mine subsidence ENGINEERING CONSULTANTS

TAHMOOR UNDERGROUND
GLENCORE

GLENCORE:

Tahmoor Colliery - Longwall 29

Subsidence Monitoring Programme – Revision B

AUTHORISATION OF MANAGEMENT PLAN

Authorised on behalf of Tahmoor Colliery:	
Name:	Ian Sheppard
Signature:	
Position:	Manager, Environment and Community
Date:	25 May 2015

DOCUMENT REGISTER

Date	Report No.	Rev	Comments
Mar-11	MSEC446-00	A	Draft for Longwall 26
Jun-11	MSEC446-00	B	Revised to include monitoring for railway infrastructure
Jul-11	MSEC446-00	C	Revised to include weekly surveys of Moorland Rd, Struan St, Krista Pl
Aug-11	MSEC446-00	D	Revised to include extra surveys across Redbank Creek, and along Main Southern Railway and Remembrance Drive
Aug-11	MSEC446-00	E	Timing of relative 3D surveys revised
Sep-11	MSEC446-00	F	Update on monitoring at Skew Culvert on Main Southern Railway, include survey marks along Hilton Park Road, which have been installed with baseline survey complete.
Mar-12	MSEC446-00	G	Update on monitoring at Redbank Creek
Sep-12	MSEC567-00	A	Updated for Longwall 27
Oct-12	MSEC567-00	B	Final for Longwall 27
May-13	MSEC567-00	C	Updated for Main Southern Railway
May-13	MSEC567-00	D	Minor clarifications following feedback from DTIRIS
Jun-13	MSEC567-00	E	Update of locations of new monitoring points along railway corridor
Aug-13	MSEC567-00	F	Information on monitoring of Redbank Creek Culvert updated.
Mar-14	MSEC646-00	A	Draft for Longwall 28
Mar-14	MSEC646-00	B	Final for Longwall 28
Sep-14	MSEC646-00	C	Updated for Longwall 28 to include Redbank Creek Culvert and Bridge Street Overbridge
Nov-14	MSEC646-00	D	Updated for Longwall 28 following feedback from DTIRIS
Mar-15	MSEC746-00	A	Updated for Longwall 29
May-15	MSEC746-00	B	Updated re Stilton Dams

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 B at the end of this report.

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 28 longwalls to the north and west of the mine's current location.

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 panels are 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.

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

The Subsidence Monitoring Programme is also consistent with detailed Subsidence Management Plans that have been developed by Tahmoor Colliery in consultation with stakeholders. Each of these management plans describe measures that will be undertaken to monitor subsidence movements and physical changes and/or impacts that occur during mining. The management plans include:

- *Tahmoor Colliery Longwalls 27 to 30 – Natural Features Subsidence Management Plan* (Revision I), November 2012.
- *Tahmoor Colliery Longwalls 28 to 30 Wollondilly Shire Council Management Plan* (Revision A), Report No. MSEC646-02, March 2014.
- *Tahmoor Colliery Management Plan for Potential Impacts to Potable Water Infrastructure due to the mining of Longwalls 28 to 30* (Revision A), Report No. MSEC646-03, January 2014.
- *Tahmoor Colliery Management Plan for Potential Impacts to Sydney Water Sewer Infrastructure due to the mining of Longwalls 28 to 30* (Revision A), Report No. MSEC646-04, February 2014.
- *Tahmoor Colliery Management Plan for Potential Impacts to Gas Infrastructure due to the mining of Longwalls 29 to 30* (Revision A), Report No. MSEC746-05, March 2015.
- *Management Plan Longwall Mining (LW 29) beneath Telstra Plant @ Tahmoor and Thirlmere NSW*, Colin Dove, 2014.
- *Tahmoor Colliery Management Plan for Potential Impacts to Built Structures due to the mining of Longwalls 28 to 30* (Revision A), Report No. MSEC646-12, March 2014.
- *Tahmoor Colliery Management Plan for Potential Impacts to Items of Heritage Significance due to the mining of Longwalls 28 to 30* (Revision A), Report No. MSEC646-13, March 2014.
- *Tahmoor Colliery Management Plan for longwall mining beneath the Main Southern Railway, Revision A (Longwalls 29 to 30)*, Report No. MSEC747, March 2015.

In a small number of cases, monitoring measures described in this Subsidence Monitoring Programme are in excess of commitments that have been made in the above-mentioned management plans.

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

1.2. Definition of Active Subsidence Zone

As a longwall progresses, subsidence begins to develop at a point in front of the longwall face and continues to develop after the longwall passes. The majority of subsidence movement typically occurs within an area 150 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 of and 450 metres behind the active longwall face, as shown by Fig. 1.1.

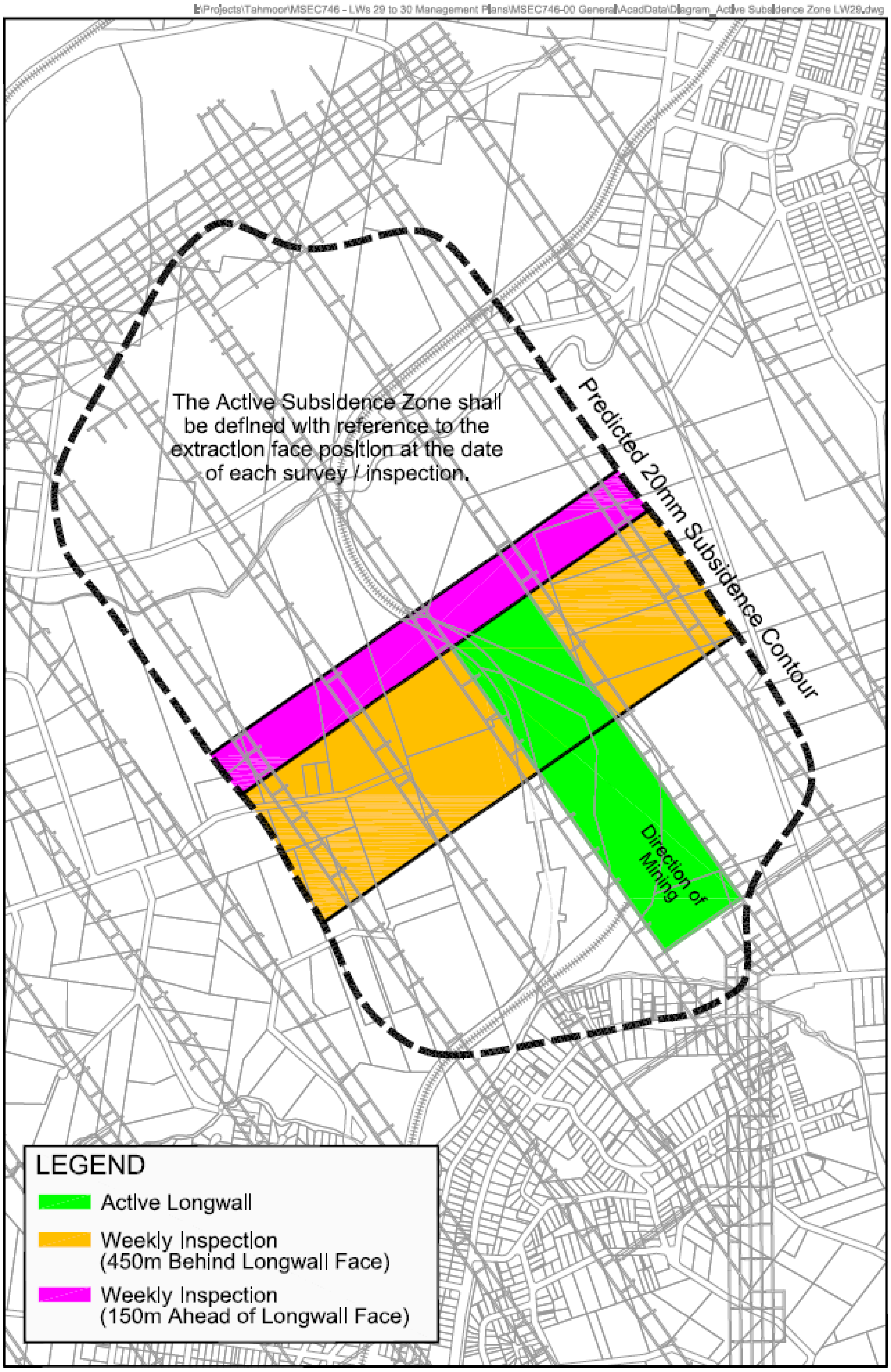


Fig. 1.1 Diagrammatic Representation of Active Subsidence Zone

1.3. 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.

A summary of the maximum predicted incremental systematic subsidence parameters, due to the extraction of Longwall 29, is provided in Table 1.1. A summary of the maximum predicted cumulative systematic subsidence parameters, after the extraction of Longwall 29, is provided in Table 1.2.

Table 1.1 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)
After LW29	730	5.9	0.06	0.13

Table 1.2 Maximum Predicted Cumulative 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 30.

1.4. 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 1.3. 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 1.3 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. 1.2 to Fig. 1.6 and a discussion on these details is presented below.

