mine subsidence
ENGINEERING CONSULTANTS

TAHMOOR UNDERGROUND
GLENCORE

GLENCORE:

Tahmoor Colliery - Longwall 29

Management Plan for Potential Impacts to Jemena Gas Infrastructure

AUTHORISATION OF MANAGEMENT PLAN

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DOCUMENT REGISTER

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Mar-06	MSEC286-0405	A	Draft for Submission to Jemena
Jul-06	MSEC286-0405	B	Agreed management plan
Aug-06	MSEC286-0405	C	Chapter 1 amended
Mar-08	MSEC286-0405	D	Draft update to mine plan and risk control procedures
May-08	MSEC286-0405	E	Agreed amended plan for Longwalls 24A to 26
Sep-08	MSEC286-0405	F	Updated for Longwalls 25 to 26 and Jemena name change
Apr-10	MSEC446-05	A	Updated for Longwall 26
Jun-10	MSEC446-05	B	Minor revisions
Sep-12	MSEC567-05	A	Updated for Longwall 27
Oct-12	MSEC567-05	B	Updated after consultation with Jemena
Mar-14	MSEC646-05	A	Updated for Longwalls 28 to 30
Mar-14	MSEC646-05	B	Updated following Jemena feedback
Apr-14	MSEC646-05	C	Final plan for Longwall 28
Mar-15	MSEC746-05	A	Updated for Longwalls 29 to 30
Apr-15	MSEC746-05	B	Updated following Jemena feedback
Apr-15	MSEC746-05	C	Final plan for Longwall 29 only

References:-

AS/NZS 4360:1999 Risk Management

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. (Report MSEC355, Revision B, July 2009), prepared by Mine Subsidence Engineering Consultants

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.

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

Tables are prefaced by the number of the chapter in which they are presented.

Figures

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

Drawings

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

Drawing No.	*Description*	*Revision*
MSEC746-05-01	Jemena Infrastructure and Predicted Incremental Subsidence due to Longwall 29	A

1.0 INTRODUCTION

1.1. Background

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 27 longwalls to the north and west of the mine's current location. It is currently mining Longwall 28.

Longwall 29 is a continuation of a series of longwalls that extend into the Tahmoor North Lease area, which began with Longwall 22. The longwall panel is located between the Bargo River in the south-east, the township of Thirlmere in the west and Picton in the north.

Longwall 29 is approximately 283 metres wide (rib-to-rib) and approximately 2.3 kilometres long. The width of the chain pillar between Longwalls 28 and 29 is 39 metres.

Longwall 29 is located beneath the rural area of Tahmoor. No infrastructure owned by Jemena is located directly above Longwall 29.

Tahmoor Colliery's mine plan has changed, in that Longwall 29 has been shortened by approximately 250 metres, when compared to the mine plan submitted with the SMP Application for Longwalls 27 to 30. This represents a significant change because the potential for impacts on the steel gas pipe crossing over Myrtle Creek on the Remembrance Drive Road Bridge has been substantially reduced.

The closest distance of Longwall 29 to the main PE gas pipe along Remembrance Drive is 230 metres. The location of Longwall 29 relative to Jemena assets is shown in Drawing No. MSEC746-05-01.

This Management Plan provides detailed information about how the risks associated with mining in the vicinity of gas infrastructure will be managed by Tahmoor Colliery and Jemena.

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

1.2. Objectives

The objectives of this Management Plan are to establish procedures to measure, control, mitigate and repair potential impacts that might occur on surface infrastructure owned by Jemena. The objectives of the Management Plan have been developed to:-

- Ensure the safe and serviceable operation of all surface infrastructure. Public and workplace safety is paramount. Disruption and inconvenience should be kept to minimal levels.
- Monitor ground movements and the condition of surface infrastructure during mining.
- Establish procedures to measure, monitor, control, mitigate and repair gas infrastructure.
- Initiate action to mitigate or remedy potential significant impacts that are expected to occur on the surface.
- Provide a plan of action in the event that the impacts of mine subsidence are greater than those that are predicted.
- Provide a forum to report, discuss and record impacts to the surface. This will involve Tahmoor Colliery, Jemena, Mine Subsidence Board, and the NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (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:-

- The main PE gas pipeline
- The local gas pipelines
- Gas mains at creek crossings

The Management Plan describes measures that will be undertaken as a result of mining Longwall 29 only.

1.4. Proposed Mining Schedule

It is planned that Longwall 29 will extract coal working northwest from the southeastern end. This Management Plan covers longwall mining until completion of mining in Longwall 29 and for sufficient time thereafter to allow for completion of subsidence effects. The current schedule of mining is shown in Table 1.1**Error! Reference source not found.**.

Table 1.1 Schedule of Mining

Longwall	Start Date	Completion Date
Longwall 29	June 2015	May 2016

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.

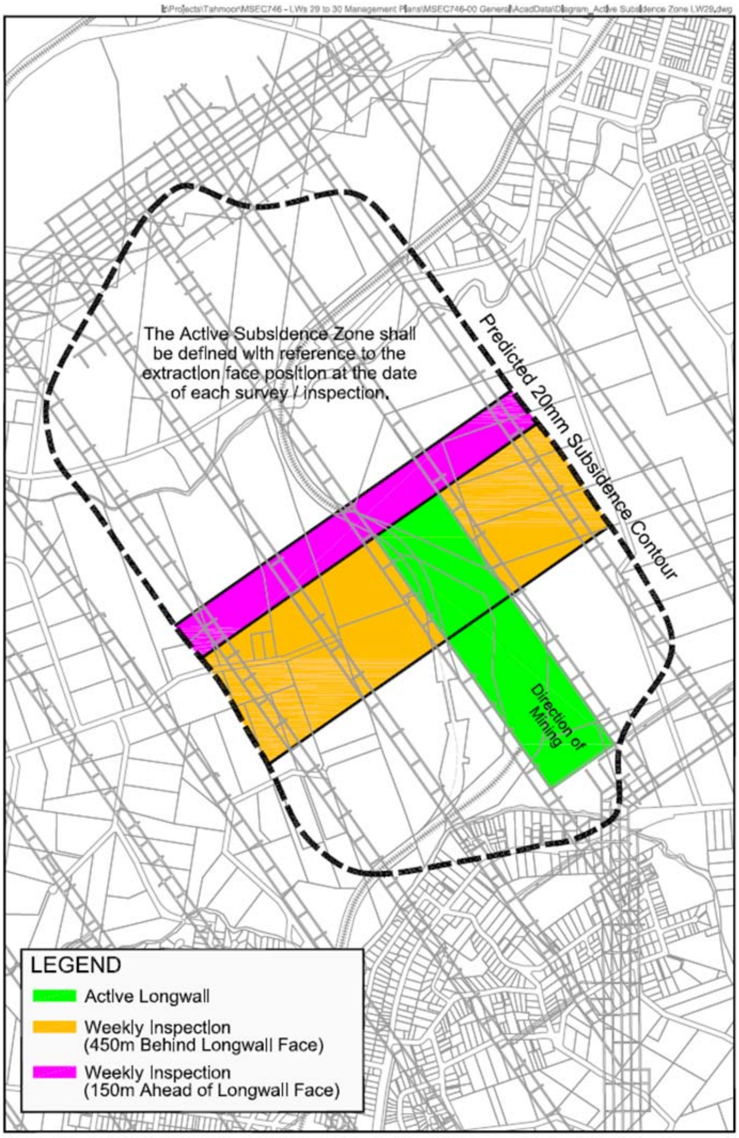


Fig. 1.1 Diagrammatic Representation of Active Subsidence Zone

2.1. 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:-

2.1.1. 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.

2.1.2. Likelihood

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

2.1.3. Hazard

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

2.1.4. 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 2.1, 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 2.1 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

3.1. 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. Tahmoor Colliery has submitted an application to modify the SMP mine layout to shorten the commencing end of Longwall 29 by approximately 250 metres. The predictions and impact assessments included in this document are based on the shortened longwall.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of Longwall 29, is provided in Table 3.1. A summary of the maximum predicted total systematic subsidence parameters, after the extraction of Longwall 29, is provided in Table 3.2.

Table 3.1 Maximum Predicted Incremental Systematic Subsidence Parameters due to the Extraction of Longwall 29

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 LW29	730	5.9	0.06	0.13

Table 3.2 Maximum Predicted Total Systematic Subsidence Parameters after the Extraction of Longwall 29

Longwall	Maximum Predicted Cumulative Subsidence (mm)	Maximum Predicted Cumulative Tilt (mm/m)	Maximum Predicted Cumulative Hogging Curvature (1/km)	Maximum Predicted Cumulative Sagging Curvature (1/km)
After LW29	1250	6.1	0.10	0.14

The values provided in the above table are the maximum predicted cumulative systematic subsidence parameters which occur within the general longwall mining area, including the predicted movements resulting from the extraction of Longwalls 22 to 29.

3.2. Observed Subsidence during the mining of Longwalls 22 to 28

The extraction of longwalls at Tahmoor Colliery has generally resulted in mine subsidence movements that were typical of those observed above other collieries in the Southern Coalfield of NSW at comparable depths of cover.

However, observed subsidence was greater than the predicted values over Longwalls 24A and the southern parts of Longwalls 25 to 27.

During the mining of Longwall 24A at Tahmoor Colliery, substantially increased subsidence was observed and further increases in observed subsidence compared to the predicted subsidence was observed in Longwall 25.

These increased levels of subsidence were a very unusual event for the Southern Coalfield and immediate investigations were undertaken to identify why it occurred. The conclusions of these studies were published in 2011 in a paper by W. Gale and I. Sheppard, which advised that the increased levels of subsidence were likely to be associated with the proximity of these areas to the Nepean Fault and the Bargo River Gorge and a recognition of the impact of a weathered zone of joints and bedding planes above the water table, which reduced the spanning capacity of the strata below this highly weathered section. This later recognition was determined after extensive computer modelling of factors that may have caused the increased subsidence.

Further subsidence monitoring has occurred over Longwalls 26, 27 and 28 within and around this zone of increased subsidence since 2011. A summary of the monitoring results over Longwalls 24A to 27 is shown in Table 3.3. It can be noted that the zone of increased subsidence extends over the Longwalls 24A to 27, though the extent of the increase in subsidence has reduced in magnitude as each longwall was extracted as shown in the table below.

Table 3.3 Maximum Observed and Maximum Predicted Incremental Subsidence and Maximum Observed and Maximum Predicted Total Subsidence within the Zones of Increased Subsidence (Longwall 24A to Longwall 28)

Longwall	Assumed Average Seam Thickness Extracted in Zone (m)	Maximum Observed Incremental Subsidence directly above LW and Proportion of Seam Thickness (mm)	Maximum Predicted Incremental Subsidence directly above LW and Proportion of Seam Thickness (mm)	Relative Increase in Incremental Subsidence	Maximum Observed Total Subsidence directly above LW and Proportion of Seam Thickness (mm)	Maximum Predicted Total Subsidence directly above LW and Proportion of Seam Thickness (mm)	Relative Increase in Total Subsidence
LW24A	2.20	1169 (53%)	500 (23%)	2.34	1262 (57%)	800 (36%)	1.58
LW25	2.20	1216 (55%)	610 (28%)	1.99	1361 (62%)	900 (41%)	1.51
LW26	2.25	893 (40%)	730 (32%)	1.22	1070 (48%)	900 (40%)	1.19
LW27	2.15	823 (38%)	710 (33%)	1.16	896 (42%)	800 (37%)	1.12
LW28	2.10	755 (36%)	710 (34%)	1.06	827 (39%)	785 (37%)	1.05

Further details of the observed zones of increased subsidence over Longwalls 24A to 27 are shown in five longitudinal cross sections along Longwall 24A, Longwall 25, Longwall 26, Longwall 27 and Longwall 28 as Fig. 3.1 to Fig. 3.5 and a discussion on these details is presented below.

