22 to 27. While impacts have been observed to some structures, mine subsidence has not directly exposed residents to any immediate or sudden safety hazards.

This Management Plan provides detailed information about how the risks associated with the mining beneath structures will be managed by Tahmoor Colliery in coordination with the Mine Subsidence Board.

Separate management plans have been or will be developed for the following structures:

- Structures owned by owners of services infrastructure, such as bridges, culverts and sewage pumping stations.
- Commercial and business establishments along Bridge Street and Redbank Place in South Picton.
- Commercial establishment on Stilton Lane, which is located directly above the commencing end of Longwall 30.
- Structures located at RSL LifeCare Queen Victoria Gardens
- Large dam on Stilton Lane
- Heritage structures

This Management Plan is an update of previous management plans, taking into account experiences gained during the mining of Longwalls 22 to 27.

The Management Plan is a live document that can be amended at any stage of mining.

1.2. Objectives

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

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

- Ensure the safety and serviceability of all structures. Public safety is paramount. Disruption and inconvenience should be kept to minimal levels.
- Monitor ground movements and the condition of structures during mining.
- Initiate or coordinate action with the Mine Subsidence Board to mitigate or remedy potential significant impacts that are expected to occur to structures.
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted.
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Colliery, Mine Subsidence Board, Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS), and consultants as required.
- Establish lines of communication and emergency contacts.

1.3. Scope

The Management Plan is to be used to protect and monitor the condition of the items of infrastructure identified to be at risk due to mine subsidence. The major items at risk are:-

- Residential Establishments
- Public Amenities
- Commercial and Business Establishments

The Management Plan describes measures that will be undertaken as a result of mining Longwalls 28 to 30 only.

Separate management plans have been or will be developed prior to the influence from mining for the following structures:

- Structures owned by owners of services infrastructure, such as bridges, culverts and sewage pumping stations.
- Commercial and business establishments along Bridge Street and Redbank Place in South Picton.
- Commercial establishment on Stilton Lane, which is located directly above the commencing end of Longwall 30.
- Structures located at RSL LifeCare Queen Victoria Gardens
- Large dam on Stilton Lane
- Heritage structures

1.4. Proposed Mining Schedule

It is planned that each longwall will extract coal working northwest from the southeastern ends. This Management Plan covers longwall mining until completion of mining in Longwall 30 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
Longwall 28	April 2014	August 2015
Longwall 29	September 2015	October 2016
Longwall 30	November 2016	December 2017

1.5. 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

2.1. Maximum Predicted Systematic Parameters

Predicted mining-induced systematic subsidence movements were provided in Report No. MSEC355, which was prepared in support of Tahmoor Colliery's SMP Application for Longwalls 27 to 30. Revised predictions have been provided in Report No. MSEC645, which was prepared in support of Tahmoor Colliery's modification to the commencing ends of Longwalls 29 and 30.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of each of the proposed longwalls, is provided in Table 2.1. A summary of the maximum predicted total systematic subsidence parameters, after the extraction of each of the proposed longwalls, is provided in Table 2.2.

Table 2.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Longwalls 28 to 30

Longwall	Maximum Predicted Incremental Subsidence (mm)	Maximum Predicted Incremental Tilt (mm/m)	Maximum Predicted Incremental Hogging Curvature (1/km)	Maximum Predicted Incremental Sagging Curvature (1/km)
Due to LW28	730	5.8	0.06	0.13
Due to LW29	720	5.8	0.06	0.12
Due to LW30	720	5.7	0.06	0.12

Table 2.2 Maximum Predicted Cumulative Systematic Subsidence Parameters after the Extraction of Longwalls 28 to 30

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 LW28	1250	6.0	0.11	0.14
After LW29	1250	6.0	0.11	0.14
After LW30	1250	6.0	0.11	0.14

The values provided in the above table are the maximum predicted total systematic subsidence parameters which occur within the general longwall mining area, including the predicted movements resulting from the extraction of Longwalls 22 to 30.

2.2. Observed Subsidence during the mining of Longwalls 22 to 27

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 27.

In summary, there is generally a good correlation between observed and predicted subsidence, tilt and curvature. Observed subsidence was generally slightly greater than predicted in areas that were located directly above previously extracted areas and areas of low level subsidence (typically less than 100 mm) was generally observed to extend further than predicted.

While there is generally a good correlation between observed and predicted subsidence, substantially increased subsidence has been observed above most of Longwall 24A and the southern end of Longwall 25, with slightly increased subsidence above the commencing ends of Longwalls 26 and 27. This was a very unusual event for the Southern Coalfield.

Observed Increased Subsidence during the mining of Longwall 24A

Observed subsidence was greatest above the southern half of Longwall 24A, and gradually reducing in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor. These observations are shown graphically in Fig. 2.1, which shows observed subsidence at survey pegs located along the centreline of Longwall 24A.

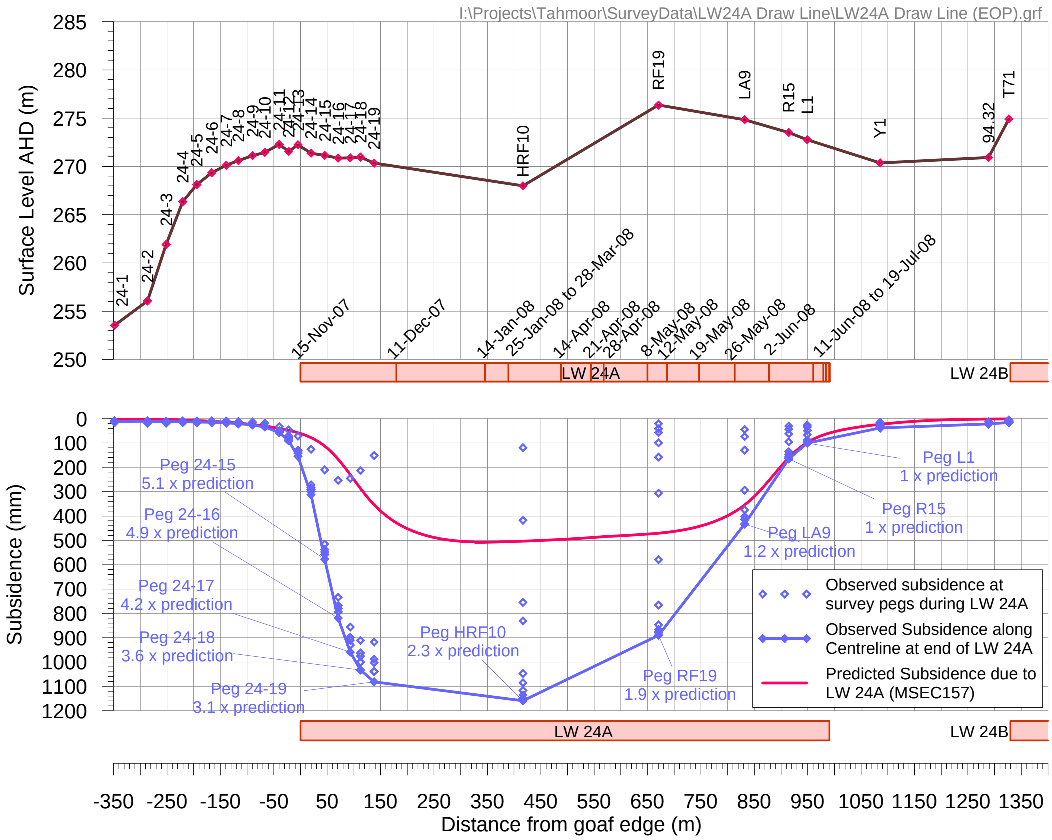

Fig. 2.1 Observed Subsidence along Centreline of Longwall 24A

It can be seen from Fig. 2.1 that observed subsidence was more than twice the predicted maximum value, reaching to a maximum of 1169 mm at Peg HRF10. It is possible that actual maximum subsidence developed somewhere between Pegs HRF10 and RF19, though this was not measured. Observed subsidence was similar to prediction near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 are located within a transition zone where subsidence gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

Observed Increased Subsidence during the mining of Longwall 25

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are shown graphically in Fig. 2.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25.

It can be seen from Fig. 2.2 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1216 mm at Peg 25-28.

Observed subsidence is similar to but slightly more than predicted at Peg RE7 and is similar to prediction at Peg Y20 and at all pegs located further along the panel. Survey pegs A6, A7, A8 and A9 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence to areas of normal subsidence.

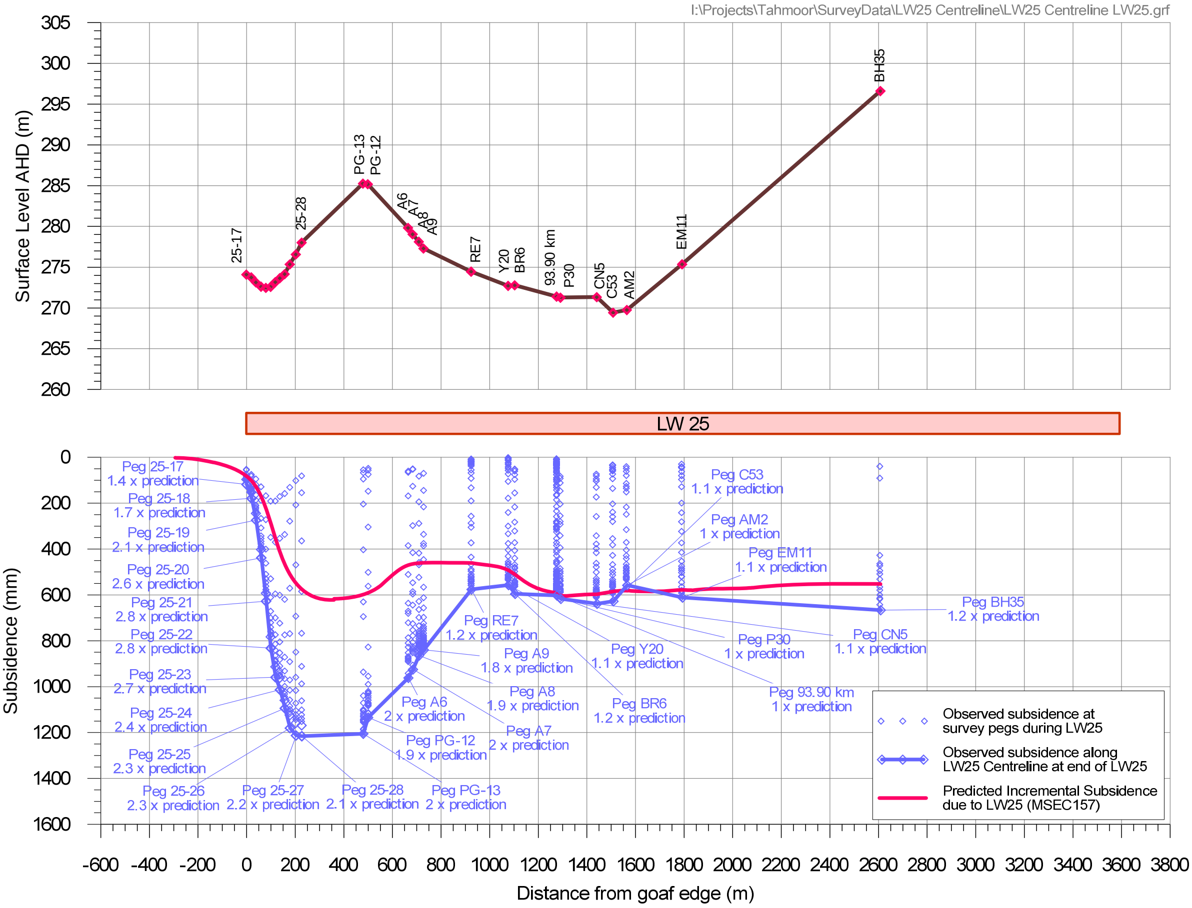

Fig. 2.2 Observed Subsidence along Centreline of Longwall 25

Observed Increased Subsidence during the mining of Longwall 26

Increased subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the subsidence observed above Longwalls 24A and 25. These observations are shown graphically in Fig. 2.3, which shows observed subsidence at survey pegs located along the centreline of Longwall 26.

It can be seen from Fig. 2.3 that observed subsidence was approximately 1.5 times the predicted maximum value, with maximum subsidence of 893 mm at Peg TM26.

Observed subsidence reduced along the panel until Peg Y40 on York Street, where it was less than prediction. Survey pegs S9 and RE27 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs TM26 and MD4 to areas of normal subsidence at Peg Y40 and beyond.

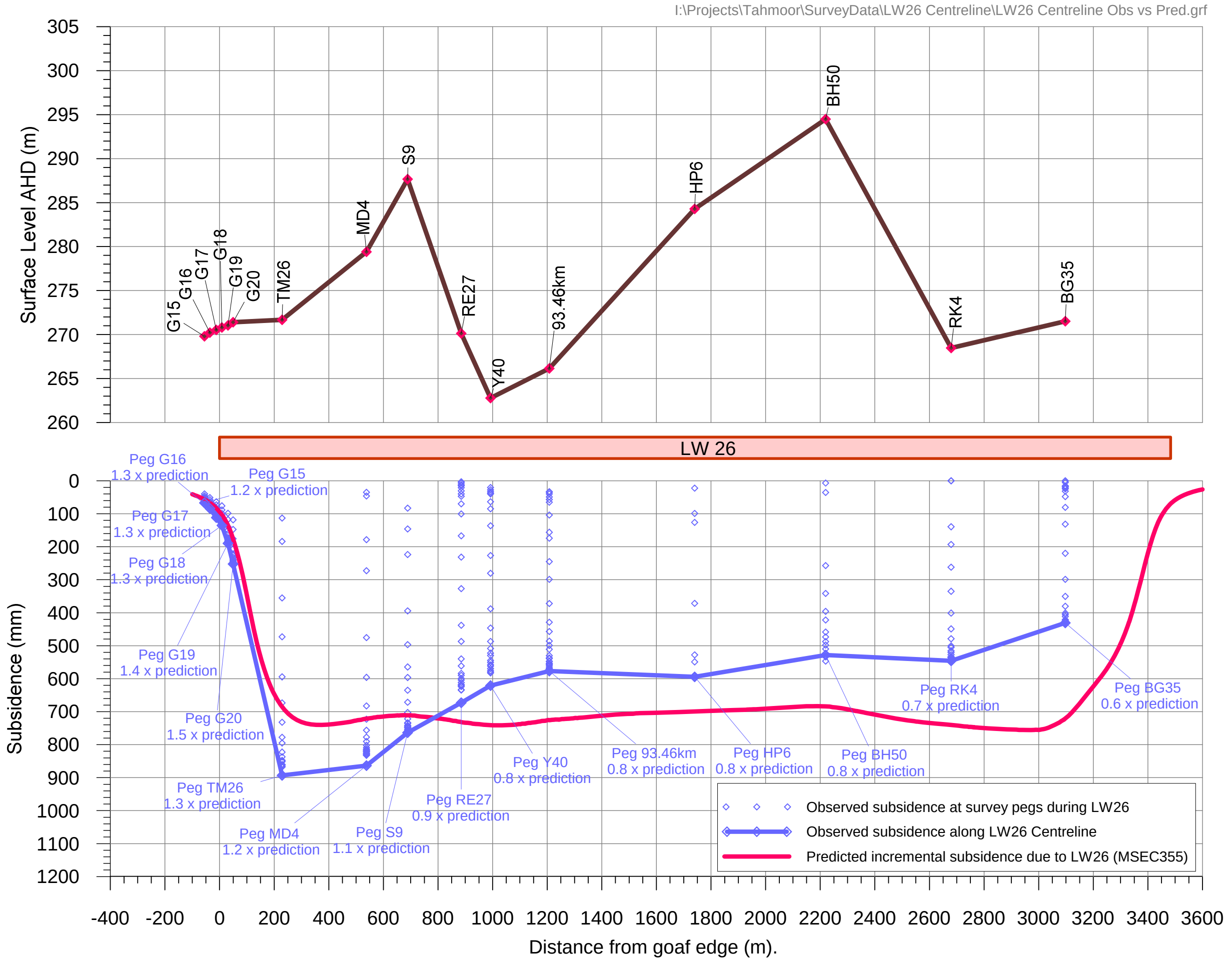

Fig. 2.3 Observed Subsidence along Centreline of Longwall 26

Observed Increased Subsidence during the mining of Longwall 27

The extraction of Longwall 27 is currently underway and is scheduled to finish in early 2014. Monitoring above the commencing end has shown that the magnitude of maximum subsidence is approximately 800 mm, which is slightly less than the measured maximum subsidence of approximately 900 mm above the commencing end of Longwall 26. Observed subsidence at survey pegs located along the centreline of Longwall 27 are shown graphically in Fig. 2.4. The graph shows the latest survey results for each monitoring line as at February 2014. It is likely that further small increases in subsidence will be observed at these pegs when they are surveyed at the completion of Longwall 27.