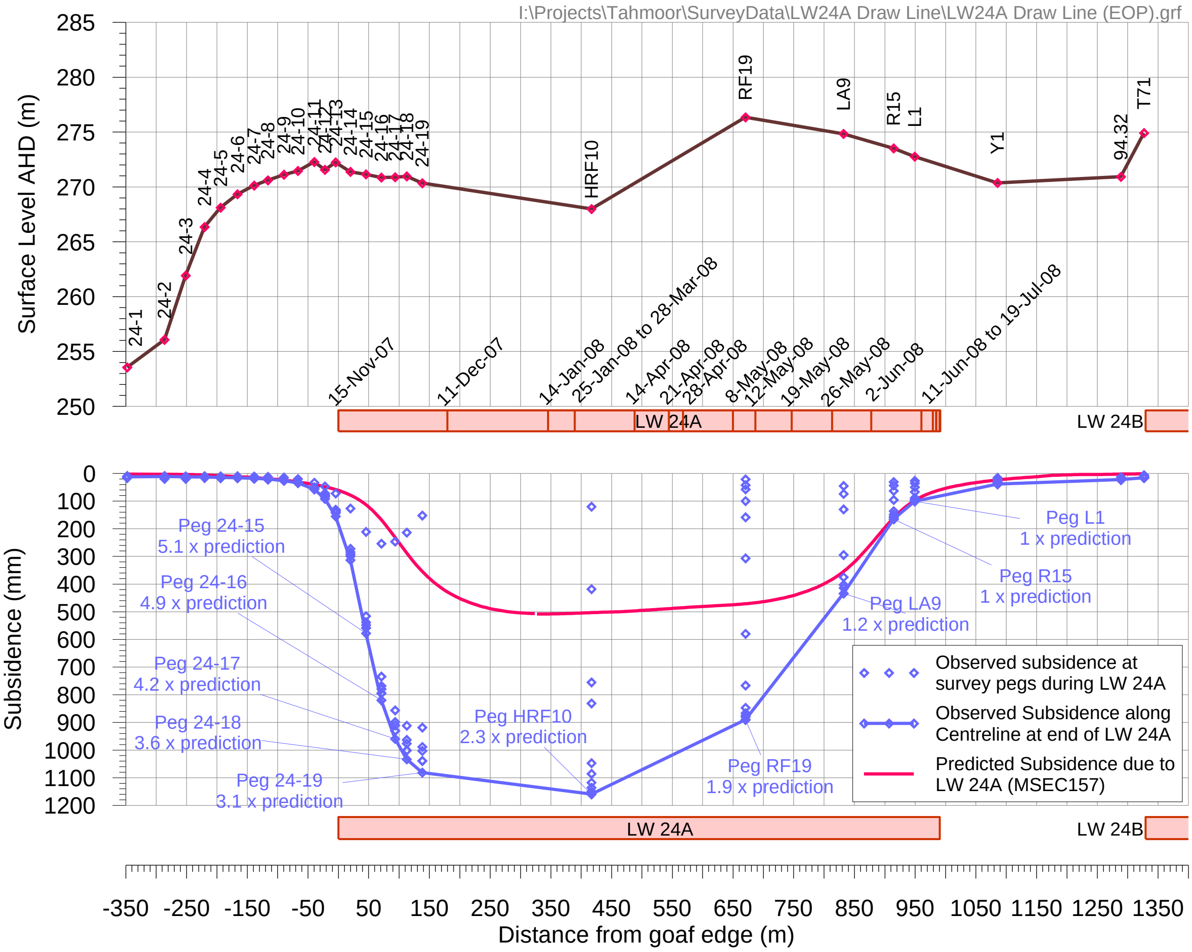


Fig. 1.2 Observed Incremental Subsidence along Centreline of Longwall 24A

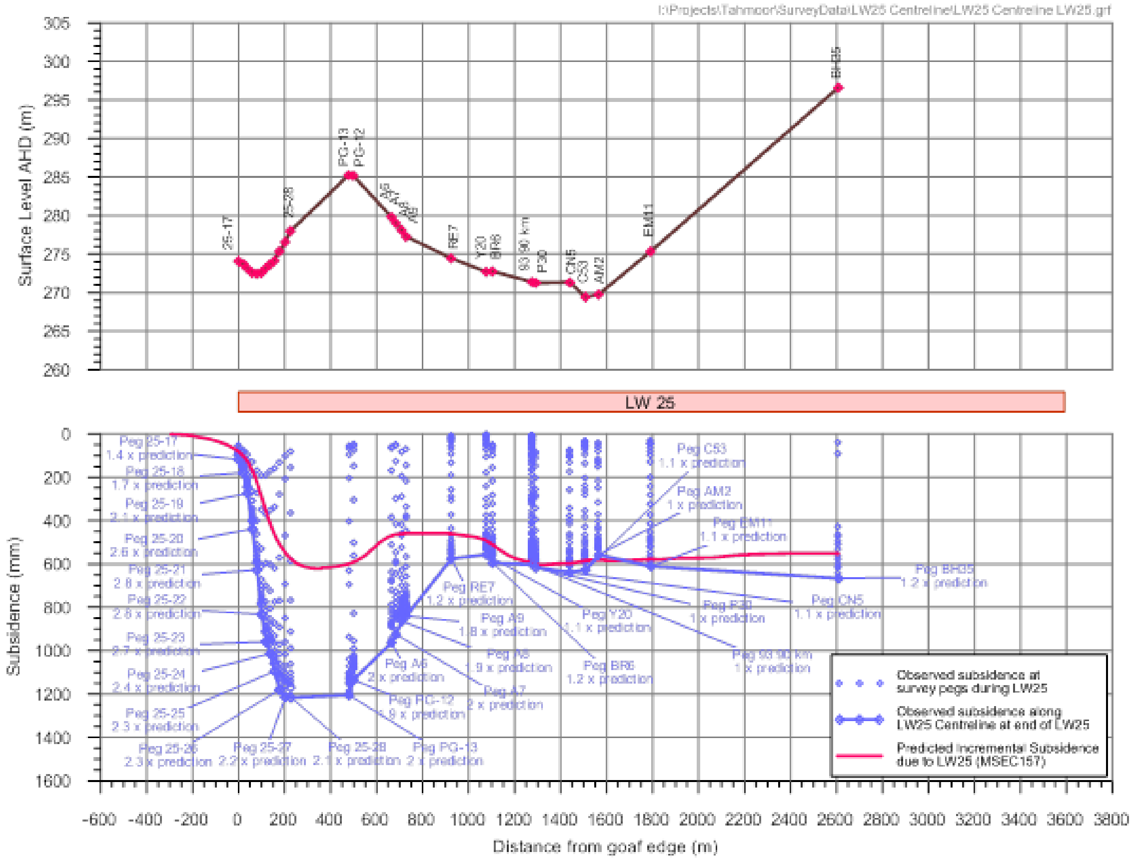


Fig. 1.3 Observed Incremental Subsidence along Centreline of Longwall 25

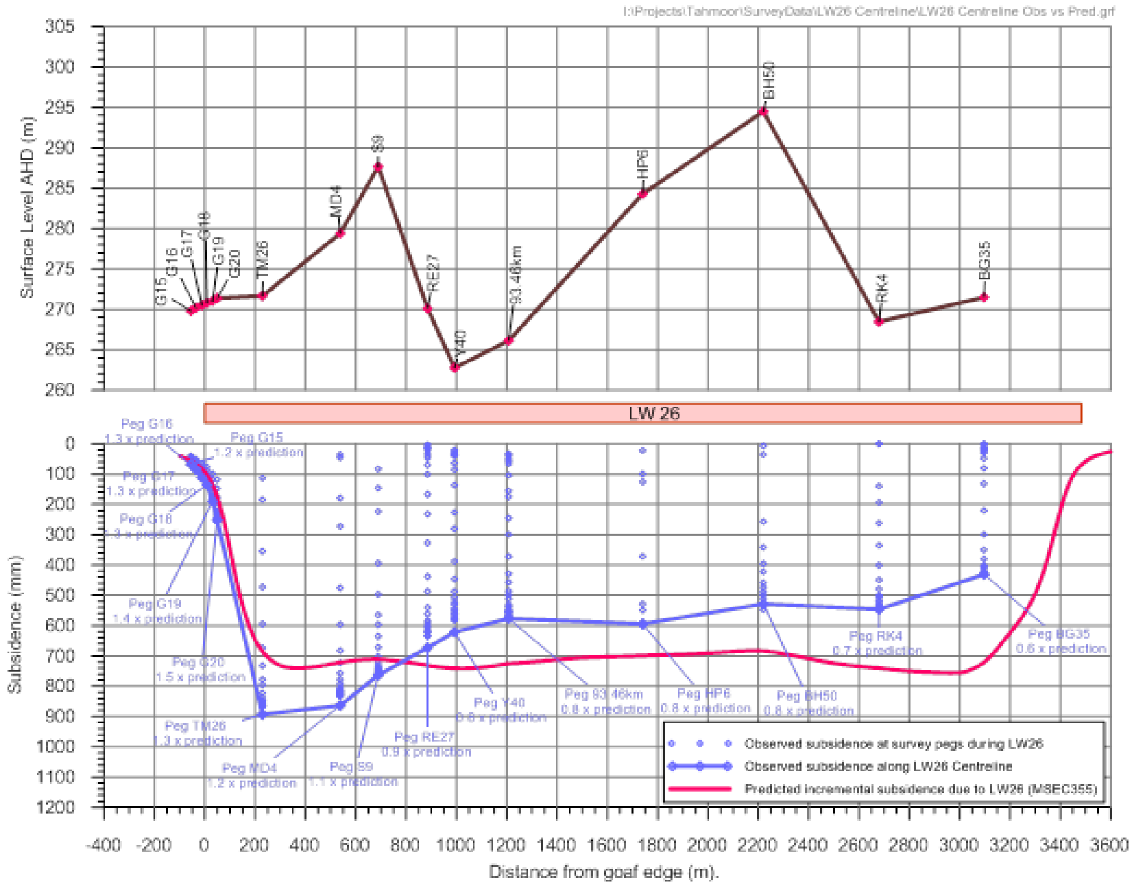


Fig. 1.4 Observed Incremental Subsidence along Centreline of Longwall 26

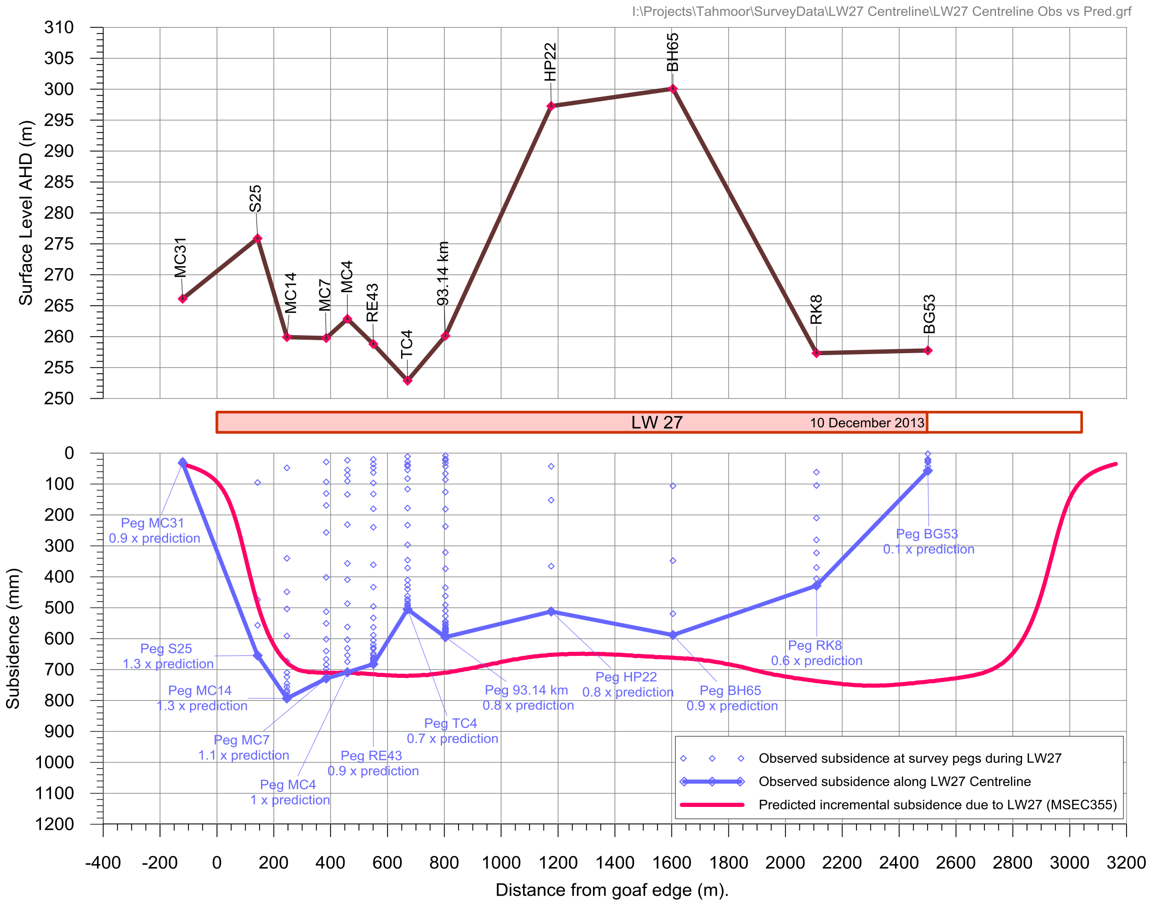


Fig. 1.5 Observed Incremental Subsidence along Centreline of Longwall 27

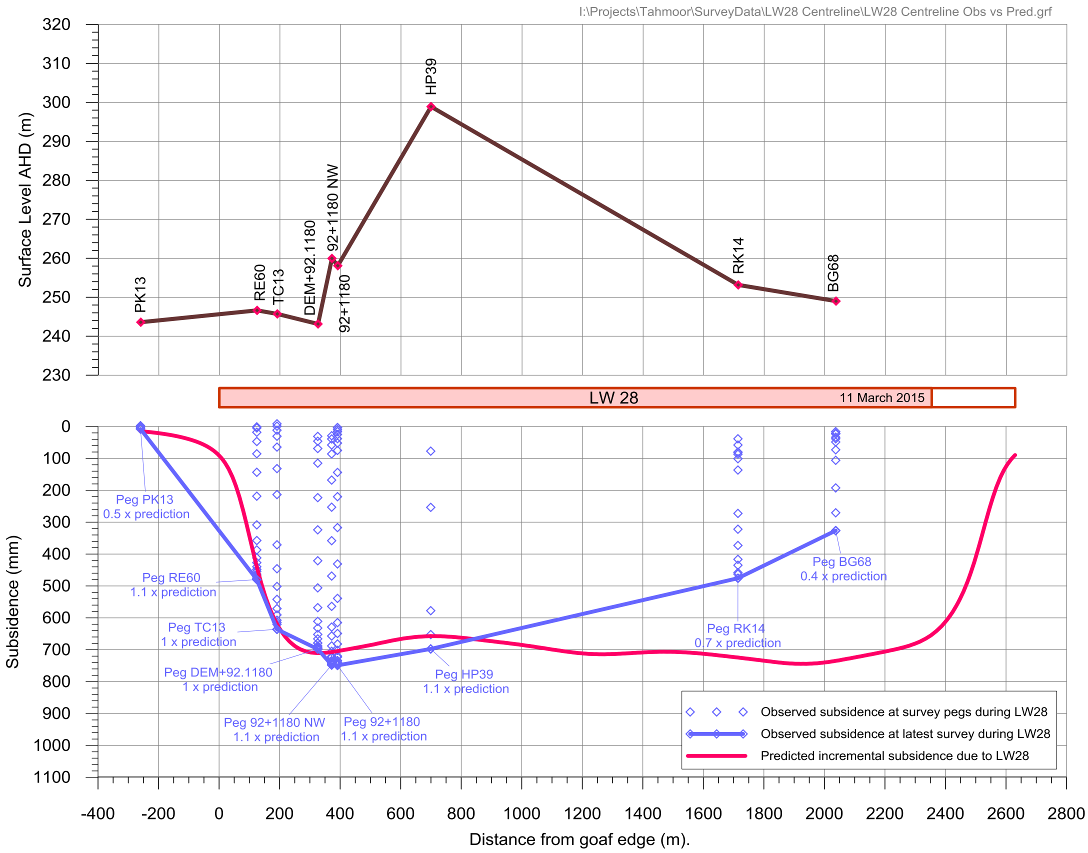


Fig. 1.6 Observed Incremental Subsidence along Centreline of Longwall 28 as at 11 March 2015

Observed Increased Subsidence during the mining of Longwall 24A

- Fig. 1.2 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. 1.2 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. 1.3 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. 1.4 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. 1.5 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. 1.5 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. 1.6 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. 1.6 there is a reasonable correlation between the observed and predicted subsidence profile along the centreline of Longwall 28.

1.4.1. 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. 1.7 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. 1.7 that the alignment of the Nepean Fault is further away from the Bargo River gorge and further away from Longwalls 26 to 29, 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.

I:\Projects\Tahmoor\MSEC847 - LWs 31 to 37 SMP\AcadData\Diagram_Observed Incremental Subsidence LW24A to LW28 for SMP.dwg

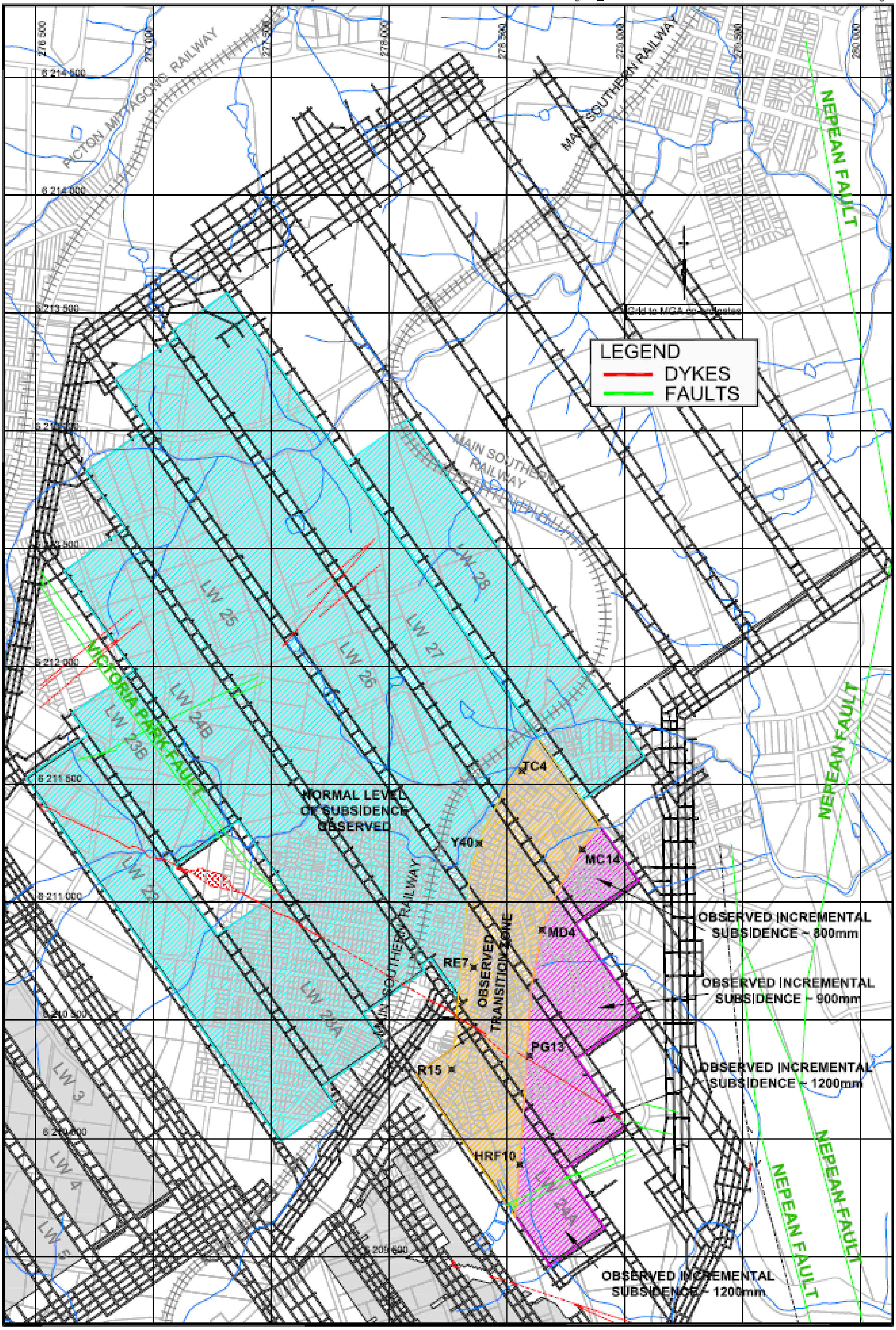


Fig. 1.7 Zones of increased subsidence over Longwalls 22 to 28

2.1. Layout of Monitoring Points

The layout of monitoring points is provided in Drawing No. MSEC746-00-01. Due to the density of survey marks, detailed layouts of monitoring points are provided for the Railway Embankment in Drawing No. MSEC747-105, the Railway Cutting in Drawing No. MSEC747-106.