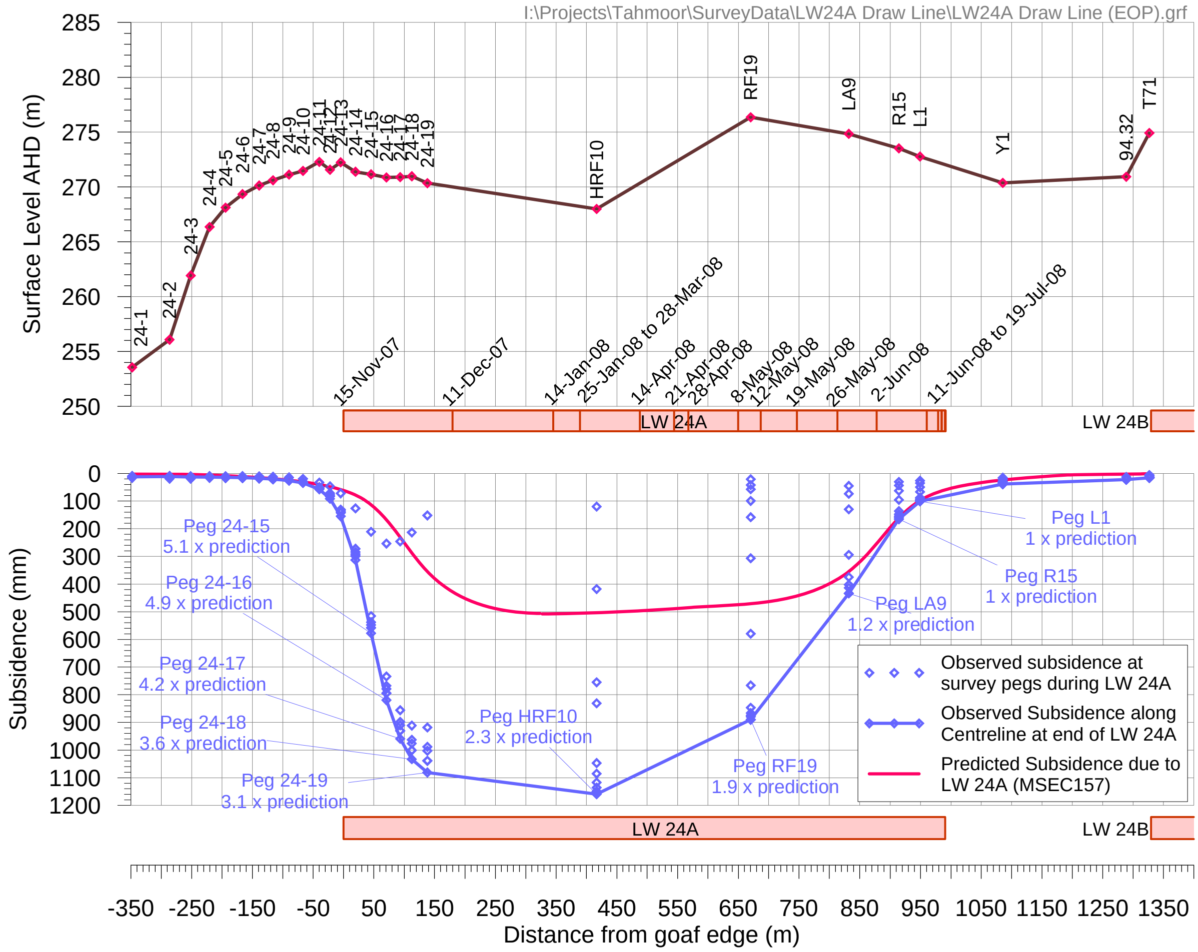


Fig. 3.1 Observed Incremental Subsidence along Centreline of Longwall 24A

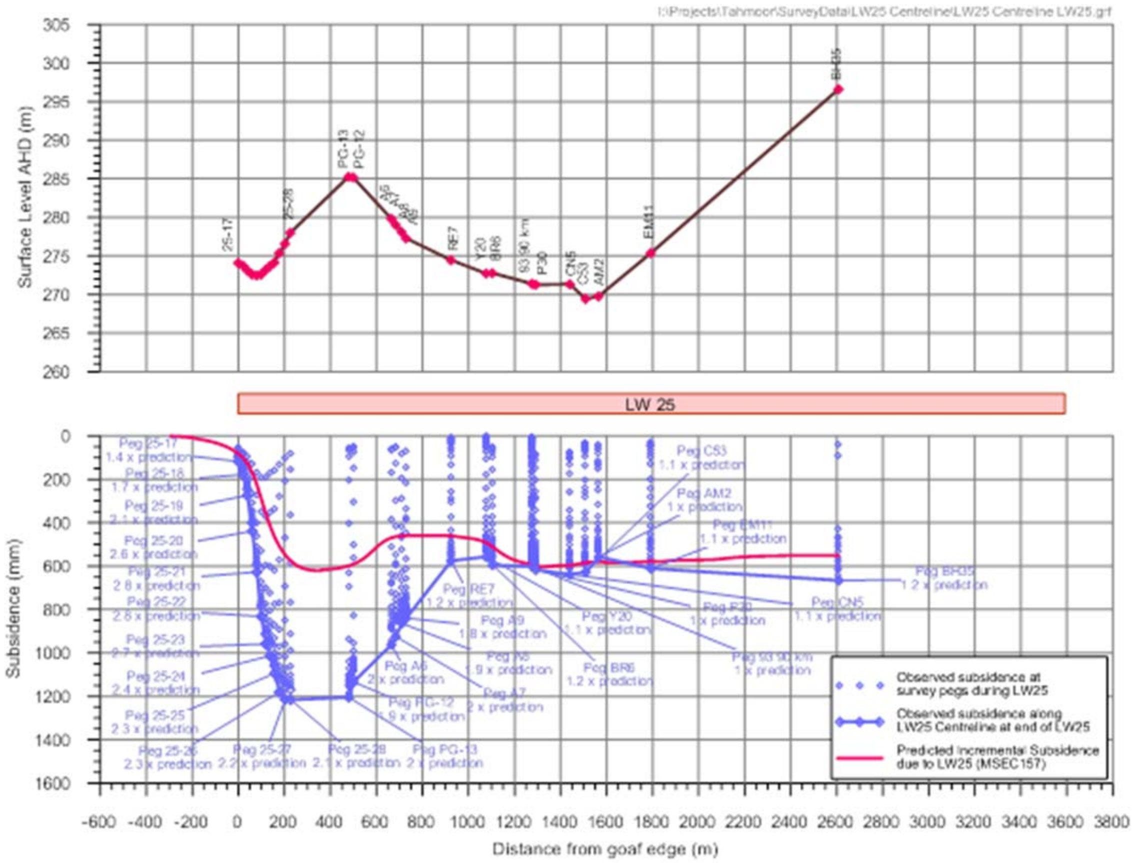


Fig. 3.2 Observed Incremental Subsidence along Centreline of Longwall 25

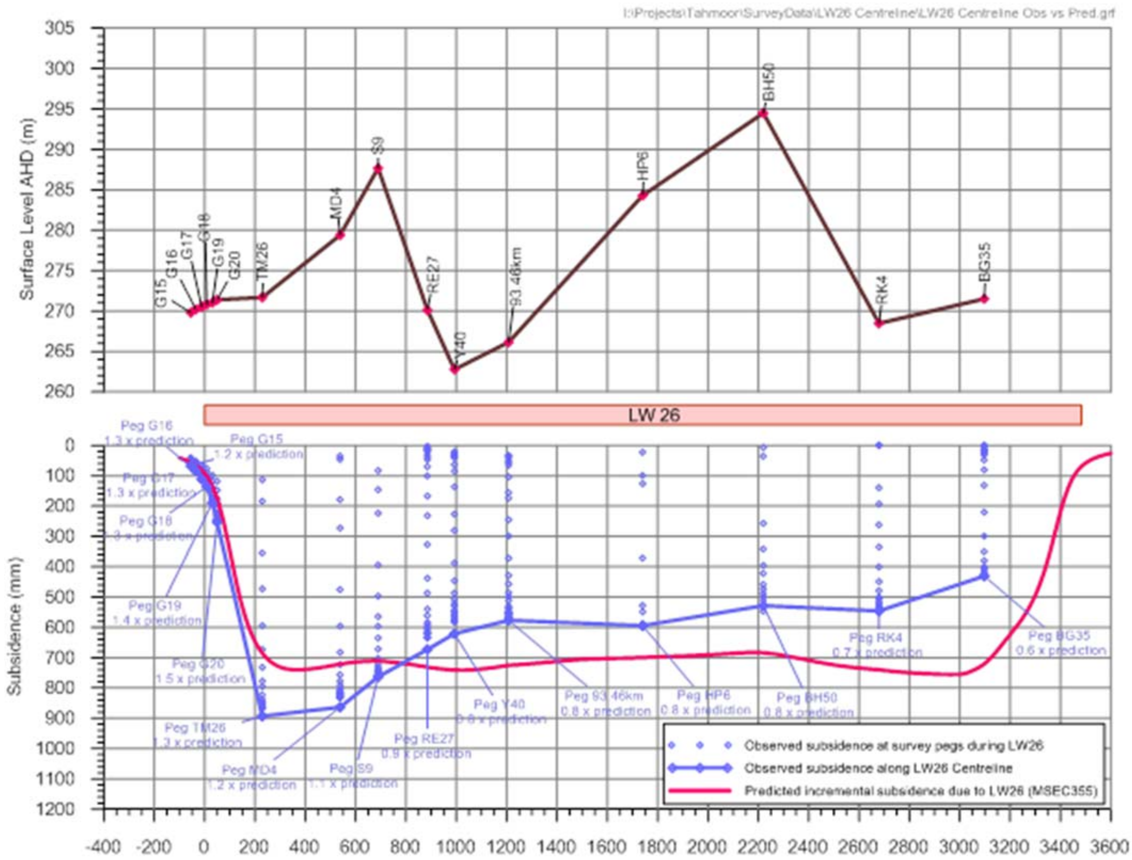


Fig. 3.3 Observed Incremental Subsidence along Centreline of Longwall 26

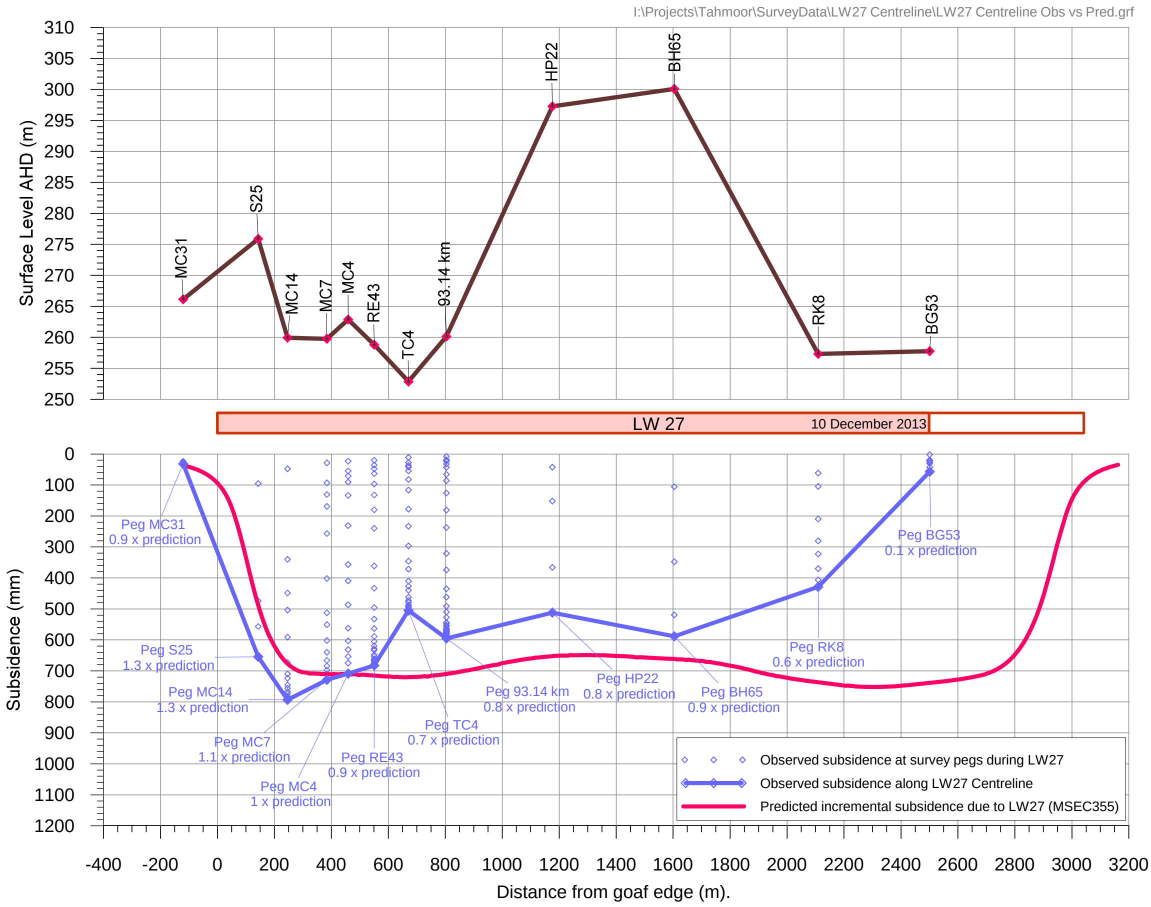


Fig. 3.4 Observed Incremental Subsidence along Centreline of Longwall 27

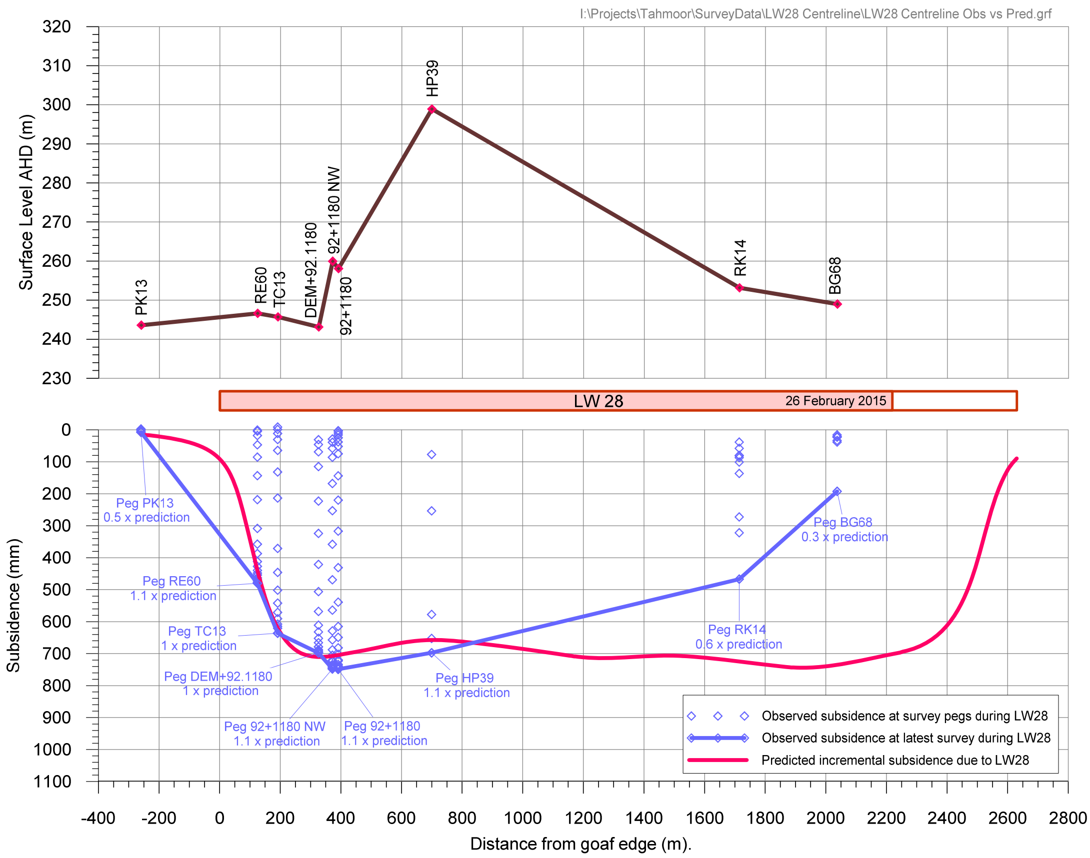


Fig. 3.5 Observed Incremental Subsidence along Centreline of Longwall 28 as at 26 February 2015