It can be seen from Fig. 2.4 that observed subsidence is approximately 1.3 times the predicted maximum value, with current maximum subsidence of 793 mm at Peg MC14.

Observed subsidence reduced along the panel from Peg MC14 until Peg TC4, which is located between Remembrance Drive and Myrtle Creek. Observed subsidence along the centreline returned to normal levels as mining progressed beyond Peg TC4.

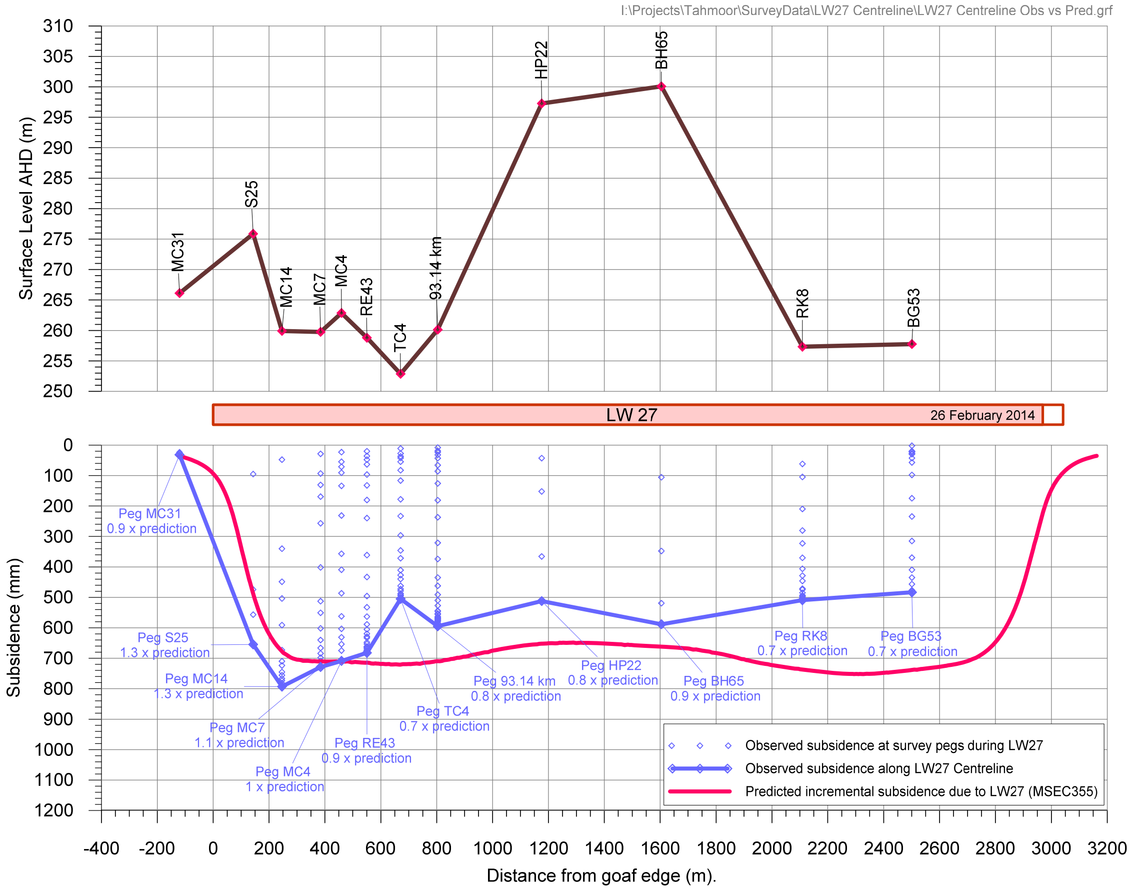

Fig. 2.4 Observed Subsidence along Centreline of Longwall 27

Analysis and commentary

The cause for the increased subsidence has been investigated by Strata Control Technologies on behalf of Tahmoor Colliery (Gale and Sheppard, 2011). The investigations concluded that the increased subsidence is consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge.

In light of the above observations, the region above the extracted longwalls at Tahmoor has been partitioned into three zones:

1. Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions
2. Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than predictions but has reached it upper limit. Maximum subsidence above the centreline of the longwalls appears to be approximately 1.2 metres above Longwalls 24A and 25, 900 mm above Longwall 26 and 800 mm above Longwall 27.
3. Transition zone – where the subsidence behaviour appears to have transitioned between areas of maximum increased subsidence and normal subsidence.

When the locations of the three zones are plotted on a map, as shown in Drawing No. MSEC646-00-01 (refer Appendix), it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26. This orientation is roughly parallel to the Nepean Fault. The transition zone then appears to change direction above Longwall 27. This may suggest a relationship to the proximity of Longwall 27 to the Bargo River and a curved transition zone has been drawn to illustrate this. .

The observations above Longwalls 24A to 27 suggest that the location of the zone of increased subsidence is linked to both the alignment of the Nepean Fault and the proximity to the Bargo River. It correlates with the findings of Gale and Sheppard that the increased subsidence is linked to localised weathering of joint and bedding planes above a depressed water table adjacent to the incised gorge of the Bargo River.

The experiences of reduced maximum subsidence above Longwalls 26 and 27 suggest that the magnitude of maximum subsidence above the commencing ends of Longwalls 28 to 30 will be less than previously observed and may return close to normal levels of subsidence elsewhere at Tahmoor.

The zones of increased subsidence and transition to normal subsidence have been conservatively projected above Longwalls 28 to 30 in Drawing No. MSEC646-00-02 (refer Appendix). The projection is conservative as it is based on the orientation of the Nepean Fault rather than its proximity to the Bargo River. A curved dashed line is also shown in in Drawing No. MSEC646-00-02 above Longwall 28, which is an alternative projection based on the observations above Longwall 27 and its proximity to the Bargo River. This alternative projection appears reasonable based on the observations above Longwall 27.Despite the above observations and projections, it is recognised that substantially increased subsidence could develop above the commencing ends of Longwalls 28 to 30 and this Management Plan has been developed to manage potential impacts if substantial additional subsidence were to occur.

With respect to structures in the vicinity of the potential zone of increased subsidence:

- There are a number of structures on Remembrance Drive located directly above the commencing end of Longwall 28.
- There are no structures located directly above the commencing end of Longwall 29.
- There is one structure located directly above the centreline of the longwall panel near the commencing end of Longwall 30. There is also a residence, horticultural sheds and an office located directly above the maingate corner of the commencing end of Longwall 30.

2.3. 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, in cases 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.

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. Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

2.3.1. 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 the previous longwalls at Tahmoor, Appin and West Cliff Collieries, 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*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 2.5. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

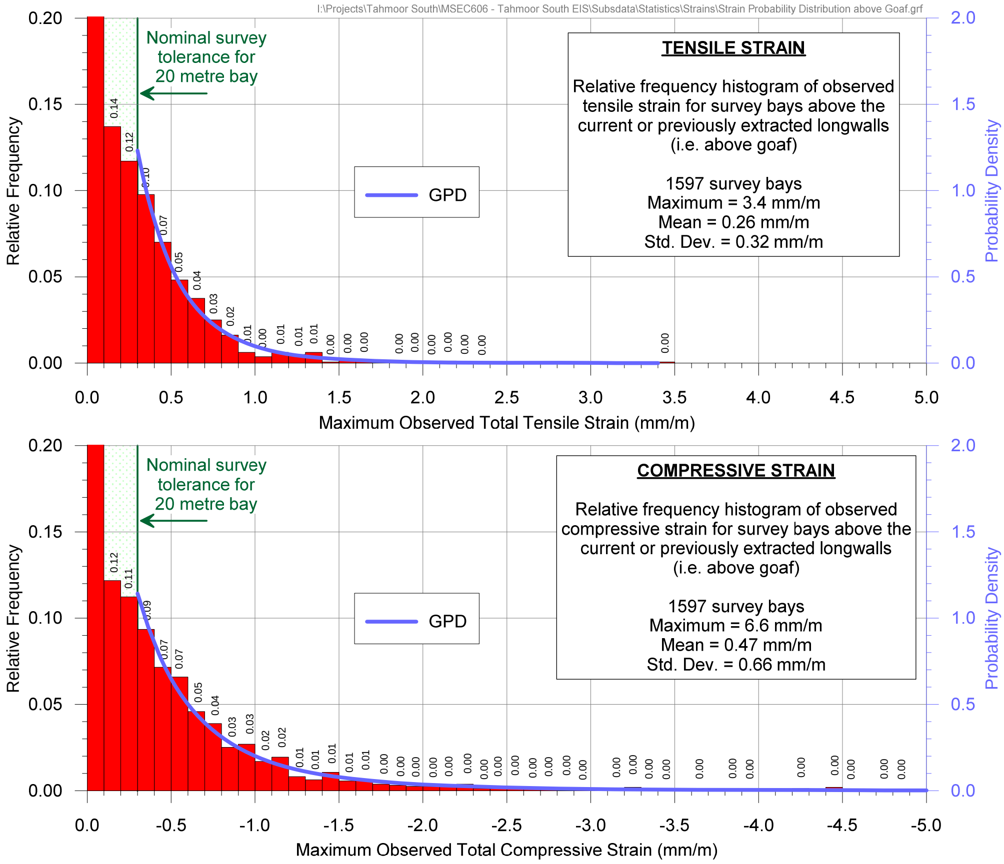

Fig. 2.5 Distributions of the Measured Maximum Tensile and Compressive Strains for Surveys Bays Located Above Goaf at Tahmoor, Appin and West Cliff Collieries

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and 1.6 mm/m compressive. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above goaf* would be less than 1.5 mm/m tensile and 2.5 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 at Tahmoor, Appin and West Cliff Collieries were 1.4 mm/m tensile and 3.1 mm/m compressive. Similarly, it is expected that 99 % of the strains measured *above goaf* for the proposed longwalls would be less than 2.0 mm/m tensile and 4.5 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 the previous longwalls at Tahmoor, Appin and West Cliff Collieries, 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*".

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal, for monitoring lines at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 2.6. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

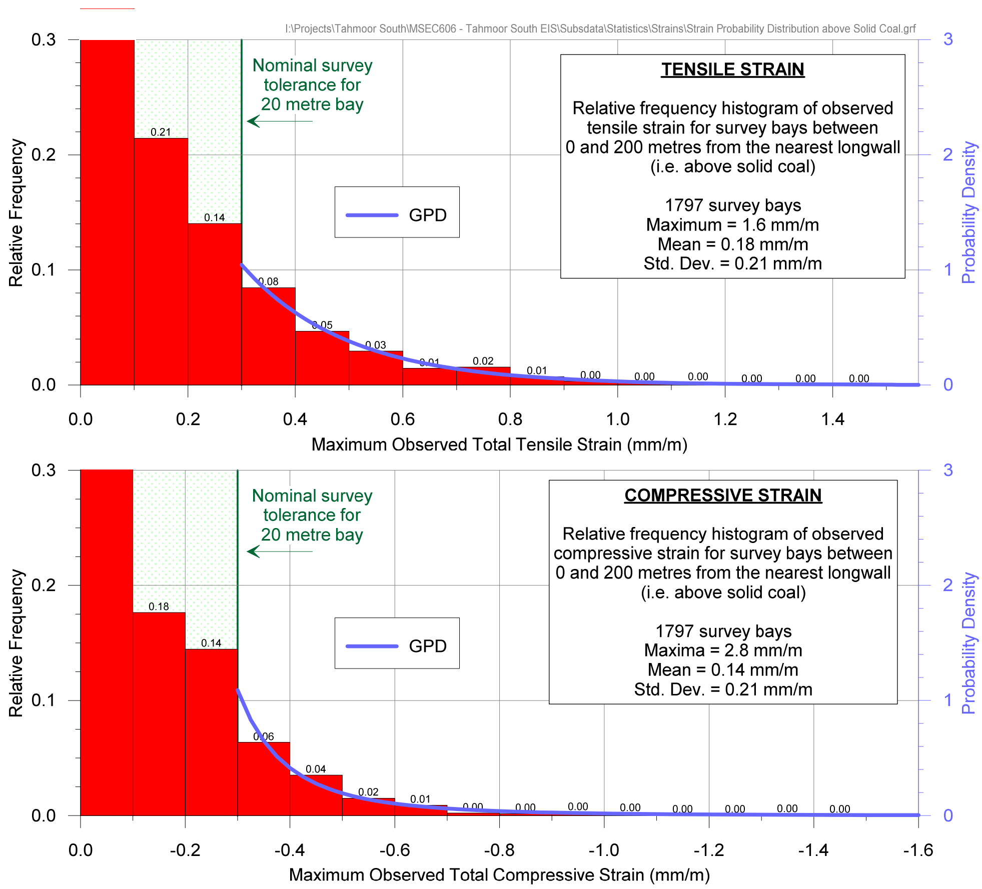

Fig. 2.6 Distributions of the Measured Maximum Tensile and Compressive Strains for Survey Bays Located Above Solid Coal at Tahmoor, Appin and West Cliff Collieries

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.6 mm/m tensile and 0.5 mm/m compressive. The strains for the proposed longwalls are predicted to be 30 % to 50 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above solid coal* would be less than 1.0 mm/m tensile and compressive.

The 99 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and compressive. Similarly, it is expected that 99 % of the strains measured *above solid coal* adjacent to the proposed longwalls would be less than 1.5 mm/m tensile and compressive.

3.1. General

The Australian/New Zealand standard for Risk Management defines the terms used in the risk management process, which includes the identification, analysis, assessment, treatment and monitoring of risk. In this context:-

3.1.1. 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.'[1] The consequences of a hazard are rated from very slight to very severe.

3.1.2. Likelihood

'Used as a qualitative description of probability or frequency.'[2] The likelihood can range from very rare to almost certain.

3.1.3. Hazard

'A source of potential harm or a situation with a potential to cause loss.'[3]

3.1.4. Risk

'The chance of something happening that will have an impact upon objectives. It is measured in terms of consequences and likelihood.'[4] The risk combines the likelihood of an impact occurring with the consequence of the impact occurring. The risk is rated from very low to extreme. In this study, the likelihood and consequence are combined via the qualitative risk analysis matrix shown in Table 3.1, to determine an estimated level of risk for particular events or situations.

The Risk Analysis Matrix is similar to the example provided in AS/NZS 4360:1995, Appendix D, p.25.

Table 3.1 Qualitative Risk Analysis Matrix

Likelihood	CONSEQUENCES				
	Very Slight	Slight	Moderate	Severe	Very Severe
Almost Certain	Low	Moderate	High	Extreme	Extreme
Likely	Low	Moderate	High	Very High	Extreme
Moderate	Low	Low	Moderate	High	Very High
Unlikely	Very Low	Low	Moderate	High	High
Rare	Very Low	Very Low	Low	Moderate	High
Very Rare	Very Low	Very Low	Low	Moderate	Moderate

This Management Plan adopts a common system of nomenclature to summarise each risk analysis, which is **"LIKELIHOOD / CONSEQUENCE → LEVEL OF RISK".**

For example, if the likelihood of a risk is assessed as "**UNLIKELY**", and the consequence of a risk is assessed as "**SEVERE**", the risk analysis would be summarised as **"UNLIKELY / SEVERE → HIGH"**.