A layout of monitoring points for the Deviation Overbridge at 92.400 km is provided in Fig. 2.8.

2.2. Monitoring Methods and Accuracy

With the exception of surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Specifications for Subsidence Monitoring Lines for Longwall 29*, by SMEC. This specification is appended to this Subsidence Monitoring Programme.

With respect to surveys undertaken within the railway corridor, the monitoring methods and accuracy are described in the report entitled *Main Southern Rail Line- Survey Monitoring Plan for LW29 and LW30* by Southern Rail Surveys. This specification is appended to this Subsidence Monitoring Programme.

Occasionally survey pegs become disturbed or lost. Tahmoor Colliery will replace the lost pegs unless approval for not replacing the pegs is provided by DTIRIS.

With respect to specialist monitoring undertaken within the railway corridor, including automated monitoring of rail stress, rail temperature and switch displacement, and automated total station monitoring in the vicinity of the geological fault at 92.850 km, please refer to details provided in the Railway Management Plan (Report No. MSEC747).

2.3. Recording and reporting of monitoring results

The recording and reporting of monitoring results is described in the report entitled *Specifications for Subsidence Monitoring Lines for Longwall 29*, by SMEC and *Main Southern Rail Line- Survey Monitoring Plan for LW29 and LW30*, by Southern Rail Surveys. These specifications are appended to this Subsidence Monitoring Programme.

Survey results will be issued to NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS) within 2 business days of survey.

2.4. Inspection regimes, parameters to be measured, timing and frequencies of surveys and inspections

The inspection regimes, parameters to be measured, timing and frequencies of surveys and inspections are outlined in Table 2.1. The information is sorted by features that are being monitored.

