XSTRATA COAL:

Tahmoor Colliery - Longwall 25

End of Panel Subsidence Monitoring Report for Tahmoor Longwall 25

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Associated reports:-

MSEC157 (Revision C) – *The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Surface and Sub-surface Features due to Mining Longwalls 24 to 26 at Tahmoor Colliery in Support of an SMP Application*, Revision C, March 2006.

MSEC, (2009). *Report on 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 an SMP Application*. Mine Engineering Consultants, Report No. MSEC355, Revision B, July 2009.

MSEC341-26 to MSEC341-41 – Inghams Monitoring Reports, issued during the extraction of Longwall 25 between September 2008 and January 2009.

MSEC373-01 to MSEC373-72 – Subsidence Monitoring Reports, issued during the extraction of Longwall 25 between October 2008 and October 2010.

MSEC384-01 to MSEC384-94 – Main Southern Railway Monitoring Reports, issued during the extraction of Longwall 25 between November 2008 and September 2010.

MSEC387-01 to MSEC387-26 – Tahmoor Town Centre Monitoring Reports, issued during the extraction of Longwall 25 between December 2008 and June 2009.

Geoterra (2011). End of Longwall 25 Streams, Dams & Groundwater Monitoring Report, Tahmoor, NSW. Report No. TA12-R1.

Background reports available at *www.minesubsidence.com*:-

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

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Drawings

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

1.0 INTRODUCTION

This report has been prepared by Mine Subsidence Engineering Consultants (MSEC) for Xstrata Coal Tahmoor Colliery to comply with conditions of the SMP Approval set by Industry and Investment NSW.

This report includes:-

- A summary of the subsidence and environmental monitoring results for Longwall 25,
- An analysis of these results against the relevant impact assessment criteria, monitoring results from previous panels and predictions provided in the SMP application,
- The identification of any trends in the monitoring results, and
- A description of actions that were taken to ensure adequate management of any potential subsidence impacts.

The location of Longwall 25 is shown in Drawing No. MSEC497-01, which together with all other drawings, is attached in Appendix B at the back of this report.

This report also includes many of the movements and impacts observed during the extraction of Longwalls 22 to 24A. Note that Longwall 24B was extracted prior to Longwall 24A. The dates of extraction for all longwalls are provided in Table 1.1.

Table 1.1 Start and Finish Dates for Longwalls 22 to 25

Longwall	Start Date	Completion Date
Longwall 22	31 May 2004	27 July 2005
Longwall 23A	13 September 2005	21 February 2006
Longwall 23B	22 March 2006	26 August 2006
Longwall 24B	14 October 2006	2 October 2007
Longwall 24A	15 November 2007	19 July 2008
Longwall 25	22 August 2008	21 February 2011

The predicted movements and impacts resulting from the extraction of Longwalls 24 to 26 were provided in Report No. MSEC157 (Revision C), which was issued in March 2006. The prediction model was re-calibrated, based on the observed movements for Longwalls 22 to 24A, which was described in Report No. MSEC355 (2009, Revision B). The comparisons provided in this report are based on the latest subsidence predictions using the calibration model.

Longwall 25 was approximately 3,592 metres long and 283 metres wide, rib to rib. The pillar width was approximately 34.5 metres, rib to rib. The depth of cover over the panel varied from 420 metres to 460 metres. The seam thickness over the panel varied from 1.7 metres to 2.2 metres.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the extraction of Longwall 25. This chapter also provides comparisons between the observed and predicted movements resulting from the extraction of Longwall 25.

Chapter 3 of this report summarises the surveys and inspections undertaken during the mining of Longwall 25.

Chapter 4 of this report describes the reported impacts on surface features resulting from the extraction of Longwall 25, and compares these with the MSEC assessed impacts. The reported impacts on surface water are provided in other reports.

Appendices A and B include all of the figures and drawings associated with this report.

2.0 COMPARISON BETWEEN OBSERVED AND PREDICTED SUBSIDENCE MOVEMENTS

Maximum observed incremental and total subsidence parameters during or after the mining of Longwall 25 are shown in Table 2.1. The maximum values do not include parameters observed in creeks, which are discussed separately in this report.

Table 2.1 Summary of Maximum Incremental and Total Subsidence Parameters due to the mining of Longwall 25 (beyond creeks)

Monitoring Line	Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Comp. Strain (mm/m)
Incremental due to LW25 only	1234	11.9	3.4	-4.8
Total after LW25	1364	12.7	3.4	-4.8

Maximum observed incremental and total subsidence parameters for monitoring lines surveyed during Longwall 25 are summarised in Table 2.2. The maximum value for each parameter is highlighted in yellow.

Table 2.2 Summary of Maximum Subsidence Parameters along Monitoring Lines

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
Abelia St	LW 25 Inc	1086	5.6	1.3	-4.7
Amblecote Pl	LW 25 Inc	571	1.7	0.4	-0.4
BC Line	LW 25 Inc	187	0.4	0.3	-0.4
	Total	966	1.8	0.0	-0.7
Bradbury St	LW 25 Inc	596	3.9	0.5	-1.4
	Total	630	4.1	0.4	-1.3
Bridge St	LW 25 Inc	24	0.3	0.4	-0.6
Brundah Rd	LW 25 Inc	680	5.0	1.3	-3.8
	Total	785	5.3	1.5	-4.6
Castlereagh St (incl. creek)	LW 25 Inc	632	3.3	0.6	-7.6 (18m bay)
	Total	818	5.7	0.7	-8.1 (18m bay)
Castlereagh-Myrtle Creek (incl. creek)	LW 25 Inc	-	4.0	4.6	-22.8 (8m bay) -10.9 (14m bay)
	Total	-	2.7	5.1	-24.3 (8m bay) -11.5 (14m bay)
Chapman St	LW 25 Inc	285	1.2	0.6	-0.5
	Total	752	4.8	0.5	-1.1
Connor Pl	LW 25 Inc	639	2.8	0.4	-0.5
Courtland Ave	LW 25 Inc	683	2.3	0.5	-0.6
	Total	1160	6.0	0.5	-0.9
Dam Line	LW 25 Inc	108	0.8	0.4	-0.5
	Total	869	5.2	0.8	-1.1
East-West Line	LW 25 Inc	74	0.9	0.4	-0.5
	Total	677	6.9	1.1	-0.4
Elphin St (incl. creek)	LW 25 Inc	400	1.4	0.4	-0.8
	Total	867	3.7	0.8	-1.3
Elphin-Myrtle Creek (incl. creek)	LW 25 Inc	611	18.5 (4m bay)	0.8 (11m bay)	-32.2 (4m bay) -10.4 (14m bay)

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
	Total	658	18.5 (4m bay)	1.1 (11m bay)	-37.0 (4m bay) -11.9 (14m bay)
Emmett St	LW 25 Inc Total	78 162	0.4 0.7	0.0 0.1	-0.1 -0.2
Greenacre Dve	LW 25 Inc	49	1.8	0.6	-0.5
High-Rise Freezer Line (incl. creek)	LW 25 Inc Total	380 1364	3.1 12.7	0.3 1.1	-0.8 -2.8
Huen Pl (incl. creek)	LW 25 Inc Total	268 902	2.0 5.6	0.6 1.0	-1.3 (9m bay) -0.8 (18m bay) -4.6 (9m bay) -3.1 (18m bay)
Janice Dve	LW 25 Inc	881	6.4	0.3	-1.2
Krista Pl	LW 25 Inc	32	0.3	0.3	-0.2
Larkin St	LW 25 Inc Total	168 253	0.5 1.8	0.3 0.4	-0.1 -0.2
Leiha Pl	LW 25 Inc	456	1.1	0.4	-0.2
Lintina St (pegs lost prior to EOP survey, last survey of whole line in February 2009)	LW 25 Inc Total	473 791	2.2 3.6	0.3 0.3	-0.6 -1.4
LW24A Draw Line	LW 25 Inc Total	73 1163	0.8 10.5	0.3 1.6	-0.4 -0.5
LW25 Centreline	LW 25 Inc	1216	10.4	2.4	-4.8
LW25 Draw Line	LW 25 Inc Total	34 33	0.4 0.3	0.9 0.8	-0.6 -0.6
LW25 XS1 Line	LW 25 Inc	1013	11.9	3.4	-2.4
LW26 Draw Line	LW 25 Inc Total	17 28	0.4 0.5	0.7 0.5	-0.7 -0.5
Main Southern Railway (3D) (incl. creek)	LW 25 Inc	602	3.9	0.7	-1.1
Marion St (incl. creek)	LW 25 Inc Total	97 280	0.9 2.4	0.6 0.8	-0.5 -1.0
Mitchell Cl (pegs lost prior to EOP survey, last survey of whole line in August 2008. Note that only surviving peg, ML1, would have experienced maximum subsidence)	LW 25 Inc Total	207 678	1.9 4.3	0.2 0.4	-0.3 -4.6
Monica Pl	LW 25 Inc	451	1.6	0.4	-0.2
Moorland Rd	LW 25 Inc	32	0.8	1.6	-0.3
Myrtle Creek Ave	LW 25 Inc	32	0.8	0.7	-0.5
North-South Line	LW 25 Inc Total	63 234	0.7 0.6	0.4 0.2	-0.5 -0.7
Oxley Gr	LW 25 Inc	200	1.9	1.0	-0.9
Pandora Pl	LW 25 Inc Total	1234 1252	6.5 6.6	0.7 0.6	-3.1 -3.1
Park Ave	LW 25 Inc	18	0.2	0.3	-0.3
Park St	LW 25 Inc Total	617 880	1.7 3.5	0.3 0.6	-0.8 -1.2
Pimelia St	LW 25 Inc	362	1.3	0.4	-0.2

Monitoring Line		Maximum Observed Subs (mm)	Maximum Observed Tilt (mm/m)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
	Total	784	2.6	0.5	-1.9
Pipe Support Line	LW 25 Inc	48	1.5	2.3	-0.7
	Total	155	0.9	2.7	-1.0
Plant Line	LW 25 Inc	53	0.7	1.2	-3.8
	Total	171	1.8	2.8	-2.3
Progress St	LW 25 Inc	1230	6.2	1.0	-1.6
	Total	1242	6.4	1.1	-1.7
Ralfe St	LW 25 Inc	1108	5.5	0.5	-0.7
	Total	1214	8.7	1.7	-3.2
Remembrance Dve	LW 25 Inc	580	3.4	0.8	-2.8
	Total	612	4.9	0.9	-2.8
Rita St	LW 25 Inc	59	0.9	0.3	-0.3
	Total	91	1.1	0.1	-0.9
Shopfronts	LW 25 Inc	241	1.1	1.3	-1.0
	Total	321	2.5	1.3	-1.0
Struan St	LW 25 Inc	122	1.1	0.3	-0.3
Tahmoor Rd	LW 25 Inc	72	1.3	0.4	-0.4
Tanya Pl	LW 25 Inc	752	3.3	0.5	-0.3
	Total	976	6.8	1.2	0.0
Thirlmere Way	LW 25 Inc	341	2.9	0.9	-1.2
	Total	841	2.9	1.2	-0.9
Winpara Cl	LW 25 Inc	353	2.3	0.0	-1.0
	Total	789	3.6	0.4	-2.6
York St	LW 25 Inc	563	4.1	0.5	-1.3
	Total	583	4.1	0.5	-1.2

Extensive ground monitoring within the urban areas of Tahmoor has allowed detailed comparisons to be made between predicted and observed subsidence, tilt, strain and curvature during the mining of Longwalls 22 to 25.

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

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

2.1.1. Observed Increased Subsidence during the mining of Longwall 24A

It is worth repeating the observations above Longwall 24A to place observations during the mining of Longwall 25 into perspective.

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

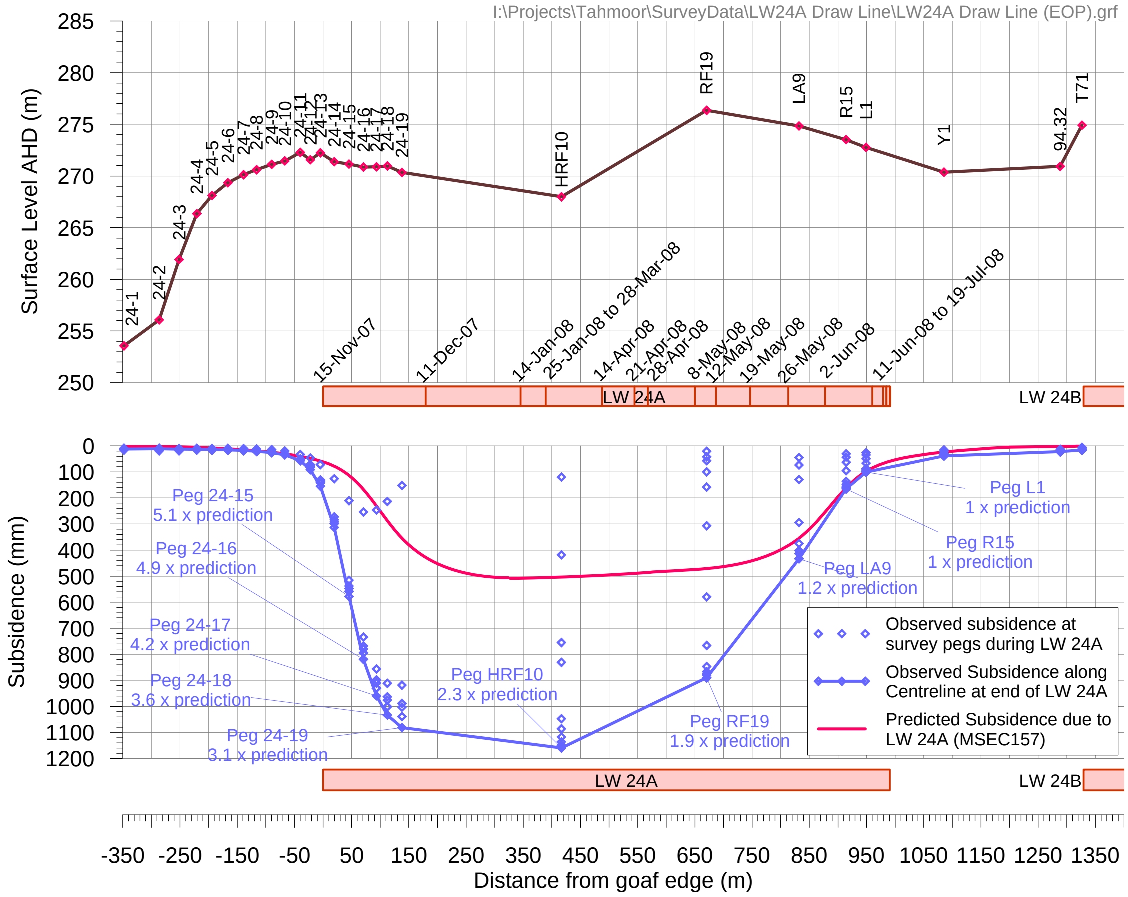


Fig. 2.1 Observed Subsidence along Centreline of Longwall 24A

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

2.1.2. Observed Increased Subsidence during the mining of Longwall 25

Increased subsidence was observed during the first stages of mining Longwall 25. These observations are illustrated graphically in Fig. 2.2, which shows observed subsidence at survey pegs located along the centreline of Longwall 25. The graph shows the latest survey results for each monitoring line.