[1] AS/NZS 4360:1999 – Risk Management pp2
[2] AS/NZS 4360:1999 – Risk Management pp2
[3] AS/NZS 4360:1999 – Risk Management pp2
[4] AS/NZS 4360:1999 – Risk Management pp3

4.1. Experience of mining beneath structures during the mining of Longwalls 22 to 27

As at March 2014, a total of 1542 houses, public amenities and commercial and business establishments have experienced subsidence movements during the mining of Longwalls 22 to 27. The following observations are made:

- Mine subsidence has not directly exposed residents to any immediate or sudden safety hazards.
- The MSB has received a total of 487 claims from individual properties (not including refused claims) of which 433 claims include impacts to main structures. The remaining 54 claims from properties relate solely to claims of damage to small improvements such as swimming pools, sheds and pavements.
- This represents an overall claim rate of 433 out of 1542 main structures, or 28%. In other words, no impacts have been reported for 72% of main structures.
- The rate of impact is understandably greater for structures located directly above extracted mining domains. A total of 1190 houses, public amenities and commercial and business establishments are located directly above the extracted Longwalls 22 to 27 (or pillars between them). A total of 385 claims have been made from this subset, which represents a claim rate of 32% for structures above goaf.
- The claim rate for structures within the predicted limit of subsidence but not located directly above extracted coal (that is, structures on 'solid coal') is 48 claims out of a total of 352 structures, or 14%.
- The majority of impacts are considered very slight to slight and consist of sticky doors and minor impacts to internal walls, ceilings or floor finishes. However, 2.7% of impacts are considered to be moderate or greater. In ten of these cases (i.e: 0.6 % of all building structures), the impacts were substantial and the costs to repair these structures were deemed to be greater than the costs to rebuild.

4.2. Impact Assessment on Structures

The methods for predicting and assessing impacts on building structures have developed over time as knowledge and experience has grown. MSEC has provided predictions and assessments for structures potentially affected by mining at Tahmoor Colliery using the latest methods available at the time.

The information collected during the mining of Longwalls 22 to 24A has been reviewed in two parallel studies: one as part of a funded ACARP Research Project C12015 and one at the request of the Department of Primary Industries (DPI).

The outcomes of the studies include:

- Review of the performance of the previous method
- Recommendations for improving the current method of Impact Classification
- Recommendations for improving the current method of Impact Assessment

A summary is provided in Appendix C of Report No. MSEC355 (2009).

The predictions of subsidence, tilt and curvature for each structure due to the extraction of Longwalls 22 to 27 are provided in Table F.02 of Report No. MSEC355 (2009).

The probability of impacts for each house has been assessed based on the parameters of predicted ground curvature and type of construction, in accordance with the revised method of assessing impacts on structures. The results are provided in Table F.02 of Report No. MSEC355 (2009).

It is noted that the commencing ends of Longwalls 29 and 30 have been shortened by approximately 250 metres since Report No. MSEC355 was prepared. Accordingly, the magnitude of subsidence and probabilities of impacts for each structure that is located near the commencing ends of Longwalls 29 and 30 would be less than previously provided. The planned management strategy for the structures, as detailed in this Management Plan, however, remains unchanged.

4.3. Managing Public Safety

The primary risk associated with mining beneath structures is public safety. Comfort is drawn from the observation that residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements. This includes the recent experience at Tahmoor, which has affected more than 1500 houses and civil structures.

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 and/or relocate residents.

Based on experiences at Tahmoor and elsewhere in the NSW coalfields, likelihood of a public safety incident occurring due to mine subsidence impacts on structures is considered to be **VERY RARE**. The worst possible consequence could, however, be **VERY SEVERE**, even though none such incident has been experienced to date. The risk is therefore considered to be **VERY RARE / VERY SEVERE → MODERATE**, based on the worst possible consequence.

4.3.1. Subsidence Impact Management Process

Tahmoor Colliery has developed and acted in accordance with a risk management plan to manage potential impacts on structures during the mining of Longwalls 22 to 27. The management strategy has been reviewed and updated based on experiences gained during the mining of Longwalls 22 and 27 and the strategy for Longwalls 28 to 30 includes the following process:

1. Regular consultation with the community before, during and after mining as described in Section 5.3. This includes letters and door knocking to all residents of structures that will soon be affected by subsidence. The letters invite the residents to contact Tahmoor Colliery should have any concerns with their structure, or alternatively contact the Mine Subsidence Board for a pre-mining inspection.
2. Site-specific investigations, where they are necessary and appropriate, into the conditions of buildings and associated structures and their surrounding environment (where access is allowed). The site-specific investigations will be undertaken early so that there is adequate time, if required, to arrange additional inspections and/or surveys and implement any mitigation measures before mining-induced impacts are experienced.

   As a general rule, site-specific investigations are undertaken before the longwall face approaches to within 300 metres of travel prior to directly mining beneath each property. For properties located directly above the first 300 metres of the commencing end of a longwall, the investigations are targeted to be undertaken prior to extraction or at the latest, they will be undertaken prior to the first 200 metres of extraction of the longwall.

   The site-specific investigations include the following:
   a) At the time of preparing Report No. MSEC355 (2009) in support of Tahmoor Colliery's SMP Application, structures were identified from aerial photographs, with structure types identified from kerbside inspections.
   b) Additional front of house inspections by Tahmoor Colliery in company with a structural engineer for all properties that are located directly above Longwalls 28 to 30. The purpose of the inspections is to identify potentially unstable structures that may warrant a structural inspection, subject to approval by the landowner.
   c) Pre-mining geotechnical inspections of structures located on or immediately adjacent to steep slopes (refer Section 4.4.1)
   d) Pre-mining structural inspections of the following structures
      i) Public amenities and commercial and business establishments that are located directly above longwalls. (refer Section 4.10 and Section 4.11)
      ii) Structures on or immediately adjacent to steep slopes that have been recommended for structural inspection by the geotechnical engineer.
      iii) Structures that have been identified as being potentially unstable or unsafe by landowners (Item 1), or front of house inspections (Item 2b), or if an issue is raised by the MSB during the course of undertaking its pre-mining inspections.
      iv) Structures of heritage significance (refer separate Heritage Management Plan).
      v) Houses and units located above hidden creeks (refer Section 4.4.2).
      vi) Houses and units located outside any Mine Subsidence District that are predicted to experience more than 150 mm of subsidence (refer Section 4.4.4).
      vii) Houses estimated to have been constructed prior to the declaration of the Mine Subsidence District (1975) that are predicted to experience more than 150 mm of subsidence (refer Section 4.4.5).

3. Implementation of mitigation measures following inspections by geotechnical and/or structural engineer. These will be implemented before the longwall face approaches to within 100 metres of travel prior to directly mining beneath each property

4. Surveys and inspections during mining within the active subsidence area (refer Table 5.1 for timing and frequencies):
   - Detailed visual inspections and vehicle based inspections along the streets
   - Ground surveys along streets
   - Visual inspections of public amenities and industrial, commercial and business establishments
   - Visual inspections of structures that have already reported impacts, where recommended by the Structures Management Group
   - Visual inspections of pool fences and gates
   - Specific ground surveys and visual inspections for selected properties, where recommended by a geotechnical or structural engineer due to their proximity to steep slopes or pre-existing condition.

The Subsidence Impact Management Process has been developed in consideration of the following facts and observations:

1. Australian standards have been available for use in the design of structures since 1948.The great majority of structures at Tahmoor and Thirlmere (approximately 80%) have been constructed after the declaration of the Bargo Mine Subsidence District in November 1975.

2. There is sufficient redundancy in structural design such that ductile deformation will develop and be noticeable to residents before structural failure occurs (JMA, 2014).

3. Subsidence movements develop gradually over time at Tahmoor Colliery as they have above other previously extracted longwalls at similar depths of cover.

4. Experiences during the mining of Longwalls 22 to 27 have found that the most effective method of managing potential impacts on the safety and serviceability of structures are by way of community consultation. Residents living within the active subsidence zone have often provided early feedback to Tahmoor Colliery and/or the Mine Subsidence Board about impacts developing at their houses or along their local roads. Contact is made well before impacts develop to a level of severity sufficient to become a safety hazard.

5. On the basis of the above, there is sufficient time for residents to notify Tahmoor Colliery or the MSB of significant displacement or deflection well before structural failure will occur.

6. The conclusions are supported by the observation that residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements at Tahmoor Colliery and above other previously extracted longwalls at similar depths of cover. This includes the recent experience at Tahmoor Colliery during the mining of Longwalls 22 to 27, which have affected more than 1500 houses and civil structures.

   While severe impacts have developed during the mining of Longwalls 22 to 27, there is sufficient redundancy in structural design such that when structures have experienced severe impacts, they have developed gradually with ample time for residents to notify Tahmoor Colliery or the MSB to repair the structure and/or relocate residents before structural failure occurs. This conclusion is supported by structural engineer, John Matheson & Associates (JMA, 2014).

While the three most important factors in managing risks to public safety are redundancy in structural design, gradual development of subsidence movements and an effective community consultation program, a number of additional management measures have been or will be undertaken, including site specific investigations, regular surveys and inspections during mining and triggered response measures as detailed in this Management Plan.

A flowchart illustrating the Subsidence Impact Management Process prior to each structure potentially experiencing impacts is shown in Fig. 4.1.

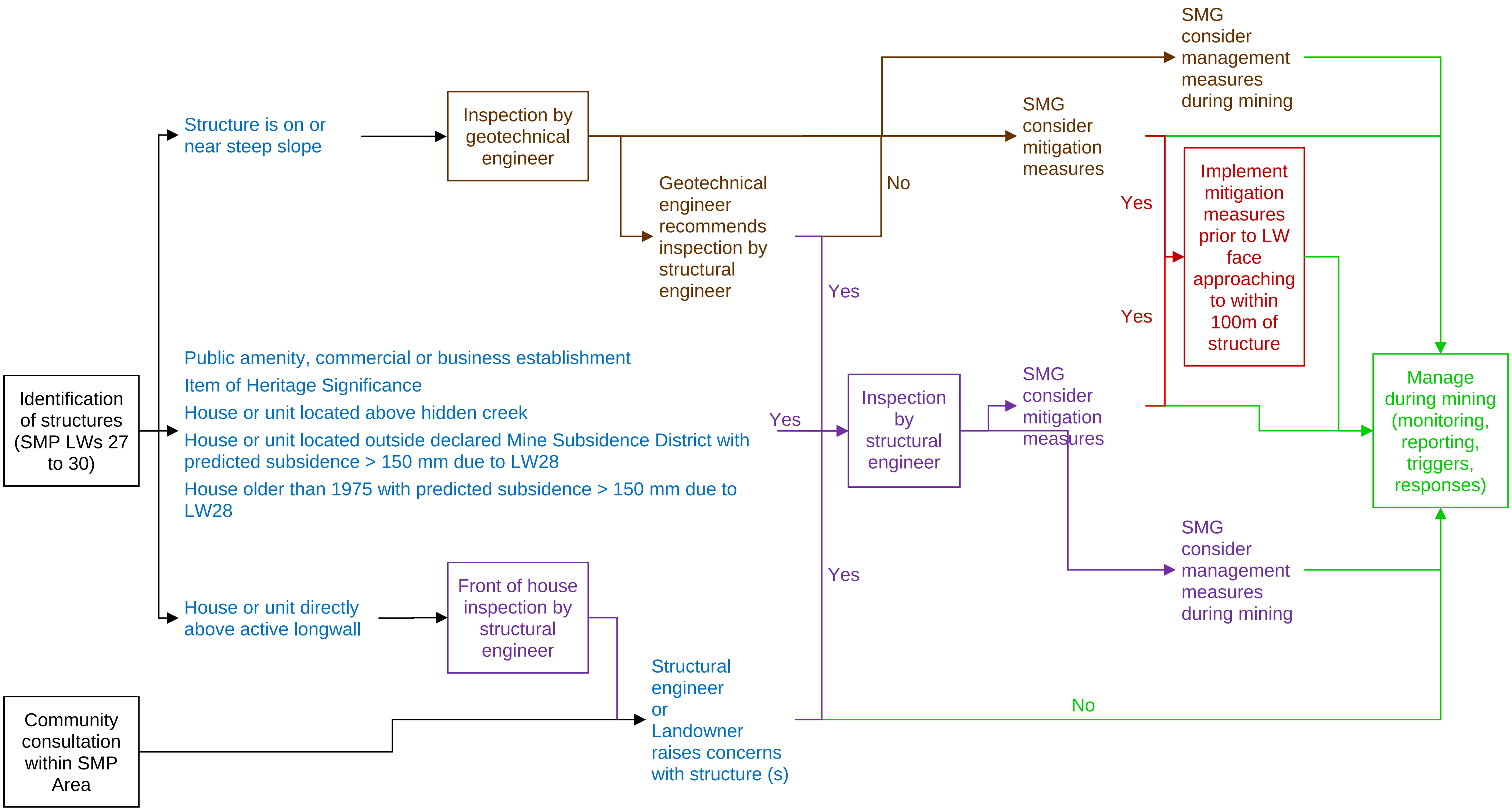

Fig. 4.1 Flowchart for Subsidence Impact Management Process prior to each structure potentially experiencing impacts

4.4. Residential Structures

This section describes observations and management measures for specific types of residential structures that have been identified as being potentially more vulnerable to subsidence movements.

4.4.1. Structures on Steep Slopes

A total of 27 properties above Longwalls 22 to 27 have been inspected by geotechnical engineer, GHD Geotechnics. Structures and dams on these properties were assessed to have been located on or immediately adjacent to steep slopes, which are conservatively defined as a slope greater than 1 in 3. There are no structures located near cliffs. It is possible, though unlikely, that tension cracks may form at the top of the slope and these may coincide with some houses and cause additional impacts to them. It is considered extremely unlikely that the houses would be severely damaged due to large-scale slope failure. No impacts have been observed to steep slopes during the mining of Longwalls 22 to 27, including steep slopes on the banks of Myrtle Creek.

Structural inspections by John Matheson & Associates (JMA) have also been undertaken where recommended by the geotechnical engineer.

Structures on a total of five properties have been identified on or near steep slopes on the banks of Myrtle Creek directly above or near Longwall 28. They include Property Refs. CC98, CC100 and CC102, as identified in 2009 in Report No. MSEC355, plus an additional two properties that have identified from a recent aerial photograph in 2013.

The properties will be inspected prior to commencement of Longwall 28.

There are no residential properties with structures on steep slopes above Longwalls 29 and 30.

4.4.2. Structures above 'Hidden' Creeks

Hidden creeks are defined as natural watercourses that appear to have been covered during development of a property or road. Hidden creeks have been identified from surface contours and historical aerial photographs.

These houses are considered to have a greater chance of experiencing non-systematic upsidence and closure movements during mining. When tested against observations during the mining of Longwalls 22 to 28, however, no clear increase in frequency of impact is observed.

A total of 52 houses above hidden creeks have experienced subsidence during the mining of Longwalls 22 to 27 and 22 houses have experienced impacts, including five houses directly above Longwall 27. The impacted houses include some on Oxley Grove, where a creek had been infilled, and houses on York Street and Remembrance Drive where a small tributary to Myrtle Creek had been infilled. The claim rate is higher than the overall claim rate of 42% and may represent a trend, though the impacts to these houses have been generally very minor (less than Category 1) and the sample size is small.

The observations of very minor impacts may be explained by the fact that the valleys in which the houses are located are very small and may not be sufficiently incised to generate significant upsidence and closure movements. If any movements do occur, it is also possible that they may not be completely transferred from the bedrock to the house through the constructed fill, depending on the design of the building foundations.

There are no hidden creeks located directly located above Longwalls 28 to 30.

4.4.3. Houses Prone to Flooding or Inundation

Potential flood prone areas have been identified along Myrtle and Redbank Creeks. None are located directly above Longwalls 28 to 30.

4.4.4. Houses outside any Mine Subsidence District

There are over one hundred houses that have or may experience subsidence during the mining of Longwalls 22 to 30 but are not located within any Mine Subsidence District. The houses are located near the township of Thirlmere, north of Redbank Creek.

A total of four houses outside Mine Subsidence Districts are predicted to experience more than 150 mm of subsidence during the mining of Longwalls 28 to 30.

The hazard associated with these houses is that they may be less tolerant to mine subsidence movements as their designs have not been checked and approved by the Mine Subsidence Board. As discussed in Report No. MSEC355, the majority of the houses are single-storey buildings that are less than 30 metres long and less than 30 years old.

Tahmoor Colliery will conduct a structural inspection on the four identified houses that are located outside a Mine Subsidence District and are predicted to experience more than 150 mm of subsidence during the mining of Longwalls 28 to 30.