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

In the case of the Main Southern Railway, the extent of ground surveys, track geometry surveys and track inspections along the rail corridor will grow to the north with the advancing longwall face during the mining of Longwall 29. This is described in Section 4.3 of the Railway Management Plan (Report No. MSEC747) and summarised as follows:

- Stage 1 – Early subsidence period
    - Monthly ground surveys are undertaken at survey marks nominally when the longwall face approaches to within 400 metres of each section of railway track.
- Stage 2 – Active subsidence period
    - Weekly ground surveys are undertaken at survey marks nominally when the longwall face approaches to within 200 metres of each section of railway track.
- Stage 3 – Post active subsidence period
    - Progressive reduction in monitoring and inspection frequencies and extents for the railway track, embankments, culverts and cuttings, in accordance with the Railway Management Plan
    - Progressive reduction does not commence until the longwall face has passed each section of track by more than 400 metres, and subject to a review of actual monitoring data and approval by ARTC via the governance meeting.

As mining progresses, monitoring measures for each section of track or associated rail infrastructure will progressively migrate from Stage 1 to Stage 2 and, subject to approval by ARTC, Stage 3. An example of the staged monitoring process is provided in Fig. 2.1.

In the case of the Main Southern Railway, when Stage 3 is reached for each section of track or item of infrastructure, Tahmoor Colliery will not reduce monitoring frequencies or stop monitoring until agreed by ARTC (via recommendation by the Rail Management Group). ARTC can agree to the proposed reduction during an ARTC / Tahmoor Colliery governance meeting as recorded by minutes of the meeting and reconfirmed separately in writing or email. The NSW Department of Trade and Investment, Regional Infrastructure and Services, Division of Resources and Energy (DTIRIS) and the Office of the National Rail Safety Regulator (ONRSR) will be informed of the change separately in writing.

In the case of other infrastructure, survey and inspection frequencies will not be reduced until agreed by DTIRIS and relevant stakeholders, unless stated in the attached Table 2.1 of this Monitoring Programme.

Increased subsidence

Increased subsidence was observed at the southern or commencing ends of Longwalls 24A and 25, and to a lesser extent Longwalls 26 and 27. It is defined as observations of subsidence that are similar in magnitude to those observed within the red zones highlighted in Drawing No. MSEC746-00-01.

Observed subsidence above the commencing end of Longwall 28 was of a magnitude considered normal, and consistent with observed subsidence elsewhere at Tahmoor.

In the case of Longwall 29, the only survey lines near the commencing end of Longwall 29 are the Longwall 29 centreline and Main Southern Railway monitoring lines. These lines will be surveyed on a weekly basis regardless of whether normal or increased subsidence develops. The survey frequency could be increased if required, based on actual monitoring data.

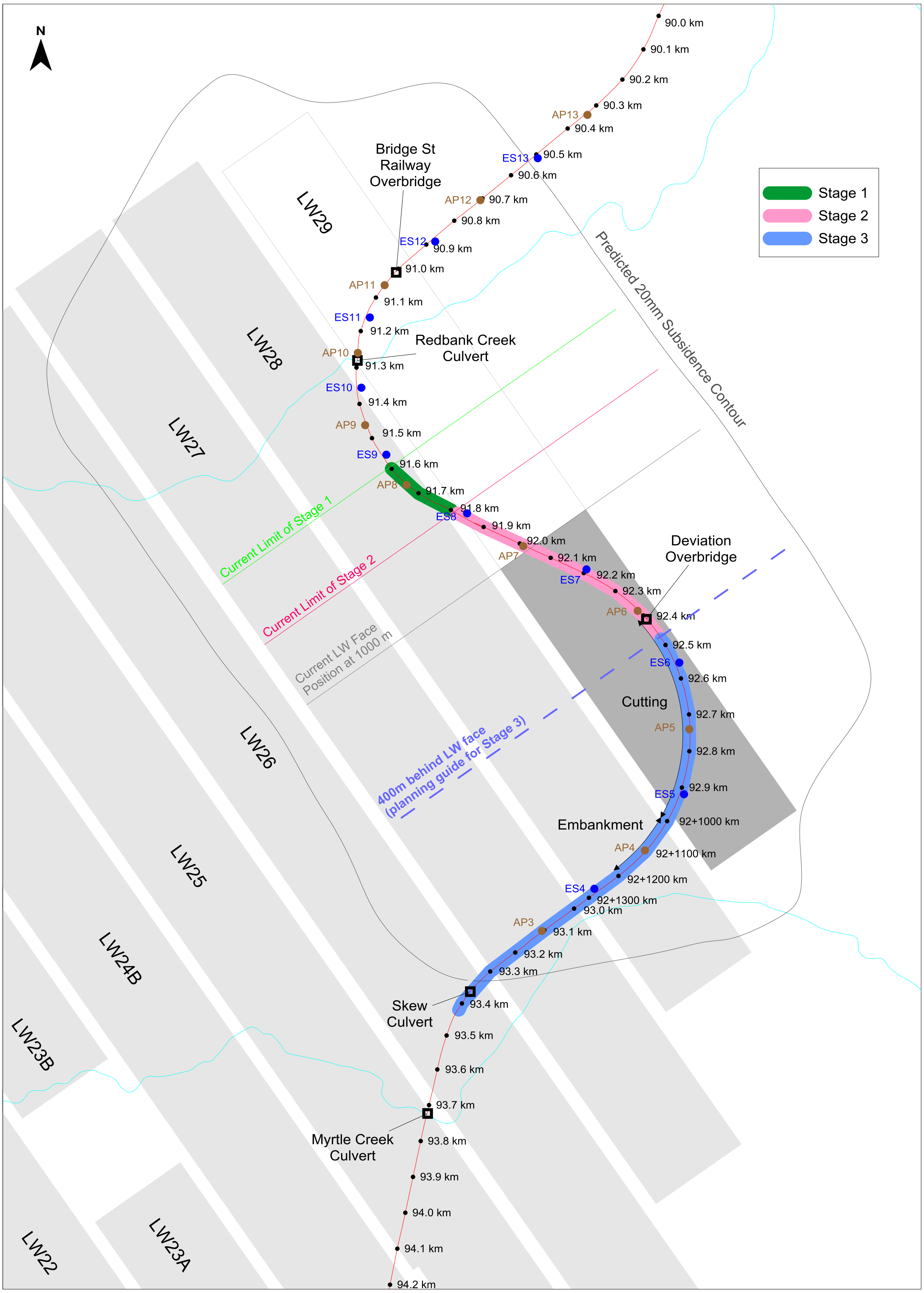


Fig. 2.1 Conceptual diagram showing stages of management during mining of Longwall 29 at 1000 metres of extraction

2.5. Surveys at Redbank Creek

The ability to survey subsidence movements along and across Redbank Creek has been significantly restricted due to refusal of landowners to permit access.

No access to private land is available on the northern bank of Redbank Creek upstream of the Main Southern Railway crossing. On the southern side of Redbank Creek, one landowner has refused access.

The lack of access on the northern bank has led to a reappraisal of the monitoring strategy for Redbank Creek, as it is not possible to install survey lines across the valley.

The revised strategy is to monitor valley closure over long bay lengths using absolute and relative 3D survey techniques. A survey line has been installed with pegs spaced approximately every 50 metres along the southern side of the valley, where the land has already been cleared. Valley closure can be calculated from changes in horizontal distance between these pegs and those located every 20 metres along Bridge Street.

A partial cross line has been installed above previously extracted Longwall 26 along a fence line, where surveyors have found a clear line of sight to Bridge Street from the southern bank. A complete cross line has also been installed within the rail corridor and at three other locations downstream of the railway crossing. These cross lines will provide information on the distribution of valley closure across Redbank Creek plus enable the surveyors to connect between the two main monitoring lines.

A 3D baseline survey has been undertaken in absolute coordinates and a final end of panel survey will also be undertaken in absolute coordinates. A local, relative 3D survey will be undertaken on a weekly basis for pegs located directly above Longwall 29.

2.6. Surveys at the Railway Cutting

Ground survey marks have been installed in the Railway Cutting in the new Deviation.

Pegs have been installed in the cutting at the locations shown in Drawing No. MSEC747-106, and will be surveyed during the mining of Longwall 29. The surveys will be undertaken by traditional ground survey across the full monitoring site by Southern Rail Surveys.

In addition to the above, automated total station monitoring of track geometry will be undertaken in the vicinity of the fault at 92.850 km. Prisms are spaced every fourth sleeper (nominally 2.4 metres apart) as shown in Fig. 2.2.

The total stations also measure selected prisms on the cutting faces and benches at the locations shown in Fig. 2.2, except that the layout of the pegs in the vicinity of the fault on the Up side of the cutting has changed to suit the new batter profile. The revised cutting profile and new locations of survey marks are shown in Fig. 2.3.

The monitoring system consists of the following features:

- Two automated total stations (TS1 and TS2). The total stations are located across the track from each other. TS1 is located on top of the bench at the Downside cutting, at the same position that manual total station surveys are undertaken by Southern Rail Surveys, and as such, it can monitor positions of survey prisms on the cutting faces and benches. TS2 is located on top of the bench at the Upside cutting and monitors survey prisms on the Down track.
- Associated loggers, cabling and other electrical and IT support systems.
- An automated weather station at TS1 to record rainfall and atmospheric pressure.
- Readings will be undertaken every 2 hours.

Further details are provided in the Railway Management Plan (Report No. MSEC747).

Photographs of the automated total station system are provided in Fig. 2.4 to Fig. 2.7.

The purposes of the automated total stations are:

- to detect potential differential subsidence movements across the identified fault near 92.850 km on the railway track and on the cutting faces
- to detect ground movements on the cutting face on the Up side in the vicinity of the fault plane, which has been stabilised by reshaping of the batter profile.

The ground surveys are part of a broader monitoring plan that includes weekly track geometry surveys and visual inspections in the vicinity of the fault, rail stress and switch displacement gauges.