It can be seen from Fig. 2.2 that observed subsidence was approximately twice the predicted maximum value, with maximum subsidence of 1168 mm at Peg 25-28 and 1187 mm at Peg PG13. .

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

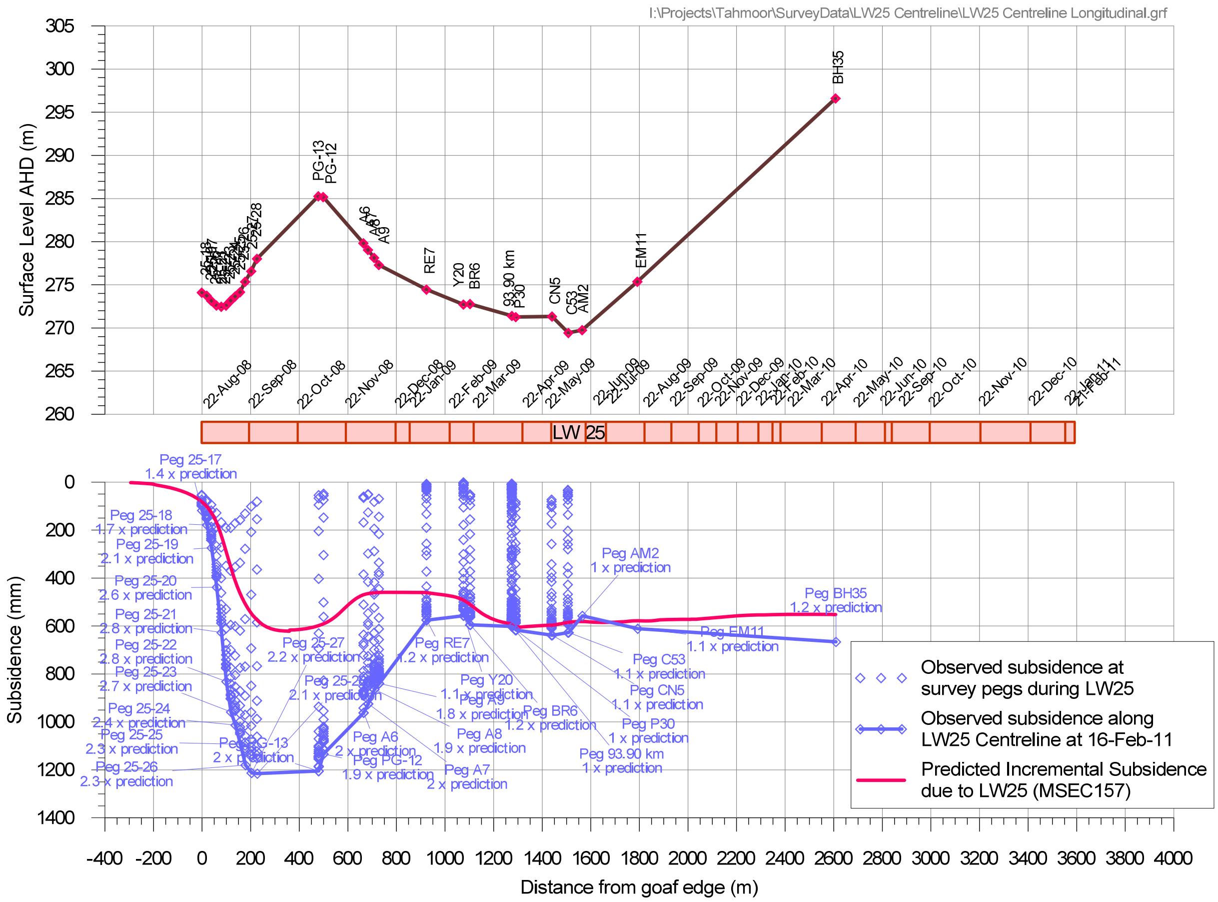


Fig. 2.2 Observed Subsidence along Centreline of Longwall 25

2.1.3. Analysis and commentary

Tahmoor Colliery has engaged a specialist in strata mechanics (SCT) to provide advice on possible causes of the increased subsidence. Current advice suggests a link with groundwater flows towards either the Bargo River or Nepean Fault.

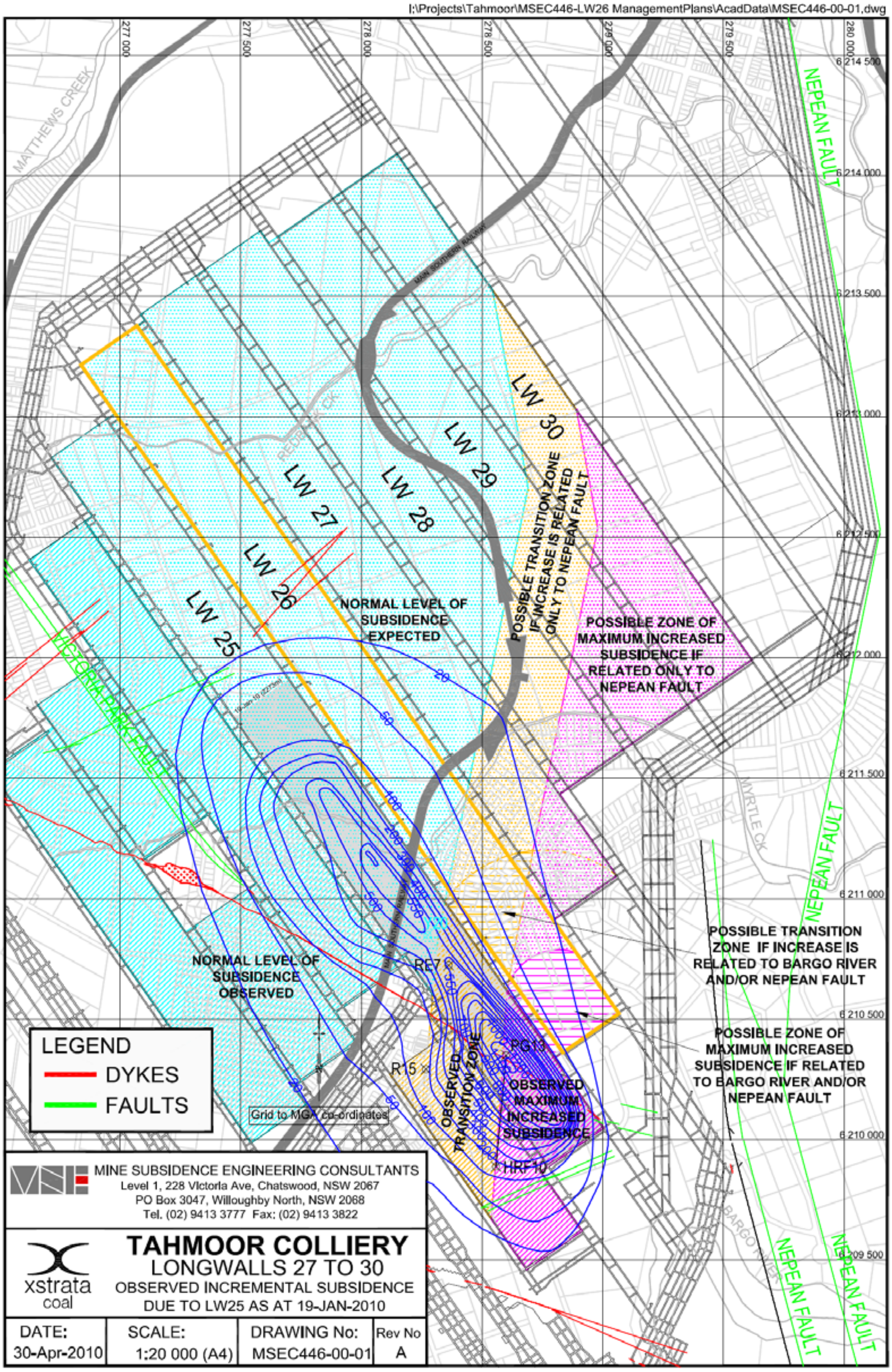
In light of the above observations, the region above the extracted longwalls at Tahmoor has been partitioned into three zones:

1. Normal subsidence zone – where the observed vertical subsidence is within the normal range and correlates well with predictions
2. Maximum increased subsidence zone – where the observed vertical subsidence is substantially greater than predictions but has reached its upper limit. Maximum subsidence above the centreline of the longwalls appear to be approximately twice the magnitude of maximum normal subsidence.
3. Transition zone – where the subsidence behaviour appears to have transitioned between areas of maximum increased subsidence and normal subsidence.

When the locations of the three zones are plotted on a map, as shown in Drawing No. MSEC446-00-01, it can be seen that the transition zone is roughly consistent in width above Longwall 24A and Longwall 25. The orientation of the transition zone is also roughly parallel to both the Bargo River and the Nepean Fault.

The zones have been projected above Longwalls 26 to 30 from the observed zones above Longwalls 24A and 25, as shown in Drawing No. MSEC446-00-01. Two projections have been provided. One represents zones with similar offsets to the Bargo River and the other represents zones with similar offsets to the Nepean Fault.

Predictions and management plans have been developed to manage potential impacts from increased subsidence due to the mining of Longwall 26.



2.1.4. Analysis of Measured Strain

The distribution of the observed incremental tensile and compressive strains along the monitoring lines from the extraction of Longwall 25, for survey bays located directly above goaf, are shown in Fig. 2.3. In the cases where the survey bays were measured a number of times during mining, the maximum tensile strain and the maximum compressive strain for each survey bay were used in these distributions.

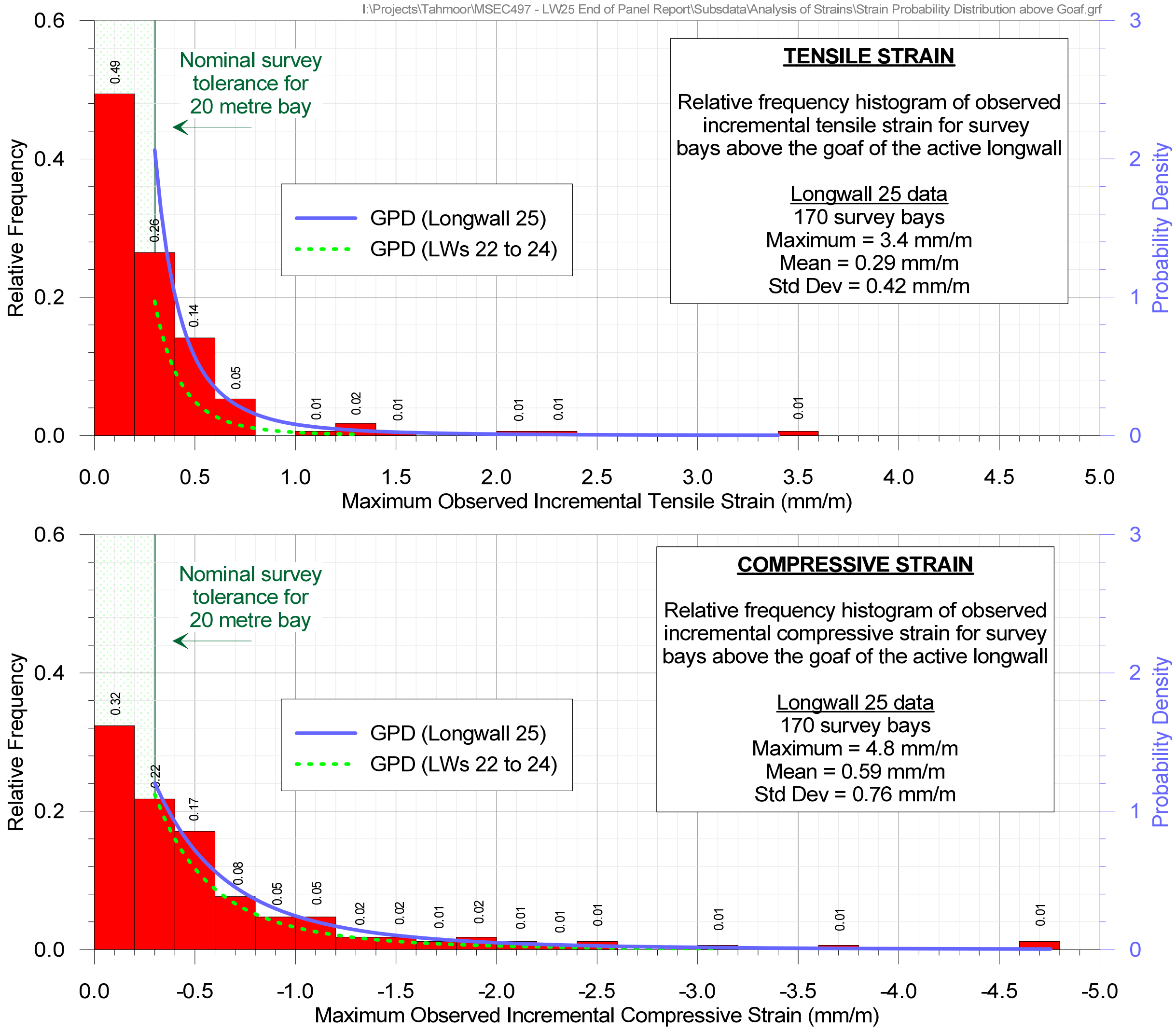


Fig. 2.3 Observed Incremental Strain for Survey Bays above Goaf resulting from the Extraction of Longwall 25

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 for Longwall 25, which are shown as the blue lines.