Observed Increased Subsidence during the mining of Longwall 24A

- Fig. 3.1 shows the surface levels, the locations of various survey pegs along the centre of Longwall 24A and the observed incremental subsidence profiles at these survey pegs. It can be seen that the area of greatest increase in observed subsidence was in an area above the southern half of Longwall 24A that is closer to the Bargo River Gorge, closer to the Nepean Fault Zone and within 100 metres of a smaller fault zone that, like several other parallel faults, runs off the Nepean Fault in an en echelon style and within 140 metres of previous total extraction workings in the 204 panel. The extent of the increased subsidence then gradually reduced in magnitude towards the northern half of the longwall, which was directly beneath the urban area of Tahmoor.
- It can be seen from Fig. 3.1 that the observed subsidence was similar to the predicted levels near Peg R15 on Remembrance Drive. Survey pegs RF19 and LA9 were 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

- Fig. 3.2 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 25. It can be seen that the area of greatest increase in observed subsidence was in an area above the southern half of Longwall 25 that is closer to the Bargo River Gorge and closer to the Nepean Fault Zone.
- The observed incremental subsidence is similar to but only slightly more than was predicted at Peg RE7 and is similar to the 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.

Observed Increased Subsidence during the mining of Longwall 26

- Fig. 3.3 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 26. Increased incremental subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the incremental subsidence observed above Longwalls 24A and 25.
- 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.

Observed Increased Subsidence during the mining of Longwall 27

- Fig. 3.4 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 27. Increased incremental subsidence was observed during the first stages of mining Longwall 26, but at a reduced magnitude compared to the incremental subsidence observed above Longwalls 24A, 25 and 26.
- As shown in Fig. 3.4 the observed subsidence reduced along the panel until Peg 93.140 km on the Main Southern Railway. Survey pegs MC4, MC7, RE43 and TC4 are located within a transition zone where subsidence has gradually reduced from areas of maximum increased subsidence between Pegs MC14 and 93.140 km to areas of normal subsidence along the Railway and beyond.

Observed Subsidence during the mining of Longwall 28

- Fig. 3.5 shows the observed incremental subsidence at survey pegs located along the centreline of Longwall 28. It can be seen that observed subsidence has returned to normal levels, and within 6% of subsidence predictions.
- As shown in Fig. 3.5 there is a reasonable correlation between the observed and predicted subsidence profile along the centreline of Longwall 28.

3.2.1. Analysis and Commentary on the Zone of Increased Subsidence

The cause for the increased subsidence was investigated during the extraction of Longwall 25 by Strata Control Technology (SCT) on behalf of Tahmoor Colliery as discussed in the previously referenced paper by Gale and Sheppard (2011).

These investigations concluded that the areas of increased subsidence was consistent with localised weathering of joint and bedding planes above a depressed water table adjacent to an incised gorge. This conclusion was further confirmed in further recent report by Gale W. of SCT (2013a), who confirms that:

> "*Longwall panels 24A and 25 both show increased maximum subsidence to approximately 1.0-1.2m, where predicted subsidence was in the order of 0.5 - 0.8m. In the study by Gale and Sheppard, (2011), it became apparent that the increased subsidence is likely to be due to reduction in joint friction and*

stiffness due to the weathering process in the strata above the water table where the water table is considerably lower due to the Bargo Gorge. The intact rock properties were not changed, only the properties of the joints were altered."

There have been many locations where monitoring near faults has revealed little increase of observed subsidence and there are many locations where monitoring near deep gorges and valleys has revealed little increases in observed subsidence. In summary, it appears that the location of the zones of increased subsidence is linked to both the;

- close proximity and the alignment of the Nepean Fault, which is within 1,000 metres of these zones; and
- close proximity to the Bargo River Gorge, which is approximately 100 metres deep, within 700 metres of these zones. The presence of the Bargo River Gorge has permitted groundwater flows to weather the joint and bedding plane properties of the surrounding strata.

In light of the above conclusions and observations, three areas or zones have been identified from the observed subsidence monitoring above the extracted Longwalls 24A to 27 at Tahmoor:

- Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than the predicted subsidence;
- Transition zone – where the subsidence behaviour appears to be transitioned between areas of maximum increased subsidence and normal subsidence; and
- Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions.

The locations of the three zones are plotted on a plan, using the surveyed pegs that were identified along the centrelines above Longwalls 24A to 28 as a guide, as shown in Fig. 3.6 it can be seen that the transition zone is roughly consistent in width above Longwall 24A, Longwall 25 and Longwall 26 and possibly slightly narrower above Longwall 27. The orientation of the transition zone is also roughly parallel to the Nepean Fault and the magnitude of the increased subsidence above Longwalls 26 and 27 is reduced compared to Longwalls 24A and 25. There was no increased subsidence identified above Longwall 28.

It can be seen in Fig. 3.6 that the alignment of the Nepean Fault is further away from the Bargo River gorge and further away from Longwalls 26 and 28, where the magnitudes of the increased subsidence reduced, indicating that the cause of the movements is clearly linked to the proximity of the Bargo River. This observation confirms the findings of Gale and Sheppard (2011) 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 and the presence of the major fault.

It should be noted that the potential impacts of increased subsidence on the structures and infrastructure within the overlying urban areas of Tahmoor Township were successfully managed by Tahmoor Colliery through the implementation of effective subsidence management plans.

With respect to Jemena infrastructure, it is not expected that any gas mains or pipes will be affected by increased subsidence during the extraction of Longwall 29.

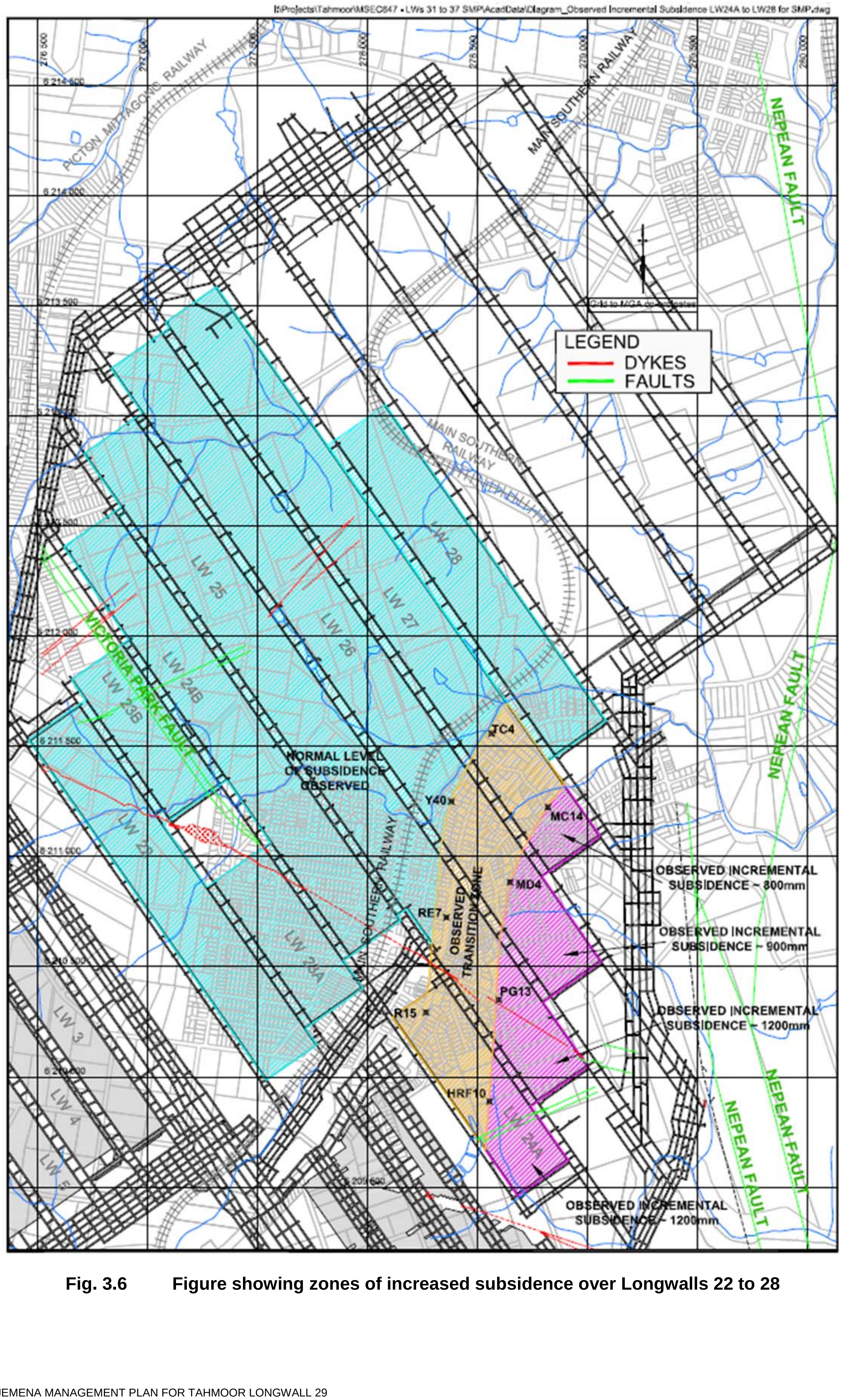


Fig. 3.6 Figure showing zones of increased subsidence over Longwalls 22 to 28

3.3. Predicted Strain

The prediction of strain is more difficult than the predictions of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, 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.

3.3.1. Analysis of Strains Measured in Survey Bays

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

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 Colliery, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

A histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf is provided in Fig. 3.7. 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, which have also been shown in this figure.

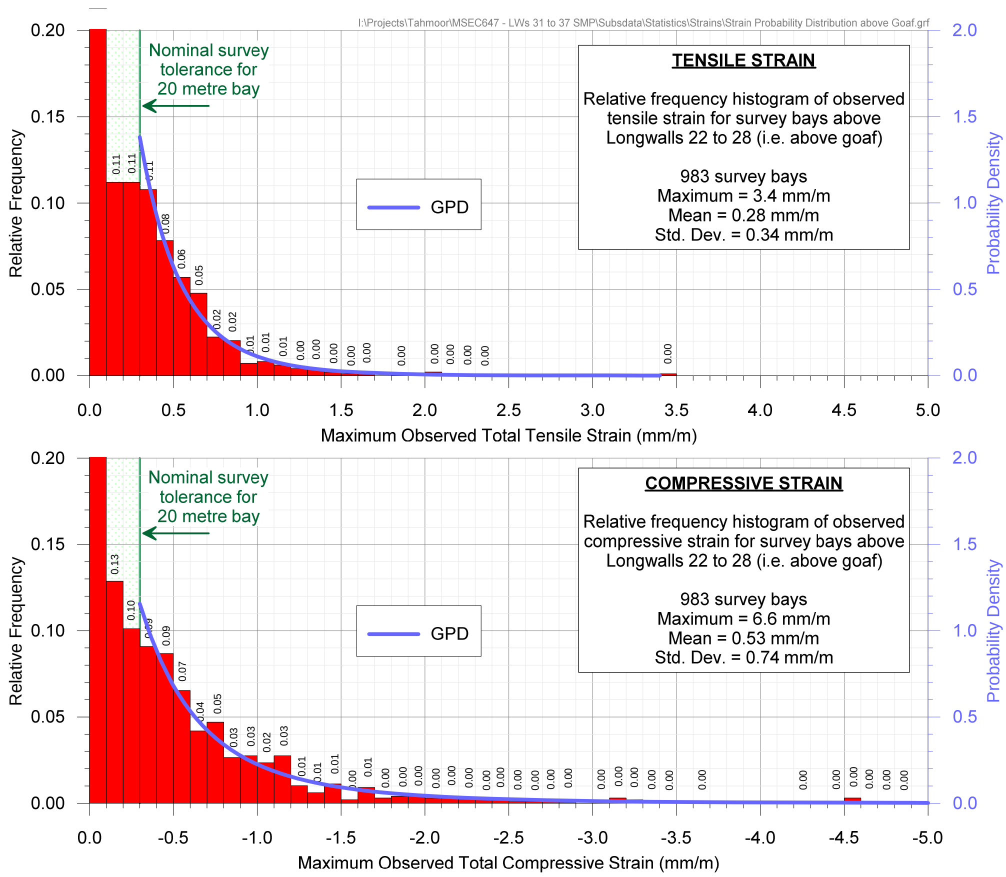


Fig. 3.7 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls at Tahmoor Colliery for Bays Located Above Goaf

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).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above goaf, based on the fitted GPDs, is provided in Table 3.4. The analysis does not include the strains resulting from valley related movements.