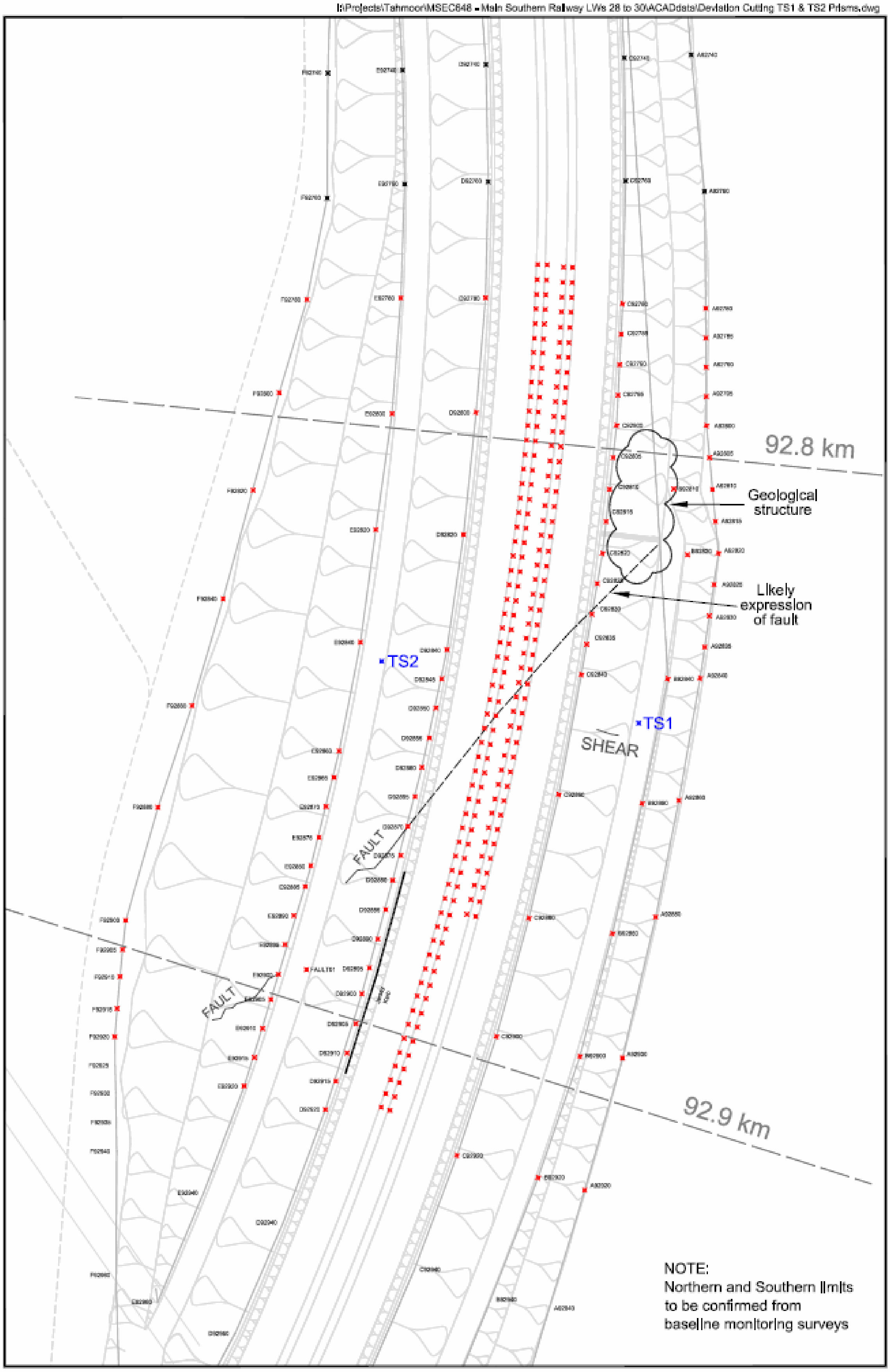


Fig. 2.2 Location of survey prisms that will be continuously monitored by Automated Total Stations in the Cutting about the geological fault at 92.850 km

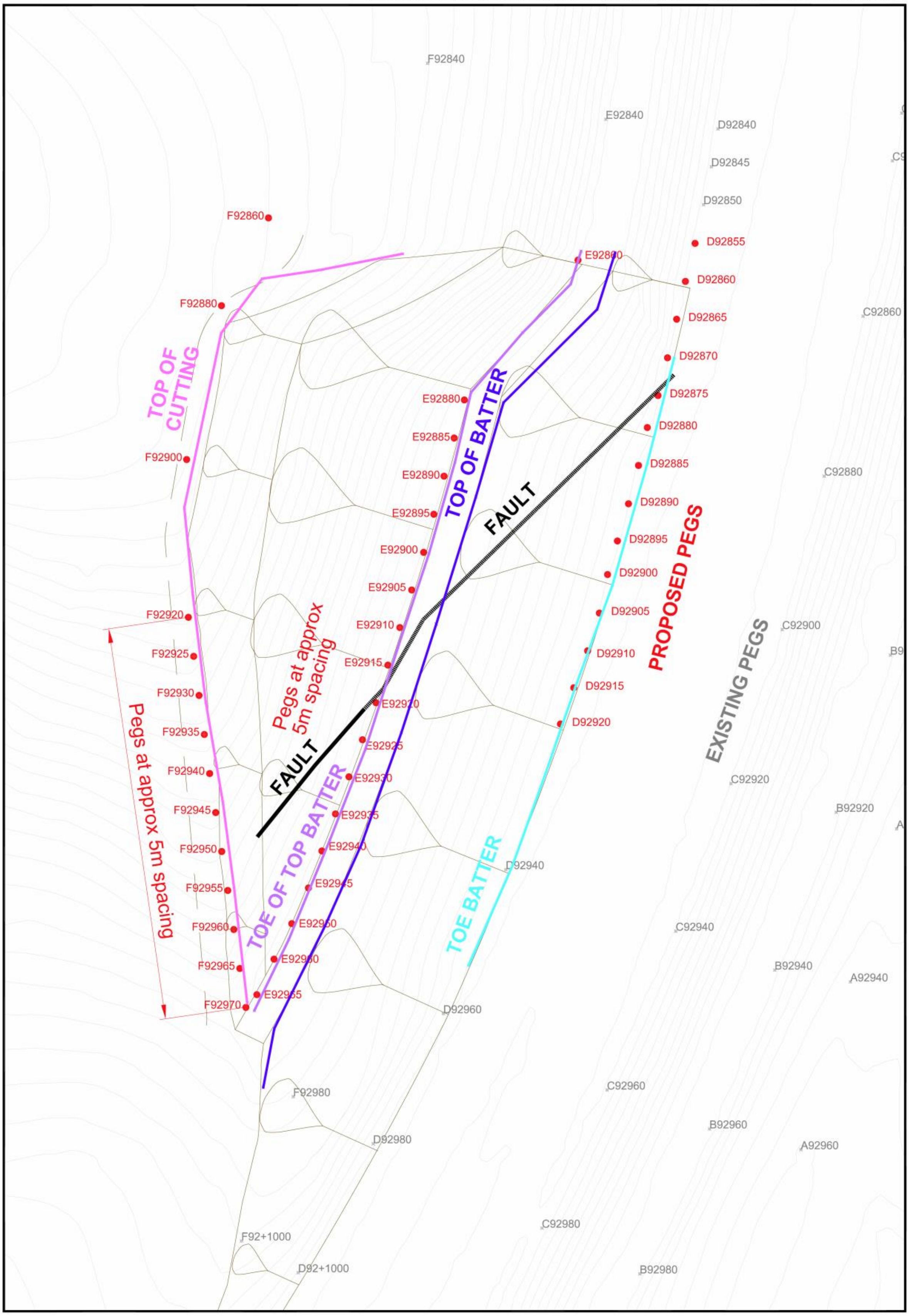


Fig. 2.3 Location of survey prisms that will be installed and continuously monitored by Automated Total Stations in on the Up side batter of the Cutting about the geological fault at 92.850 km

Fig. 2.4 Total Station 1 with weather station

Fig. 2.5 Prisms on Up track looking south facing Total Station 1

Fig. 2.6 Typical survey prism on railway sleeper

Fig. 2.7 Total Station 1 and 2 across the railway track

2.7. Surveys at the Railway Embankment

Ground survey marks have been installed at the Railway Embankment in the new Deviation. The purpose of the surveys is to measure absolute and differential movements at the embankment, which will provide information areas of focus during visual inspections for signs of distress in the embankment.

The locations of the survey marks are shown in Drawing No. MSEC747-106. The marks were installed during the early stages of mining Longwall 27. Due to bulk earthworks to reshape the southern end of the cutting during Longwall 28, new prisms will be installed and a baseline survey completed prior to the commencement of Longwall 29.

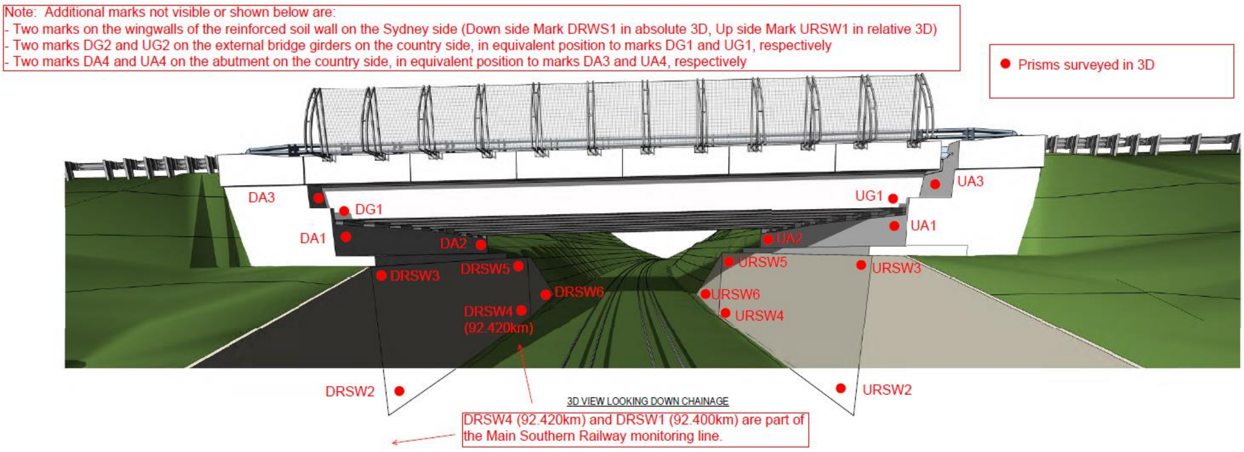
The ground surveys within the railway corridor are undertaken by Southern Rail Surveys. Surveys across Myrtle Creek (MXB, MXC and MXD lines) are undertaken by SMEC.

The ground surveys are part of a broader monitoring plan that includes track geometry surveys, visual inspections, rail stress gauges and expansion switch displacement sensors.

2.8. Surveys of Deviation Overbridge at 92.400 km

A network of pegs have been installed and initially surveyed at the Deviation Overbridge at 92.400 km. A diagram showing the location of survey marks on the Deviation Overbridge is provided in Fig. 2.8. The layout of marks in plan view is shown in Drawing No. MSEC747-106. A photograph showing survey prisms is provided in Fig. 2.9.

The purpose of the surveys is to detect potential differential movements between the abutments, the reinforced soil walls, the bridge deck, the natural ground and the engineered fill between the abutments and the natural ground behind them.



Design Image courtesy GHD

Fig. 2.8 Location of monitoring points on Deviation Overbridge at 92.400 km

Fig. 2.9 Survey prisms located on abutment and bridge deck of Deviation Overbridge at 92.400 km

2.9. Monitoring and inspections at Redbank Creek Culvert (RBCC) and Bridge Street Overbridge

This Subsidence Monitoring Programme does not include management or monitoring measures for the Redbank Creek Culvert or the Bridge Street Overbridge during the mining of Longwalls 29 and 30. These will be addressed in a revision to this Subsidence Monitoring Programme.