The probability distribution functions for previous monitoring during the mining of Longwalls 22 to 24 are also shown in this figure, as the dashed green lines. It can be seen from these comparisons, that the overall distribution of strain resulting from the extraction of Longwall 25 was greater in magnitude when compared with those observed during the mining of Longwalls 22 to 24.

2.1.5. Analysis of Measured Curvatures

It is difficult to make meaningful comparisons between the profiles of raw observed curvature and predicted conventional curvature. The reason for this is that survey tolerance can represent a large proportion of the measured curvatures, which can result in very irregular profiles. The survey tolerance for relative vertical movements is typically around ±3 mm, which equates to a survey tolerance for curvature of approximately 0.05 km^{-1} over a 20 metre bay length. This is significant when compared to the magnitudes of curvatures measured in the Southern Coalfield, which are typically in the order of 0.05 km^{-1} to 0.15 km^{-1}.

To make meaningful comparisons, the observed curvatures have been derived from smoothed observed subsidence profiles, which removes the small deviations resulting from, amongst other things, survey tolerance. In this way, comparisons can be made based on the overall (i.e. macro) curvatures, rather than the localised (i.e. micro) curvatures. The observed subsidence profiles have been smoothed using *Loess* smoothing, which uses local regression to fit low order polynomials to the observed subsidence profiles.

The profiles of incremental curvature, derived from the smoothed observed subsidence, are compared with the profiles of predicted curvature due to Longwall 25 along Remembrance Drive and the Main Southern Railway are shown in Fig. 2.4 and Fig. 2.5, respectively. The raw and the smoothed observed curvatures are shown as the grey and cyan lines, respectively, and the predicted curvatures are shown as the red lines in these figures.

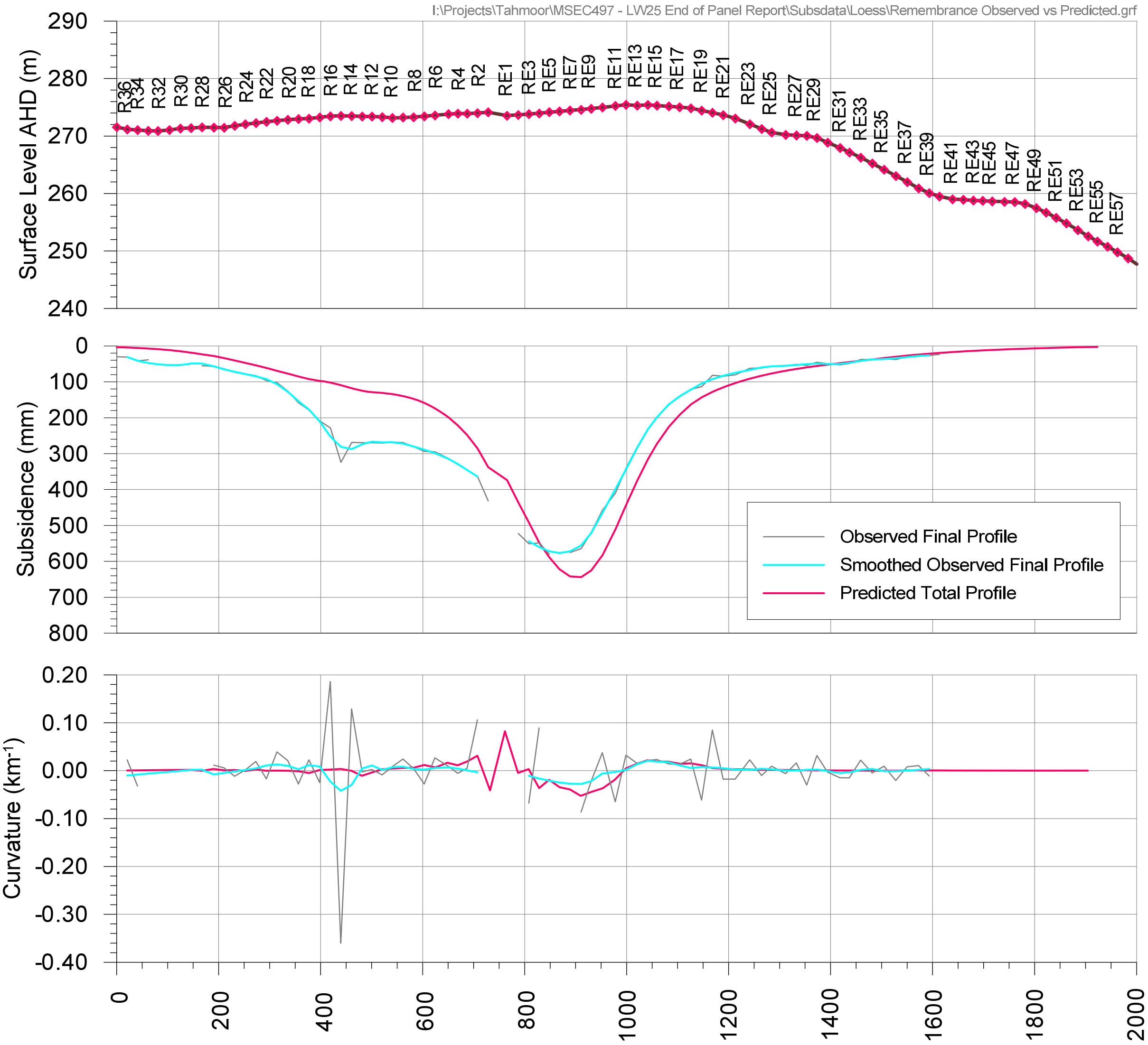


Fig. 2.4 Observed Curvature derived from Smoothed Subsidence and Predicted Curvature along Remembrance Drive resulting from the extraction of Longwall 25

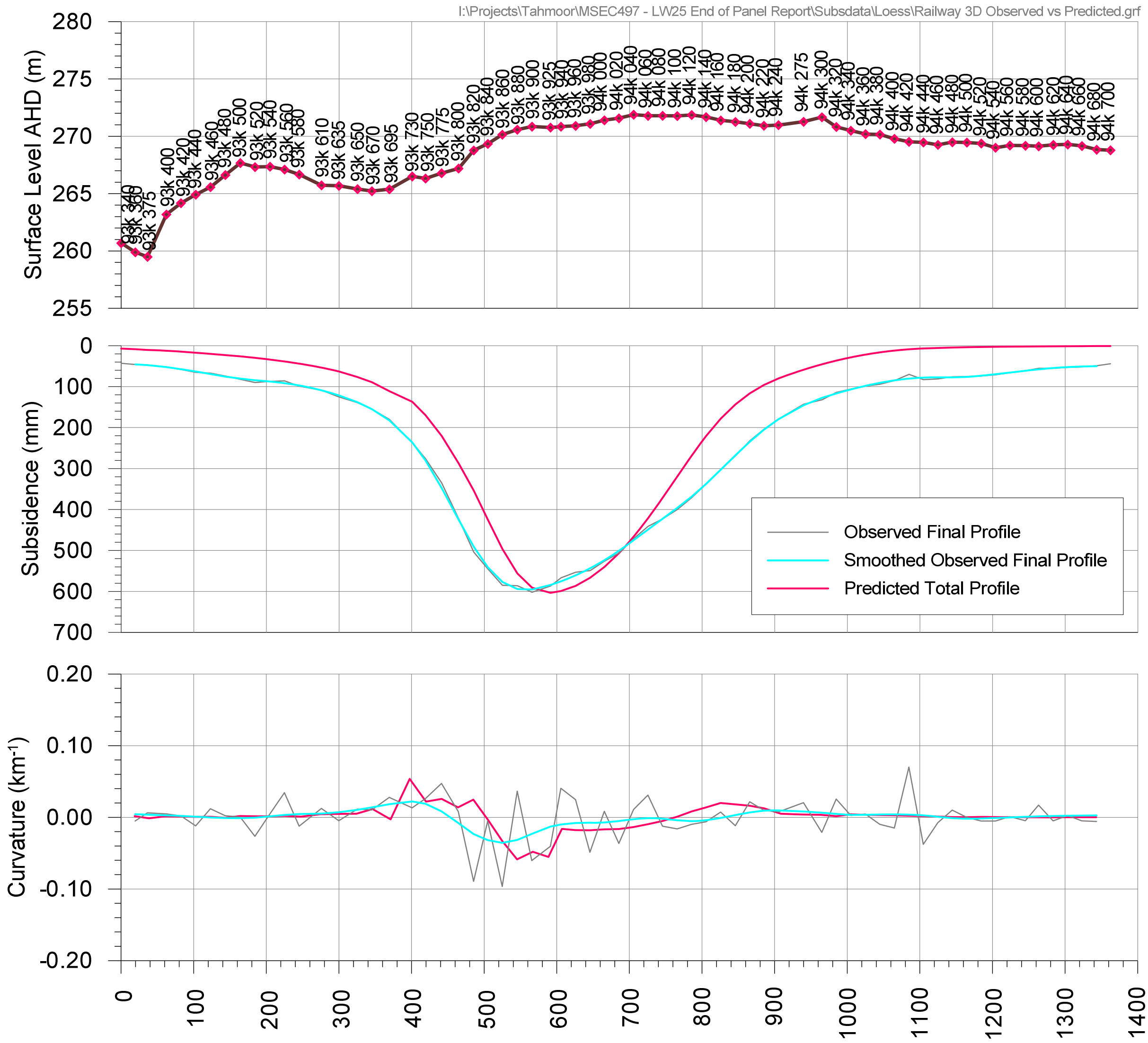


Fig. 2.5 **Observed Curvature derived from Smoothed Subsidence and Predicted Curvature along the Main Southern Railway Resulting from the Extraction of Longwall 25**

It can be seen from these figures, that the maximum observed curvatures derived from smoothed subsidence profiles along these monitoring are reasonably similar to the maximum predicted curvatures. Also, the observed locations of hogging (i.e. convex) curvature and sagging (i.e. concave) curvature reasonably match the locations predicted along Remembrance Drive and the Main Southern Railway.

In locations of increased subsidence, however, it is expected that observed curvatures will be greater than predicted. The magnitude is difficult to calculate as the monitoring lines are short in length, making smoothing difficult. Maximum raw hogging curvature along the LW25 XS1 line was 0.24 km^{-1} and maximum raw sagging curvature was 0.18 km^{-1}. It is expected that maximum observed curvatures derived from smoothed subsidence would be similar to but slight less in magnitude when compared with the raw values.

2.2. Identification of Non-Systematic Subsidence Movements

A plan showing the locations of observed non-systematic movements at Tahmoor is shown in Fig. 2.6. The locations were selected based on ground monitoring results or observed impacts that appear to have been caused by non-systematic movement. A total of approximately 36 locations (not including valleys) have been identified over the extracted Longwalls 22 to 25, of which 6 locations are above Longwall 25.

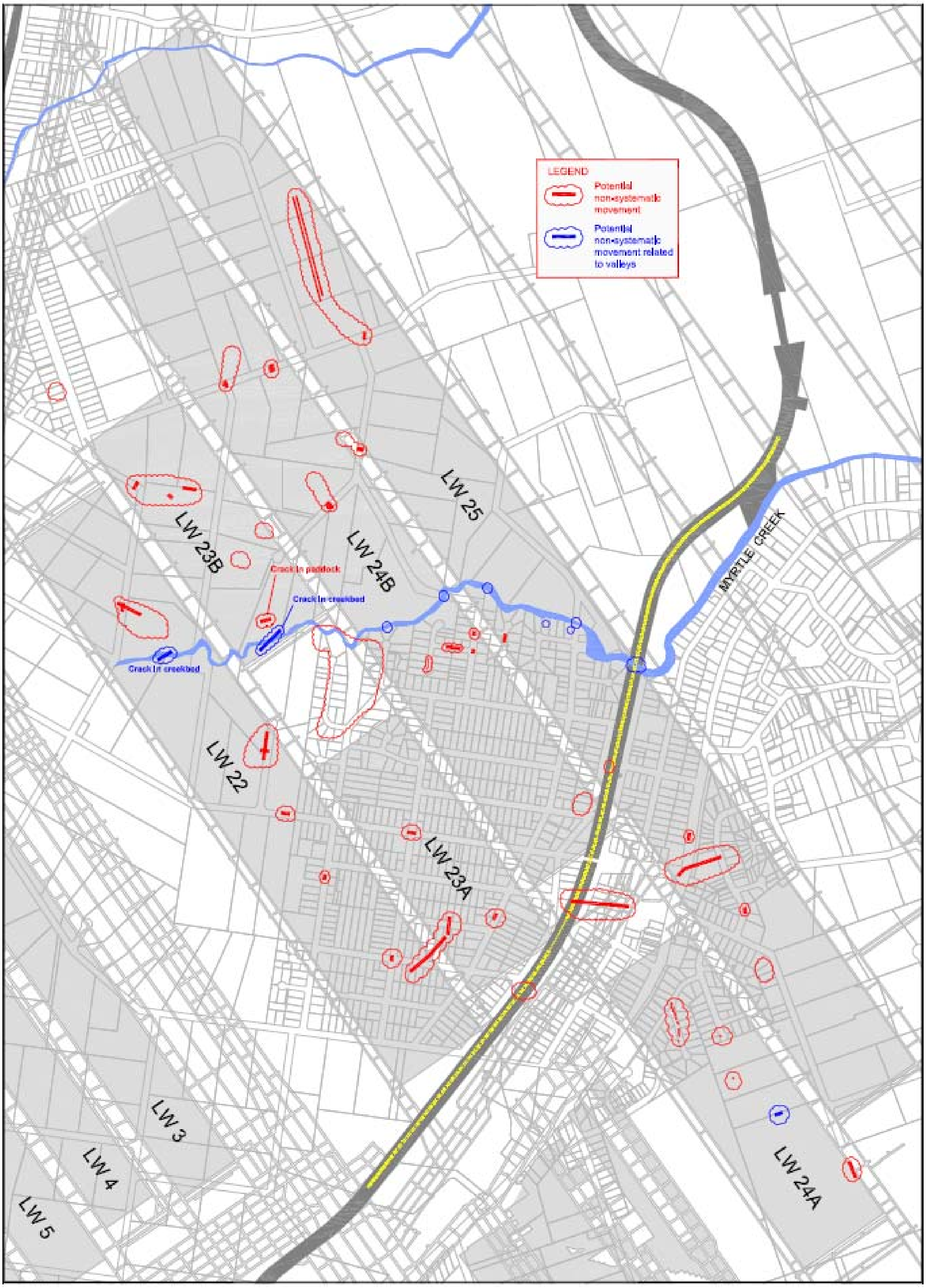


Fig. 2.6 Map of Locations of Potential Non-Systematic Movements

Monitoring lines were surveyed where non-systematic movement was identified. A summary of non-systematic movements at these locations is provided below in Table 2.3.