4.4.5. Older Houses

Approximately 20% of houses are estimated to have been constructed prior to the proclamation of the Bargo Mine Subsidence District in 1975. The hazard associated with these houses is that these houses may be less tolerant to mine subsidence movements as their designs have not been checked and approved by the Mine Subsidence Board. Some old houses may also be in poor condition. Many of the houses, particularly houses over 39 years old, are constructed with timber frames and weatherboard panels or fibro sheets.

Analysis of impacts to structures during the mining of Longwalls 22 to 25 in December 2008 did not find any significant trend between the rate of impacts and structure age.

Tahmoor Colliery will conduct a structural inspection on all houses that were constructed prior to 1975 that are predicted to experience more than 150 mm of subsidence during the mining of Longwalls 28 to 30.

4.4.6. Future House Construction

As discussed in Report No. MSEC355, an analysis on the rate of growth of Tahmoor suggests that approximately 1 new house is constructed per month at Tahmoor.

The hazard associated with these houses is considered to be generally low for the following reasons.

- The design for new houses will be approved by the Mine Subsidence Board (unless they are located outside any Mine Subsidence District),
- The condition of the houses will generally be high as they are newly constructed.

As described in Section 5.3, Tahmoor Colliery attempts to notify landowners at multiple stages during the mining process. New landowners may be contacted in this manner.

In addition to the above process, new houses have been identified from an aerial photograph commissioned by Tahmoor Colliery in 2013. The houses have been mapped and included in Drawing No. MSEC646-12-01.

If it is discovered that a new house has been constructed, Tahmoor Colliery will offer a pre-mining inspection by the MSB and offer to conduct and provide an impact assessment and risk analysis to the landowner upon request.

In the event that a new house is assessed to have a moderate level of risk or greater, the results of the risk analysis will be provided to the NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS) and the Mine Subsidence Board. Standard risk control procedures will be applied to these houses, which are provided in this Management Plan.

4.5. Flats or Units

A total of 20 flats or units have been identified within the general mining area, though none are predicted to experience more than 20 mm of subsidence during the mining of Longwalls 28 to 30.

4.6. Pools

4.6.1. Pool Damage

As of March 2014, a total of 155 pools have experienced mine subsidence movements during the mining of Longwalls 22 to 27. A total of 32 pools have reported impacts, all except 2 of which are located directly above the extracted longwalls. This represents an impact rate of approximately 21%. A higher proportion of impacts have been observed for in-ground pools, particularly fibreglass pools.

The majority of the impacts related to tilt or cracking, though in a small number of cases the impacts are limited to damage to skimmer boxes or the edge coping.

Mining-induced tilts are more noticeable in pools than other structures due to the presence of the water line and small gap to the edge coping, particularly when the pool lining has been tiled. Skimmer boxes are also susceptible of being lifted above the water line due to mining tilt. The Australian Standard AS2783-1992 (Use of reinforced concrete for small swimming pools) requires that pools be constructed level within ± 15 mm. This represents a tilt of approximately 3.3 mm/m for pools that are 10 metres in length. Australian Standard AS/NZS 1839:1994 (Swimming pools – Premoulded fibre-reinforced plastics – Installation) also requires that pools be constructed with a tilt not exceeding 3 mm/m.

4.6.2. Pool Gates

The hazard to pool gates is that they may not close due to mine subsidence impacts, even if they are spring-loaded.

A number of pool gates have been impacted by mine subsidence during the mining of Longwall 22 to 27. While the gates can be easily repaired, the consequence of breaching pool fence integrity is considered to be severe.

While consultation with the pool owners is considered to be the most effective method of managing potential impacts on pool gates, Tahmoor Colliery will inspect pool fences on a weekly basis during the active subsidence period. Any damage to pool fences and gates caused by mine subsidence will be repaired by the Mine Subsidence Board.

4.7. Septic Tanks

The risk to septic tanks is that they could be damaged and/or rendered unserviceable from mine subsidence impacts. There are two types of potential damage to septic tanks.

- Compressive ground strains could cause cracking and leaking of tanks.
- Shearing could also occur at the joint connecting the sewer pipes to the septic tank, as sewer pipes are generally able to slide as the ground moves horizontally beneath them, while the septic tanks are fixed and unable to slide relative to the sewer pipes.

Given that tanks are quite small (usually less than three (3) metres in diameter), constructed of reinforced concrete, and are usually bedded in sand and backfilled, the likelihood of cracking to septic tanks is assessed as very rare. It is noted that no impacts to septic tanks have been reported during the mining of Longwalls 22 to 27.

Pipe joints are usually flexible and consist of relatively short lengths, due to the proximity of the septic tank to the house. However, given that both the house and septic tank are effective ground anchors, it is possible that pipe joints can pull out or shear as a result of subsidence. The MSB reports that this has been observed in a small number of cases during the mining of Longwalls 22 to 27. This impact is relatively easy to repair.

The MSB also report that on two occasions during the mining of Longwalls 22 to 26, the grade of the sewer pipe to the septic tank has been reversed. The impacts are considered to have been partially due to very low pre-mining grades. In both cases, the repairs have been straight-forward, where the pipes were re-laid at an improved fall, entering the septic tank at a slightly lower level.

4.8. Sheds and Other Domestic Structures

The risk to sheds and other domestic structures is that they could be damaged and/or rendered unserviceable from mine subsidence impacts. These include garages, sheds, carport, tanks, greenhouses, hothouses, playhouses and shade structures.

These structures are able to withstand greater subsidence impacts than houses as they are generally lighter, more flexible in construction, and smaller in size. The risk of damage to sheds and other domestic structures is therefore considerably less when compared to houses.

A small number of sheds and other domestic structures have reported impacts during the mining of Longwalls 22 to 27, all of which are considered to be relatively minor and easy to repair. Any damage to sheds and other domestic structures will be repaired by the Mine Subsidence Board.

4.9. Private Roads and Walking Trails in close proximity of steep slopes

There are a small number of private driveways that are located on steep slopes. These driveways are found on properties along the banks of Myrtle Creek, and at the end of Tickle Drive on a spur of the Redbank Range.

It is possible that tension cracks may form at the tops of the slopes, and compression ridges may form at the bottoms of the slopes, and that these may coincide with private driveways. If the tension cracks are left untreated, these may cause erosion to occur, which may further damage driveways. It is unlikely that large-scale slope failure will occur.

Small ripples were observed at locations along the private driveway of a house on Tickle Drive during the mining of Longwall 26.

4.10. Public Amenities

A number of public amenities have experienced subsidence movements during the mining of Longwalls 22 to 27.

Structures at RSL LifeCare Queen Victoria Gardens may experience small mining-induced movements during the mining of Longwalls 28 to 30. A separate management plan will be developed by Tahmoor Colliery and Queen Victoria Gardens

There are no other public amenities predicted to experience more than 20 mm of additional subsidence during the mining of Longwalls 28 to 30.

4.11. Commercial and Business Establishments

The commercial and business establishments within the SMP Area have been identified and are described in Report No. MSEC355. There are no known commercial and business establishments located directly above Longwalls 28 and 29.

A number of commercial and business establishments will experience minor subsidence movements during the mining Longwalls 29 and 30.

- Commercial, industrial and business establishments along Bridge Street and Redbank Place in South Picton.
- Commercial establishment on Stilton Lane, which is located directly above the commencing end of Longwall 30.

Separate management plans will be developed for these establishments prior to the influence of mining of Longwalls 29 and 30.

4.12. Risks associated with Existing Structural Condition

The existing structural condition of structures varies within the general mining area. This is a function of age, structural design, construction workmanship and maintenance. Pre-mining inspections undertaken by Tahmoor Colliery have identified elements of structures that did not appear to comply fully with Australian Standards, in regard to design and construction. In a small number of cases, the existing structural condition has been considered unsafe and Tahmoor Colliery has undertaken measures to repair the defect, or has informed the landowner of the hazard.

There is a remote possibility that the comparatively small additional contribution of mine subsidence movements could be sufficient to result in the structures that do not meet Australian Standards to become potentially unsafe. While the warnings appear dire, it should be noted that the likelihood of structural failure is still considered to be remote as no structures have collapsed as a result of mine subsidence movements in the Southern Coalfield.

The experience from the mining of Longwalls 22 to 27, affecting more than 1500 structures shows that residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements. 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 relocate residents.

The management strategy described in Section 4.3 includes measures to identify potentially 'unstable structures:

A total of 889 pre-mining inspections, 226 pre-mining checks and 106 front of house inspections have been undertaken by the Mine Subsidence Board and Tahmoor Colliery to date. Tahmoor Colliery has undertaken thousands of visual inspections of structures during the mining of Longwalls 22 to 27. A reduced amount of inspections is expected to be undertaken during the mining of Longwalls 28 to 30 as there are fewer structures above these longwalls.

Tahmoor Colliery will undertake a structural inspection of any structures that have been identified from front of house inspections as being potentially unstable. Further management measures may be implemented following the findings of the inspection.

4.13. Farm dams

A total 55 dams have been directly mined beneath by Longwalls 22 to 27 with one impact having been reported to a dam located directly above the extracted Longwall 27. This represents an impact rate of less than 0.5%. The dataset includes some large water treatment dams above Longwall 24A. A similar experience is found at dams located above other extracted longwalls at Appin and West Cliff Collieries, where the depth of cover is similar. While no impacts have been reported to dam walls, seepage was observed at the base of one dam wall that is located above Longwall 702 at Appin Colliery.

A total of four dams are located directly above Longwall 28 and parts of two dams are located directly above the chain pillar between Longwalls 27 and 28. One dam is located directly above Longwall 29 and six dams are located directly above Longwall 30.

The dams are typically constructed from cohesive soils with reasonably high clay contents. The walls of the farm dams should be capable of withstanding tensile strains of up to 3 mm/m without significant impacts, because of their inherent plasticity.

The likelihood of leakage of the dam wall or floor due to subsidence is considered to be **VERY RARE**. If impacts occur to the dams, Tahmoor Colliery will supply water to the landowner on a temporary basis until the dam is repaired by the Mine Subsidence Board. The consequence of loss of water storage is therefore considered to be **MODERATE**. The risk is therefore assessed as **VERY RARE / MODERATE → LOW.**

As undertaken during the mining of Longwalls 22 to 27, Tahmoor Colliery will visually inspect the dams immediately prior to and immediately after active subsidence of the dam. If impacts occur to the dams, Tahmoor Colliery will supply water to the landowner on a temporary basis until the dam is repaired by the Mine Subsidence Board.

From a public safety point of view, there are no structures or driveways located immediately downstream of the dams directly above Longwalls 28 and 29. There is a large dam on Stilton Lane (MSEC Ref. GG37a) with a height of approximately 8 metres. A number of structures are located immediately downstream of the dam. A separate management plan will be developed for this dam.

5.1. Structures Management Group (SMG)

The SMG is responsible for taking the necessary actions required to manage the risks that are identified from monitoring of structures. The SMG's key members are:

- Tahmoor Colliery
- John Matheson and Associates
- Mine Subsidence Engineering Consultants

The Mine Subsidence Board also participates at SMG meetings as observers when available. The SMG may invite other specialist consultants from time to time, including GHD Geotechnics where issues relate to slope stability.

5.2. Mitigation Measures

Mitigation measures have been undertaken to strengthen a small number of structures prior to the influence of mine subsidence movements prior to the mining of Longwalls 24A and 25. No additional structures have been identified for strengthening prior to the mining of Longwalls 28 to 30 at the writing this management plan.

5.3. Community Consultation

Experiences during the mining of Longwalls 22 to 27 have found that the most effective method of managing potential impacts on the safety and serviceability of structures are by way of community consultation. Residents living within the active subsidence zone have often provided early feedback to Tahmoor Colliery and/or the Mine Subsidence Board about impacts developing at their houses or along their local roads. Contact is made well before impacts develop to a level of severity sufficient to become a safety hazard.

The initial community consultation commenced when the Colliery applied for development consent to mine. A commission of inquiry was undertaken as part of this process. Tahmoor Colliery continued to develop their mine plans after development approval was received. These plans were discussed with the Tahmoor Colliery Community Consultative Committee (TCCCC), which was set up in accordance with the conditions of development consent. Prior to mining the first longwall beneath Tahmoor, the Colliery increased the level of communication with the community.

The approaches adopted by Tahmoor Colliery are listed below.

- *Undertake conservative predictions and impact assessments*

  Tahmoor Colliery and MSEC have adopted a conservative approach to predicting subsidence and assessing impacts. This reduces the likelihood of under-stating the predicted impacts. For example, predictions for each structure have been made by predicting the maximum subsidence, tilt and strain within a 20 metre radius around each structure.

- *Undertake detailed predictions and impact assessments*

  By undertaking detailed subsidence predictions, the Colliery is able to provide residents with predictions for their own structures. Individual assessments provide some comfort to concerned residents. This is particularly helpful for residents that live beyond the extent of mining and are expected to experience only small movements.

- *Community Information Days*

  A number of advertised information days are held by the Colliery through the year. The Information Days allow members of the community to directly meet Colliery representatives and its consultants. The Mine Subsidence Board is also present on Information Days to answer questions.
  The information exchanged at Information Days also assist the Colliery, as members of the community sometimes provide information about particular surface features or impacts that the Colliery might not have been aware of.

- *Tahmoor Colliery Community Consultative Committee*
  This committee meets at regular (bi-monthly to quarterly) intervals. It allows the Colliery to present information to the committee and receive feedback. The committee is committed to ensuring that the concerns of the community are well understood by the Colliery. Many of the members have been part of the committee for several years, and this allows for informed discussion to take place.

- *Letters and door knocking to residents*
  The Colliery sends many letters to community advising of imminent longwall mining in their area. By continuing to engage with residents at each stage of mining, the Colliery is able to find new residents who might not have been aware that mining was taking place. The letters include:

  - Notification of preparation of SMP application for LWs 27 to 30 and notification of lodgement of SMP application. The notification letter attached a Subsidence Information Pack, which included information on longwall mining and mine subsidence, claims process with the MSB, recommendation to undertake pre-mining inspections with the MSB (or the Colliery if preferred), a list of emergency contact numbers and point of contact at Tahmoor Colliery.

  - Notification to all landowners within the application area of SMP approval for LWs 27 to 30. These were within 30 days of the date of approval (31 October 2012) in accordance with Clause 7 of the SMP approval. The Subsidence Information Pack was resent as part of this notification.

  - Notification of imminent commencement of each longwall. The letter is sent to all landowners whose properties are located directly above the active longwall panel plus landowners whose properties are located directly above the next longwall panel. The letter encourages the landowners to undertake pre-mining inspections with the MSB.

    - Prior to the commencement of Longwall 27, the notification letter was sent to all properties that were located directly above Longwalls 27 and 28.

    - Prior to the commencement of Longwall 28, a notification letter will be sent to all properties that are located directly above Longwalls 28 and 29.

    - Prior to the commencement of Longwall 29, a notification letter will be sent to all properties that are located directly above Longwalls 29 and 30.

    - Prior to the commencement of Longwall 30, a notification letter will be sent to all properties that are located directly above Longwalls 30 and 31.

  - For properties where pre-mining inspections or checks will be undertaken in accordance with this Management Plan, Tahmoor Colliery will make direct contact to arrange access with the landowner by mail, letterbox drop, phone and/or door knocking.

  - Door knocking of houses located directly above the active longwall

    - This exercise is an attempt to directly engage with residents and is undertaken in conjunction with Front of House inspections (refer Section 5.4.1).

    - This exercise will be undertaken before the longwall face approaches within 300 metres of each property, so that there is adequate time, if required, to arrange additional inspections and/or surveys and implement any mitigation measures if required before mining-induced impacts are experienced.

- *Individual meetings with residents*
  Many members of the community prefer to meet with Colliery representatives face to face. The

Colliery has held many individual meetings with concerned residents to explain how mine subsidence develops and what the impacts might be. This is a time consuming but rewarding process for residents and the Colliery.

- *Newspaper advertisements*
  The Colliery places advertisements in the newspaper from time to time to advise the community at large about community consultation opportunities, including community information days.