2.10. Surveys of Telstra Mobile Phone Tower and Optical Fibre Cable

As described in the Telstra Management Plan, the following surveys are undertaken with respect to the Telstra Mobile Phone Tower. A map of survey marks in the vicinity of the Tower is shown in Drawing No. MSEC746-00-01 and Fig. 2.10.

- Survey marks HP41, HP42 and HP43 on the Hilton Park Road survey line
- Survey marks OF1 to OF53 along the alignment of the Telstra optical fibre cable which runs from the Telstra mobile phone tower to Stilton Lane
- Changes in verticality of the Tower, using a mark at the base of the tower and a reflectorless mark near the top of the Tower.
- Tiltmeters have been installed on the base slab of the Tower.
    - The primary tiltmeters are installed in due North and due West directions.
    - Back-up secondary tiltmeters have been installed. Tiltmeter A1 points to 330 degrees clockwise from north, and Tiltmeter A2 points to 200 degrees clockwise from north. These directions match the approximate bearings of the two antennae on the Tower.
    - Data is displayed on the Lynton Surveys website.

It is understood from Telstra that the operating tolerances of the antennae are approximately 1 degree change in tilt. The predicted maximum change in tilt due to the mining of Longwalls 28 to 30 is approximately 0.3 degrees, which is well within the operating tolerances of the antennae.

In the extremely unlikely event of tilts occurring that are greater than 1 degree, the following responses can be undertaken:

a) Remote controlled adjustment of the antennae, by rotating supports that connect the antennae to the tower.

b) Manual adjustment of the antennae, if the rotation is greater than the capacity of the rotating supports.

c) Manual adjustment of the lean of the tower by adjusting the bolt cage assembly at the base of the Tower.

The locations of the survey marks in the vicinity of the mobile phone tower are shown in Drawing No. MSEC746-00-01 and Fig. 2.10.

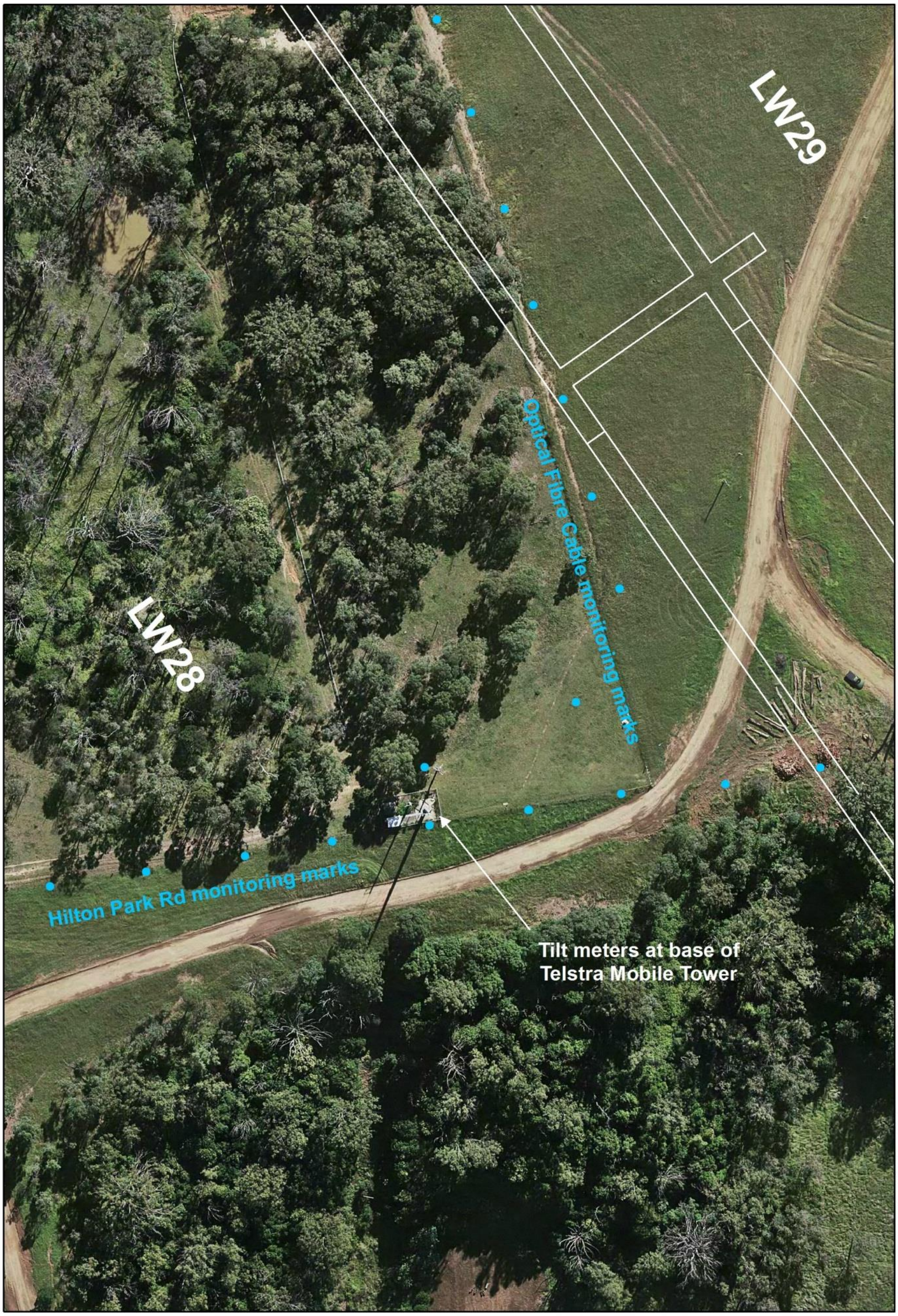


Fig. 2.10 Location of monitoring marks in vicinity of Telstra Mobile Tower

2.11. Surveys above commencing end of Longwall 29

A short, temporary survey line will be installed above the commencing end of Longwall 29 for the purposes of confirming that initial subsidence has commenced as expected above the commencing end of the longwall. The survey line will consist of small number of pegs located above the commencing end of Longwall 29 near the longwall centreline to measure the development of initial vertical subsidence as mining commences. The survey line is temporary only and will be removed as soon as possible after approximately 800 metres of extraction has occurred, so as not to interfere with farming activities. The survey pegs will be spaced nominally every 50 metres and measure changes in height.

Tahmoor Colliery has developed measures to manage potential impacts on the Main Southern Railway in the unlikely event of delayed initial subsidence.

The proposed locations of the survey pegs are shown in Fig. 2.11.

(Note: Construction compound has been rehabilitated since aerial photo was taken)

Fig. 2.11 Subsidence survey line above commencing end of Longwall 29 near the centreline

2.12. Monitoring and Inspections of Large Dams on Stilton Lane

2.12.1. No. 2290 Remembrance Drive

The property at 2290 Remembrance Drive is located off Stilton Lane above the commencing end of Longwall 30, as shown in Fig. 2.12. There are two dams on the property, the larger of which (GG37a) is highlighted. A photograph of the dam is shown in Fig. 2.13.

Whilst the likelihood is considered to be extremely low, there is a potential for the large dam wall to experience adverse impacts from the mining of Longwall 29. Tahmoor Colliery initially planned to undertake ground surveys along the top of the dam wall and along the base of the dam wall on the southern side but the landowner has not permitted access to the property. An alternative survey line will be installed along the fenceline of the adjoining property and along Stilton Road, as shown in Fig. 2.12. Baseline surveys will be undertaken prior to the commencement of Longwall 29. Weekly surveys and inspections will be undertaken from the commencement of mining of Longwall 29 until 800 metres of extraction, unless adverse changes are observed at this time.

If damage is observed to the dams during mining, Tahmoor Colliery will consider whether any further management measures are required in consultation with the landholder. The determination of appropriate measures will depend upon the nature of the impacts observed. It may include draining of water in the dam and provision of alternative water supply. The property already has a metered connection to the Sydney Water mains supply.

Fig. 2.12 Location of Dam GG37a relative to Longwall 29

Fig. 2.13 View of dam wall at the southern end

2.12.2. No. 155 Stilton Lane

Tahmoor Colliery will undertake ground surveys along the top of the dam wall and along the base of the dam wall on the southern side, as shown in Fig. 2.12. Baseline surveys will be undertaken prior to the commencement of Longwall 29. Weekly surveys and inspections will be undertaken from the commencement of mining of Longwall 29 until 800 metres of extraction, unless adverse changes are observed at this time.

Tahmoor Colliery will also undertake ground surveys at the corners of each of the eight greenhouses on the property, as shown in Fig. 2.12. Baseline surveys will be undertaken prior to the commencement of Longwall 29 and a follow up survey will be undertaken at the completion of Longwall 29. Additional surveys may be undertaken during the mining of Longwall 29 if impacts are reported at the site or substantial differential movements are observed from the results of the ground surveys of the dams.

Table 2.1 Subsidence Monitoring Programme for Longwall 29

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Natural Features			
Myrtle Creek	Survey lines MXB, MXC and MXD across Myrtle Creek	2D subsidence and distance	Weekly within active subsidence zone, commencing after LW start End of LW29
	Visual inspection of Myrtle Creek, including archaeological site 52-2-2078	-	Weekly, commencing after 200m of extraction within active subsidence zone
Redbank Creek	Absolute and relative 3D survey	Local easting, northing and level to calculate valley closure (refer Section 2.5)	Monthly, commencing after 1300m of extraction Weekly when within active subsidence zone, commencing after 1500m of extraction End of LW29 for all lines
	Visual inspection of Redbank Creek	-	Weekly, commencing after 1500m of extraction within active subsidence zone
Wollondilly Council Infrastructure			
Local roads	Ground surveys along streets	2D subsidence and distance	Please refer Dwg. No. MSEC746-00-01 *For street surveys with lines coloured red and labelled as "Surveys during LW29":* One survey along Remembrance Drive after 800m of extraction, unless by exception, based on actual monitoring data Weekly surveys along Bridge Street within the active subsidence zone For other street survey lines: Conduct surveys every 200m of extraction for survey pegs located within the active subsidence zone, commencing after 200m of extraction *For street surveys with lines coloured yellow and labelled as "Monitoring Lines Before & End of LW29":* Before and end of LW29
	Visual inspections of streets	-	Detailed inspection once a week within the active subsidence zone, commencing from start of LW Vehicle based inspection once a week within the active subsidence zone (on alternate day to detailed inspection), commencing after 200m of extraction
Remembrance Drive Road Bridge and Pedestrian Bridge	Conduct surveys of Bridges, and survey of ground pegs located in the valley sides between the two bridges	2D subsidence and distance	Weekly from start of LW until 800m of extraction, unless by exception, based on actual monitoring data End of LW29
	Detailed visual inspections of bridges	-	Weekly from start of LW until 800m of extraction, unless by exception, based on actual monitoring data
Potable Water Infrastructure			
Potable water infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Stilton Lane Dams			
Stilton Lane Dams	Ground survey of pegs around top and base of dam wall at No. 155 Stilton Lane. Ground survey of pegs along fence line and on Stilton Lane alongside dam wall at No. 2290 Remembrance Drive	Local 3D survey	Baseline survey prior to the commencement of LW29. Weekly surveys of survey pegs after start of LW29 until 800 metres of extraction, unless by exception, based on actual monitoring data. Survey at end of LW29.
	Visual inspections of dams	-	Weekly visual inspections of dam walls after start of LW29 until 800 metres of extraction, unless by exception, based on actual monitoring data.