Table 2.3 Locations of New Identified Non-Systematic Movements during Longwall 25

Monitoring Line or Location	Maximum Change in Vertical Alignment during LW25 (mm)	Maximum Incremental Strain during LW25 (mm/m)	Maximum Incremental Tilt during LW25 (mm/m)	Type	Impacts on Surface Features
Abelia St (Pegs A4 to A5)	20	-1.9	2.5	Anomaly	Impacts on houses, of which one was severely impacted Cracking to kerb Adjustment to tension of aerial power and telecommunications cables
Abelia St (Pegs A12 to A13)	45	-4.7	5.6	Anomaly	Compression hump in pavement. Damage to kerbs and driveway pavements. Impacts on houses, of which two were severely damaged Impacts on sewer pipe Adjustment to tension of aerial power and telecommunications cables
Progress St (Pegs PG11 to PG12)	60	-1.6	6.2	Anomaly	Severe impacts on houses, of which three were severely impacted Compression bump and cracking in pavement
Brundah Rd / Tickle Dve (Pegs BH37 to BH38)	30	-3.8	5.0	Anomaly	Compression bump and cracking in pavement Impacts on houses, pool and brick wall on Rita St
Remembrance Dve (Pegs R1 to RE1)	10	-2.8	1.0	Anomaly	Damage to roundabout, kerbs and pavements. Impacts on sewer pipe Distortion of fences.
Remembrance Dve (Pegs RE4 to RE5)	20	-1.5	1.6	Anomaly	Minor impacts to road pavement and kerbs

Changes in vertical alignment have been calculated by measuring the difference in subsidence between each peg and average subsidence of the adjacent two pegs. The calculations quantify the small 'bumps' that are observed in the subsidence profile.

The most severe non-systematic movement observed during the mining of Longwall 25 occurred along Progress Street and Abelia Street. At Progress Street, three houses experienced severe impacts during mining, where the MSB and landowners agreed to rebuild them as the cost of repair exceeded the cost of replacement. Small bumps and cracks were observed in the road pavement.

At Abelia Street, a large hump developed in the road pavement and vertical bending was observed in a sewer pipe. These irregular, non- systematic movements extended to Remembrance Drive, where a hump was observed in the roundabout at the intersection with Thirlmere Way. A number of houses and units experienced impacts in this area, two of which were severely impacted. Photographs of the impacts are shown in Fig. 4.1.

2.3. Bargo River

The location of Longwall 25 relative to the Bargo River is shown in Fig. 2.7.

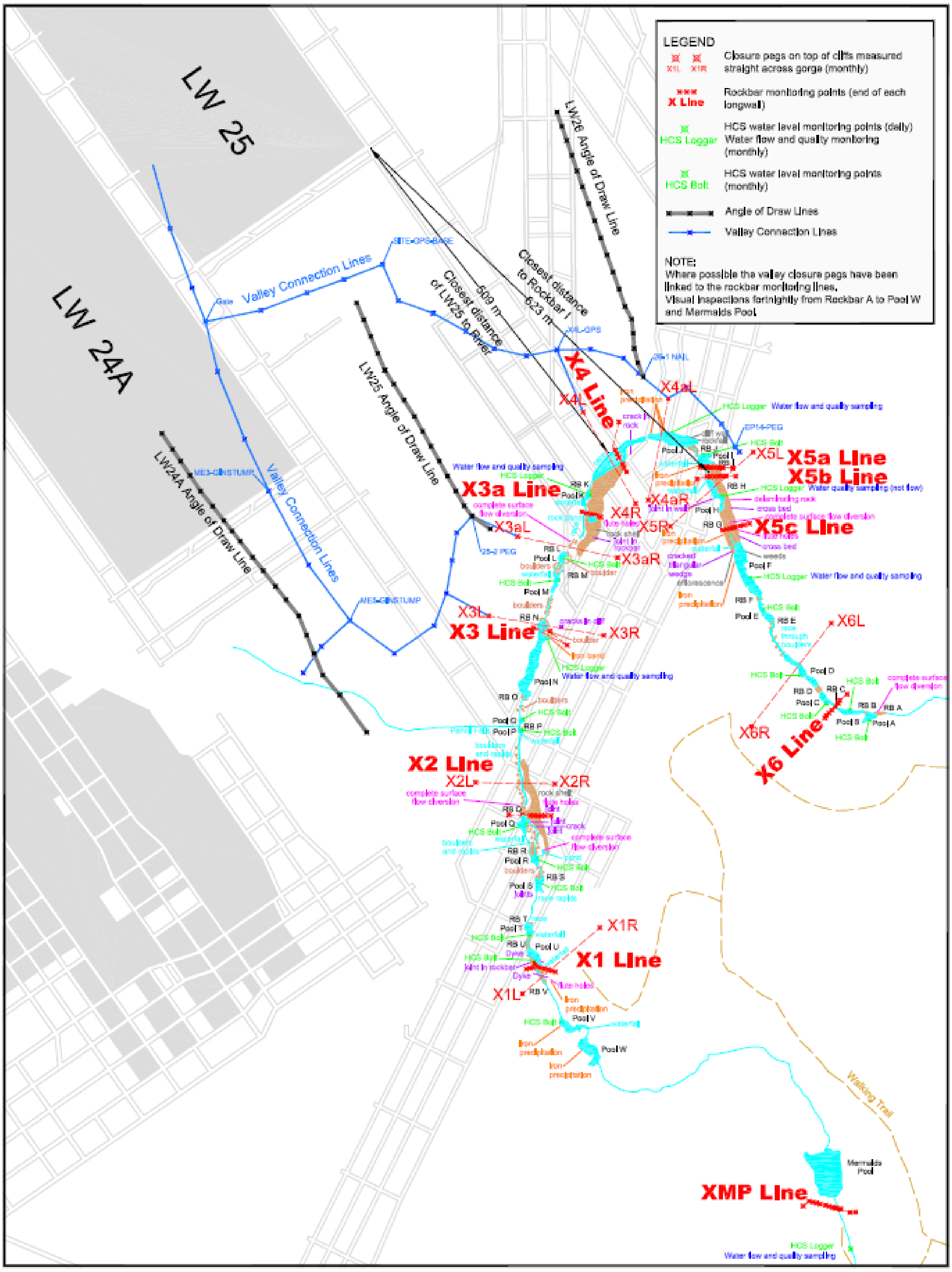


Fig. 2.7 Location of Longwall 25 in relation to the Bargo River

A summary of observed subsidence parameters for monitoring lines at the Bargo River is provided in Table 2.4

Table 2.4 Observed Subsidence, Upsidence and Closure along Bargo Gorge Cross Lines

Monitoring Line		Maximum Observed Subsidence at Top of Gorge (mm)	Maximum Observed Subsidence at Base of Gorge (mm)	Upsidence (mm)	Closure (mm)
Survey Tolerance	LW 25 Inc Total	± 5 mm	± 10 mm between top and bottom of gorge	± 3 mm differential vertical subsidence	± 3 mm for horizontal distance across top of gorge
Mermaid Pool	LW 25 Inc Total	No Pegs	Not connected to Datum	< survey tolerance	1 1
X1 Cross Line	LW 25 Inc Total	Not connected to Datum	Not connected to Datum	< survey tolerance	6 8
X2 Cross Line	LW 25 Inc Total	Not connected to Datum	Not connected to Datum	< survey tolerance	7 9
X3 Cross Line	LW 25 Inc Total	Pegs lost	6 20	< survey tolerance	2 2
X3a Cross Line	LW 25 Inc Total	7 15	7 17	< survey tolerance	1 3
X4 Cross Line	LW 25 Inc Total	16 28	31 41	< survey tolerance	3 6
X4a Cross Line	LW 25 Inc Total	16 23	No Pegs	No Pegs	6 8
X5a Cross Line	LW 25 Inc Total	10 16	8 20	< survey tolerance	2 5
X5b Cross Line	LW 25 Inc Total	10 16	10 18	< survey tolerance	4 6
X5c Cross Line	LW 25 Inc Total	10 16	8 18	< survey tolerance	3 5
X6 Cross Line	LW 25 Inc Total	Not connected to Datum	Not connected to Datum	< survey tolerance	8 8

The monitoring results indicate that little to no measureable upsidence has occurred across any of the monitoring lines across the Bargo Gorge during the mining of Longwall 25. All differential movements have been very small and close to or within stated survey tolerance. Given that measurements across the Gorge have consistently recorded closure movements, it is possible that a small amount of closure has developed.

The Gorge has experienced a small amount of subsidence in the order of 20 mm since the commencement of Longwall 24A. A comparison between survey results along the Angle of Draw lines (refer next section of report), with the cross line survey results indicates that subsidence of the X4 Cross Line may be incorrect and less than measured. This opinion is supported by the surveyor.

The current observed movements during the mining of Longwall 25 are less than the predicted Longwall 25 maximum incremental upsidence of 20 mm and maximum incremental closure of 40 mm. Given the incised nature of the Gorge and its significant valley height, it was considered possible that actual upsidence and closure movements might exceed predictions but this has not occurred.

The reason for the lack of valley bulging movement is not known. It is possible that the strata above Longwall 25 had already been stress-relieved by past geological activity. An unusually large amount of vertical subsidence has been observed directly above Longwall 25. The combination of increased subsidence, tilt and curvature without substantially increased ground strain directly above the goaf suggests that horizontal movements into the goaf have not been substantial, with the predominant direction of ground movement being vertical. The lack of significant differential horizontal movement suggests that mining, therefore, may not have significantly changed the stress environment in the overlying strata in the base of the valley. The above comments only represent our considered opinion, and is based on limited observations.

2.3.1. Angle of Draw Surveys

As shown in Drawing No. MSEC497-01, monitoring lines were installed off the commencing ends of Longwalls 24A, 25 and 26 to measure the extent of vertical subsidence that occurs between the extracted longwalls and the Bargo Gorge.

A summary of observed subsidence parameters along these three monitoring lines is shown in Table 2.5.

It can be seen from this table that the pegs closest to the edge of Bargo Gorge have subsided approximately 20 mm due to the mining of Longwalls 24A to 25. The magnitude of subsidence is slightly greater than predicted, though at these very small magnitudes of subsidence, it is recognised that the differences are within the accuracy of the prediction model. Differential movements between pegs located close to the Gorge, such as tilt and strain, are very small as expected.

Table 2.5 Observed Incremental and Total Subsidence Parameters along Angle of Draw Monitoring Lines from the mining of Longwalls 24A to 25

Monitoring Line		Maximum Observed Subsidence (mm)	Maximum Observed Tilt (mm)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
LW24A Draw Line					
Maximum along line	LW 25 Inc Total	73 1163	0.8 10.3	0.3 1.6	-0.2 -0.2
Subsidence of peg closest to Gorge (24-1)	LW 25 Inc Total	8 26	-	-	-
LW25 Draw Line					
Maximum along line	LW 25 Inc Total	33 34	0.4 0.3	0.2 0.4	-0.3 -0.4
Subsidence of peg closest to Gorge (25-1)	LW 25 Inc Total	15 20	-	-	-
LW26 Draw Line					
Maximum along line	LW 25 Inc Total	17 28	0.4 0.5	0.4 0.5	-0.7 -0.5
Subsidence of peg closest to Gorge (26-1)	LW 25 Inc Total	7 18	-	-	-

2.4. Myrtle and Redbank Creeks

A number of monitoring lines crossed Myrtle Creek and one line crossed Redbank Creek. A summary of the maximum observed incremental and total subsidence, upsidence and closure movements for each of the monitoring lines, resulting from the extraction of Longwalls 22 to 25, is provided in Table 2.6

Table 2.6 Summary of the Maximum Observed Subsidence, Upsidence and Closure across Creeks after the Extraction of Longwall 25

Monitoring Line	Stream		Maximum Observed Subsidence (mm)	Maximum Observed Upsidence (mm)	Maximum Observed Closure (mm)	Maximum Observed Closure Strain (mm/m)
Castlereagh-Myrtle	Myrtle	LW 25 Inc Total	380 440	20 30	159 171	-22.8 (8m bay) -10.9 (14m bay) -24.3 (8m bay) -11.5 (14m bay)
Elphin-Myrtle	Myrtle	LW 25 Inc Total	450 540	100 110	173 181	-32.2 (4m bay) -10.4 (14m bay) -37.0 (4m bay) -11.9 (14m bay)
Elphin Street	Myrtle	LW 25 Inc Total	400 660	20 20	52 55	-0.8 (24m bay) -1.3 (24m bay)
Huen Place	Myrtle	LW 25 Inc Total	160 620	20 20	5 25	-1.3 (9m bay) -0.8 (18m bay) -4.6 (9m bay) -3.1 (18m bay)
Main Southern Railway	Myrtle	LW 25 Inc	250	20	41	-1.1 (32m bay)
Myrtle Ck Upstream Railway	Myrtle	LW 25 Inc	250	20	86	-3.3 (15m bay)
Myrtle Ck Downstream Railway	Myrtle	LW 25 Inc	200	20	57	-4.2 (6m bay)
Marion Street	Redbank	LW 25 Inc Total	30 40	10 10	16 20	-0.4 (18m bay) -0.4 (18m bay)

Other locations along the creeks may have experienced greater movements beyond those measured at the monitoring lines. While it is not possible to estimate what the actual maximum closure and upsidence values might be, it is possible to estimate observed contours in the region of Myrtle Creek by interpolation between the discrete survey points. Based on this analysis, it is inferred that Myrtle Creek has subsided a maximum of approximately 540 mm during the mining of Longwall 25, and a total of approximately 800 mm during the mining of Longwalls 22 to 25.

The observed valley related movements have been compared with predictions in Report No. MSEC355 (2009, Revision B), which was issued in support of Tahmoor Colliery's SMP application for Longwalls 27 to 30. The predictions in this report had been revised upwards following a review of observed valley related movements in Myrtle Creek after the mining of Longwall 24B. The previous predictions were provided in Report No. MSEC157 (2006, Revision C), which had been issued in support of Tahmoor Colliery's SMP application for Longwalls 24 to 26.

A comparison between predicted and observed incremental and total subsidence, upsidence and closure profiles along Myrtle Creek is provided in Fig. 2.8 and Fig. 2.9.