- *Monthly reporting*
  The Colliery provides regular updates on the progress of mining in the area. This is conducted mainly by community newsletter by mail, email, website and notice boards for any member of the community who wishes to be regularly informed. The updates advise the current position of the longwall and what impacts have been observed during the past week.

- *Prompt response to reported impacts*
  While this is traditionally the role of the MSB, the Colliery also responds quickly to impacts that are reported by the community. If a severe impact is reported, the Colliery checks neighbouring properties to see whether the incident is localised or part of a larger potential issue.

- *Ongoing monitoring if impacts occur*
  Where impacts have been reported, the Colliery offers to continue monitoring the property for further impacts. This offer is in addition to those provided by the Mine Subsidence Board, who also monitors the property as mining continues.

The Mine Subsidence Board also plays a very important role in managing the expectations of the community. The MSB's concerted efforts to quickly respond to residents' concerns, particularly where they relate to emergency repairs to doors, gates or service pipes, have greatly assisted the community in coping with any inconvenience that may have occurred as a result of mine subsidence.

5.4. Site-Specific Structure Inspection Plan

5.4.1. Pre-mining Kerbside and Front of House inspections

At the time of preparing Report No. MSEC355 (2009) in support of Tahmoor Colliery's SMP Application, structures were identified from aerial photographs, with structure types identified from kerbside inspections. A number of newly constructed structures have been identified from an aerial photograph in 2013.

Additional front of house inspections are being undertaken by Tahmoor Colliery in company with a structural engineer to identify potentially unstable structures that may warrant a structural inspection, subject to approval by the landowner. The inspections include houses located directly above Longwalls 28 to 30. An internal inspection will be recommended if a potential structural deficiency is perceived.

5.4.2. Pre-mining Geotechnical Inspections of Steep Slopes

A qualified geotechnical engineer (GHD Geotechnics) has inspected steep slopes on which structures are located to determine whether there is any potential for slope instability prior to, during or after mining. The inspection findings are detailed in Section 4.4.1. A plan showing planned steep slope inspections is shown in Fig. 5.1.

Five additional properties on the southern bank of Myrtle Creek will be inspected prior to 400 metres of extraction of Longwall 28. There are no residential properties with structures on steep slope inspections directly above Longwalls 29 and 30.

5.4.3. Pre-mining Structural Inspections

Structural inspections will be undertaken for structures as defined in Section 4.3.1. A plan showing planned pre-mining inspections is shown in Fig. 5.1.

Structural inspections will be undertaken before the longwall face approaches to within 300 metres of travel prior to directly mining beneath each property.

5.4.4. Pre-Mining Inspections by the Mine Subsidence Board

The Mine Subsidence Board (MSB) has undertaken a number of pre-mining inspections above Longwalls 22 to 30. These are shown in Fig. 5.2. Further inspections may be conducted by the MSB in the future if requested by a landowner. Tahmoor Colliery will undertake a structural inspection of a property if a potential structural deficiency is perceived by the MSB as a result of its pre-mining inspections.

5.4.5. Visual kerbside inspections during mining

Detailed visual inspections will be undertaken along streets on a weekly basis within the active subsidence area during the mining of Longwalls 28 to 30, commencing after 200 metres of extraction.

A second, vehicle based inspection will also be undertaken once a week within the active subsidence area during the mining of Longwalls 28 to 30, commencing after 200 metres of extraction.

The frequency of inspections can be increased, if required, based on actual observations.

5.4.6. Visual Inspections of Structures during mining

Weekly visual inspections will be conducted for the following structures or slopes when they are located within the active subsidence zone:

- Public amenities and commercial and business establishments
- Houses and units that have experienced impacts as a result of mining previous longwalls
- Pool gates
- Structures and driveways located on steep slopes, where recommended by the geotechnical engineer or structural engineer.
- Farm dams immediately prior to and after the period of active subsidence for each dam.

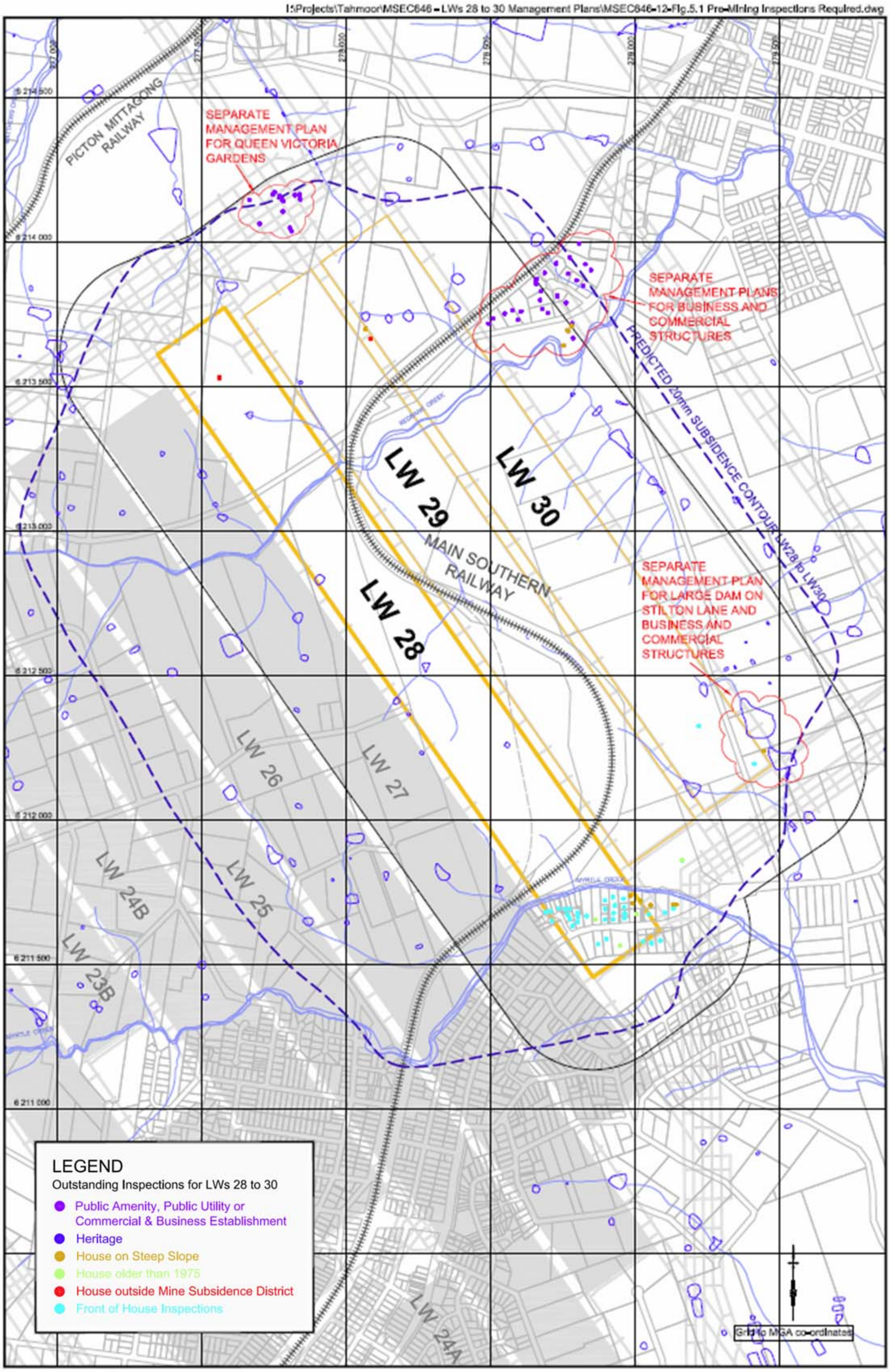

Fig. 5.1 Location of all Outstanding Structures planned for Pre-Mining Inspections for Longwalls 28 to 30

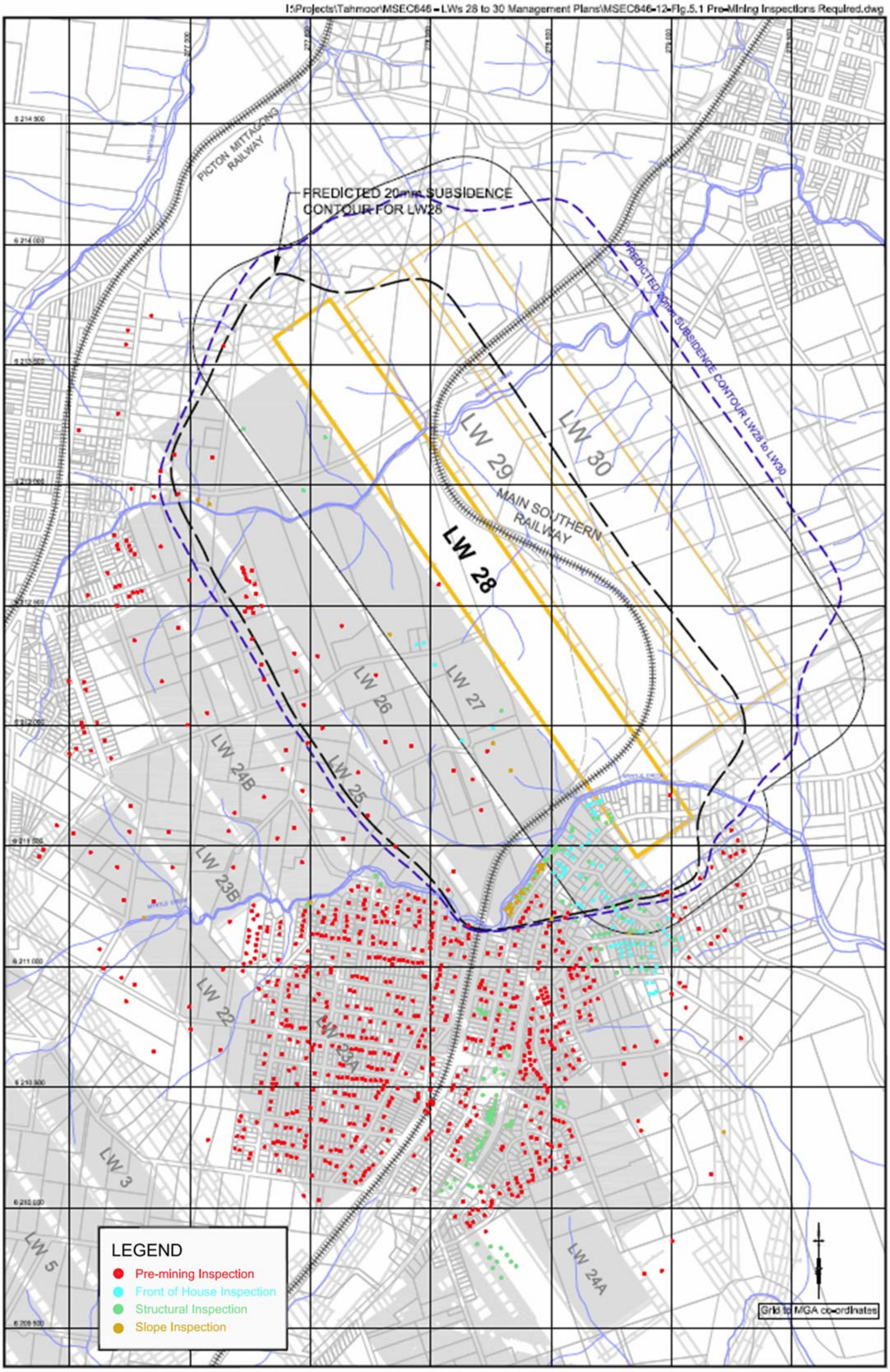

Fig. 5.2 Properties for which Pre-Mining Inspections or Front of House Inspections have been completed

5.5. Ground and Structure Monitoring Plan

5.5.1. Ground Surveys along Streets

Monitoring lines have been installed along streets within the urban area above Longwalls 28 to 30, as shown in Drawing No. MSEC646-00-03. The monitoring lines have been initially surveyed to provide a baseline reference. Monitoring of street survey lines will be conducted for every 200 metres of longwall travel as a minimum for pegs located within the active subsidence zone.

5.5.2. Specific Structure Surveys

Tahmoor Colliery will undertake building surveys where recommended by a geotechnical or structural engineer.

Ground surveys around structures are used as a baseline monitoring tool. Surveys are undertaken following completion of each longwall unless impacts or high tilts are observed. Tahmoor Colliery will place permanent ground survey pegs around each subject building. The Colliery will endeavour to place pegs at each external and internal corner of the building, and one peg at the centre of each external side of reasonable length (this will depend on the overall size of the building, but is approximately 10 metres).

The Colliery will record the reduced levels of each peg, as well as the horizontal distance between each peg around the perimeter of the building. The survey information will provide subsidence, tilt, curvature and strain information on the ground around the building. This general surveying scheme is illustrated in Fig. 5.3. It is recognised that in some cases, it will not be possible to gain access and suitable lines of sight to the entire perimeter of the building, and in some cases, the number of survey pegs may be reduced. However, as a minimum, survey marks will be placed at every corner of the building.

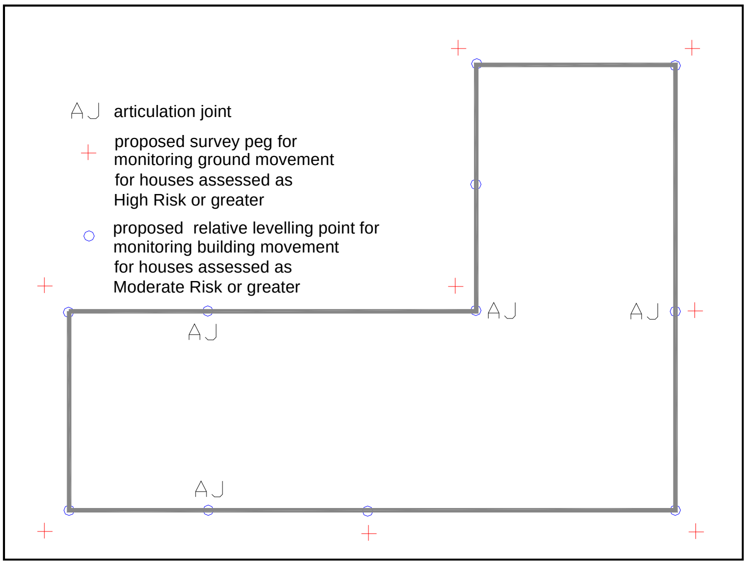

Fig. 5.3 Schematic layout for ground movement and building level surveys around a typical building

5.6. Schedule of Inspections and Surveys

A schedule of inspections and surveys is maintained using an electronic database. Weekly job sheets are issued by Tahmoor Colliery to all inspection and survey contractors. Tahmoor Colliery can, at any time, provide a copy of the schedule of inspections to DTIRIS.

5.7. Inspection and Survey Register

A register will be kept by Tahmoor Colliery, recording when inspections and surveys are conducted. Tahmoor Colliery can, at any time, provide a copy of the register to DTIRIS.

5.8. Triggers and Responses

Trigger levels have been developed by Tahmoor Colliery based on observed ground movements or impacts. Trigger levels for each monitoring parameter are described in the risk control procedures in Table 5.1.

Structural inspections will be undertaken for any structure where ground tilt is observed to exceed 7 mm/m or curvature is observed to exceed 0.2 km^{-1}.

Tahmoor Colliery will coordinate with the Mine Subsidence Board and ensure that building contractors are on standby for immediate call out and service in the event of impacts occurring. Temporary alternative accommodation will also be arranged by Tahmoor Colliery in the unlikely event that a residence becomes unsafe as a result of mine subsidence impacts.

Immediate responses will be undertaken by Tahmoor Colliery or the Mine Subsidence Board for the following impacts:

- Impacts that create a serious public safety hazard
- Impacts to all entry and exit doors, and all other doors that must remain operational for security and fire egress reasons, even if further impacts are anticipated.
- Impacts that impair any essential services.
- Impacts to sensitive equipment, even if further impacts are anticipated.

5.9. Risk Control Procedures for Longwalls 28 to 30

The risk control procedures for the management of potential impacts to residential, public amenities and commercial or business establishments are provided in Table 5.1.