Table 3.4 Probabilities of Exceedance for Strain for Survey Bays Located above Goaf

Strain (mm/m)		Probability of Exceedance
Compression	-8.0	1 in 1,100
	-6.0	1 in 450
	-4.0	1 in 140
	-2.0	1 in 25
	-1.0	1 in 7
	-0.5	1 in 3
	-0.3	1 in 2
Tension	+0.3	1 in 3
	+0.5	1 in 5
	+1.0	1 in 25
	+2.0	1 in 330
	+3.0	1 in 2,500

The 95 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 0.9 mm/m tensile and 1.8 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above goaf experienced at any time during mining were 1.5 mm/m tensile and 3.5 mm/m compressive.

The probabilities for survey bays located above goaf are based on the strains measured anywhere above the previously extracted longwalls at Tahmoor Colliery. As described previously, tensile strains are more likely to develop in the locations of hogging curvature and compressive strains are more likely to develop in the locations of sagging curvature.

This is illustrated in Fig. 3.8, which shows the distribution of incremental strains measured above previously extracted longwalls in the Southern Coalfield. The distances have been normalised, so that the locations of the measured strains are shown relative to the longwall maingate and tailgate sides. The approximate confidence levels for the incremental tensile and compressive strains are also shown in this figure, to help illustrate the variation in the data.

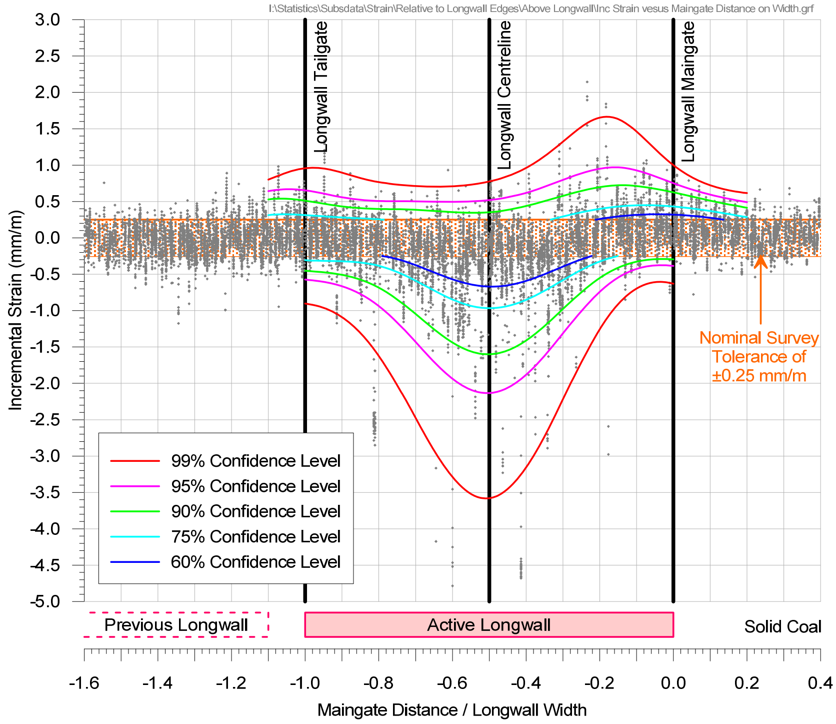


Fig. 3.8 Observed Incremental Strains versus Normalised Distance from the Longwall Maingate for Previously Extracted Longwalls in the Southern Coalfield

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 in the Southern Coalfield, for survey bays that were located outside and within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

A histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal is provided in Fig. 3.9. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

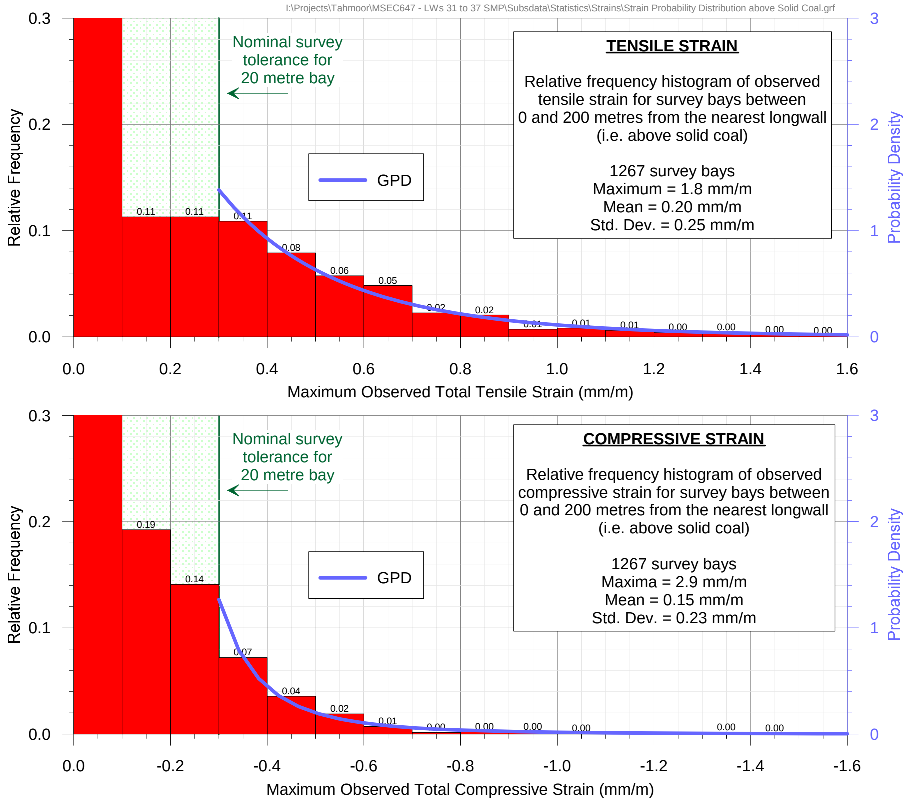


Fig. 3.9 Distributions of the Measured Maximum Tensile and Compressive Strains during the Extraction of Previous Longwalls at Tahmoor Colliery for Bays Located Above Solid Coal

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).

A summary of the probabilities of exceedance for tensile and compressive strains for survey bays located above solid coal, based on the fitted GPDs, is provided in Table 3.5. The analysis does not include the strains resulting from valley related movements.

Table 3.5 Probabilities of Exceedance for Strain for Survey Bays Located above Solid Coal

Strain (mm/m)		Probability of Exceedance
Compression	-3.0	1 in 2,200
	-2.0	1 in 800
	-1.5	1 in 400
	-1.0	1 in 150
	-0.5	1 in 25
	-0.3	1 in 7
Tension	+0.3	1 in 4
	+0.5	1 in 10
	+1.0	1 in 80
	+1.5	1 in 400
	+2.0	1 in 1,600

The 95 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 0.6 mm/m tensile and 0.5 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays above solid coal experienced at any time during mining were 1.1 mm/m tensile and 0.9 mm/m compressive.

3.3.2. Analysis of Strains Measured Along Whole Monitoring Lines

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

A histogram of maximum observed total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls at Tahmoor Colliery, is provided in Fig. 3.10.

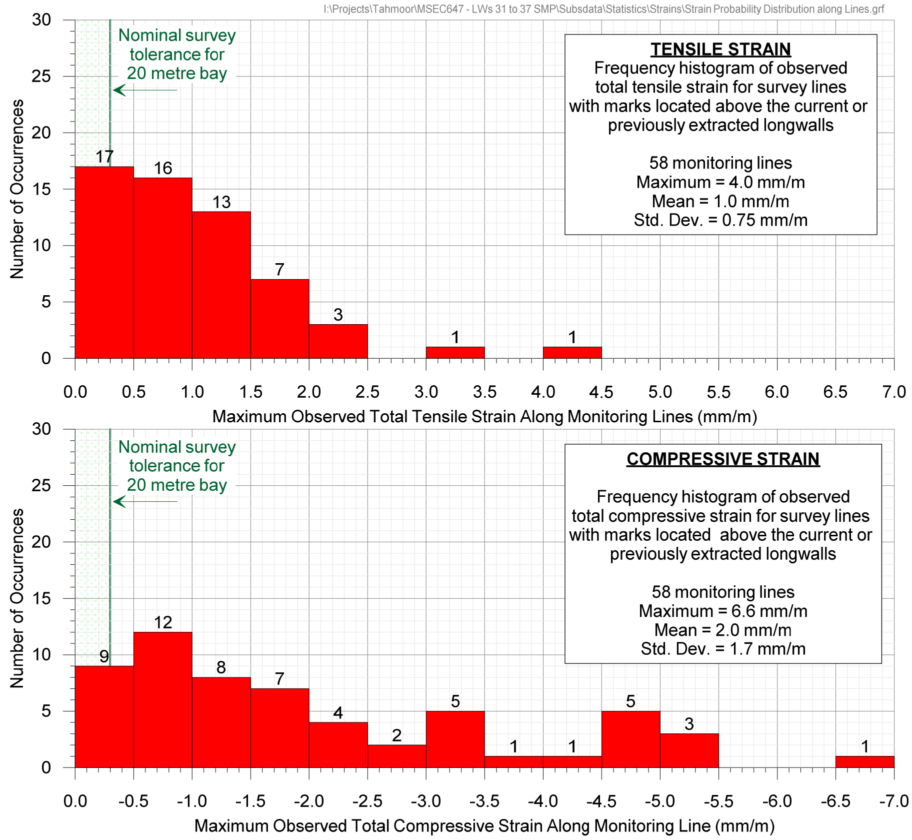


Fig. 3.10 Distributions of Measured Maximum Tensile and Compressive Strains along the Monitoring Lines during the Extraction of Previous Longwalls at Tahmoor Colliery

It can be seen from the above figure, that 33 of the 58 monitoring lines (i.e. 57 %) had recorded maximum total tensile strains of 1.0 mm/m, or less, and that 53 monitoring lines (i.e. 91 %) had recorded maximum total tensile strains of 2.0 mm/m, or less. It can also be seen, that 36 of the 58 monitoring lines (i.e. 62 %) had recorded maximum compressive strains of 2.0 mm/m, or less, and that 48 of the monitoring lines (i.e. 83 %) had recorded maximum compressive strains of 4.0 mm/m, or less.

3.4. Predicted and Observed Valley Closure across creeks

A number of bridges and culverts in the vicinity of Longwall 29 carry road transport over Myrtle Creek, Redbank Creek and other watercourses. Predictions of valley closure and upsidence at each of these features are provided later in this Management Plan.

A comparison between predicted and observed valley closure movements is provided in Table 3.6.

A map of monitoring lines across Myrtle Creek and a small creek that crosses the Main Southern Railway (called the Skew Culvert) is shown in Fig. 3.11.

Fig. 3.11 Monitoring lines across Myrtle Creek and Skew Culvert

A summary graph showing the development of valley closure across Myrtle Creek at each monitoring line is shown in Fig. 3.12.

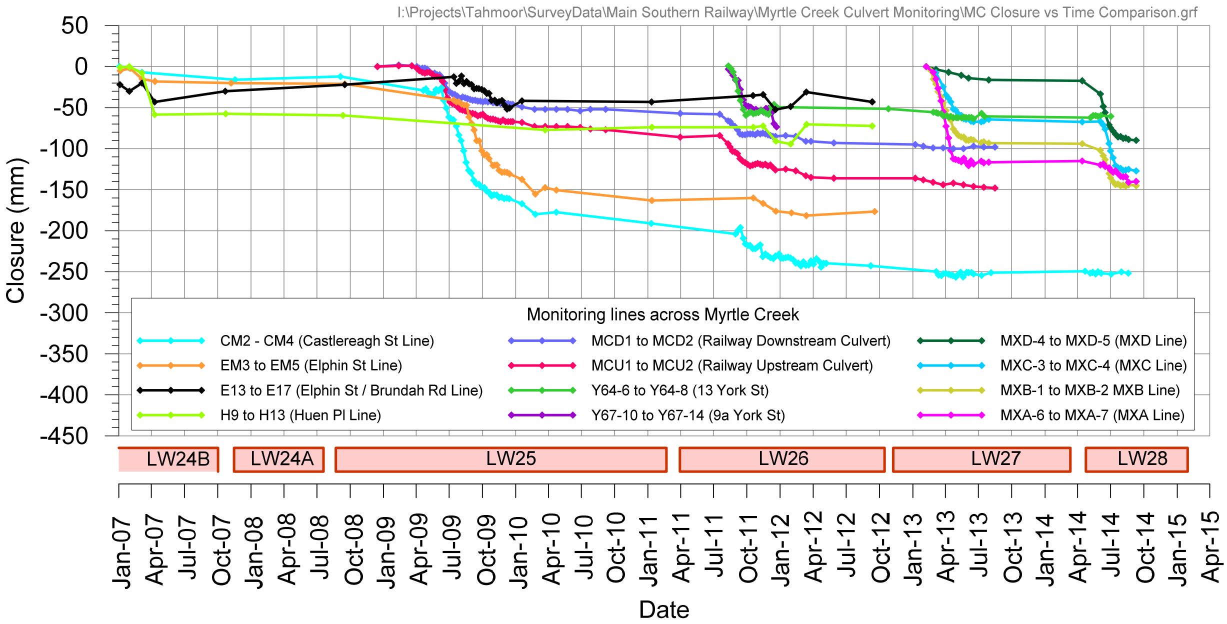


Fig. 3.12 Development of closure across Myrtle Creek during the mining of Longwalls 24B to 28

The development of valley closure across the creek at the Skew Culvert is shown in Fig. 3.13.