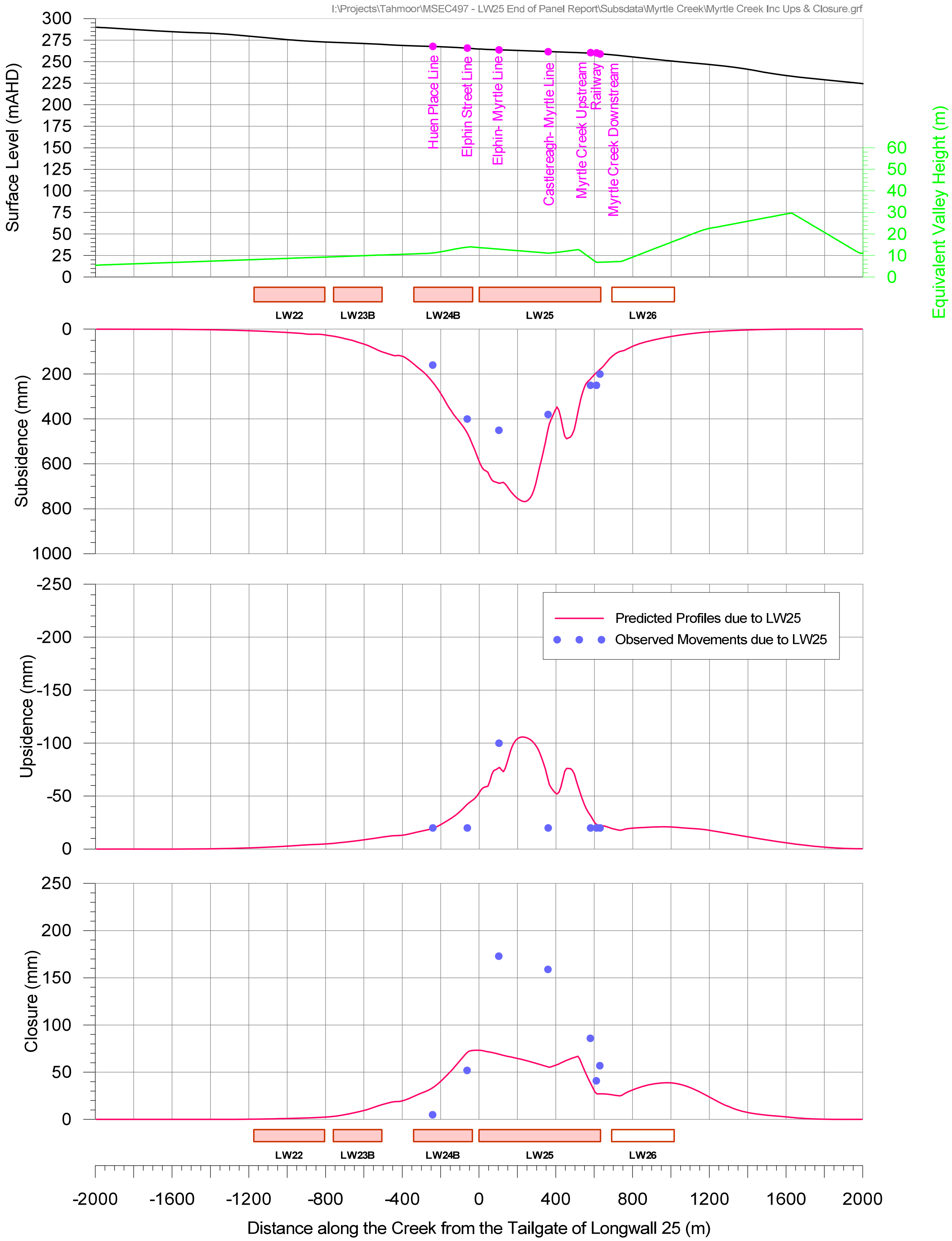


Fig. 2.8 Observed and Predicted Incremental Subsidence, Upsidence and Closure along Myrtle Creek due to the mining of Longwall 25

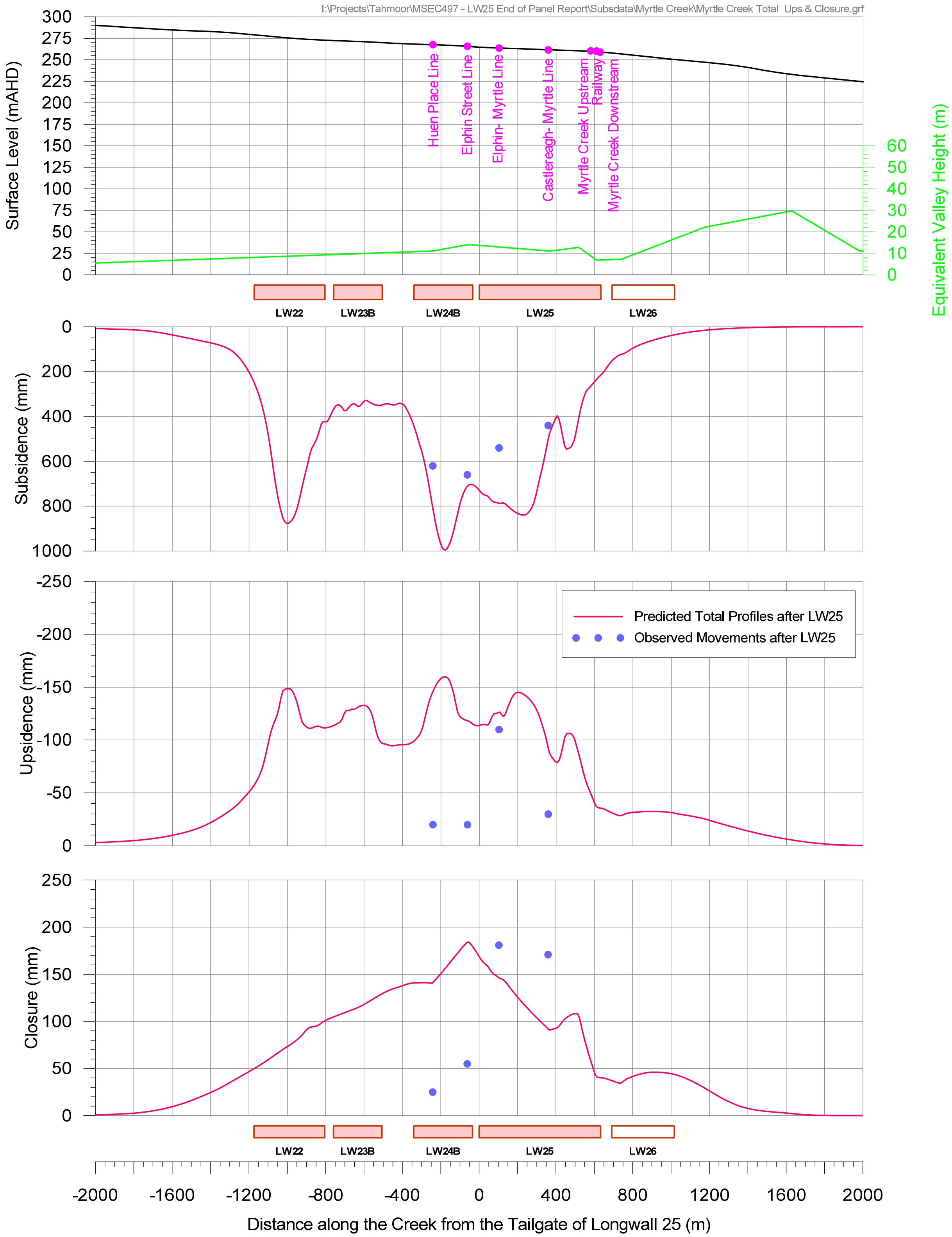


Fig. 2.9 Observed and Predicted Total Subsidence, Upsidence and Closure along Myrtle Creek due to the mining of Longwalls 22 to 25

It can be seen from the above comparison that observed incremental valley closure movements due to the mining of Longwall 25 have exceeded predictions, particularly along the Elphin-Myrtle and Castlereagh-Myrtle monitoring lines. Observed upsidence is generally less than prediction, with substantial upsidence only detected along the Elphin-Myrtle monitoring line.

While the exceedances of the predicted incremental closure during the mining of Longwall 25 are large, it can be seen from Fig. 2.9 that observed total closures are much closer to prediction.

Although these exceedances are rare, similar observations have been recorded over other collieries and for each of these exceedances investigations have showed that the probable cause was associated with specific geological conditions or landforms. A current ACARP funded research programme has examined the surface geology at virtually all sites where subsidence monitoring lines crossed valleys to examine the effects of geology on upsidence and closure, however, this report is not due to be completed until later this year.

In this case, it is considered that valley closure is greater than predicted because the valley is situated on the interface between the Wiannamatta Shale Group on the valley sides and the Hawkesbury Sandstone bedrock at the base of the creek. It can be noted that the majority of observed valley closure data, upon which the valley upsidence and closure empirical predictions have been based, were located where the valley floor and sides were situated in Hawkesbury Sandstone.

It is further noted that a component of the observed closure across Myrtle Creek along the Castlereagh-Myrtle and the Elphin-Myrtle monitoring lines can be attributed to normal systematic compression movements as the monitoring lines interect Myrtle Creek near the centre of the panel.

It is considered that observed valley upsidence is less than prediction because the model is conservative and the Hawkesbury Sandstone units are not thinly bedded. In the case of the Main Southern Railway crossing, passive rock bolts were installed in the creekbed. It is also possible that the observed upsidence are small because the ground pegs are not located exactly in the middle of Myrtle Creek, but it is noted that the pegs had been installed within a few metres of the base of the valley and if significant upsidence had developed, it would very likely have been detected to some extent by the ground surveys.

Observed movements on Redbank Creek could only be measured along the end of the Marion Street monitoring line during the mining of Longwall 25. Only one peg was located across Redbank Creek due to access restrictions. While the monitoring data shows a small amount of valley closure, it is difficult to undertake meaningful analysis based on one data point. Additional monitoring lines are proposed to be installed across Redbank Creek prior to the influence of Longwall 26.

2.5. Main Southern Railway

The Main Southern Railway was surveyed in either 2D or 3D for a total of 137 times on a weekly, twice weekly and thrice weekly basis during the extraction of Longwall 25. Details of the monitoring undertaken are provided in the monitoring reports prepared by MSEC on behalf of Tahmoor Colliery and these reports have been provided to ARTC throughout the mining period.

The Main Southern Railway experienced a maximum of 602 mm of subsidence during the mining of Longwall 25.

When comparing predicted and observed subsidence, the following comments are provided.

- There is a very good correlation between predicted and observed maximum subsidence.
- At the southern end of the site, the monitoring line is located above the coal barrier between Longwalls 24A and 24B. Subsidence of 50 to 150 mm in addition to the subsidence predicted by the standard prediction model was expected to occur in this location. As shown in Fig. A.49, additional subsidence of 50 to 100 mm was observed, which was within expectations.
- There is also a good correlation between predicted and observed maximum tilt.
- While there is a good relationship between the predicted and observed shape of the subsidence profile, the observed profile is shifted over the maingate (solid coal) side by approximately 60 metres. This means that observed subsidence exceeds predicted subsidence along this section of railway by approximately 100 mm, including at Myrtle Creek Culvert.
- Observed ground strains along the railway corridor were relatively small in magnitude. Increased ground strains were observed across Myrtle Creek as expected. The overall valley closure across Myrtle Creek was greater than predicted and further comments concerning movements are discussed in Section 2.4 and Section 2.5.4.

2.5.1. Automated Track Monitoring

Rail Stress Transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 to 33 metres. They measured changes in rail strain every 5 minutes during the mining of Longwall 25. While some low level (Blue) alarms were triggered during mining, the causes of the alarms were mainly associated with rail maintenance issues or high rail temperatures with nil or only minor contributions from subsidence movement.

Expansion switch displacement sensors

Displacement sensors have been installed at each expansion switch. Measurements were recorded every 5 minutes during the mining of Longwall 25. Mining-induced changes were observed, though larger changes were due to thermal effects. While some low level (Blue) alarms were triggered as a result of subsidence, responses had already been planned in anticipation of the alarm.

2.5.2. Thirlmere Way Overbridge

A total of 31 surveys and 67 visual inspections were undertaken of the Thirlmere Way Overbridge on a weekly basis in accordance with the agreed management plans with ARTC and Wollondilly Council.

The Bridge subsided approximately 130 mm during the mining of Longwall 25, which amounts to a total of 225 mm since the mining of Longwall 24B. Measured tilts and strains at the abutments are very small. The results indicate a fall of up to 0.7 mm/m between the bridge abutments from east to west, towards Longwall 24B.

No impacts were observed to the Bridge during the mining of Longwall 25, as expected, following extensive strengthening works undertaken by Tahmoor Colliery prior to commencement of Longwall 24B.

2.5.3. Platform Clearance Surveys

A total of 32 platform clearance surveys were undertaken during the mining of Longwall 25. All platform clearances are currently greater than minimum design clearances. Measured changes in clearances were within survey tolerance.

2.5.4. Myrtle Creek Culvert

A total of 51 ground surveys, 53 extensometer surveys and 46 visual inspections were undertaken for the Myrtle Creek Culvert on a weekly basis in accordance with the agreed management plans with ARTC.

While changes were observed, no impacts were observed to the Culvert and associated structures. This is despite the observation of increased valley closure compared to predictions.

Subsidence movements across Myrtle Creek were observed along three monitoring lines during the mining of Longwall 25: the Main Southern Railway line, and lines upstream and downstream of Myrtle Creek Culvert. While none or very little valley upsidence was observed, valley closure was observed across Myrtle Creek. A graph showing the development of valley closure along the three monitoring lines is shown in Fig. 2.10.