Table 5.1 Risk Control Procedures for Residential Establishments for Longwalls 28 to 30

Infrastructure	Hazard / Impact	Risk	Trigger	Control Procedure/s	Timing and Frequency	By Whom?
Residential Establishments that will experience mine subsidence movements due to the mining of Longwalls 28 to 30	Impacts occur	Low to Moderate	Baseline monitoring for LW28	Kerbside inspection to identify any potentially unstable structures	Completed first time in 2009	Tahmoor Colliery (MSEC)
				Front of house inspection to identify any potentially unstable structures, for properties located directly above each active longwall	*For properties on Remembrance Drive located directly above LW28:* Prior to extraction of LW28 *For other structures:* Prior to longwall face approaching to within 300 m of each property	Tahmoor Colliery & JMA
			Prior to mining	Contact residents to inform them of commencement of mine subsidence. Request owners for information on any potential issues with existing structures	Prior to subsidence occurring	Tahmoor Colliery
				Conduct geotechnical assessment of steep slopes in vicinity of structure to check whether there is any potential for slope instability prior to, during or after mining.	Complete, except for 5 properties above LW28 on Myrtle Creek. These will be completed prior to 400m of LW28	Tahmoor Colliery (GHD Geotechnics)
				Conduct pre-mining structural inspection and assessment of: • Structures that have been recommended for structural inspection by the geotechnical engineer • Structures that have been identified as being potentially unstable • Houses built outside Mine Subsidence District which are predicted to experience more than 150 mm of subsidence • Houses built prior to declaration of the Mine Subsidence District (1975) and predicted to experience more than 150 mm of subsidence • Houses above potential hidden creeks	Prior to longwall face approaching to within 300 m of each property. (For properties located above the first 300m of extraction above each LW, the inspection will be undertaken prior to 100m of extraction).	Tahmoor Colliery (JMA)
				Installation of additional monitoring measures or mitigation/strengthening measures as recommended by structural engineer	Complete	Tahmoor Colliery
				Install survey lines on all streets above Longwalls 28 to 30 and survey initial levels and strain distances (as shown in Drawing No. MSEC646-00-03).	Complete	Tahmoor Colliery (SMEC Urban)
			Discovery of potential structural issue prior to mining	Conduct structural pre-mining inspection and assessment and consider: - any mitigation / strengthening measures to improve the existing structural condition - any management measures that should be undertaken prior to or during mining - any monitoring and inspection measures, triggers and responses during mining	Within 1 week of discovery	SMG
				Advise property owner, MSB and DTIRIS of findings of structural engineer	Within 1 week of inspection	Tahmoor Colliery
				Undertake mitigation / strengthening measures if decided by SMG	Prior to longwall face approaching to within 100 m of structure	Tahmoor Colliery

Infrastructure	Hazard / Impact	Risk	Trigger	Control Procedure/s	Timing and Frequency	By Whom?
Residential Establishments that will experience mine subsidence movements due to the mining of Longwalls 28 to 30	Impacts occur	Low to Moderate	During mining of Longwalls 28 to 30	Survey levels of street survey lines within active subsidence area	Every 200 metres of longwall face movement	Tahmoor Colliery (SMEC Urban)
				Conduct kerbside visual inspection of streets and structures	Detailed inspection once a week Vehicle based inspection once a week within active subsidence area	Tahmoor Colliery (Colin Dove)
				Assess subsidence results and project likely ground movements for structures. Provide subsidence monitoring report and commentary.	Weekly after 200 m of extraction of LWs 28, 29 & 30	Tahmoor Colliery (MSEC)
				Confirm arrangements through MSB for building contractors to remain on standby for immediate call out and service in the event of impacts affecting safety or serviceability.	Prior to subsidence occurring	Tahmoor Colliery
				Conduct inspections during mining for following structures: a) Public amenities and commercial business establishments b) Structures that have previously experienced mine subsidence impacts, where recommended by the SMG c) Pool gates d) Any other structures recommended for regular inspections and/or structure surveys by geotechnical or structural engineer due to their proximity to steep slopes or pre-existing condition	Weekly within active subsidence zone, or as required by geotechnical or structural engineer	Tahmoor Colliery
			Observed tilts are greater than 7 mm/m or observed curvatures are greater than 0.2 km^{-1} near structure	Conduct inspection of building and provide photographic survey and impact report	Within one week	Tahmoor Colliery
				Consider structural inspection/additional monitoring and/or mitigation/strengthening measures	Immediately after building inspection.	Tahmoor Colliery (JMA)

Infrastructure	Hazard / Impact	Risk	Trigger	Control Procedure/s	Timing and Frequency	By Whom?
Residential Establishments that will experience mine subsidence movements due to the mining of Longwalls 28 to 30	Impacts occur	Low to Moderate	Significant non-systematic movement occurs or Impacts observed to any surface infrastructure (not just structures) or Slope slippage observed	Consider whether any additional management measures are required in light of observations, including additional geotechnical or structural inspections, increase frequency of surveys and inspections, additional community consultation	As required by SMG	SMG
				Notify landowner, Tahmoor Colliery, Mine Subsidence Board, DTIRIS	Within one week	Tahmoor Colliery
			Any impact occurs to structure	As information can come from many possible sources: If not already done, notify landowner, Tahmoor Colliery, Mine Subsidence Board	Within 24 hours	Tahmoor Colliery
				Inspect impact of subsidence on building	As soon as possible	MSB
				Inspect condition of building, where recommended by the SMG based on feedback from the MSB or TC	As recommended by SMG with active subsidence area or as agreed with owner	Tahmoor Colliery
				Rectify any adverse impacts that impair upon: - the safety, access and mobility, security or fire egress - any essential services - sensitive equipment used for commercial and business establishments	As soon as possible at any stage during mining	Tahmoor Colliery and/or MSB
				Repair damage to structure	When subsidence impacts cease	MSB
			Observed impacts are greater than predicted impacts	Investigate cause(s) for greater impacts, including possibility of non-systematic or anomalous movements, type of structure. Investigate spatial trends in data to identify any pattern.	Within one week of observation	Tahmoor Colliery
			Observed impact is AS2870 Category 3 or greater	Notify landowner, Tahmoor Colliery, Mine Subsidence Board, DTIRIS	Within 24 hours	Tahmoor Colliery
				Inspect structural condition of building.	Within two days and then as recommended by structural engineer	Tahmoor Colliery
				Reassess final level of damage based upon likelihood of further damage and structural condition.	Immediately after structural re-inspection.	SMG
				Consider additional monitoring and/or mitigation/strengthening measures	Immediately after structural re-inspection.	SMG
			SMG considers that property is likely to be unsafe during or after mining	Coordinate with MSB and provide temporary accommodation for residents.	Immediately	MSB &Tahmoor Colliery
				Utilise acquisition and compensation procedure from DA67/98-1999 Development Consent Conditions 18-26 and MSB procedures	Immediately	MSB &Tahmoor Colliery
			Property owner does not accept acquisition	Temporarily relocate residents until building is repaired	Immediately	MSB &Tahmoor Colliery

Infrastructure	Hazard / Impact	Risk	Trigger	Control Procedure/s	Timing and Frequency	By Whom?
Houses	House subsides below 100 year ARI flood level	Moderate	Prior to Mining	Assess potential for houses to subside below 100 year ARI flood level, including transverse ground surveys of Myrtle and Redbank Creeks.	Complete	Tahmoor Colliery
			Completion of Mining	Conduct transverse ground surveys of Myrtle and Redbank Creeks	Completion of mining when subsidence movements along Myrtle and Redbank Creeks cease	Tahmoor Colliery (SMEC Urban)
				Assess whether any houses has subsided below 100 year ARI flood level	Completion of mining when subsidence movements along Myrtle and Redbank Creeks cease	Tahmoor Colliery
			House(s) subside below 100 year ARI flood level	Raise house so that floor level is above 100 year ARI flood level	As required	Tahmoor Colliery
Houses	Impacts to future houses	Low to Moderate	Prior to mining	Contact residents to inform them of commencement of mine subsidence. Request owners for information on whether any new houses have been constructed since 2009.	Prior to subsidence occurring	Tahmoor Colliery
			Owner notifies of new house	Conduct pre-mining inspection by MSB, if requested	Prior to subsidence occurring	MSB
				Conduct impact assessment and risk analysis, if requested	Prior to subsidence occurring	Tahmoor Colliery (MSEC)
			New house has maximum plan dimension greater than 30 m	Conduct subsidence predictions, impact assessment and risk analysis	Prior to subsidence occurring	Tahmoor Colliery (MSEC)
				Follow risk control procedures, as for other houses	Immediately	Tahmoor Colliery
Swimming pools and pool gates	Damage to pool	Low	None	Notify owner of potential impacts to pool	Before mine subsidence impacts occur	Tahmoor Colliery
	Pool gate – won't shut	High	None	Notify owner of potential impact to pool gate and fence	Before mine subsidence impacts occur	Tahmoor Colliery
				Visually inspect pool gate to check that it is operating properly	Weekly when each pool is within active subsidence zone, and at completion of each longwall	Tahmoor Colliery
			Pool gate won't close	Contact MSB to repair gate	Immediately	Tahmoor Colliery
				Repair gate	As soon as possible	MSB
Farm dams	Loss of water storage due to leakage of dam wall or floor	Low	During mining	Visual inspection of dam	Immediately prior to and after period of active subsidence at each dam	Tahmoor Colliery (GeoTerra)
			Cracks observed in dam	Repair cracks	As required	MSB
			Loss of water supply due to leakage of dam wall or floor	Supply water to landowner	As required	Tahmoor Colliery

6.0 SMG REVIEW MEETINGS

SMG meetings will be held between for discussion and resolution of issues raised in the operation of the Management Plan. The frequency of meetings shall be as agreed by the parties.

SMG meetings will discuss any incidents reported in relation to the relevant surface feature, 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 risk is identified for a particular surface feature, any member of the SMG may call an emergency SMG Meeting, with one day's notice, to discuss proposed actions and to keep other parties informed of developments in the monitoring of the surface feature.

7.0 AUDIT AND REVIEW

All Management Plans within this document have been agreed between parties. The Management Plan will be reviewed following extraction of each longwall.

Should an audit of the Management Plan be required during that period, an auditor shall be appointed by the Tahmoor Colliery to review the operation of the Management Plan and report at the next scheduled Plan Review Meeting.

Other factors that may require a review of the Management Plan are:-

- 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.

8.0 RECORD KEEPING

Tahmoor Colliery will keep and distribute minutes of any SMG Meeting.

9.0 CONTACT LIST

Organisation	Contact (* SMG Member)	Phone	Email / Mail	Fax
NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS)	Phil Steuart	(02) 4931 6648	phil.steuart@industry.nsw.gov.au	(02) 4931 6790
	Gang Li	(02) 4931 6644 0409 227 986	gang.li@industry.nsw.gov.au	(02) 4931 6790
	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@industry.nsw.gov.au	(02) 4931 6790
John Matheson & Associates (JMA)	John Matheson*	(02) 9979 6618 0418 238 777	jma.eng@bigpond.net.au	(02) 9999 0121
Mine Subsidence Board (MSB)	Darren Bullock	(02) 4577 1967 0425 275 567	d.bullock@minesub.nsw.gov.au	(02) 4677 2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777 0416 191 304	daryl@minesubsidence.com	(02) 9413 3822
Glencore Tahmoor Coal – Environment and Community Manager	Ian Sheppard*	(02) 4640 0156 0408 444 257	Ian.Sheppard@glencore.com.au	(02) 4640 0140
Glencore Tahmoor Coal – Community Coordinator	Belinda Treverrow*	(02) 4640 0133	Belinda.Treverrow@glencore.com.au	(02) 4640 0140
Tahmoor Colliery 24 hour contact	Tahmoor Colliery Control	1800 154 415	-	-

APPENDIX A.

Please refer to the following documents:

- Drawings
- JMA (2014). Review of LW28-LW30 Subsidence Management. John Matheson & Associates, Report No. R0234, Rev 1, March 2014.

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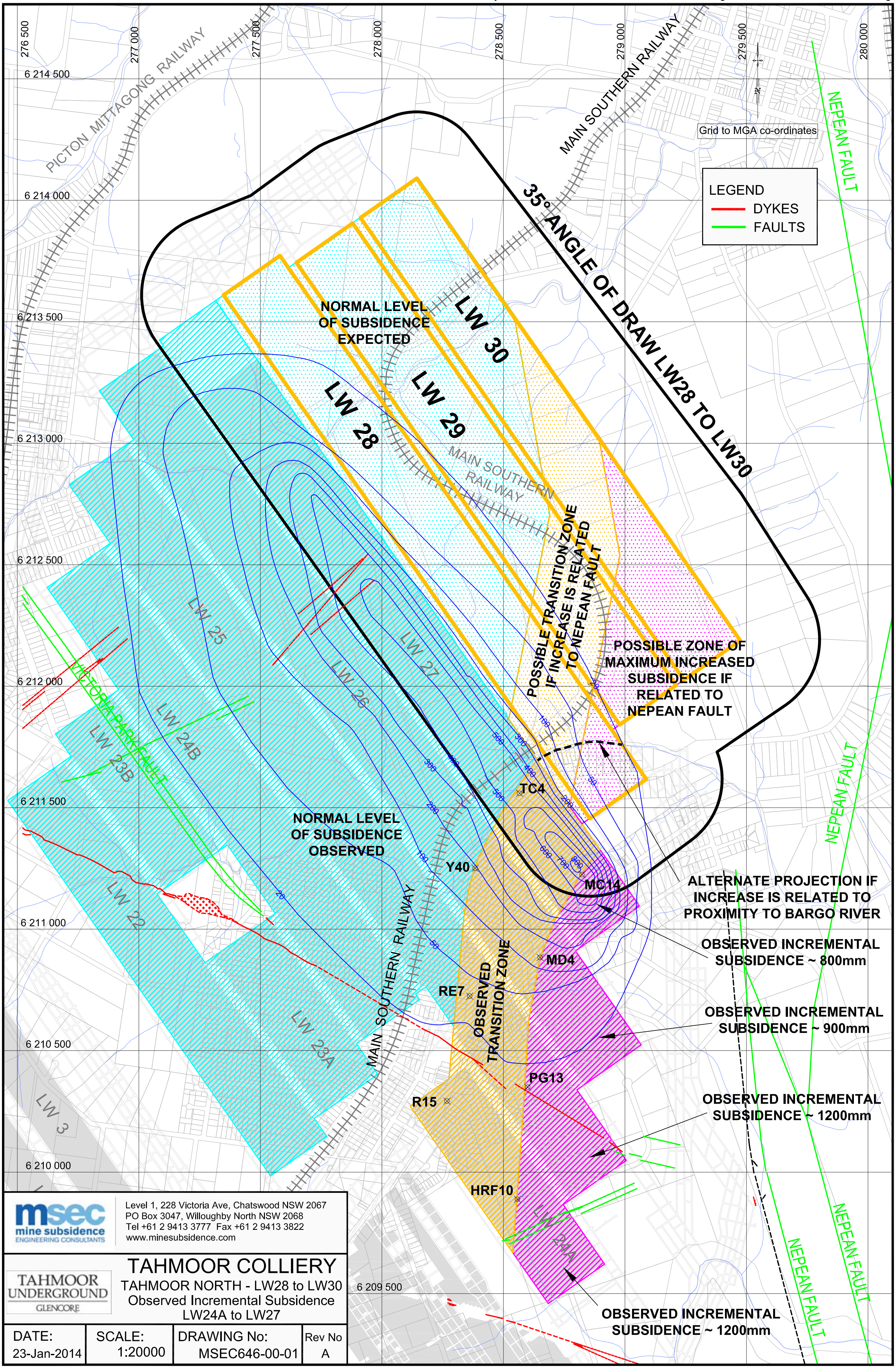

msec mine subsidence ENGINEERING CONSULTANTS

Level 1, 228 Victoria Ave, Chatswood NSW 2067
PO Box 3047, Willoughby North NSW 2068
Tel +61 2 9413 3777 Fax +61 2 9413 3822
www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30
Observed Incremental Subsidence
LW24A to LW27