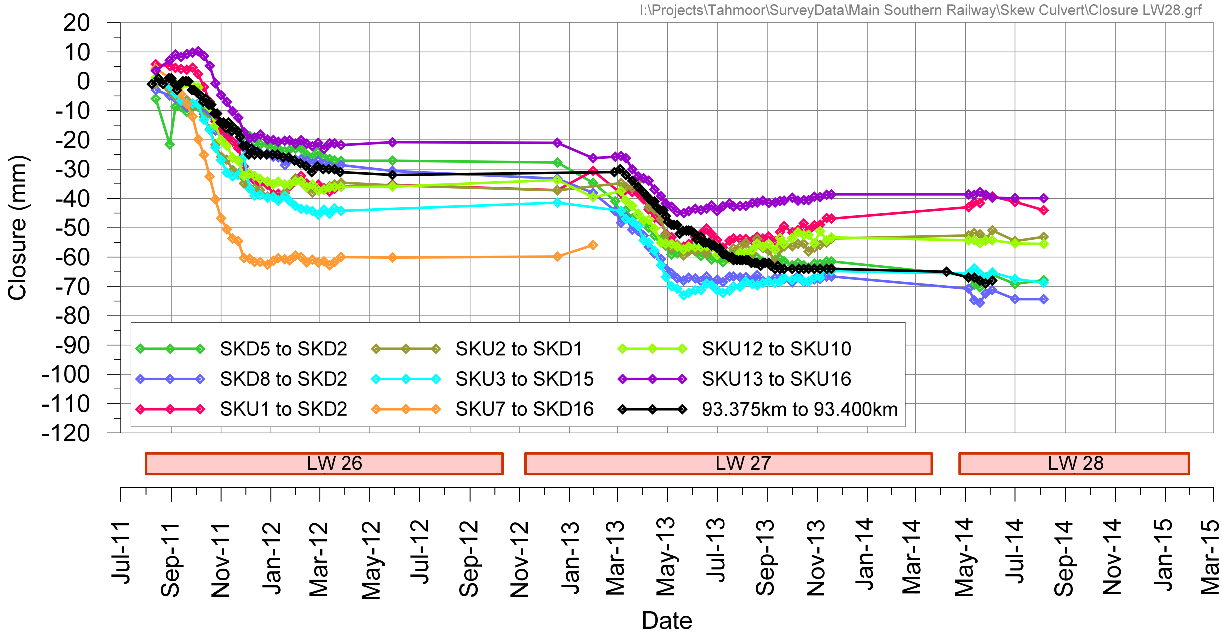


Fig. 3.13 Development of closure across Skew Culvert during the mining of Longwalls 26 to 28

A summary of predicted and observed valley closure across Myrtle Creek is provided in Table 3.6. The predictions are consistent with those provided in Report No. MSEC355, in support of Tahmoor Colliery's SMP application to extract longwalls 27 to 30.

Table 3.6 Predicted and Observed Incremental Valley Closure across Myrtle Creek and Skew Culvert at monitoring lines

Location	Category	Predicted and Observed Valley Closure due to Mining of Each Longwall (mm)				
		Due to LW24	Due to LW25	Due to LW26	Due to LW27	Due to LW28
Castlereagh St (Pegs CM2 to CM4)	Predicted	30	55	45	25	< 20
	Observed	12	179	52	8	1
Elphin-Myrtle (Pegs EM3 to EM5)	Predicted	60	70	40	-	-
	Observed	21	142	22	-	-
Elphin St / Brundah Rd (Pegs E13 to E17)	Predicted	75	75	30	-	-
	Observed	0	21	6	-	-
Huen Pl (Pegs H9 to H13)	Predicted	60	35	15	-	-
	Observed	58	15	20	-	-
Main Southern Railway Upstream (MCU1 to MCU4) Downstream (MCD1 to MCD4)	Predicted	15	30	30	15	-
	Observed	-	57 (d/s) to 86 (u/s)	36 (d/s) to 50 (u/s)	5 (d/s) to 12 (u/s)	-
Skew Culvert (8 cross-sections)	Predicted	< 5	10	25	25	10
	Observed	-	-	21 to 60 (average 36)	8 to 36 (average 21)	+3 to -8 (average 3)
13 York St (Pegs Y64-6 to Y64-8)	Predicted	-	-	65	50	< 20
	Observed	-	-	51	9	0
9a York St (Pegs Y67-10 to Y67-14)	Predicted	-	-	85	85	25
	Observed	-	-	73	No access	No access
MXA Line (Pegs MXA-6 to MXA-7)	Predicted	-	-	-	150	75
	Observed	-	-	-	116	25
MXB Line (Pegs MXB-1 to MXB-2)	Predicted	-	-	-	170	150
	Observed	-	-	-	93	51
MXC Line (Pegs MXC-4 to MXC-5)	Predicted	-	-	-	150	170
	Observed	-	-	-	64	106
MXD Line (Pegs MXD-4 to MXD-5)	Predicted	-	-	-	50	70
	Observed	-	-	-	16	73
Remembrance Drive (Pegs R77 to R80)	Predicted	-	-	< 5	10	15
	Observed	-	-	1	3	3

It can be seen that observed valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and to a lesser extent the crossing of the Main Southern Railway during the mining of Longwall 25. It is considered that the reason for the differences in observations may be linked to the change in orientation of Myrtle Creek as the three above-mentioned monitoring lines are located along the same stretch of Myrtle Creek. It is noted, however, that less closure has developed at Castlereagh Street than predicted during the mining of Longwall 27.

Observed valley closure across the creek at the Skew Culvert has also slightly exceeded predictions, where the differences between predicted and observed closure are relatively small for most cross sections.

Observed valley closure across Myrtle Creek during Longwalls 27 and 28 has been less than prediction, but greater than previously observed. Predictions for this section of creek were greater than upstream sections because the valley is deeper.

3.5. Observations during Longwalls 22 to 28

Longwalls 22 to 28 have directly mined beneath approximately 16.9 kilometres of gas pipes and no impacts have been recorded so far. The local nylon pipes and the 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced at Tahmoor to date. While no impacts have been experienced to date, the most vulnerable element of the system are rigid copper pipe connections between the gas mains and houses.

3.6. Gas Infrastructure

Jemena has an extensive gas infrastructure network at Tahmoor and Thirlmere. The gas pipelines are shown according to their pipe sizes in Drawing Nos. MSEC746-05-01. It can be seen that no part of the network is located directly above Longwall 29.

It can be seen from Drawing No. MSEC746-05-01 that a small number of 32 mm diameter gas pipes in Tahmoor are predicted to experience between 20 mm and 50 mm additional vertical subsidence due to the extraction of Longwall 29. The 160 mm PE gas main along Remembrance Drive is predicted to experience additional vertical subsidence up to 20 mm due to the extraction of Longwall 29.

It can be seen from Drawing No. MSEC746-05-02 that a small section of 32 mm diameter gas pipes on Bridge Street, Thirlmere are predicted to experience between 20 mm and 50 mm additional vertical subsidence due to the extraction of Longwall 29.

The main gas pipe, which is a 160 mm diameter polyethylene pipe with glued joints, is located along Remembrance Drive. Longwalls 24A, 25, 26, 27 and 28 have mined directly beneath this pipe and no impacts were observed. This gas main crosses over Myrtle Creek on the Remembrance Drive Road Bridge via a steel pipe with flanged ends. The creek crossing is not directly undermined by Longwall 29 but is expected to experience small upsidence and closure movements during the mining of this longwall.

3.7. Hazard Identification

The hazard associated with gas infrastructure is that it may be damaged as a result of mine subsidence impacts. This damage could involve rupturing of pipes and hence become a dangerous hazard to the public.

3.7.1. Main PE Gas Pipeline along Remembrance Drive

The main gas pipeline is a 160 mm diameter polyethylene pipe, which is laid along the eastern side of Remembrance Drive. The pipeline has experienced no impacts during the mining of Longwalls 24A to 28.

During this time, ground surveys have measured maximum subsidence of approximately 980 mm with two sites of increased compressive ground strains:

- A maximum compressive ground strain of approximately 3.0 mm/m over a 37 metre bay between Pegs R1 and RE1 along Remembrance Drive at the intersection with Thirlmere Way above Longwall 25. If all of the compressive strain is concentrated at one location, this would equate to a strain of approximately 6 mm/m over a 20 metre bay. A noticeable bump in the pavement and roundabout was also observed at this site. Regular gas patrols were undertaken in response to the observations though no impacts were observed.
- A maximum compressive ground strain of approximately 3.7 mm/m over a 20 metre bay along Remembrance Drive above Longwall 26 between Pegs RE28 and RE29. A bump was observed in the road pavement and concrete footpath. Regular gas patrols were undertaken in response to the observations though no impacts were observed.

The pipeline is expected to experience an additional 20 mm of subsidence movement during the mining of Longwall 29. Predicted subsidence, tilt and curvature due to the mining of Longwalls 27 to 29 are shown in Fig. 3.14.

The experience of mining beneath Longwalls 24A to 28 provides confidence that the pipeline can accommodate typical mining-induced strains without adverse impacts, and protective works should not be necessary. While the pipelines are quite flexible, the 160 mm diameter pipes are connected with socket joints that are glued together. It is unlikely that these joints will be adversely affected by the proposed longwalls.

The likelihood of impacts occurring to the pipeline is therefore assessed as **VERY RARE**.

Given that this pipe is the main gas pipeline, any leakage of the pipeline would require emergency procedures, and since there is significant surface infrastructure in the vicinity of the pipeline, the consequence of damage to the pipeline is assessed as **VERY SEVERE**.

The level of risk for this pipeline is therefore assessed as **VERY RARE / VERY SEVERE → MODERATE.**

Please refer to Section 3.7.3 for an assessment on the steel gas pipe crossing over Myrtle Creek on the Remembrance Drive Road Bridge.

3.7.2. Local Gas Pipeline

Remaining gas pipes are generally 32 mm diameter nylon pipes, which are located along most of the urban streets of Tahmoor and Thirlmere. These smaller diameter local reticulation pipes should be sufficiently flexible to accommodate the predicted levels of strain. It is noted that no impacts were observed during the extraction of Longwalls 22 to 28. This includes no impacts at a site on Abelia Street, where a large measured ground strain of 6.5 mm/m (over a 22 metre bay length) was observed between Pegs A12 and A13, coinciding with a measured vertical bump in the subsidence profile and an observed hump in the road pavement.

It is noted that a ground survey line has already been installed and monitored along Bridge Street, extending to the intersection with Redbank Place. This survey line covers the upstream part of a 32 mm nylon pipe on Bridge Street, which lies within the area of predicted subsidence for future Longwall 30.

The likelihood of damage occurring to these small pipes is therefore assessed as **VERY RARE**. The consequence of damage to these pipes is less than the main gas pipelines that run along Remembrance Drive and Thirlmere Way due to their size. The consequence of damage to these pipelines is therefore assessed as **MODERATE**.

The level of risk for this pipeline is therefore assessed as:- **VERY RARE / MODERATE → LOW**.

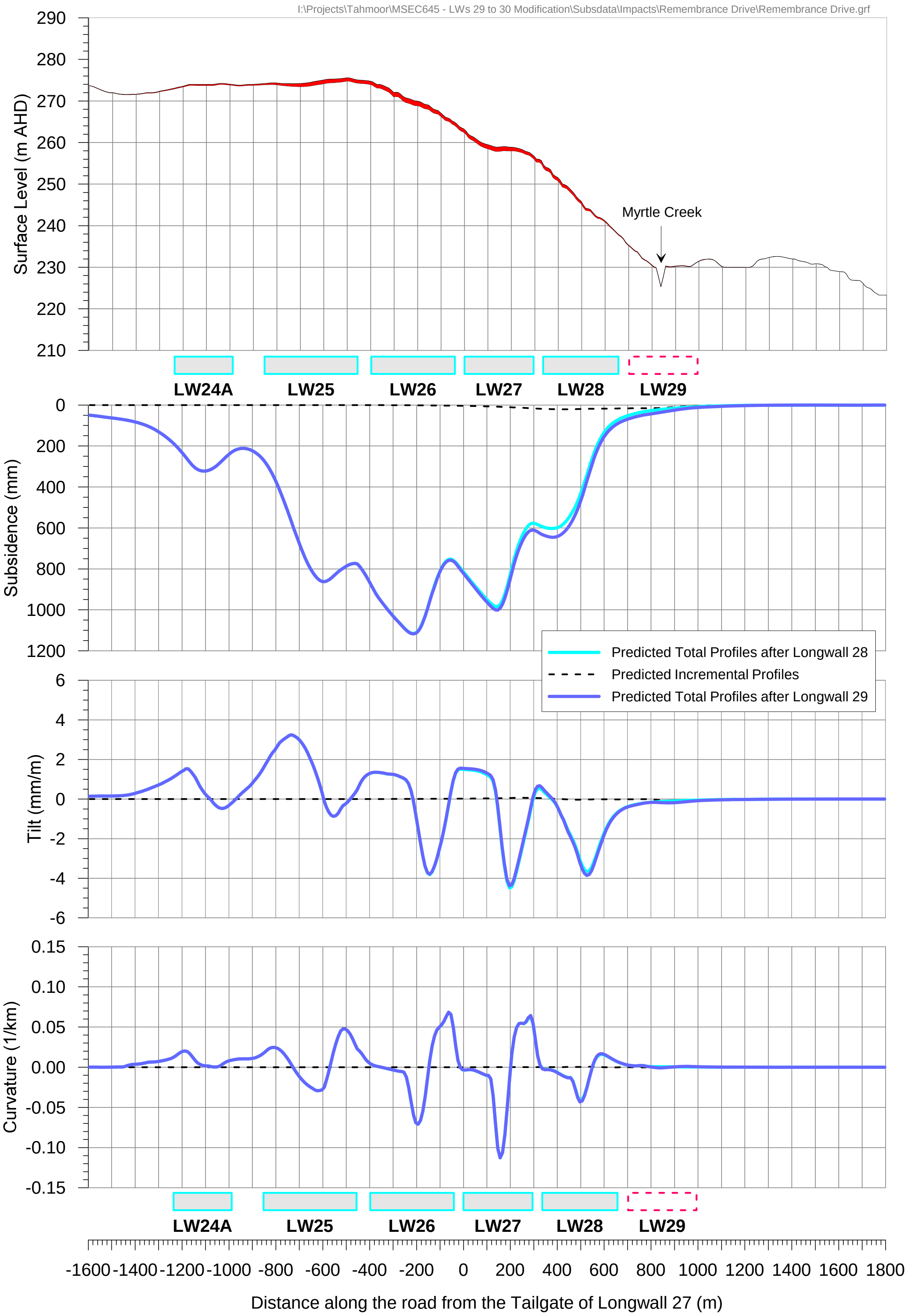


Fig. 3.14 Predicted Subsidence, Tilt and Curvature along Remembrance Drive due to the mining of Longwalls 22 to 29

3.7.3. Gas Mains at Remembrance Drive Creek Crossing

The gas main crosses over Myrtle Creek on the Remembrance Drive Road Bridge via a steel pipe with flanged ends, as shown in Fig. 3.15 and Fig. 3.16. The bridge is located approximately 250 metres southeast of the commencing end of Longwall 29 as shown in Drawing No. MSEC746-05-01.