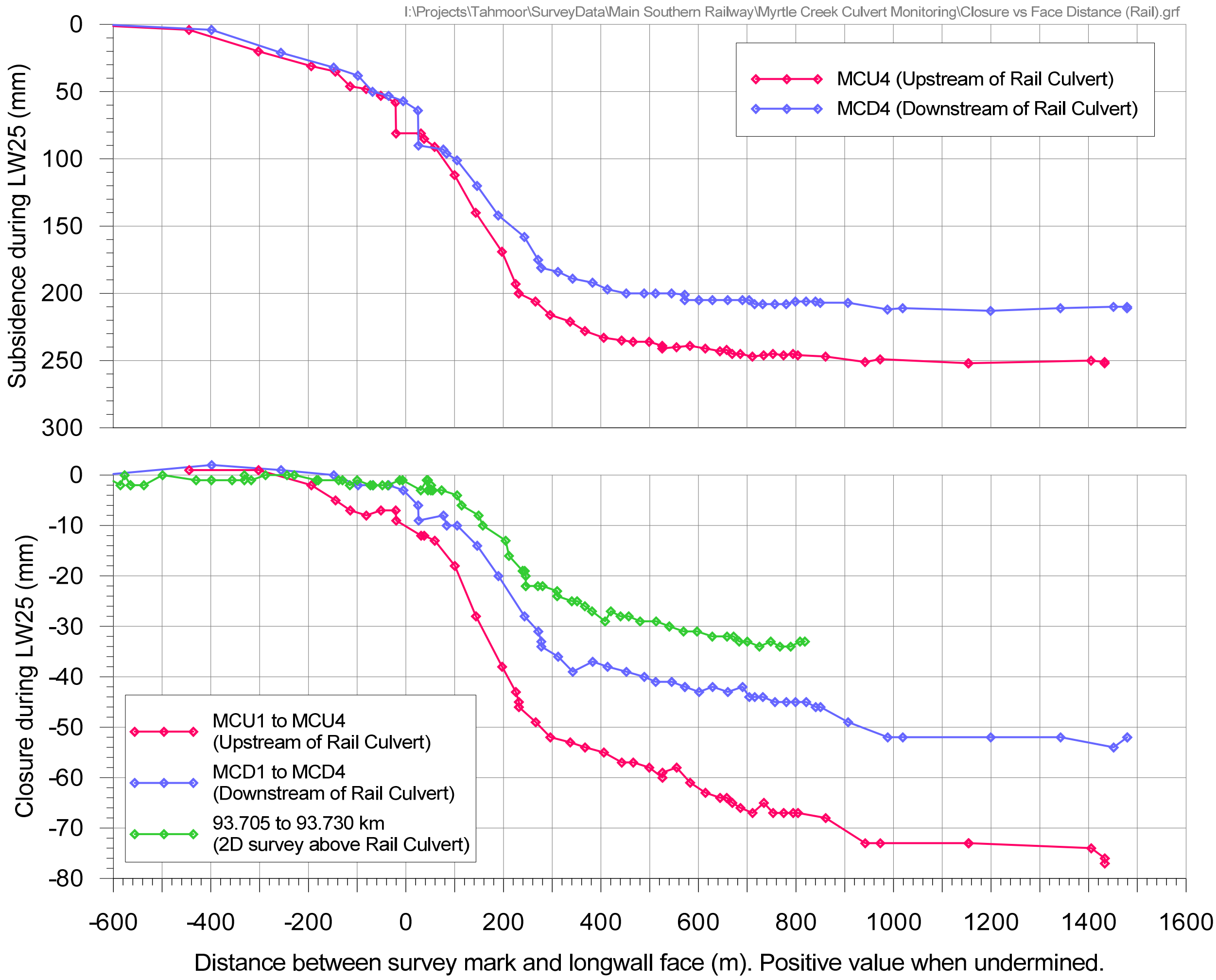


Fig. 2.10 Observed development of Valley Closure across Myrtle Creek at Main Southern Railway during the mining of Longwall 25

The observed ground movements during the mining of Longwall 25 are presented in plan view in Fig. 2.11.

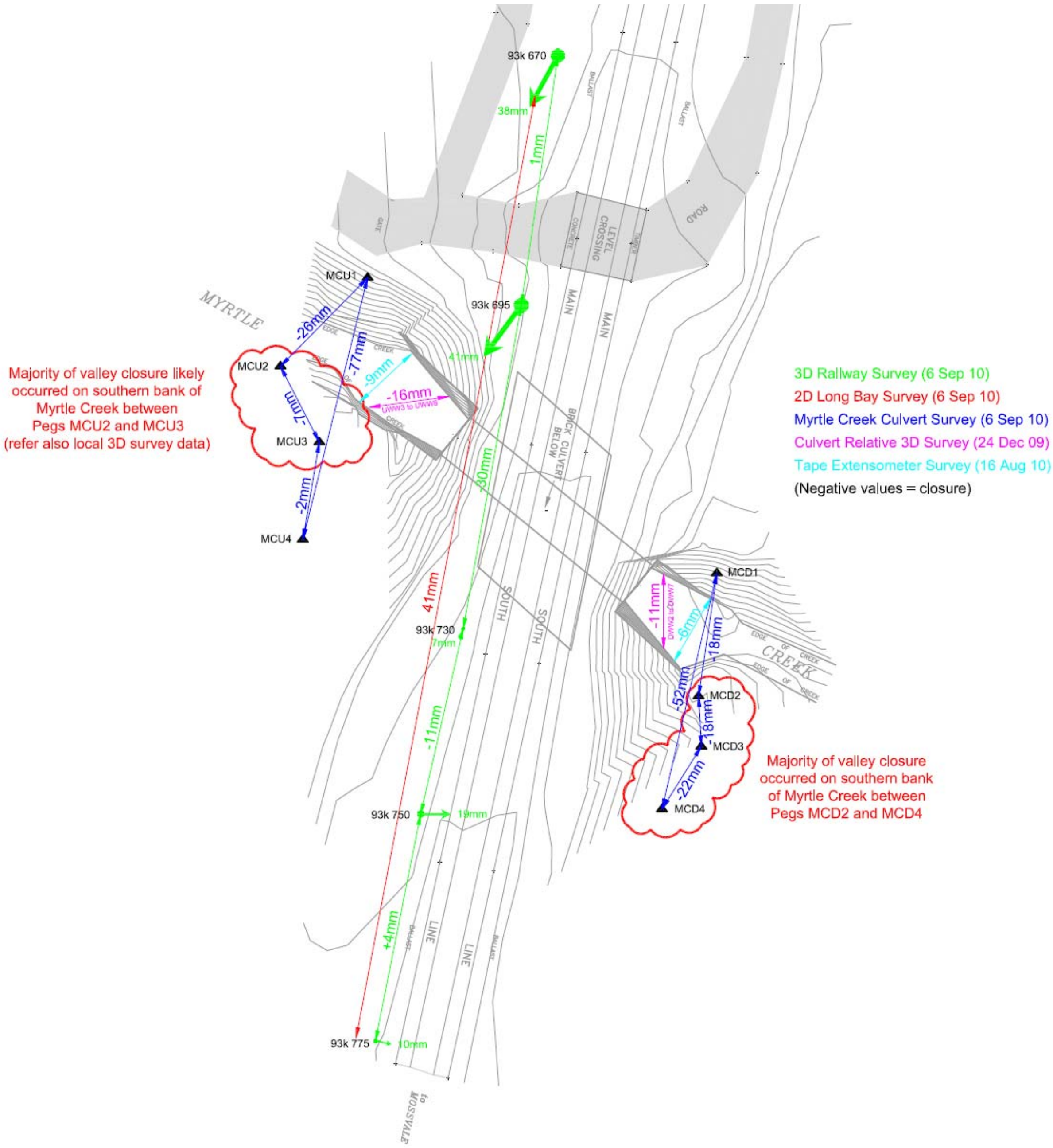


Fig. 2.11 Observed Changes in Horizontal Distance between Survey Points at Myrtle Creek Culvert due to the mining of Longwall 25

It can be seen from Fig. 2.11 that the observed movements along the railway line were less than those across the upstream and downstream monitoring lines.

The upstream and downstream monitoring lines were surveyed in local, relative 3D and reported in 2D, as required in the Management Plan. It can be seen from the representation of 2D data in Fig. 2.11 that the sum of the changes in horizontal movement between the pegs is substantially less than the overall total closure that was measured across the banks. This is particularly the case with the upstream monitoring line.

The reason for the discrepancy can be explained by the bend in the monitoring line, particularly between Pegs MCU2 and MCU3. The monitoring data suggests that the majority of the valley closure was focussed between these pegs, but in a direction normal to the monitoring line. A similar result is observed along the downstream line, where the majority of valley closure movements appear to have been focussed between Pegs MCD2 and MCD4.

The raw monitoring data for the upstream and downstream monitoring lines has been processed by the surveyor Meadows Consulting in local, relative 3D coordinates. A plot of the movement of each survey peg on each monitoring line, relative to Peg 4 and the alignment between Pegs 1 and 4, is shown in Fig. 2.12.

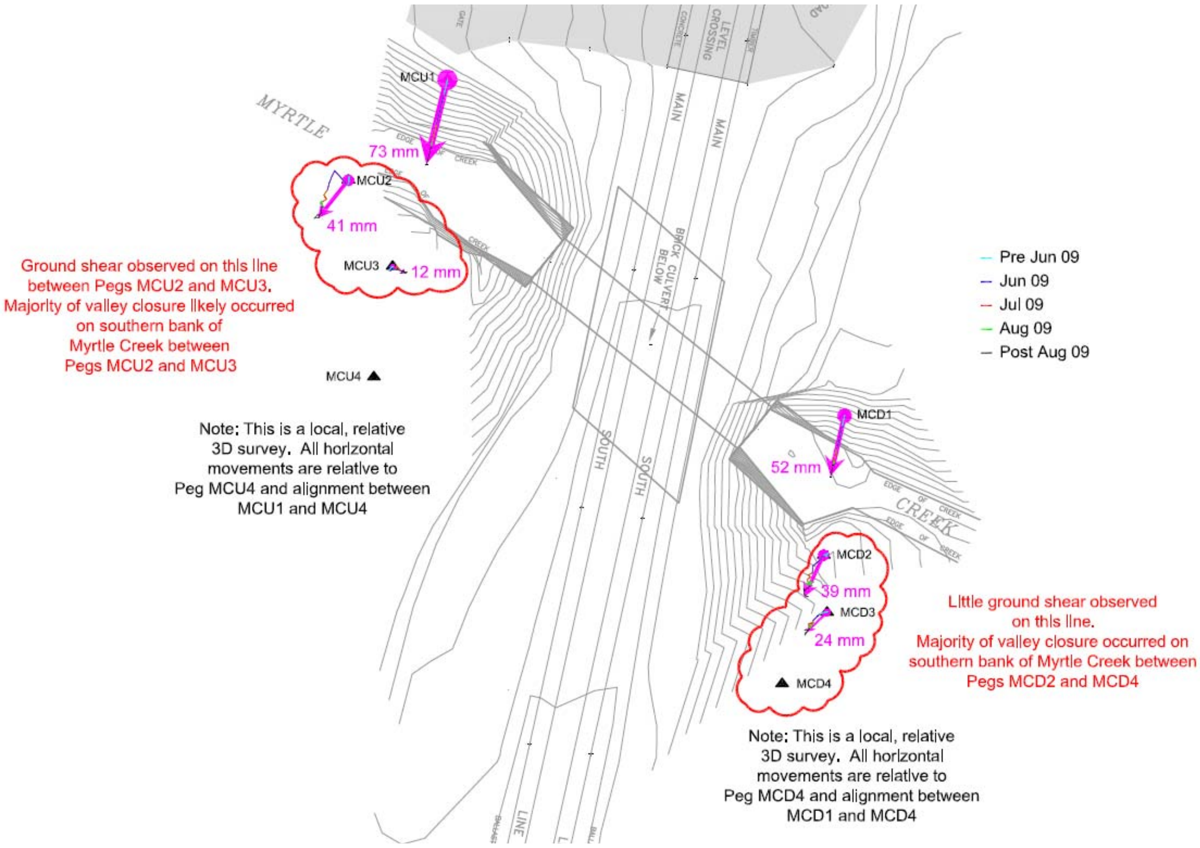


Fig. 2.12 Observed Horizontal Movement of Survey Pegs along Upstream and Downstream Monitoring lines across Myrtle Creek during the mining of Longwall 25

The above results show that horizontal ground shearing has developed on the upstream monitoring line between Pegs MCU2 and MCU3, with less ground shear apparent across the downstream monitoring line. Approximately 30 mm of closure has been observed across the base of the culvert between Pegs MCU1 and MCU2 by both 2D and 3D survey. Given that 41 mm of closure can be inferred from the 3D survey to have developed between Pegs MCU2 and MCU3, the majority of the valley closure movements appear to have focussed between two pegs.

Analysis of ground movements at the culvert has concluded the following:

- Observed valley closure across the Main Southern Railway of 30 mm (at culvert), 52 mm (downstream) and 77 mm (upstream) have exceeded the original prediction of 20 mm and in two cases, exceeded the revised prediction of 40 mm. While the amount of exceedance may appear large when expressed as a percentage of the predictions, the magnitude of the exceedance are less than 40 mm. The observed and predicted movements are of a similar order of magnitude.
- Very little or no valley upsidence has been observed.
- The development of valley closure movements was gradual as expected, as shown in Fig. 2.10.
- The cause for the reduction in valley closure directly above the Culvert is not known. The topography and creek alignment is complicated at this location and the variation may simply be due to these factors. An alternative explanation is that the culvert with its associated mitigation measures and the embankment have “propped” the valley sides.
- An analysis of local, relative 3D movement of the monitoring lines upstream and downstream of the Culvert, and closure of survey pins located on the wingwalls suggest that the majority of the valley closure movements have focussed in the southern bank of Myrtle Creek, and not directly beneath the Culvert structure.
  The observation of valley closure focussed to the side of a valley rather than across the base is not unusual and has been observed previously at other valleys that have experience valley closure movements. While it is possible that the focal point of valley closure has been shifted due to the influence of the stiffened Culvert, it is noted that the upstream and downstream monitoring lines are located beyond the ends of the wingwalls where the influence of the Culvert on the ground survey data is likely to be small.
- Changes in grade along the culvert were less than 1 mm/m, which is very small compared to the existing grade of the culvert. This is confirmed by higher resolution and higher accuracy monitoring with tiltmeters.

Analysis of tape extensometer, tiltmeter and inclinometer data at the culvert by GHD Geotechnics has concluded the following:

- Evidence has not been observed in the recorded response of the ribs or the wingwalls that indicates existence of unsafe track conditions.
- Baseline and post mining monitoring has shown that the distances across the Culvert horizontally and vertically undergo seasonal changes over time.
- The amount of additional horizontal closure and vertical dilation of the Culvert due to valley closure can be estimated by measuring the shift in the seasonal changes. The maximum amount of additional closure was found to be 1.6 mm by tape extensometer. The maximum amount of vertical opening was found to be 1.7 mm by tape extensometer.
- Neither distress within the barrel of the culvert, nor at the intersections of the wingwalls and barrel of the culvert, has been observed.
- An analysis of tape extensometer and tiltmeter monitoring data within the culvert indicate that the culvert structure has moved largely as a rigid body during mining. This is supported by surveys of local, relative 3D movement of fixed prisms within the culvert.
- The inclinometer located on top of the northern bank on the UP side of the track recorded shearing of the rock mass at 27 metres below the surface, which is well below the base of the culvert.