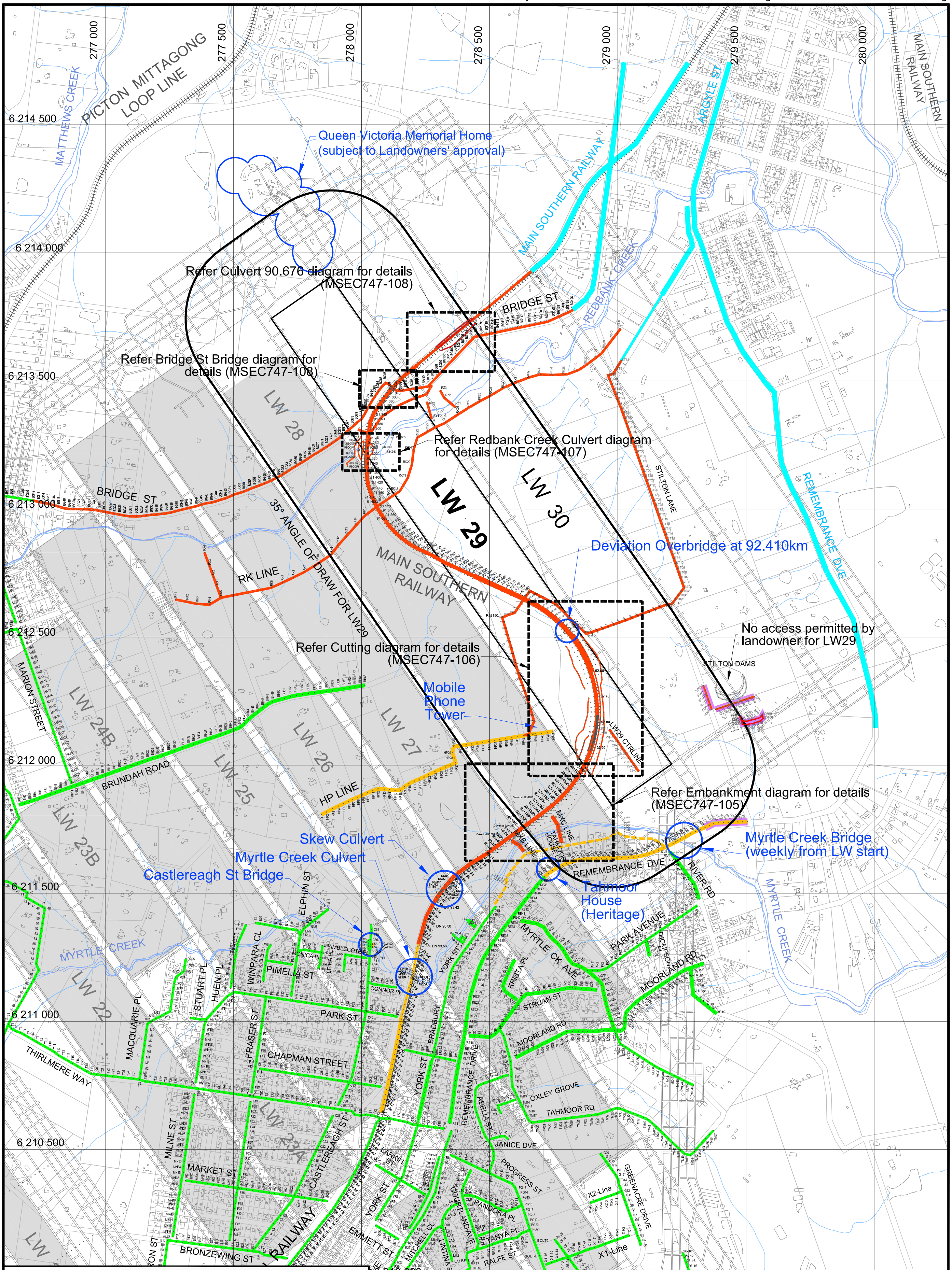
Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Sewer Infrastructure			
Sewer infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Surveys of marks along THC Line, which follows the route of the Thirlmere Carrier Pipe that deviates away from Bridge Street where it crosses the Main Southern Railway	2D subsidence and distance	Weekly surveys when THC Line is within the active subsidence zone
	CCTV inspection of Thirlmere Carrier pipe	-	Thirlmere Carrier (Bridge St for pipe section directly above LWs 28 to 30) – prior to 1500m of extraction, and end of LW29
Gas Infrastructure			
Gas infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Remembrance Drive Bridge over Myrtle Creek	Survey and visual inspections	2D subsidence and distance	As described for Wollondilly Council
Electrical Infrastructure			
Electrical infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
Critical power poles	Power pole surveys, as shown in Drawing No. MSEC746-00-01.	Subsidence at base and vertical offset (or tilt)	Monthly for each pole within active subsidence zone, and for following three months thereafter End of LW29 for all poles within limit of subsidence for panel
Telecommunications Infrastructure			
Telstra infrastructure	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Detailed visual inspections of pits and streets	-	Weekly when within active subsidence zone, and monthly at other times
	Ground survey at base of mobile phone tower above former Redbank Railway Tunnel	Subsidence and tilt of the tower	Every 200m of extraction when Tower is within active subsidence zone
	Automated continuous tilt monitoring of mobile phone tower in two orthogonal directions.	Change in tilt	Readings every hour
	Ground survey along path of cable optical fibre cable from Mobile Phone Tower above former Redbank Railway Tunnel to Stilton Lane	2D subsidence and distance	Weekly when within active subsidence zone End of LW29
Department of Lands			
Permanent survey marks	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
Structures			
Houses, units, public amenities, Business and Commercial Establishments, pools	Ground surveys along streets	2D subsidence and distance	As described for Wollondilly Council
	Visual inspections of streets	-	As described for Wollondilly Council
	Visual inspections of specific structures, including pools	Varies depending on structure	Refer Structures Management Plan (Weekly when within active subsidence zone or as required by geotechnical or structural engineer)

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Main Southern Railway			
Railway Track	3D ground survey along rail corridor *Full length start and end of LW = 90.30 km to 94.28 km* *Initial extent for monthly survey = 92.38 km to 93.43 km and then extend to the north to include pegs that are at least 400 metres in front of the longwall face, up to 90.46 km.*	Subsidence, changes in easting and northing (MGA coordinates)	Monthly from start of LW Full length at end of LW
	2D ground survey along rail corridor *Full length start and end of LW = 90.30 km to 94.28 km* *Initial extent for Stage 2 Weekly survey = 92.38 km to 93.43 km and then extend to the north to include pegs that are at least 200 metres in front of the longwall face, up to 90.46 km.*	2D subsidence and distance	Weekly from start of LW Full length at end of LW
	Conduct 3D ground survey of survey lines along tops, benches and base of cuttings. Pegs every 20m, with additional pegs located where monitoring lines intersect identified geological structures (Refer Drawing No. MSEC747-106 for peg locations).	Subsidence, changes in easting and northing (MGA coordinates)	Install and baseline survey of replacement pegs on Up side of Cutting near fault at 92.850 km prior to LW start Monthly from start of LW29 End of LW
	Survey of vertical subsidence above commencing end of Longwall 29 centreline	2D subsidence and distance	Weekly at start of LW29 until 800m of extraction unless adverse changes observed
	Long bay length ground surveys *Initial extent for Stage 2 Weekly survey = 92.38 km to 93.31km and then extend to the north to include long bays that are at least 200 metres in front of the longwall face, up to 90.50 km.*	2D distance	Weekly at start of LW29 (Stage 2) For AP10 (92.260 km) to ES10 (91.360 km) only across Redbank Creek, commence weekly surveys after 1000 m
	Continuously monitor rail stress, rail temperature and switch displacement *Full extent = 90.460 km to 93.430 km* *Initial active subsidence monitoring extent = 92.380 km to 93.430 km (alarmed at LW start)* *Activate alarms during Stage 2 only to include gauges that are at least 200 metres in front of the longwall face, up to 90.460 km*	Rail stress, rail temperature and switch displacement	Gauges installed from 90.880 km to 93.310 km Install and commission new gauges from 90.520 km to 90.880 km prior to LW approaching within 400 m Readings every 5 minutes Alarmed at start of LW29 (Stage 2)
	Continuously monitor rail stress, rail temperature and switch displacement *Residual subsidence monitoring = at least one working gauge every 120 m along each rail from 93.376 km to 93.795 km (southern end may be shortened based on future assessment)*	Rail stress and rail temperature	Every 5 minutes
	Track geometry surveys using Amber track mounted device or equivalent *Full length start and end of LW = 90.30 km to 94.28 km* *Initial extent for monthly and weekly survey = 92.38 km to 93.43 km and then extend to the north to include track that is at least 200 metres in front of the longwall face, up to 90.46 km*	Superelevation (cant), twist, gauge	Weekly at start of LW29 (Stage 2)
	Continuously monitor track geometry by Automated Total Station in Deviation Cutting for track located near fault at 92.850 km (refer Fig. 2.2 for locations of prisms)	Local 3D survey: Changes in easting, northing and height relative to total stations	Every 2 hours Operating at LW start
	Track inspection by qualified track certifier *The extent of visual inspections is the same as the extent of track geometry surveys.*	The inspection will check ARTC infrastructure within the rail corridor, including the track, track expansion system, integrity of monitoring systems, culverts, cuttings, embankments and fences	Daily from start of LW29