DATE:	SCALE:	DRAWING No:	Rev No
23-Jan-2014	1:20000	MSEC646-00-01	A

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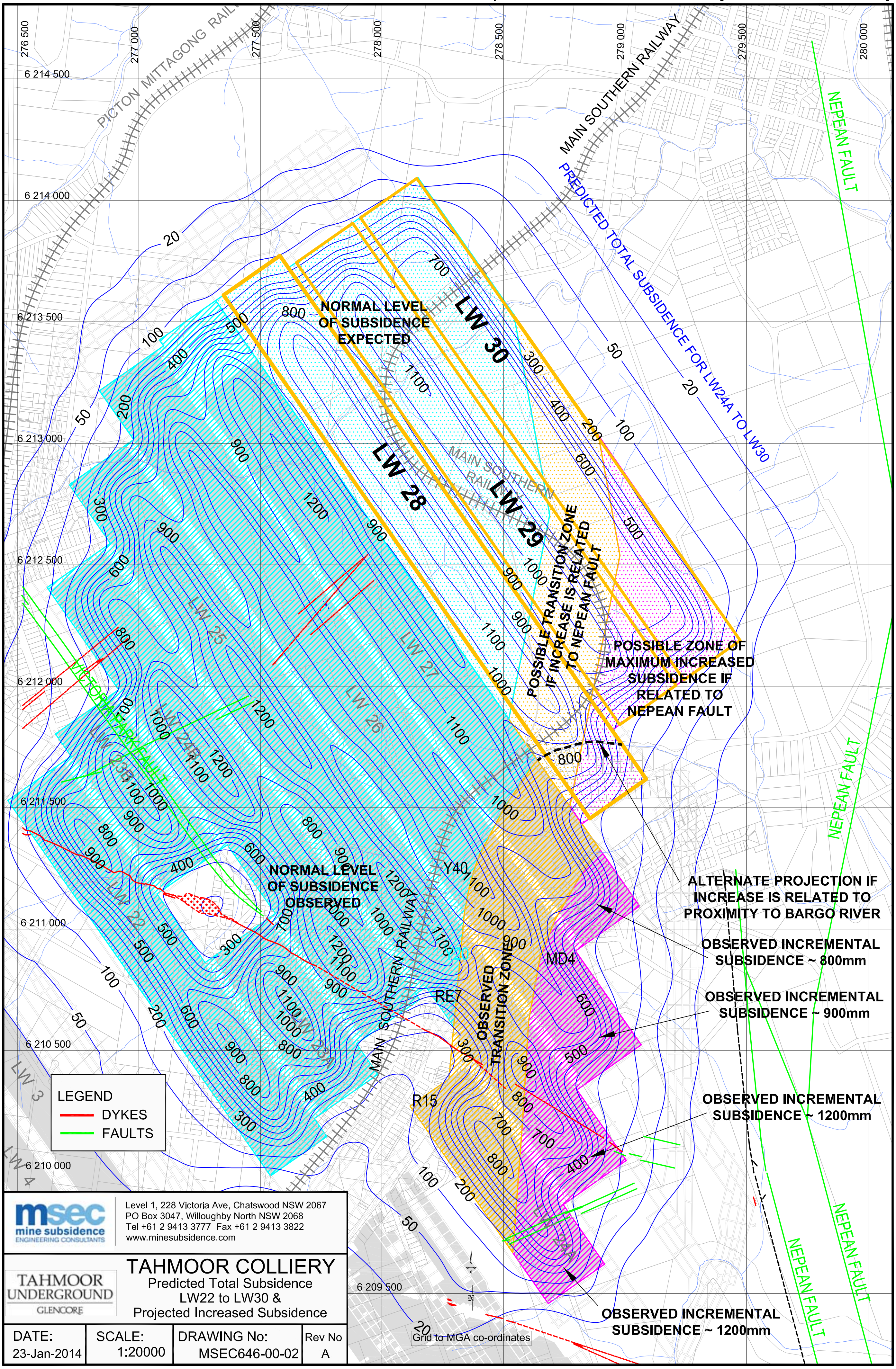

msec mine subsidence ENGINEERING CONSULTANTS	Level 1, 228 Victoria Ave, Chatswood NSW 2067 PO Box 3047, Willoughby North NSW 2068 Tel +61 2 9413 3777 Fax +61 2 9413 3822 www.minesubsidence.com
TAHMOOR UNDERGROUND GLENCORE	TAHMOOR COLLIERY Predicted Total Subsidence LW22 to LW30 & Projected Increased Subsidence

DATE:	SCALE:	DRAWING No:	Rev No
23-Jan-2014	1:20000	MSEC646-00-02	A

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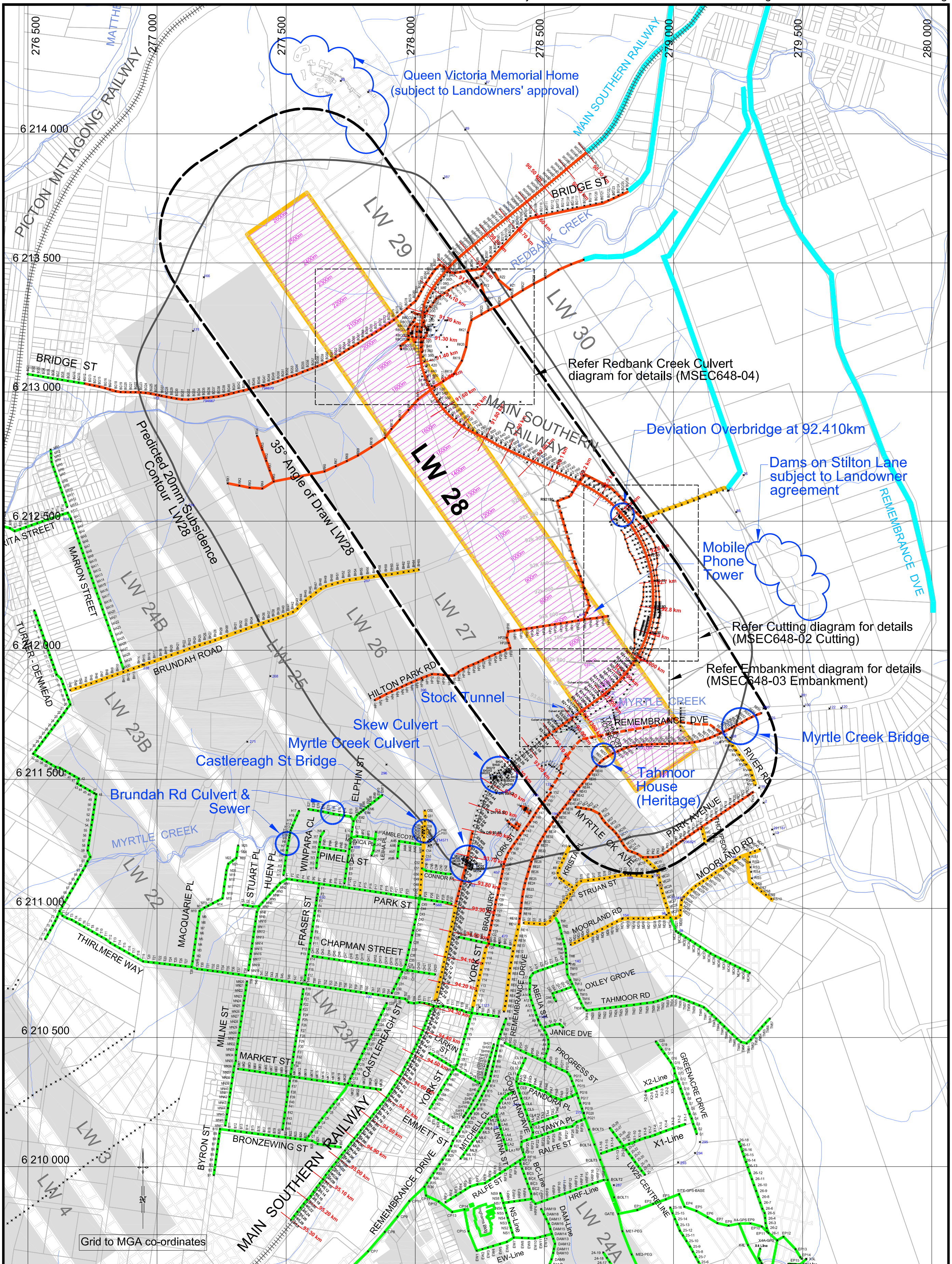

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW28
- Monitoring Lines Before & End of LW28
- Surveys During LW28
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

msec mine subsidence ENGINEERING CONSULTANTS

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30 MONITORING OVER LW28

DATE:	SCALE:	DRAWING No:	Rev No
19-Mar-2014	1:20000	MSEC646-00-03	B

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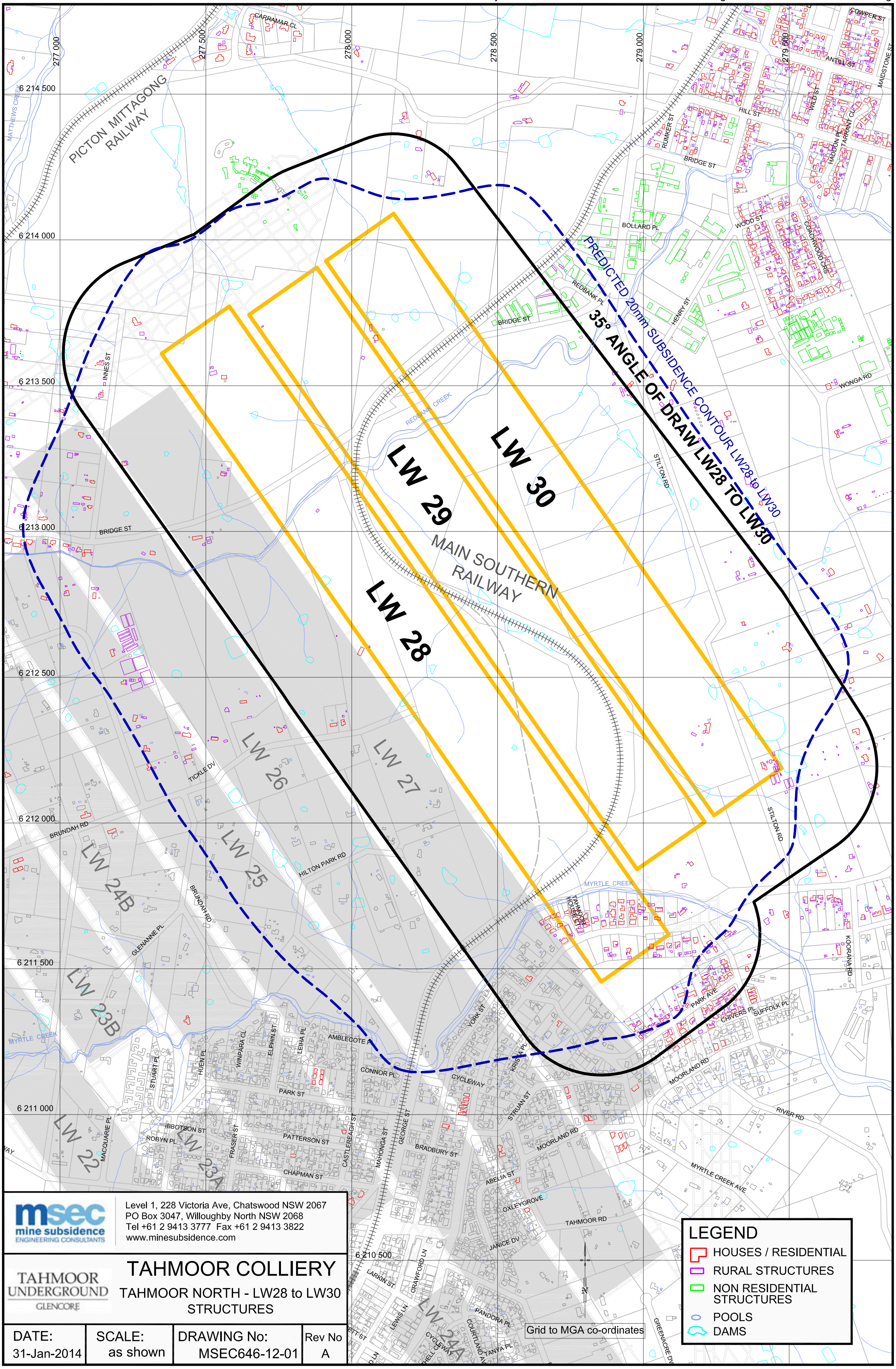

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TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW28 to LW30 STRUCTURES

DATE:	SCALE:	DRAWING No:	Rev No
31-Jan-2014	as shown	MSEC646-12-01	A

John Matheson & Associates Pty Ltd

Review of Longwall LW28-LW30 Subsidence Management.

Structural Report: R0234 Rev 1

John Matheson & Associates Pty Ltd
Consulting Civil & Structural Engineers
2/1767 Pittwater Road
Mona Vale NSW 2103
Tel: 9979 6618
Email: jme.eng@bigpond.net.au
ABN 49 061 846 795

2 April 2014

Tahmoor Colliery
Remembrance Drive
Tahmoor NSW 2573

Attention; Mr. Ian Sheppard

Re: Subsidence Management Plan for Longwall LW28-LW30, Tahmoor

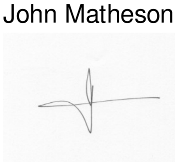
Dear Ian,

Please find enclosed our report concerning MSEC646-12 Built Structures Management Plan Rev A for Longwalls LW28-LW30 at Tahmoor.

In summary, a review has been conducted of the structures management plan in the context of possible structure impacts due to LW28-LW30, previous experience of subsidence impacts in Tahmoor resulting from LW22-LW27 and comparative data concerning damage to residential structures cause by reactive soil foundations.

The intent, approach and processes included in MSEC646-12 Built Structures Management Plan Rev A for Longwalls LW28-LW30, are adequate to manage the safety and serviceability of any public, commercial, residential or farm building and associated structures that may be affected by mine subsidence from the extraction of Longwall LW28-LW30.

Yours faithfully
John Matheson & Associates Pty Ltd



John Matheson
Director

DOCUMENT HISTORY			
Revision	Date	Amendments	Author
Draft	28.03.2014	Issued	JM
Rev 1	02.04.2014	Amended to include LW28-LW30	JM

TABLE OF CONTENTS

1 INTRODUCTION

This report was prepared by Mr John Matheson from this office at the request of Mr Ian Sheppard on behalf of Tahmoor Colliery. The purpose of this investigation is to examine the MSEC646-12 Built Structures Management Plan Rev A for Longwall LW28-LW30 prepared by MSEC and report concerning the suitability of the management process adopted, including proposed controls in terms of structure serviceability and safety.

At the completion of coal extraction from Longwall Panel LW27, subsidence movements during mining of Longwall panels LW22-LW27 had been imposed on a total number of 1542 dwellings, public amenities and commercial buildings, 1190 of which sit directly above the goaf. The MSB has received a total number of 487 claims from individual properties (not including refused claims) of which 433 claims relate to main structures or 28% of the 1542 dwellings affected by subsidence.

The majority of impacts are considered very slight-slight (Cat 0, 1 and low level Cat 2 damage to Table C1 in Appendix C of AS2870) and consist of sticky doors and minor impacts to walls, ceiling or floor finishes. However, 2.7% of impacts are considered to be moderate or greater and in ten cases (0.6per cent of all building structures), the impacts were substantial and the cost to repair the structure exceeded the cost to replace.

2 STRUCTURAL REDUNDANCY IN RESIDENTIAL BUILDING STRUCTURES

The design of residential building structures is typically carried out in accordance with AS4055: Wind Loads for Housing, AS1684 Residential Timber Framed Construction, AS3700 Masonry Structures and AS2870 Residential Slabs & Footings and AS1170.1 & 4. These Australian Standards were first produced as follows:

i. AS4055: First published in 1992. Prior to this, wind loads were calculated in accordance with AS1170.2-1975
ii. AS1684: First published in 1992. Prior to this, AS O56—1948.
iii. AS3700: First published in 1998. Prior to this, AS CA32—1963.
iv. AS2870: First Published in 1986.
v. AS1170.1: First Published in 1971. Prior to this, ASCA34.1
vi. AS1170.4: First Published in 1993. Prior to this, AS 2121—1979.

The above list demonstrates that a comprehensive list of material engineering design standards have been available for the use in the design of residential building structures since 1948, with reference to clad and brick veneer timber framed construction.