Fig. 3.15 Remembrance Drive Road Bridge over Myrtle Creek

Fig. 3.16 Termination of steel gas pipe at end of Remembrance Drive Road Bridge

Roads and Maritime Services have provided a copy of the structural design drawings, which show that the dual-span bridge is constructed with a concrete deck on concrete abutments and central pier, as shown in Fig. 3.15. The span of the deck is approximately 18 metres and the heights of the abutments are approximately 7 metres.

The bridge units have been integrated with a reinforced concrete slab. The reinforced concrete abutments appear to rest on pad and strip footing foundations. The pre-tensioned bridge deck units are connected to the central pier with dowels. The drawings do not include the abutment connections, but it appears that the bridge units rest on a corbel at each end. It is likely that a concrete upstand has been constructed at the ends of the deck.

Predictions of systematic subsidence, tilt and strain movements have been made at the gas pipe crossing and bridge, and these are shown in Table 3.7.

Table 3.7 Predicted Subsidence Parameters at the Gas Pipe Crossing at the Remembrance Drive Road Bridge

Stage of Mining	Maximum Predicted Subsidence (mm)	Maximum Predicted Tilt (mm/m)	Maximum Predicted Hogging Curvature (1/km)	Maximum Predicted Sagging Curvature (1/km)
Due to LW29	< 20	< 0.2	< 0.01	< 0.01
Total after LW28	< 20	< 0.2	< 0.01	< 0.01
Total after LW29	35	0.2	< 0.01	< 0.01

The Bridge will also be subjected to upsidence and closure movements, and these are shown in Table 3.8.

Table 3.8 Predicted Upsidence and Closure at the Gas Pipe Crossing and at the Remembrance Drive Road Bridge

Stage of Mining	Maximum Closure (mm)	Maximum Upsidence (mm)
Due to LW29	10	20
Total after LW28	25	25
Total after LW29	35	45

It can be seen from Table 3.8 that small additional valley closure and upsidence is predicted to occur during the mining of Longwall 29. It is noted that the predicted closure refers to closure across the whole valley. It is possible that the predicted closure will not concentrate entirely between the gas crossing and the bridge abutments. This was observed during the mining of Longwall 28, which is discussed below.

Survey marks were installed on the Remembrance Drive Road Bridge prior to the extraction of Longwall 24A. The Bridge has experienced approximately 30 mm of subsidence after the mining of Longwalls 24A to 28, which was a net reduction in total subsidence (i.e. an incremental uplift) since the completion of mining of Longwall 27. Measured changes in horizontal distances between termination points of the steel gas pipes have generally been small (in the order of 5 mm) and within survey tolerance, as shown in Fig. 3.17. Vertical subsidence is relatively consistent across all survey marks, indicating that no measureable upsidence has occurred to date that might result in bending of the bridge deck and gas pipe, as shown in Fig. 3.18 and Fig. 3.19.

The pipes over Remembrance Drive Road Bridge were surveyed at multiple locations to track potential changes in the shape of the pipe during the mining of Longwall 28. It can be seen from Fig. 3.20 that only minor changes were observed to the pipe shape during mining, much of it in the form of rotation about the horizontal plane, recognising that changes in pipe position have been plotted to an exaggerated scale in Fig. 3.20.

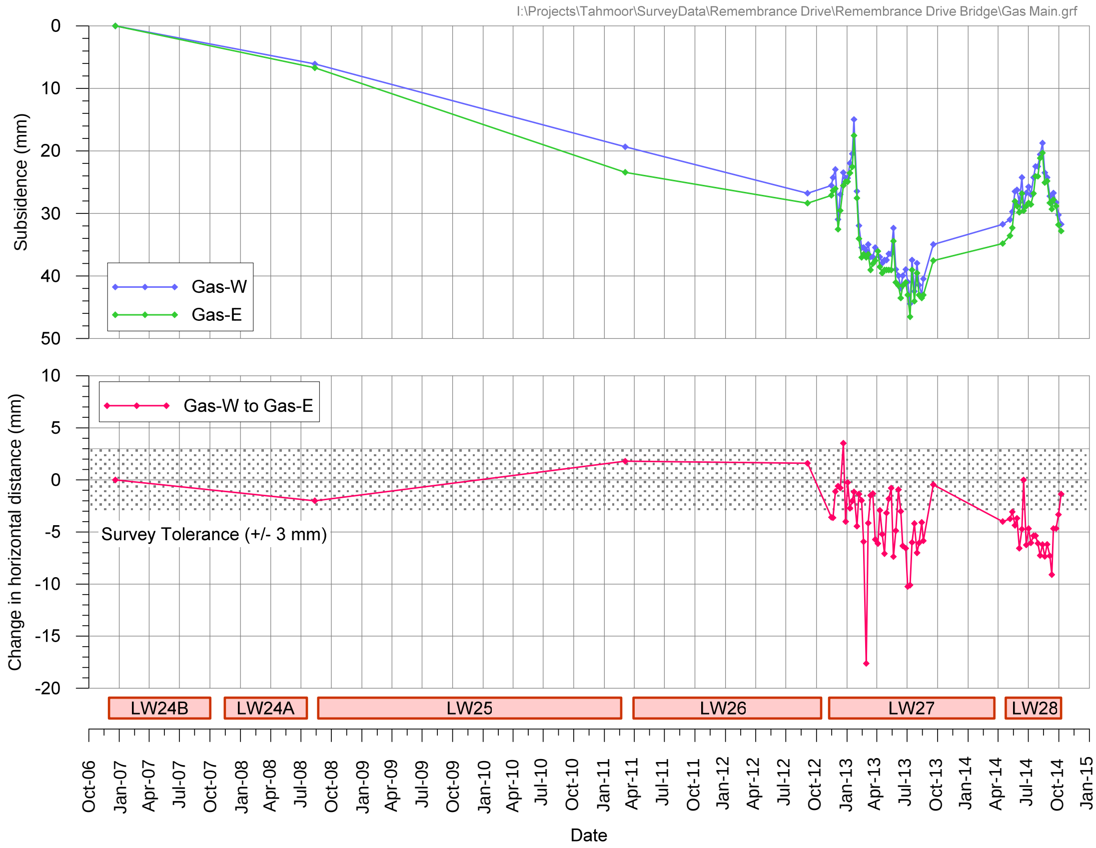


Fig. 3.17 **Observed subsidence and changes in horizontal distances across the abutment of Remembrance Drive (Myrtle Creek) Road Bridge**

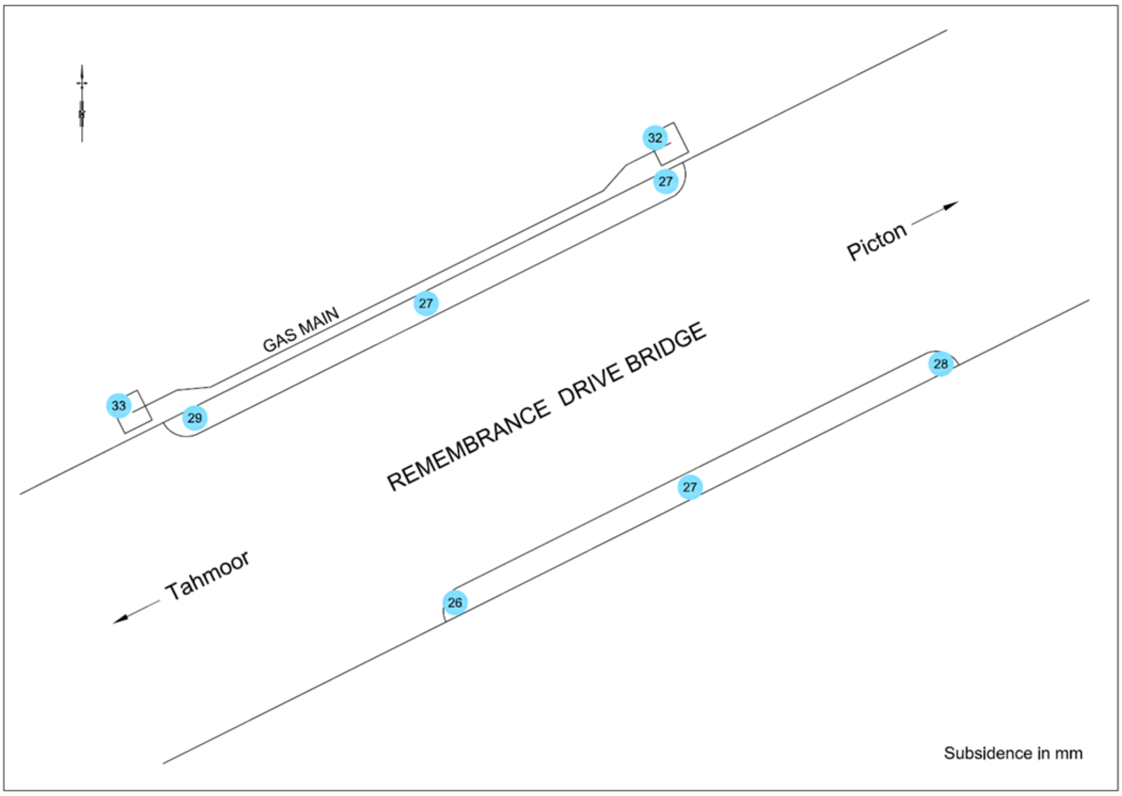


Fig. 3.18 **Observed subsidence along Remembrance Drive (Myrtle Creek) Road Bridge**