Analysis of steel stresses within the ribs of the culvert by John Matheson & Associates has concluded the following:

- Baseline and post mining monitoring has shown that the steel stresses within the culvert undergo seasonal changes over time.
- The amount of additional stress due to valley closure across the culvert can be estimated by measuring the shift in the seasonal changes. The amount of additional stress was found to be less than 16 % of the yield stress of the steel.

It is therefore concluded that the Culvert has experienced only minor deformation or stress as a result of the mining of Longwall 25.

2.6. Sewer Infrastructure

2.6.1. Sewer grades

One of the key items of infrastructure that had potential to experience impacts as a result of increased subsidence were the self-cleansing sewer pipes within the urban area. Subsidence monitoring was undertaken along the streets and at key sewer pit lids during mining.

Prior to Longwall 25 mining beneath the urban area, the potential changes in sewer grades were re-assessed based on observations of increased subsidence above Longwall 24A for all sewer pipes within the urban area. The reassessment indicated that the grades on the majority of the pipes were expected to remain greater than the minimum grades required for self-cleansing following the mining of Longwall 25. However, the analysis identified two pipe sections where the projected grades were assessed to be only just greater than the minimum grade required for self-cleansing. The pipes identified were:

- SMH31 to SMH32: A 55 metre long section of pipe with a pre-mining grade of 0.71% and a measured grade of 0.28% after the mining of Longwall 24A
- SMH23 to SMH22: A 90 metre long section of pipe with a pre-mining grade of 0.78%

A plot of observed changes in grade during and after the mining of Longwall 25 is provided in Fig. 2.13.

Relative height differences between the sewer pit lids were measured up to three times a week in accordance with an agreed management plan with Sydney Water. A total of 57 surveys were conducted between SMH31 and SMH32, and a total of 28 surveys were conducted between SMH23 and SMH22 during the mining of Longwall 25. A plot of observed height differences and changes in grade is provided in Fig. 2.13.

It can be seen that the pipes between SMH31 and SMH32 had gradually reduced in grade as mining progressed but the grade remained positive (i.e. no grade reversal) and the pipe was considered to remain self-cleansing. Similarly, the grade between SMH23 and SMH22 reduced but the grade remained positive and the pipe was considered to remain self-cleansing.

2.6.2. Sewer Creek Crossings

A total of 53 surveys along two sewer pipes that cross Myrtle Creek were conducted on a weekly and twice weekly basis in accordance with the agreed management plan with Sydney Water. The results are shown in Fig. 2.14.

It can be seen that very little change was observed across the Brundah Road crossing during the mining of Longwall 25 and an additional 20 mm closure developed across the Huen Place crossing.

In accordance with the management plan, daily visual inspections and CCTV inspections were conducted. No impacts were observed to the sewer pipes during the mining of Longwall 25. Comfort is drawn from CCTV observations, which did not detect changes at pipe joints.

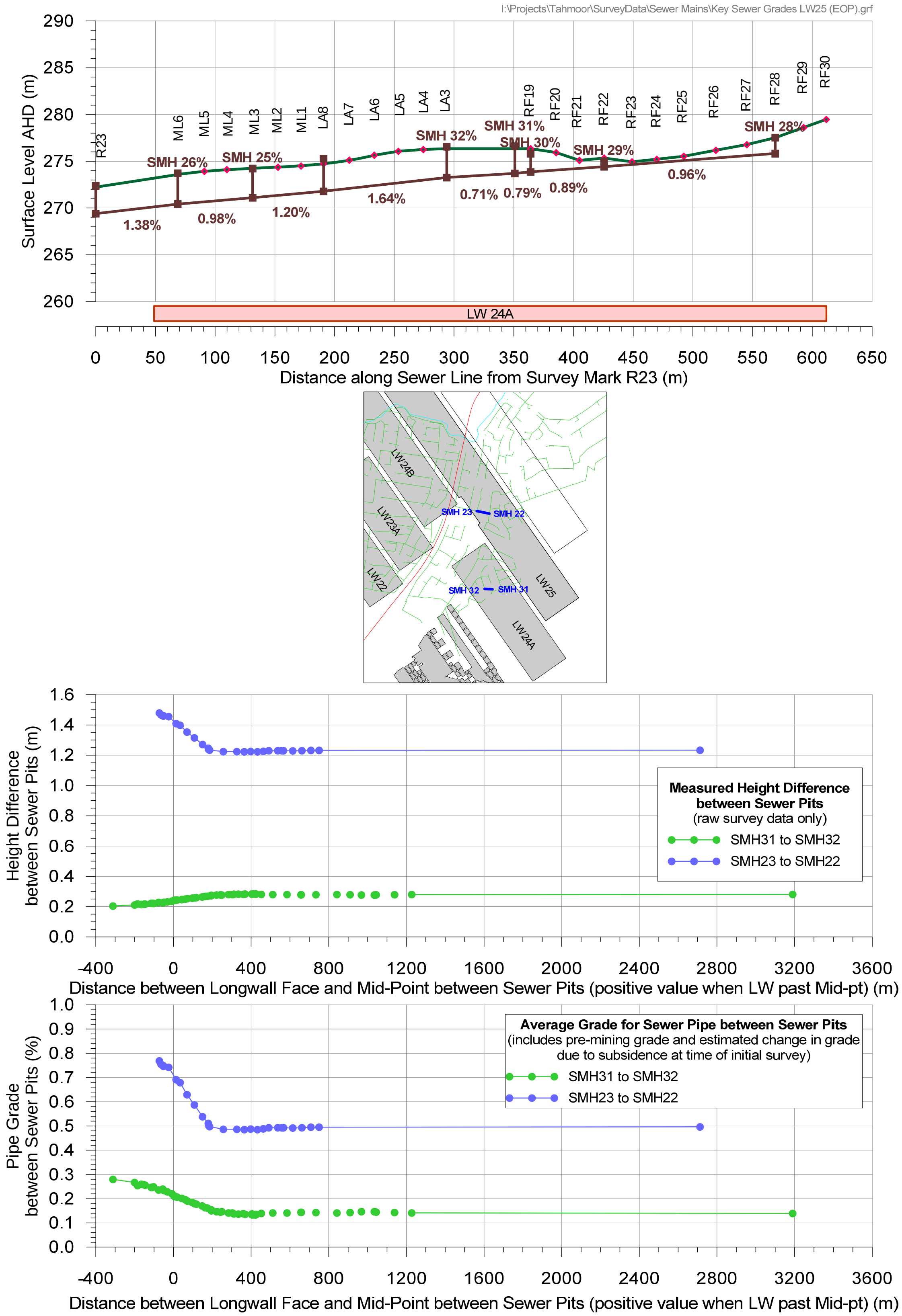


Fig. 2.13 Observed Changes in Grade between selected Sewer Pits

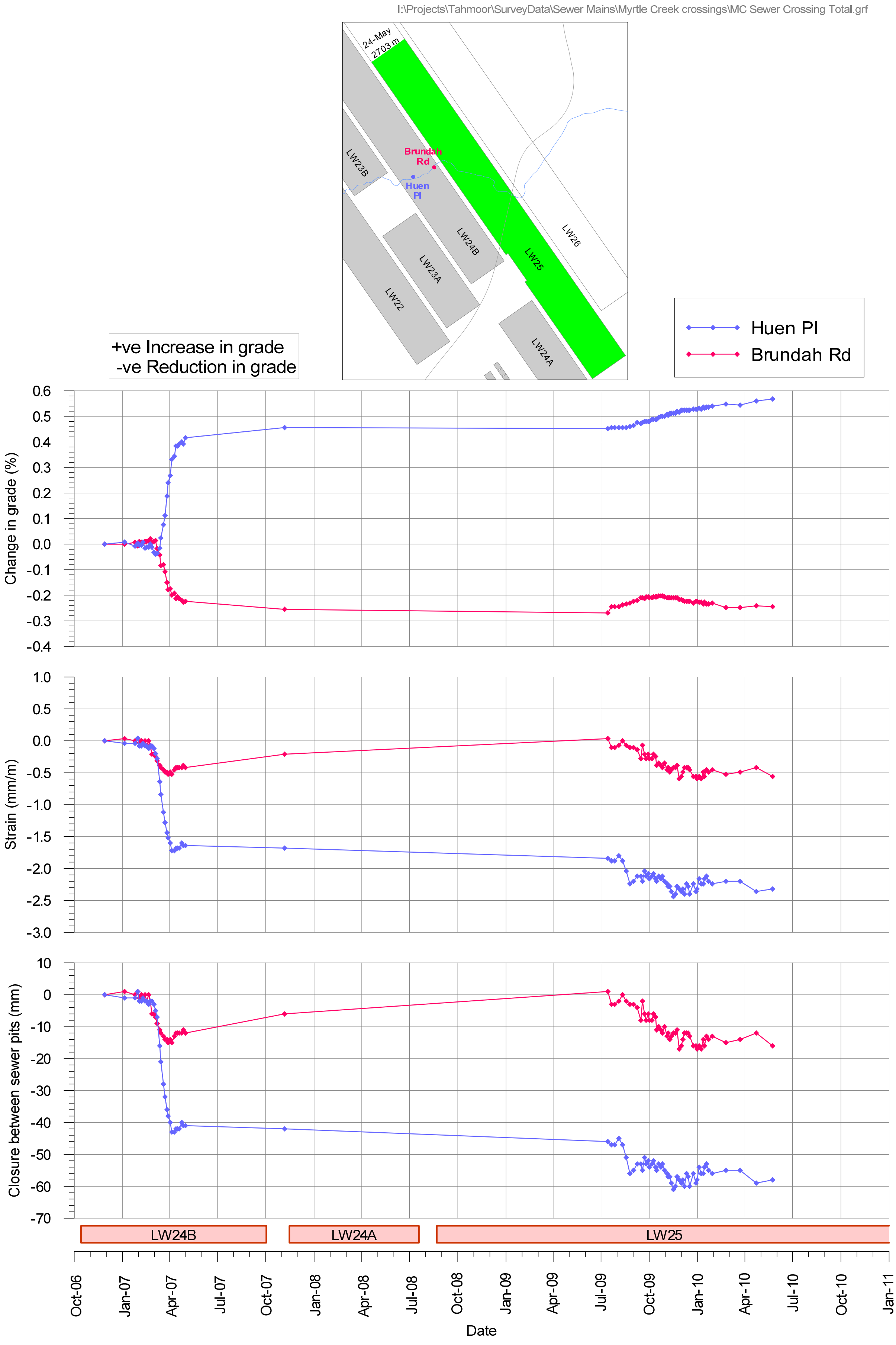


Fig. 2.14 Observed Total Change in Grade, Strain and Closure along Sewer Pipes that cross Myrtle Creek during the mining of Longwalls 24B to 25

2.6.3. Sewer Pumping Station

The Sewer Pumping Station on Castlereagh Street was monitored during the extraction of Longwall 25. Ground survey pegs at the corners of the Pumping Station were monitored weekly during the active subsidence zone. Tiltmeters were installed within the chamber at three locations and readings for tilt and temperature were obtained at ten minute intervals.

Ground monitoring around the pumping station during the mining of Longwall 25 showed that the pumping station subsided approximately 400 mm, as shown in Fig. 2.15. Observed tilts were within expectations. The majority of ground strains around the pumping station were relatively small, with the exception of strain between Pegs PS2 and PS3 on the northern or downslope side. Compressive strain between the pegs was 2.2 mm/m in January 2010, with a maximum of 3.4 mm/m observed in December 2009.

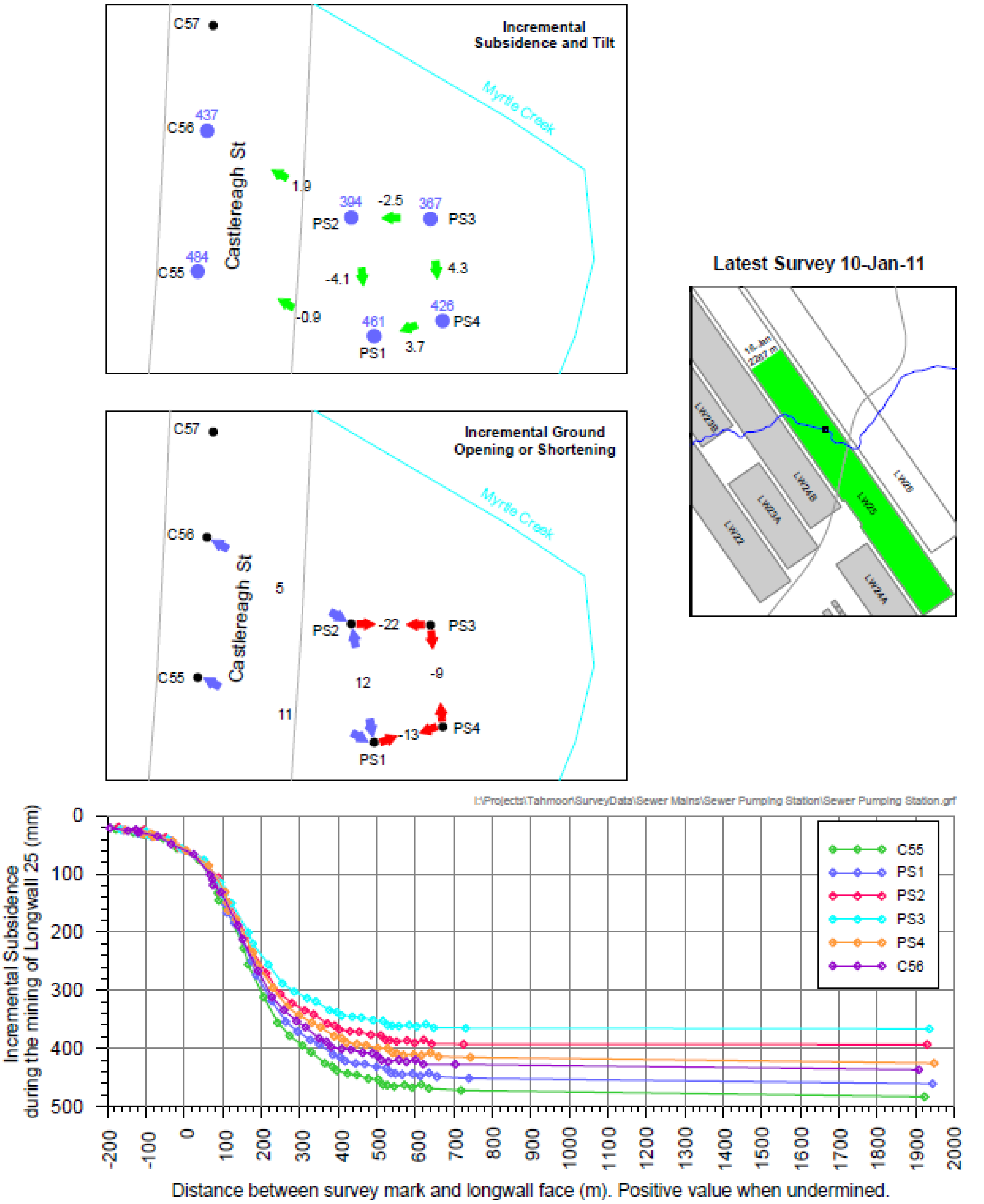


Fig. 2.15 Sewer Pumping Station Monitoring during Longwall 25

Automated continuous tiltmeters monitored changes in tilt in 3 vertical lines, placed at the top, base and mid-point on the internal face of the chamber wall. As shown in Fig. 2.16, observed curvatures are well within trigger levels as defined under the Management Plan.