Timber-framed construction is generally a ductile form of construction that is able to tolerate significant deformation whilst maintaining structural integrity. Prior to the late 1960's, the majority of timber framed residential construction consisted of a pitched timber framed roof supported by under-purlins and roof struts, ceiling joists and hanging beams to transmit the roof load down to the perimeter and internal timber framed stud walls, suspended timber ground floor framing and supporting brick piers and perimeter brick pedestal walls. The timber stud walls usually incorporated timber bracing cut into and nailed to the timber studs, which were internally plasterboard lined and externally weatherboard lined or clad with a brick veneer. The timber member sizes and frame layout was frequently chosen by the builder based on the "light timber framing code" and what was considered then to be normal practice.

These structures are generally smaller than dwellings constructed more recently and the roof and floor framing form relatively stiff bracing diaphragms ensuring distribution of horizontal wind loads to the timber framed stud walls with minimal frame distortion. These structures have been in service for upwards of fifty years and have been subject to significant environmental wind loads and earthquake; Robertson and Bowral (Magnitude 5.6) on 21 May 1961 (some damage Moss Bale, Bowral, Robertson) and Picton (Magnitude 5.6) 9 March 1973 (Minor damage in Picton) neither of which caused loss of life or substantial damage. Whilst these structures may not have been engineer designed at the time of construction, they have generally proved to be resilient and serviceable if properly maintained.

Systematic curvature and ground strain of the magnitude typically predicted in Tahmoor (±1.5mm/m) tends to be distributed along the structure length (typically not more than 15metre in length pre-1975) building with damage generally occurring at frequent intervals rather than accumulating at one location. However, in the unlikely event that a differential displacement develops between the roof and the supporting walls in response to a tensile ground strain of 1.5mm/m strain, it is unlikely for a common rafter or ceiling joist to lose support from a wall top plate should a relative displacement of 11mm occur at each end of the building.

Construction that is more recent has been subject to considerably more engineering oversight in terms of engineered timber frames and roof trusses used to construct considerably larger residential dwellings. Structures post 1975, have seen increasing use of metal strap and plywood sheet bracing and tie down elements (post Cyclone Tracy) to ensure that the timber frames used in the construction of residential dwellings are safe and serviceable for the expected wind loads. Furthermore, roof and wall framing consists of multiple parallel members that can effectively share load with adjacent members should some members become overstressed for any reason. Provided that overall tilt-induced loads (5mm/m to 7mm/m tilt) do not exceed 10% of the calculated 20Year ARI wind load (serviceability design wind load) at eaves level, previous analysis carried out on over 100 residential dwellings in Tahmoor indicates that the braced timber frames can generally be expected to remain serviceable during subsidence.

In summary, provided the buildings have been appropriately maintained, the majority of timber framed dwellings (clad and brick veneer) are expected to have numerous redundant load paths to resist additional lateral loads induced between the roof and ground floor framing by tilt caused by subsidence.

3 Previous Experience in Tahmoor

Mine subsidence related to coal extraction from Longwall Panels LW22 to LW27 has been imposed on a total number of 1542 dwellings, public amenities and commercial buildings and to date, there has been no record of an immediate or sudden safety hazard emerging, refer to section 4.1 of MSEC646-12 Built Structures Management Plan Rev A.

Structural responses to ground movements caused by mine subsidence develop in proportion to the rate of change in subsidence (strain, curvature & tilt). Consequently, structural damage of this nature is the result of structure deformation in response to imposed strain and not specifically applied load. Whilst the strains generated in masonry and plasterboard wall linings in response to subsidence may exceed the tensile strength of the brickwork and plasterboard respectively, the structure effectively becomes articulated (less stiff) and more able to dissipate additional strain.

There have been some instances where geology or topographic features (such as valley incisions, in some cases hidden but identified by MSEC) have caused non-systematic subsidence to develop and surface ground movements have exceeded the non-systematic predictions, particularly in Progress Street, Abelia Street, Tahmoor Road and Moorland Road. In each case, the monitoring required by the Management Plan for Potential Impacts to Public, Commercial and Residential Structures for

Longwall 26, detected the development of non-systematic ground surface bumps and spikes in the road survey data along Progress Street, Abelia Street and Tahmoor Road, before detection of the impacts in the main dwelling structures at the adjoining properties. In response, the frequency of inspections and contact with the property owners/occupants increased in the affected areas with structure affects being recorded and categorised (in terms of Tables C1 & C2 of Appendix C of AS2870).

3.1 SUPPLEMENTARY STRENGTHENING PRIOR TO ACTIVE SUBSIDENCE

Prior to approval to mine Longwall 24, a detailed investigation of the Ingham's Large Bird Plant and the Tahmoor Commercial Centre to determine the potential for subsidence impacts on the main structures. Some other minor supplementary measures were carried out in the Tahmoor/Thirlmere area during LW22 to LW26 such as guy-wire restraint of isolated brick chimney structures and some alterations to long roof structures bridging two adjacent structures to limit the possible extent of damage due to ground strain and tilt.

Where perceived structure deficiencies were identified, each structure possessed some degree of structural capacity to resist tilt-induced horizontal loads. In the event that the supplementary strengthening had not occurred, the structures would have responded elastically up to the point where cracking developed and the displacement of the structure had become more apparent. If an alternate approach had been adopted, where no mitigation measures were undertaken prior to mining, the structures management plan would have been designed differently to include increased monitoring frequencies with displacement/strain/crack width triggers set to manage risk. It was decided that whilst subsidence impacts would be noticeable and were expected to develop gradually before a structural failure could develop under the alternate approach, the conservative approach of supplementary strengthening prior to subsidence was preferred to avoid the need, whilst unlikely, for short lead-time activity if subsidence caused significant structure damage to develop during subsidence.

3.1.1 BICYCLE SHOP IN REMEMBRANCE DRIVE

This single storey shop was formed by removing most of the central common wall between two adjoining commercial units and some internal walls to the rear of the building. There were insufficient records of the built structure and the structure alterations and a decision was taken to provide additional temporary support along the line of the original common wall and to provide some cross bracing to increase the transverse rigidity of the building in response to the predicted transient transverse tilt. There was little discernable impact on the structure due to Longwalls 24 or 25 and the supplementary strengthening was removed.

3.1.2 AQUARIUM

This two-storey full masonry structure had been modified over time, internal ground floor walls had been removed, and there appeared to be a limited amount of transverse structure rigidity for the mass of the structure. Whilst the predicted tilt and ground strain were not particularly large, a decision was taken to introduce a plywood bracing wall in the transverse direction between the ground and first floor slab to increase the transverse resistance to earthquake and wind load during the active and subsidence period and limit possible damage due to subsidence.

3.1.3 TAHMOOR TOWN CENTRE

Some workmanship issues were detected at the base of approximately 20 basement columns and a decision was taken to strengthen the base of the columns by wrapping the bottom 800mm of the reinforced concrete columns in carbon fibre to improve concrete confinement prior to active subsidence.

During the active subsidence period, frequent inspection and monitoring of the structure was carried out and any new damage or change in existing damage was recorded. There was a concentration of subsidence movement in the retaining walls along the eastern elevation basement retaining walls of the main shopping centre and the MSB replaced some of these walls after Longwall 25. Displacements occurred gradually between precast concrete wall panels and the overlying suspended concrete ground floor slab around the basement perimeter, which were accommodated by the ductile wall panel connections and flexible joint sealants.

A light pole toward the northeast corner of the main shopping centre building, and the columns supporting the canopy roof above the petrol bowsers at the petrol station developed substantial tilt. Remedial actions were taken in both cases after the developing tilts had reached a trigger level after having been monitored continuously over a period of several weeks. Some remedial works were also carried out on the in-ground pipework below the driveway slab at the petrol station.

3.2 Supplementary Strengthening During Active Subsidence

During the active subsidence period for Longwall 26, non-systematic ground movements were detected in Progress Street and Moorland Road, which resulted in significant structure damage to two main dwellings, which triggered a response to install supplementary strengthening during the active subsidence period. Ground surface bumps and survey spikes were first detected in Progress Street and Tahmoor Road (near Moorland Road) shortly before the adjacent structures were affected and monitoring frequency was increased in response.

The structure impacts increased gradually over time and they were monitored by a building inspector on a daily basis and by a structural engineer twice weekly. This occurred up to the point that where a decision was taken to provide limited supplementary support to one wall, in each case, as the structure damage transitioned through Category 4 towards Category 5 in response to compressive ground strain pushing a strip footing back into the building underneath an overlying perimeter brick wall.

4 Proposed Risk Management Plan

A key element of the risk management plan is regular consultation with the community before, during and after mining to enable effective lines of communication to operate when subsidence impacts occur. This has been successfully undertaken at Tahmoor (refer to section 5.3 of MSEC646-12).

The development of subsidence impacts on residential building structures in Tahmoor has a direct correlation with the development of subsidence irrespective of whether the impacts are caused by systematic or non-systematic effects. The greatest structural damage reported in Tahmoor has generally occurred where brick veneer structures have been constructed on strip footings above hidden creeks or where near surface geological features have caused localised anomalous ground movements to affect these structures. In such cases, whilst Cat 4 & Cat 5 damage may have ultimately developed, the impact of the anomaly was detected early in the form of compression impacts in the adjacent street and the early development of subsidence impacts on the residential structure were notified to either Tahmoor colliery, the MSB or both. The structures were then monitored frequently with structural intervention taking place where circumstances required.

A front of house inspection has been conducted for all of the residential properties above the first 600metres of LW28. The main dwelling structures have generally been identified as clad or brick veneer timber framed structures with a timber-framed roof supported by a concrete raft slab or strip footings. The front of house inspections provides an indication of the general condition and level of maintenance of each structure. An internal inspection will be recommended if a potential structural deficiency is perceived. While the inspections are a responsible method of managing risk, it should be recognised that it might not always be possible to discern structural deficiencies in every structure as many structural elements are concealed.

The three most important factors in managing risk are the structural redundancy normally present in building structures, the gradual development of subsidence movements at Tahmoor and the implementation of an effective community consultation program. Due to these three factors, it is likely that the owner will have notified Tahmoor Colliery or the MSB of significant displacement or deflection well before structural failure will occur. The undertaking of pre-mining inspections and monitoring undertaken during mining provide a valuable additional level of risk management but are secondary in importance.

The site-specific investigations, monitoring, trigger and response plan outlined in MSEC646-12 Built Structures Management Plan Rev A Longwalls LW28-LW30 appear to be sufficient to identify the structures that are most at risk of significant subsidence impacts to enable adequate response time should circumstances arise during the mining of Longwalls LW28-LW30.

5 APPENDIX A: STRUCTURAL RESPONSE TO GROUND MOVEMENT

The paper "Damage to residential building structures due to ground movement" by Gad, Sivanerupan and Wilson (Swinburn University of Technology, Hawthorn, Victoria) presents the findings of a preliminary research project seeking to identify and quantify the causes of damage to residential building structures constructed in Victoria post-1986, after AS2870-1986 came into use. This report was based on damage data collected by Foundation and Footings Society Victoria (FFSV) specifically for the study. The damage reports were sourced from consultants and only properties constructed since the implementation of the first edition of AS 2870 (1986) were chosen for the study.

The paper reports the percentage of damage categories grouped in terms of site classification (foundation reactivity) based on an assessment of 367 houses (71% single story, remainder two storey) of which 95% were of brick veneer construction and the remainder light cladding or full masonry construction, refer to Table 1 in Appendix A. In each case, inspection of the damage was carried out on average within 5years of construction, which seems consistent with the owners desire to resolve issues prior to the end of the 7year warranty period.

Approximately 10% of all houses surveyed had Cat 1 damage indicating that the owners had requested an inspection even though Cat 1 damage is considered minor damage in accordance with AS2870. This suggests that a significant number of owners have a relatively low tolerance to structure damage and possibly little understanding of the significance of crack width. This pattern of behaviour of a low tolerance to damage reported by Gad et al, has positive implications in terms of monitoring building structures during the active subsidence period for Longwall 28. The survey and monitoring team can expect contact from owners at relatively low levels of damage beyond which stage regular inspections can be carried out by a qualified building inspector.

A comparison of the data reported for reactive soils in Victoria and the subsidence impacts recorded for main dwelling structures in Tahmoor for Longwalls 22-27 (MSEC646-12 Built Structures Management Plan Rev A.), indicates that where the structures have been damaged by ground movement, the distribution of damage to structures caused by reactive soil foundation movement (constructed on raft slabs post 1986) is more negatively skewed toward higher damage categories than structures damaged by mine subsidence reported by MSEC (including structures constructed pre-1986 including strip footings and suspended timber floors), which is positively skewed toward lower damage categories. It is noted that the structures impacted by subsidence in Tahmoor have been generally constructed on soils of moderate reactivity and thus the effects of subsidence have been superimposed on any pre-existing effects of a reactive soil foundation.

Some inferences drawn from the two data sets are:

i. Whilst a greater proportion of structures have been affected by subsidence in Tahmoor (LW22-LW27) than those constructed upon raft slabs on reactive soil foundations across Victoria (since 1986), the impact of subsidence on the affected residential structures in Tahmoor, appears to be less severe than for residential building structures affected by reactive soil foundations in Victoria.

ii. The profile of structure damage on reactive soil foundations in table 1 suggests that there has been a tendency to underpredict the reactivity of soil foundations in Victoria.

iii. The experience of subsidence in Tahmoor and reactive soil foundations in Victoria show that owners react to minor structural damage (Cat 1).

Table 1(Category of recorded damage (% of houses in the sample) versus site classification, extract data from paper by Gad, Sivanerupan, Wilson)

Site Classification	Cat 0 (%)	Cat 1 (%)	Cat 2 (%)	Cat 3 (%)	Cat 4 (%)	No Cat (%)
S	0	0	0.8	0.8	0	0.6
M	0	2.7	9	6.8	4.4	6.2
H	0	4.9	21.6	7.4	4.1	7.4
E	0	0	1.4	2.5	2.2	2.2
P	0	2.5	3.8	3.6	0.5	0.5
None Classified	0	0	2.2	0.5	0	1.4
Sum	0	10.1	38.8	21.6	11.2	18.3

Table 2 Distribution of damage to main dwelling structures damaged in Tahmoor inferred from MSEC MSEC646-12 Built Structures Management Plan Rev A.

Damage Category	Cat 0, 1 & 2 (%)	Cat 3 (%)	Cat 4, 5 (%)
Percentage	97.3	0	2.7

Table 3 Classification of Tilt Impacts generally based on Digest 475: British Research Establishment and work conducted by Waddington Kay & Associates Pty Ltd

Description	Measured Building Tilt	Category
• Building tilt can be noticeable at this level of tilt but remedial work unlikely. Tilt induced load at eave level approximately 5% of 20-year ARI wind load.	5mm/m	A
• Adjustment to roof drainage and wet area floors might be required. Tilt induced load at eave level approximately 10% of 20-year ARI wind load.	5mm/m<Tilt<7mm/m	B
• Minor structural work may be required to rectify for tilt. Adjustments to roof drainage and wet area floors will probably be required and remedial work to surface water drainage and sewerage systems might be necessary. Tilt induced load at eave level approximately 15% of 20-year ARI wind load.	7mm/m<Tilt<10mm/m	C
• Considerable structural work may be required to rectify tilt. Jacking to level or rebuilding could be necessary in the worst cases. Remedial work to surface water drainage and sewerage systems might be necessary. Tilt beyond 20mm/m, structure distress may be apparent.	>10mm/m	D

Table 4 AS2870: Classification of Damage With Reference to Walls

Description of typical damage and required repair	Approximate crack width (w) limit (see note 1)	Damage Category
Hairline cracks	w<0.1mm	0
Fine cracks, which do not need repair	0.1mm<w<1mm	1
Cracking that is noticeable but easily filled. Doors and windows stick slightly	1mm<w<5mm	2
Cracking that can be repaired and possibly a small amount of wall may need to be replaced. Doors and windows stick. Service pipes can fracture. Weather tightness often impaired.	5mm<w<15mm (or a number of cracks 3mm or more in one group)	3
Extensive repair work involving the breaking-out and replacement of wall sections, especially over doors and windows. Window and doorframes distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted.	15mm<w<25mm but also depends on the number of cracks	4