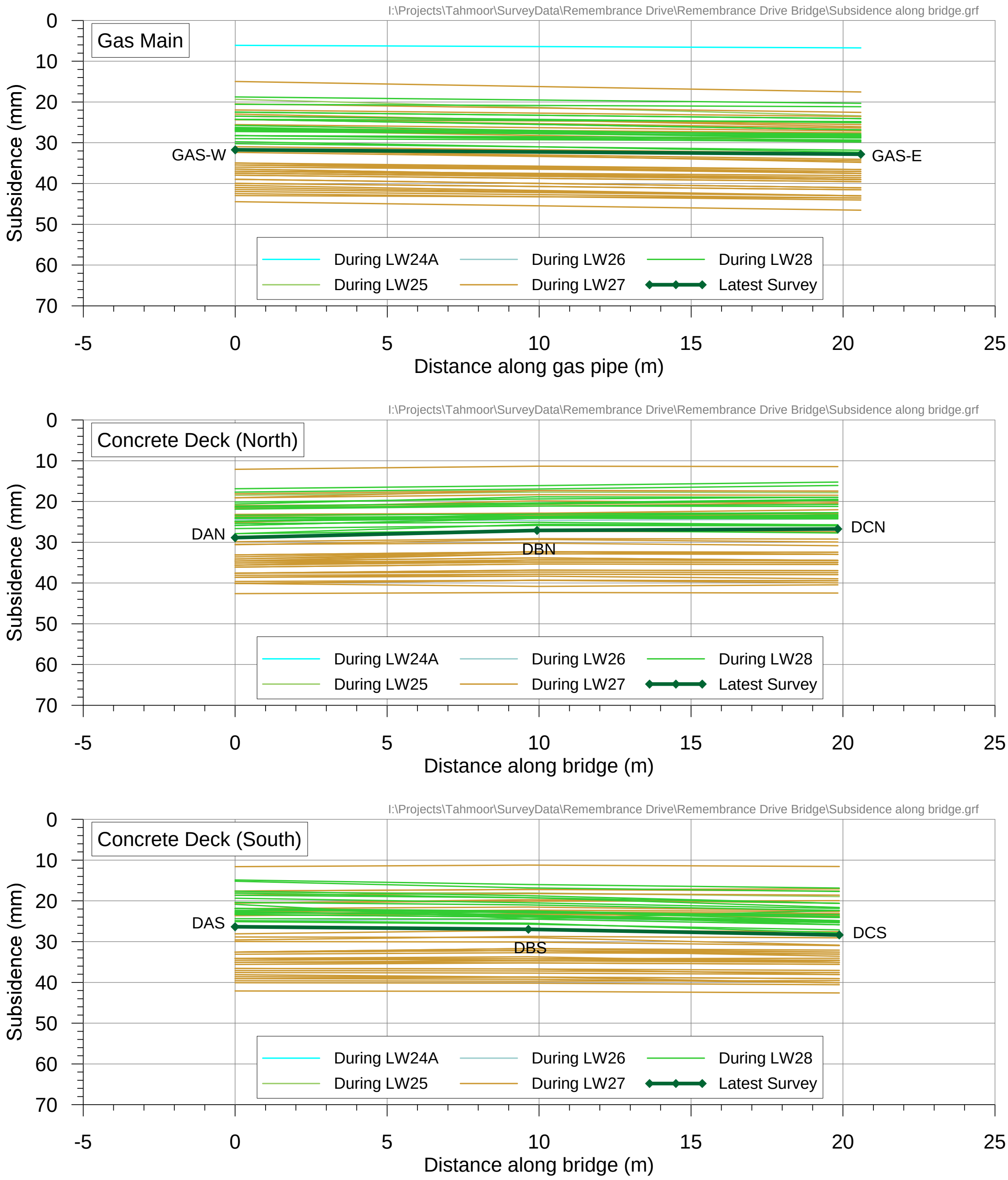


Fig. 3.19 Observed subsidence along Remembrance Drive (Myrtle Creek) Road Bridge

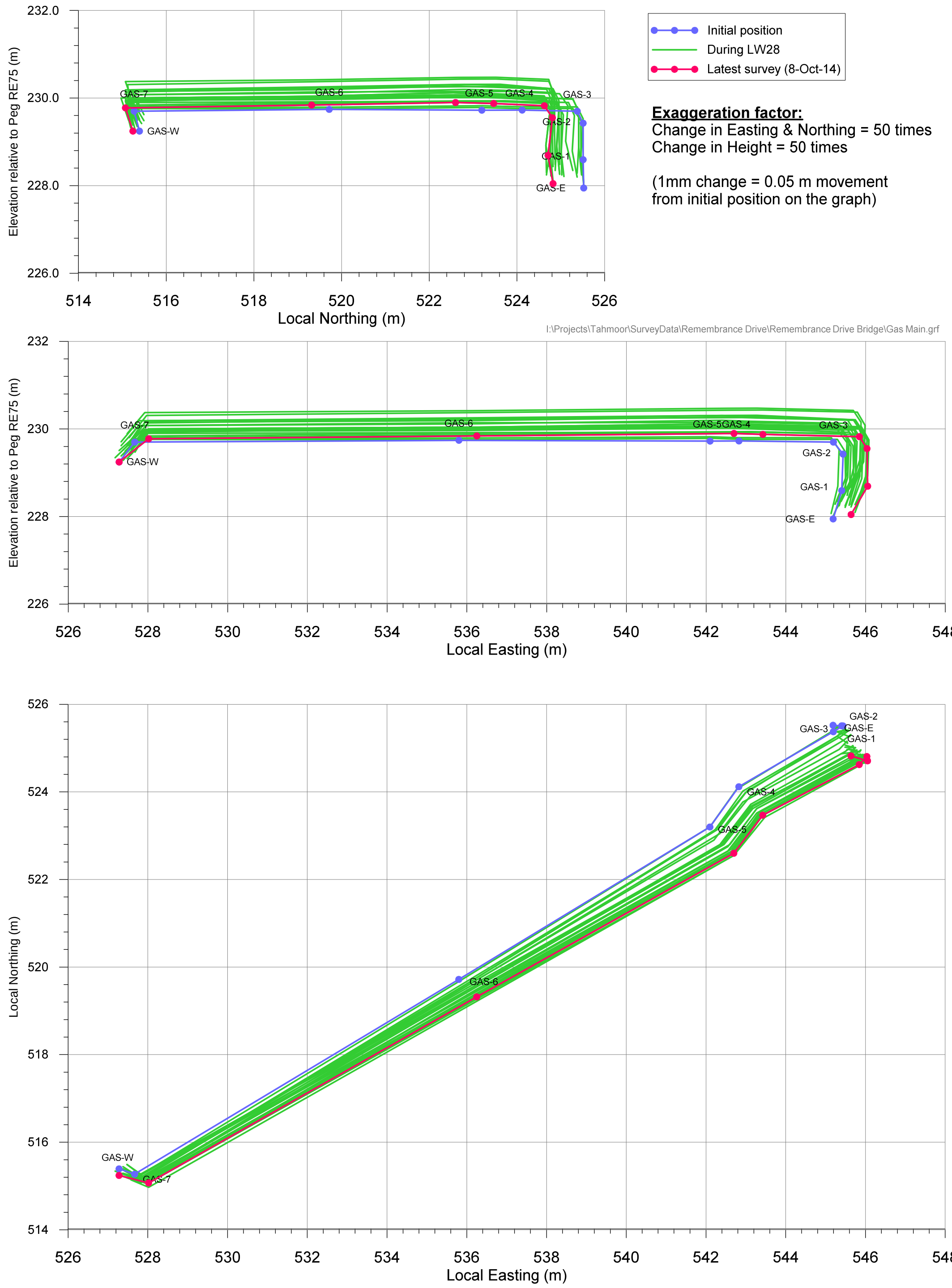


Fig. 3.20 Observed displacement of survey marks on gas pipe along Remembrance Drive (Myrtle Creek) Road Bridge

The Remembrance Drive survey line crosses Myrtle Creek between the Remembrance Drive Road Bridge and Pedestrian Bridge. Measured changes in horizontal distances between survey pegs within the Myrtle Creek valley are very small and within survey tolerance.

The steel gas pipe can tolerate some closure movements. The flanged ends of the gap pipe were included in the design to allow some flexibility in the pipework. If the ground on either side of the pipe crossing moves towards each other due to valley closure, the pipe is able to accommodate the compression through bending at the elbow. The most likely elbow to bend in response to differential horizontal movement is located at the northern end, as the vertical arm is high. The vertical arm below the elbow at the southern end is comparatively short. If actual ground closure exceeds the capacity of the pipe, the foundations at one end of the steel pipe can be excavated, to allow the foundations to slide and relieve pipe stresses.

This management strategy is possible because the ground movements will develop gradually, providing sufficient time to detect early the development of adverse movements and respond prior to impacts occurring on the Bridge or gas pipe.

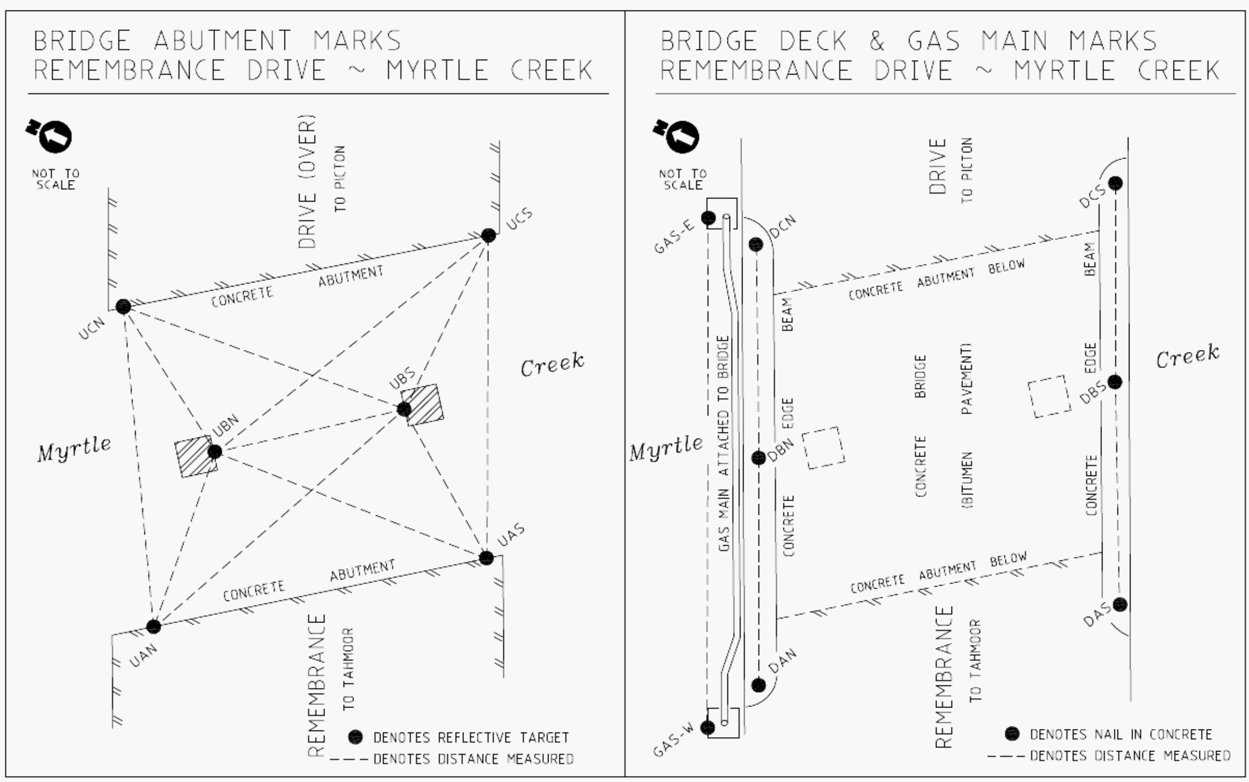
As the pipe is supported by the Remembrance Drive Road Bridge, it may potentially also experience impacts due to differential movements of the bridge in response to mine subsidence. Upsidence may cause the central pier to move upwards, relative to the abutments. This may result in vertical bending of the steel pipe. Closure of the bridge abutments are unlikely to result in impacts on the pipe as it is free to slide through the brackets. In addition to potential impacts due to movements, the pipe may also be exposed to damage if repairs are required to be carried out on the Bridge in response to mine subsidence movements. Despite the above-mentioned potential causes of impacts, the predicted movements are quite small.

Prior to the decision to shorten the commencing end of Longwall 29, it had been planned to undertake detailed investigations and potentially undertake mitigation works on the Bridge to reduce the potential for mine subsidence impacts on the Bridge. The shortening of Longwall 29, however, substantially reduces the potential for impacts on the Bridge and the steel gas pipe. In light of the shortening, it is planned to manage potential impacts on the Bridge and the gas pipe through monitoring and, if necessary, response measures.

Given the offset distance of the pipe crossing and the Bridge from Longwall 29, and the anticipated small amount of movement that is expected to occur to the pipe and the Bridge, the likelihood of impact on the steel gas pipe, is assessed as **VERY RARE.** The consequence of impacts on the steel gas pipe is assessed as **VERY SEVERE**. The risk is therefore assessed as **VERY RARE / VERY SEVERE → MODERATE**.

The gas pipe crossing and the Bridge will be surveyed and visually inspected on a weekly basis from the start of extraction of Longwall 29 until the length of extraction is 800 metres unless adverse changes are being observed at this time. A survey will also be undertaken at the completion of Longwall 29. The surveys include monitoring of survey points on the Bridge and include survey marks on the concrete pads at each end of the gas pipe. A map of survey points is shown in Fig. 3.21.

Prior to the commencement of Longwall 28, Jemena undertook a gas detection survey of the bridge crossing pipework and the section of the 160 mm diameter PE pipe along Remembrance Drive from the intersection of Tahmoor House Court to the intersection of Koorana Road. No issues were detected.



Sketch courtesy of SMEC (Urban)

Fig. 3.21 Survey marks on Remembrance Drive (Myrtle Creek) Road Bridge

3.7.4. Summary of Risk Analysis for Gas Infrastructure

A summary of the levels of risk for the gas pipes are provided in Table 3.9.

Table 3.9 Risk Analysis Matrix for Gas Infrastructure

Risk	Likelihood	Consequence	Level of Risk
Damage to main gas pipeline on Remembrance Drive (160 mm)	VERY RARE	VERY SEVERE	MODERATE
Damage to local reticulation pipes	VERY RARE	MODERATE	LOW
Castlereagh Street gas main crossing at Myrtle Creek	VERY RARE	MODERATE	LOW
Remembrance Drive gas main crossing at Myrtle Creek	VERY RARE	VERY SEVERE	MODERATE

4.1. Gas Management Group (GMG)

The Gas Management Group (GMG) is responsible for providing advice on all technical issues relating to mine subsidence related impacts to gas infrastructure due to the mining of Longwall 29 on which decisions are made by Jemena and Tahmoor Colliery. The GMG develops and reviews this management plan, collects and analyses monitoring results, determines potential impacts and provides advice to Jemena and Tahmoor Colliery regarding appropriate actions. The members of the GMG are highlighted in Chapter 8.0

4.2. Avoidance and Mitigation Measures

Given the results of the risk assessment and nature of the gas infrastructure, which has been constructed with flexible materials and buried beneath the surface in urban areas, it is considered impractical and unnecessary to implement avoidance and mitigation measures to the gas infrastructure that will experience mine subsidence movements as a result of the mining of Longwall 29, as it does not mine directly beneath the infrastructure network.

Further confidence is drawn from the experience of mining Longwalls 22 to 28, where no impacts have been observed, even where predicted subsidence movements have been exceeded.

4.3. Monitoring Plan

A number of monitoring measures will be undertaken during mining.