Feature	Survey or Inspection Regime	Parameters to be Measured	Timing and Frequency (may be increased if triggered by monitoring results)
Culverts and embankments	Conduct 3D ground survey of embankment monitoring lines at 92+1340 km km and 92+1180 km, and monitoring line along the toe of the embankment on the Down side (Refer Drawing No. MSEC747-05 for peg locations)	Subsidence, changes in easting and northing (MGA coordinates)	Absolute 3D Monthly from start of LW Local 3D weekly from start of LW
	Conduct 2D survey of MXB and MXC survey lines across Myrtle Creek	2D subsidence and distance	Weekly from start of LW
	Survey changes in level and horizontal distance between survey marks installed at the inlet and outlet of the new Deviation concrete pipes after installation	2D subsidence and distance	Start of LW End of LW
	Measure gaps between the pipe joints of the new Deviation concrete pipes after installation	Steel tape or calliper	Baseline survey complete
	Absolute 3D surveys along monitoring lines along crest and toe of embankment at 90.676 km on both sides of track, and inside brick arch culvert at outlet, midpoint and inlet	Subsidence, changes in easting and northing (MGA coordinates)	Monthly survey after 1450m (~400m from LW face)
Deviation Overbridge at 92.400 km	3D survey of abutment and bridge deck at locations shown in Fig. 2.8. *Note: Pegs DRSW1 and DRSW4 on base of reinforced soil wall on Down side will also be surveyed in absolute 3D as part of the main railway corridor survey line.*	2D survey: subsidence and distance 3D survey: subsidence, changes in easting and northing (MGA coordinates)	Absolute 3D Monthly from start of LW Local 3D weekly after 450m
	Visual inspection of bridge, including bearings	-	Monthly after 250m Weekly after 450m

APPENDIX A. DRAWINGS

I:\Projects\Tahmoor\MSEC746 - LWs 29 to 30 Management Plans\MSEC746-00-01.dwg



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 8412 0222
www.minesubsidence.com

TAHMOOR UNDERGROUND GLENCORE

TAHMOOR COLLIERY

TAHMOOR NORTH - LW29 to LW30 MONITORING OVER LW29

DATE:	SCALE:	DRAWING No:	Rev No
22-May-2015	1:20000	MSEC746-00-01	B

LEGEND

- Existing Monitoring Lines
- Future Monitoring Lines
- Future Monitoring Lines Prior to LW29
- Monitoring Lines Before & End of LW29
- Surveys During LW29
- Critical Power Poles
- Specific Structure Inspections

Refer to Management Plans for Timing & Frequencies

APPENDIX B.
SURVEY SPECIFICATION BY SMEC

SPECIFICATIONS FOR SUBSIDENCE MONITORING LINES FOR LONGWALL 29

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2007(NSW Coal)* In particular *Section 3. (Survey Procedures)* will be complied with (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

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

3. Establishment

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

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys". (see http://www.icsm.gov.au/icsm/publications/sp1/sp1v1-7.pdf)
   4.2. One, or a combination of, the following survey methods may be used and target accuracy must be achieved. Primarily EDM survey methods will be used where possible. Other survey methods are included herein in the event that they are required in specific circumstances.
   4.3. EDM Methods ~ For both Subsidence & Strain and Three Dimensional Survey Traversing
      4.3.1. Conventional Theodolite/EDM levelling traverse for measuring subsidence & strain.
      4.3.2. Additional survey for three dimensional location of subsidence marks by conventional Theodolite/EDM traverse adjusted between GPS Baseline(s).
      4.3.3. Height Datum to be carried through traverse by height traversing.
      4.3.4. Maximum traverse line length 150 metres.
      4.3.5. Maximum intermediate line length 80 metres.
      4.3.6. Target at each subsidence station to generally be either a handheld miniprism or prism & fixed pole with dual-support for stability.

4.4. Conventional Subsidence Method.

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

4.5. GPS Survey Control for Three Dimensional Survey of Subsidence Lines:

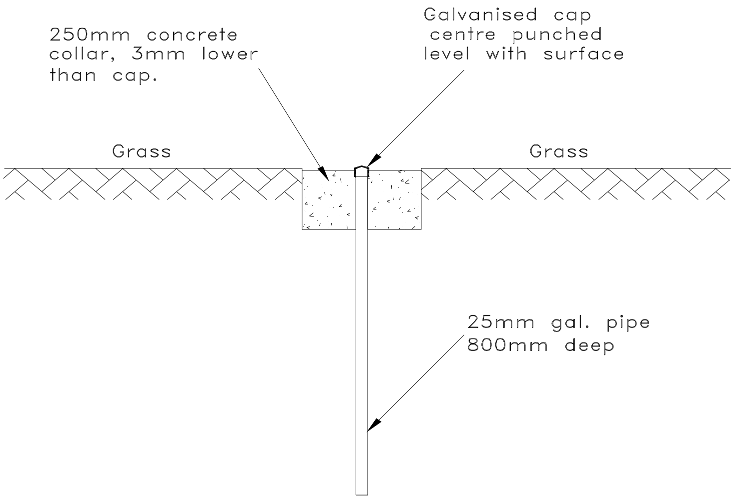
4.5.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.5.2. Site GPS Base Stations are to be monitored periodically (typically start and end of Long Walls) by connection to an established stable 'outer' network of GPS Stations.
4.5.3. GPS Baselines are to be surveyed relative to a Site GPS Base Station. Baselines are then used for the adjustment of Theodlite/EDM traverse lines locating subsidence marks in three dimensions (MGA~AHD).

5. Target Accuracies

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

6. Subsidence Station Placement

6.1. Installation. Subsidence stations are to be installed level or below the ground and in such a way so as not to become a danger or hazard (to the public, railway employees or other persons).
6.2. Location. Subsidence stations are to be installed in locations that will not be damaged or run over by vehicles. Where subsidence stations are located in a position near where vehicles or other equipment may access, the location of the subsidence station should be clearly indicated with an adjacent stake or other warning marker.
6.3. Spacing. All subsidence stations are to be placed at nominal 20 metre intervals and in a straight line where possible.
6.4. Line length. The subsidence line will cover the area affected by mining and shall be specified by Tahmoor Colliery.
6.5. Station type. The subsidence stations are generally to be 20mm diameter galvanised pipe, approximately 800mm length, driven into the ground, capped and centre punched (or rivet placed), together with a concrete collar (as shown below).
Where an area of bitumen or concrete needs to be crossed marks may be installed as a galvanized iron nail, ramset nail or drill hole.



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

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

7. Monitoring frequency

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

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

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

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

8. Reports

The following information shall be included in the report:

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

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

Yours faithfully,
SMEC Australia Pty Ltd
per .. **Gary Warren**
Senior Registered Surveyor
PO Box 232
Campbelltown NSW 2560
Ph: 02 4640 8222
gus.warren@smec.com

Tahmoor Colliery Contacts:
Mark Rundle
Registered Mining Surveyor
Tahmoor Colliery
PO Box 100 Tahmoor 2573
Ph.02 4640 0155
Fax.02 4640 0140
mark.rundle@glencore.com.au

Belinda Treverrow
Community & SMP Coordinator
Tahmoor Colliery
Tel 02 4640 0133
belinda.treverrow@glencore.com.au

APPENDIX C.
SURVEY SPECIFICATION BY SOUTHERN RAIL SURVEYS

TAHMOOR UNDERGROUND
GLENCORE

Southern Rail Surveys Pty Ltd

PO Box 3078

Exeter, NSW, 2579

Main Southern Rail Line- Survey Monitoring Plan for LW29 and LW30

1. General Requirements

   1.1. All surveys will be provided to the Tahmoor Colliery Mining Survey as digital Excel file/s.
   1.2. *Survey and Drafting Directions for Mine Surveyors 2007(NSW Coal)* In particular *Section 3. (Survey Procedures)* will be complied with (see. www.dpi.nsw.gov.au/minerals and use search).

2. Required Surveys

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

3. Establishment

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

4. Surveying Methods

   4.1. ICSM SP1 refers to The Inter-Governmental Committee on Surveying and Mapping Special Publication 1 "Standards and Practices for Control Surveys".
   (see http://www.icsm.gov.au/icsm/publications/sp1/sp1v1-7.pdf)

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

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

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

Southern Rail Surveys Pty Ltd

PO Box 3078

Exeter, NSW, 2579

4.4. GPS Survey Control for Three Dimensional Survey of Subsidence Lines (in conjunction with SMEC Urban):

4.4.1. Establishment of Site GPS Base Stations. Site Base Stations located not closer than 2 kilometres from active subsidence.
4.4.2. Site GPS Base Stations are to be monitored periodically (typically start and end of Long Walls) by connection to an established stable 'outer' network of GPS Stations.
4.4.3. GPS Baselines are to be surveyed relative to a Site GPS Base Station. Baselines are then used for the adjustment of Theodlite/EDM traverse lines locating subsidence marks in three dimensions (MGA~AHD).

4.5. Culvert pipe joints:

4.5.1. Culvert pipe joints will be measured by calliper.

5. Target Accuracies

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

5.2. Strain distances measured to an accuracy of ±5mm (Strain 0.25mm/m over a 20 m bay) for measurement by EDM/theodolite traverse.
5.3. Traversing shall be minimum Class D or LC as prescribed in ICSM SP1 or better.
5.4. Co-ordinates derived from horizontal movement surveys (by traverse &/or GPS) shall have an absolute accuracy of ± 10mm or better (Relative two dimensional accuracy of ± 5mm).
5.5. Rail creep surveys shall be measured to an accuracy of ±3mm
5.6. Long bay surveys shall be measured to an accuracy of ±3mm
5.7. 2D Bridge surveys across the arches shall be measured to an accuracy of ±3mm

6. Survey Instrument Calibration

6.1. In accordance with the Surveying and Spatial Information Regulation 2012 the survey instruments associated with this project will be calibrated annually.
6.2. A calibration certificate will be supplied to Tahmoor Colliery.

7. Subsidence Station Placement

7.1. Survey marks in the ground are a combination of galvanized pipe/star picket flush with the ground or raised star picket (driven at least 800 mm's into ground) with fixed prism or steel spigot.
7.2. The noise wall survey marks are fixed prisms attached to steel supporting beams.
7.3. The Deviation Overbridge survey marks are fixed prisms attached to the concrete bridge elements.
7.4. The base and bench survey marks with cutting are steel rod, drilled and epoxy anchored with a fixed prism.

Proposed track kilometrage range and monitoring frequencies are defined in the Tahmoor LW29 and LW30 Railway Subsidence Management Plan.

TAHMOOR UNDERGROUND
GLENCORE

Southern Rail Surveys Pty Ltd

PO Box 3078

Exeter, NSW, 2579

8. Monitoring frequency

   The lines will be established and surveyed initially before subsidence affects the line.
   Various timing for resurvey frequency may be requested by the Tahmoor Colliery based on the requirements of the Subsidence Management Plans. The frequency may be 3 monthly, 1 monthly, bi-weekly, weekly or daily.
   A final survey will be completed at the end of each longwall before the area is affected by extraction of the next adjacent longwall.
   Please refer to Tahmoor LW29 and LW30 Railway Subsidence Management Plan for survey frequencies.

9. Reports

   The following information shall be included in the report:

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

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

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

John Rolles
Registered Surveyor
Southern Rail Surveys Pty Ltd
30 March 2015

Tahmoor Colliery Contacts:

David Talbert
Rail Contracts Manager
Tahmoor Colliery
Tel 02 4640 0028
David.Talbert-c@glencore.com.au