4.3.1. Ground Monitoring Lines

Ground surveys of level and strain distance will be conducted during mining along monitoring lines that are generally located in streets.

General Ground Monitoring along streets

As a general guide, the frequency of ground monitoring within urban areas is every 200 metres of longwall extraction for all survey marks that are located within the active subsidence zone. This includes a survey line along Bridge Street, on which a small 32 mm nylon pipe is located. The timing of surveys within rural areas is determined by the location of street monitoring lines, where a survey has been scheduled to occur when the longwall face has passed each monitoring line by approximately 200 metres.

At the completion of each longwall, surveys will be undertaken along the full length of each monitoring line expected to have experienced some subsidence movements as a result of mining the longwall.

Monitoring of Remembrance Drive Bridge over Myrtle Creek

Weekly surveys of the Remembrance Drive Bridge over Myrtle Creek and the termination points of the steel gas pipe will be undertaken after the start of extraction of Longwall 29 until the length of extraction is 800 metres, unless adverse changes are being observed at this time. The survey will also include tilt measurements on both sides of the elbows at each end of the pipe crossing to measure potential bending at the elbow in response to subsidence. A survey will also be undertaken at the completion of Longwall 29.

4.4. Visual Inspections

Visual inspections will be undertaken within the active subsidence zone during mining.

4.5. Jemena Gas Patrols

Jemena pipeline officers conduct routine gas patrols in the Tahmoor area, which can be quickly increased in frequency in response to increased subsidence, curvature or strains. Prior to the start of Longwall 28, Jemena undertook a pre-mining gas detection survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek and section of 160 mm diameter PE pipe along Remembrance Drive from the Bridge to the intersection of Remembrance Drive and York Street, with no issues detected. Another pre-mining survey will be undertaken prior to the start of Longwall 29.

4.6. Triggers and Responses

Trigger levels have been developed by Jemena based on the capacity of the gas services to tolerate ground movements. Trigger levels for each monitoring parameter are described in Table 4.1.

Table 4.1 Control Measures and Response for Tahmoor Colliery Longwall 29 on Jemena AGN Gas Facilities

<table>
<tr><th>Level</th><th>Control Measures</th><th>Frequency</th><th>Analysis</th><th>Trigger Level</th><th>Action</th></tr>
<tr><td rowspan="3">1</td><td>Ground Inspections:
- 2D survey
- ground inspection</td><td>Ground surveys by Tahmoor Colliery:
Submit data within 24 hours duration
Baseline survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek prior to start of LW28 (complete)
Local 3D survey: weekly survey of Remembrance Drive Bridge over Myrtle Creek, including pipe crossings after start of LW29 until the length of extraction of LW29 is 800m, unless adverse changes are observed at this time. Survey at completion of Longwall 29.
Ground inspections by Tahmoor Colliery:
Weekly inspections of Remembrance Drive Bridge over Myrtle Creek from start of LW29 until the length of extraction is 800m, unless adverse changes are observed at this time.</td><td>Tahmoor
surveys and provides Jemena with
- ground surveys
- ground movements / features reports</td><td rowspan="3">Ground Movement Survey and Measurements:
* Radius of ground curvature greater than 4 (km)
* Ground strain 0 to 2 (mm/m)
* Ground movements rate of change steady
* Closure or opening of pipe crossing 0 to 15 (mm)

Ground Conditions Monitoring:
- ground cracks reported
- ground subsidence reported
- impacts observed on Remembrance Drive Road Bridge
____
- ground movements showing a step change indicating shear and / or discontinuity in humps near the gas services</td><td rowspan="3">Go to LEVEL 2 if LEVEL 1 limit is exceeded:
* normal ground patrol by Jemena pipeline officer

Jemena actions following receipt of reported incidents: inspects site to confirm operation of gas facilities not affected

Assess potential for impacts on the pipe crossing due to valley closure. Consider trigger level for Level 2.
____
* undertake additional inspection e.g. exposing and inspecting gas service as applicable to determine gas facilities integrity
*based on above findings, undertake corrective action per Level 3 activities where gas services integrity affected</td></tr>
<tr><td>Ground Subsidence Validations:
- Observed against predictions</td><td>Weekly: verify and track results against predictions</td><td>MSEC
analyses and reports findings to stakeholders</td></tr>
<tr><td colspan="2">Baseline Gas Detection Survey: (Prior to start of LW29)
Jemena undertook a pre-mining gas detection survey of pipe crossing on Remembrance Drive Bridge over Myrtle Creek and section of 160 mm diameter PE pipe along Remembrance Drive from the Bridge to the intersection of Remembrance Drive and York Street</td><td>Jemena reviews:
- 2D ground surveys report
- pipe integrity
- ground conditions report</td></tr>
<tr><td rowspan="3">2</td><td>Ground Inspections:
- 2D survey
- ground inspection</td><td>Submit data within 24 hours duration
Twice weekly 2D survey</td><td>Tahmoor
surveys and provides Jemena with
- ground surveys
- ground movements / features reports</td><td rowspan="3">Ground Movement Survey and Measurements:
* Radius of ground curvature 2 to 4 (km)
* Ground strain 2 to 5 (mm/m)
* Ground movements rate of change increasing with increasing upward trend

Ground Conditions Monitoring:
- ground cracks reported
- ground subsidence reported
- minor emergency repairs required to Remembrance Drive Road Bridge (treatment of cracks)
____
- ground movements showing a step change indicating shear
and / or discontinuity in humps near the gas services</td><td rowspan="3">Go to LEVEL 3 if LEVEL 21 limit is reached:
* weekly ground patrol by Jemena pipeline officer

Jemena actions following receipt of reported incidents: inspects site to confirm operation of gas facilities not affected

Jemena reviews planned minor emergency repair works on Remembrance Drive Road Bridge
____
* undertake additional inspection e.g. exposing and inspecting gas service as applicable to determine gas facilities integrity, or adjust supports between steel gas pipe and Remembrance Drive Road Bridge
*based on above findings, undertake corrective action per Level 3 activities where gas services integrity affected
* if no immediate corrective actions required, Jemena may put field construction on standby</td></tr>
<tr><td>Ground Subsidence Validations:
- Observed against predictions</td><td>Twice weekly: verify and track results against predictions</td><td>MSEC
analyses and reports findings to stakeholders</td></tr>
<tr><td colspan="2"></td><td>Jemena reviews:
- 2D ground surveys report
- pipe integrity
- ground conditions report</td></tr>
<tr><td rowspan="3">3</td><td>Ground Inspections:
- 2D survey
- ground inspection</td><td>Submit data within 24 hours duration
Daily 2D survey</td><td>Tahmoor
surveys and provides Jemena with
- ground surveys
- ground movements / features reports</td><td rowspan="3">Ground Movement Survey and Measurements:
* Radius of ground curvature less than 2 (km)
* Ground strain greater than 5 (mm/m)
* ground movements showing a step change indicating shear and / or discontinuity in humps near the gas services
* ongoing severe impacts on Remembrance Drive Road Bridge, requiring extensive emergency repairs including jacking and relevelling the bridge deck.</td><td rowspan="3">Jemena's field corrective actions:
- mobilisation construction in the field
- excavate affected area
- inspect gas facilities to confirm integrity
- repair and / or replace gas services as applicable to maintain supply and safe operation
- adjust supports between steel gas pipe and Remembrance Drive Road Bridge
- undertake works to protect gas pipe from impacts caused by construction activities to repair Remembrance Drive Road Bridge</td></tr>
<tr><td>Ground Subsidence Validations:
- Observed against predictions</td><td>Daily: verify and track results against predictions</td><td>MSEC
analyses and reports findings to stakeholders</td></tr>
<tr><td colspan="2"></td><td>Jemena reviews:
- 2D ground surveys report
- pipe integrity
- ground conditions report (as applicable)</td></tr>
</table>

5.0 GMG MEETINGS

The monitoring of natural surface features and surface infrastructure which forms an integral part of this Management Plan will be carried out by Tahmoor Colliery. GMG Meetings will be held between Tahmoor Colliery and Jemena for discussion and resolution of issues raised in the operation of the Management Plan.

GMG 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 party may call an emergency GMG 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.

6.0 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.

7.0 RECORD KEEPING

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

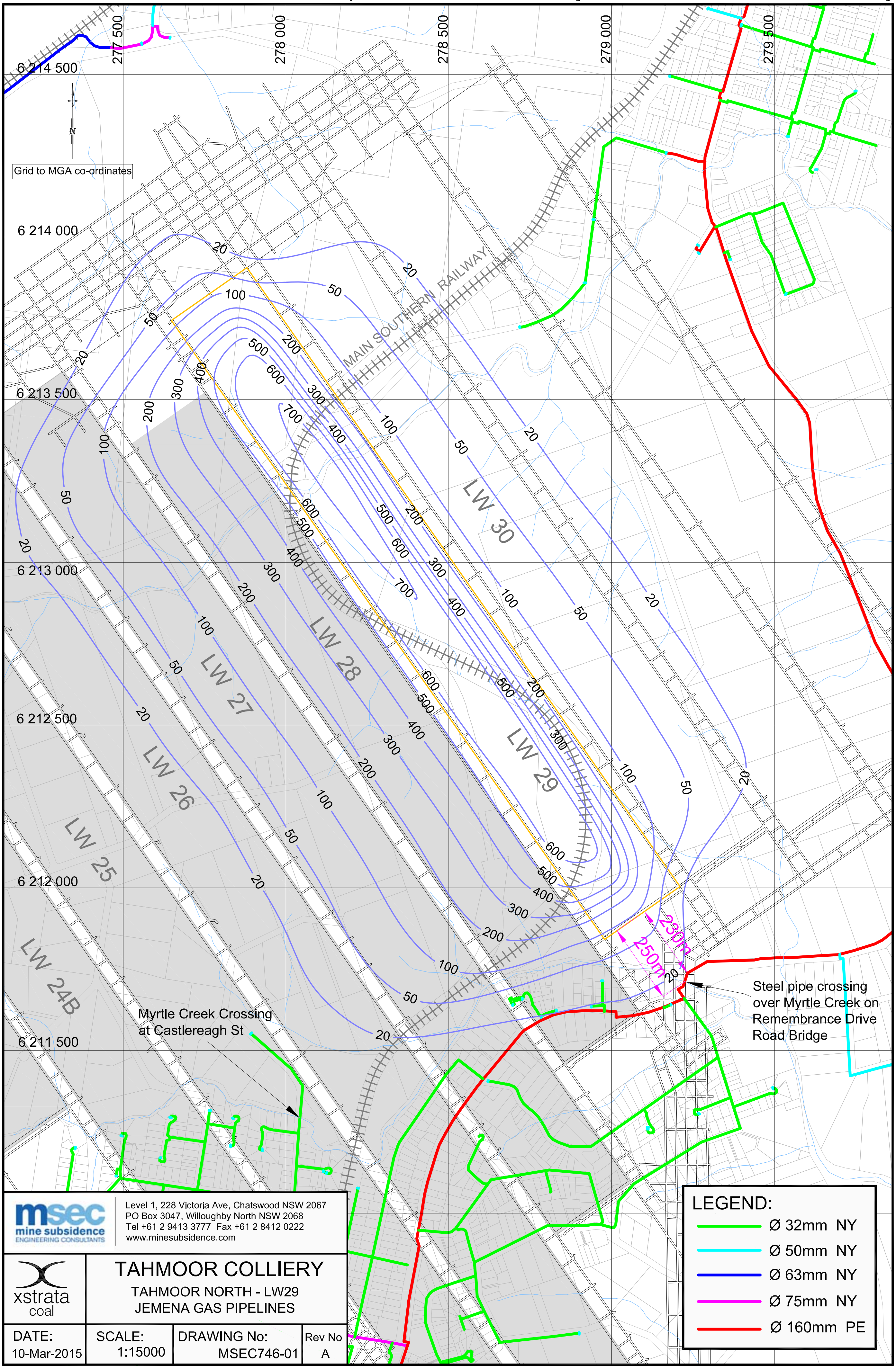
8.0 CONTACT LIST

Organisation	Contact	Phone	Email / Mail	Fax
Jemena Control Centre	Emergency Contact	131909		
Jemena	Meng Cheng*	(02) 9867 7075 0408 469 091	meng.cheng@jemena.com.au	
NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS)	Phil Steuart	(02) 4931 6648	phil.steuart@dpi.nsw.gov.au	(02) 4931 6790
	Gang Li	(02) 4931 6644 0409 227 986	gang.li@dpi.nsw.gov.au	(02) 4931 6790
	Ray Ramage	(02) 4931 6645 0402 477 620	ray.ramage@dpi.nsw.gov.au	(02) 4931 6790
Mine Subsidence Board	John Rawes	(02) 4677 1967 0457 727 263	j.rawes@minesub.nsw.gov.au	(02) 4677 2040
Mine Subsidence Engineering Consultants (MSEC)	Daryl Kay*	(02) 9413 3777 0416 191 304	daryl@minesubsidence.com	(02) 8412 0222
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 0428 260 899	Belinda.Treverrow@glencore.com.au	(02) 4640 0140

* denotes member of Gas Management Group

APPENDIX A. DRAWINGS

I:\Projects\Tahmoor\MSEC746 - LWs 29 to 30 Management Plans\MSEC746-05 Jemena\AcadData\MSEC746-01.dwg



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xstrata coal

TAHMOOR COLLIERY

TAHMOOR NORTH - LW29
JEMENA GAS PIPELINES

DATE:	SCALE:	DRAWING No:	Rev No
10-Mar-2015	1:15000	MSEC746-01	A