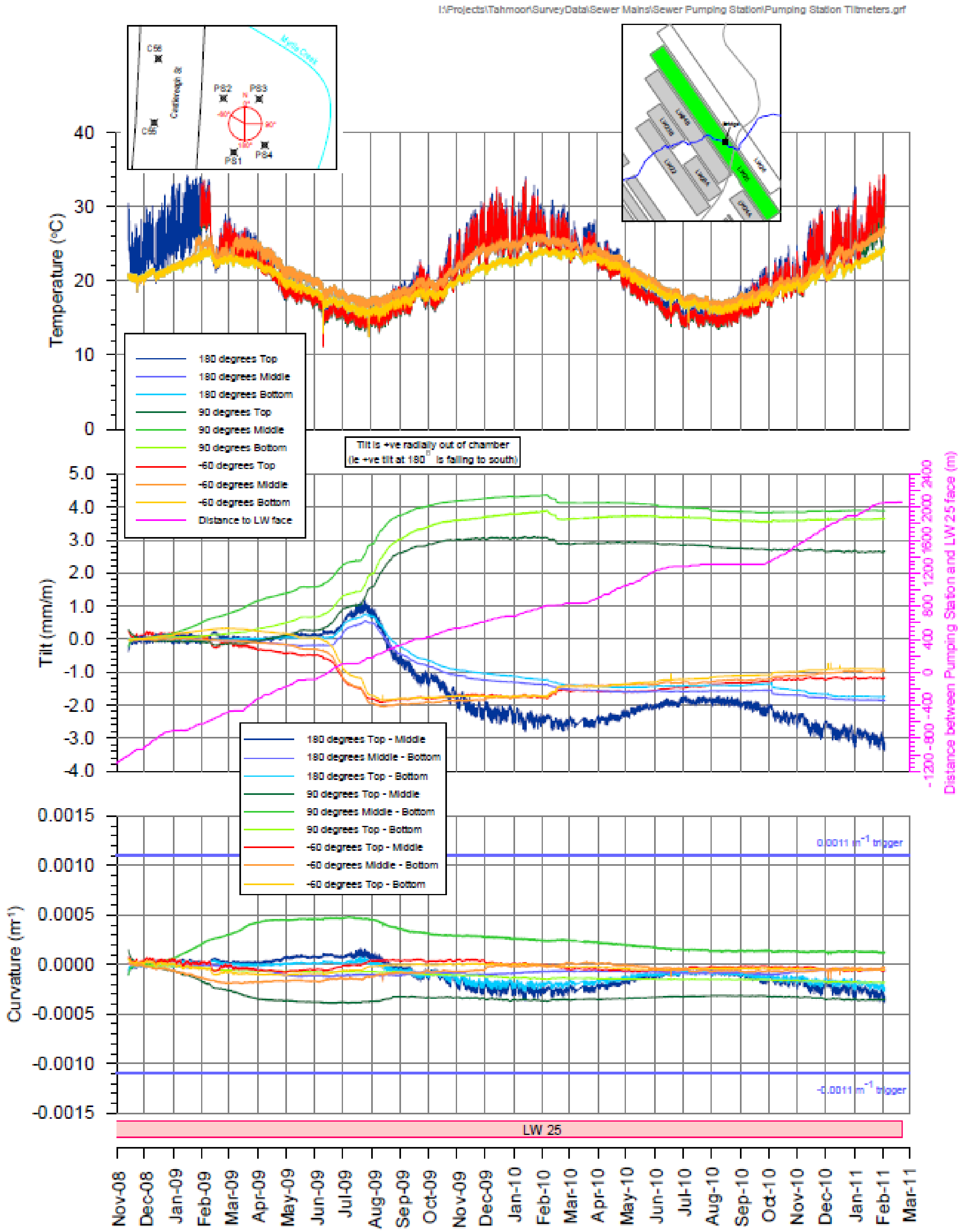


Fig. 2.16 Sewer Pumping Station Tiltmeters during Longwall 25

2.6.4. Rising Main

Ground monitoring along Castlereagh Street in the vicinity of the rising main indicate very small differential movements during the mining of Longwall 25 (refer Fig. A.11). No impacts have been observed along this main.

2.7. Power Pole Surveys

A total of 36 surveys of selected power poles were conducted in accordance with the agreed management plan with Integral Energy. No impacts were observed to any power pole or cables during the mining of Longwall 25, as expected.

Of the poles that were surveyed, maximum subsidence of 1149 mm was observed at Pole 275 on Progress Street.

2.8. Tahmoor Town Centre

A total of 52 detailed surveys of the Tahmoor Town Centre and basement carpark were undertaken in accordance with the conditions of SMP Approval by the Department of Primary Industries and management plan with Tahmoor Town Centre. Maximum observed incremental subsidence due to the mining of Longwall 25 was 214 mm at the north-east corner of the complex. Maximum observed total subsidence after the mining of Longwall 25 was approximately 244 mm since the commencement of Longwall 24B. Observed profiles along the Exterior line after Longwall 25 are shown in Fig. 2.17 below.

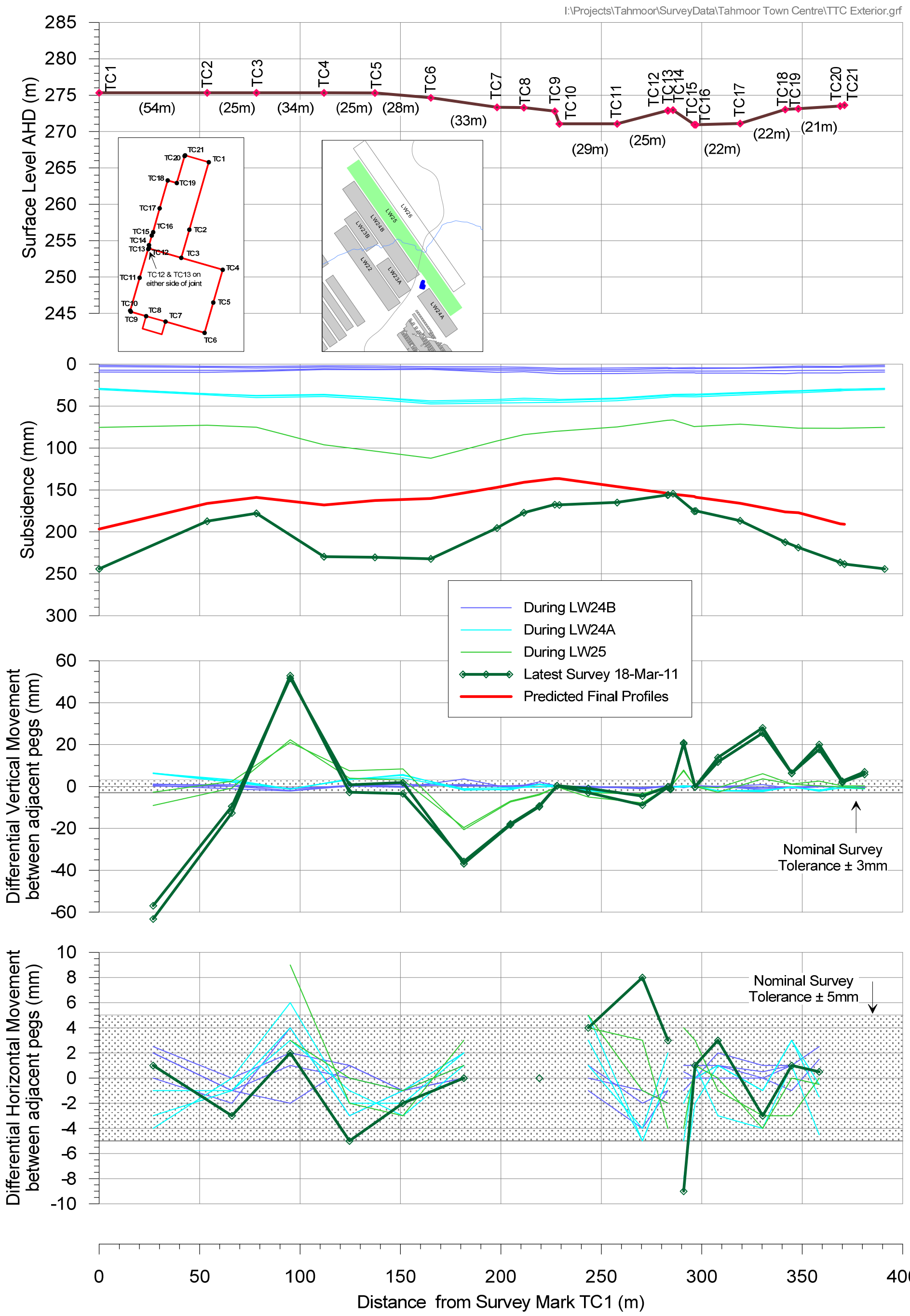


Fig. 2.17 Observed Profiles along Tahmoor Town Centre Exterior Line after Longwall 25

The distances across the width and length of the TTC basement were measured on a weekly basis during mining. The results indicate small movements in the North-South and East-West directions, slightly greater closure movement across the diagonal NW/SE direction and small opening movements in the NE/SW direction.

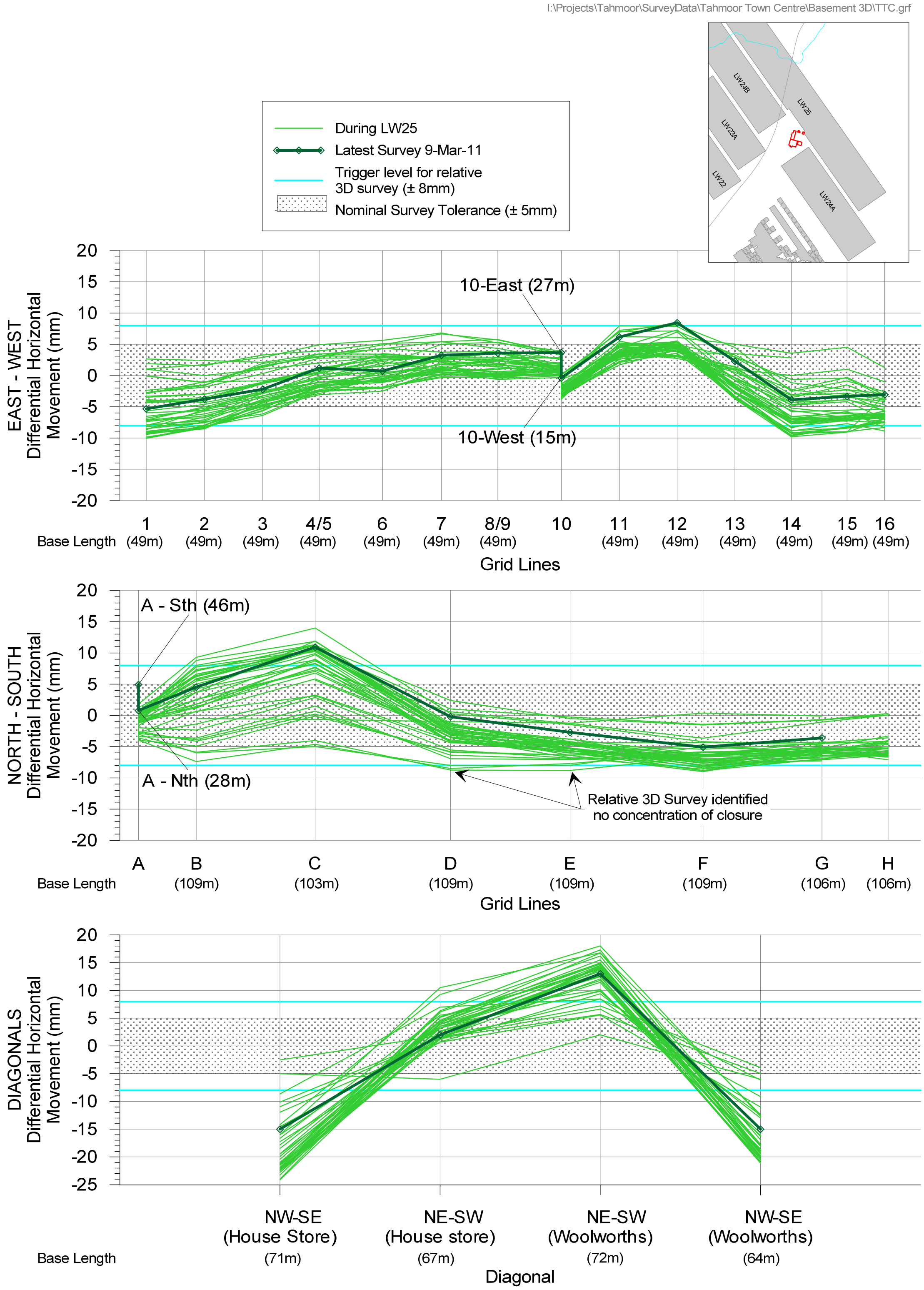


Fig. 2.18 Basement Width and Length Surveys during Longwall 25

2.9. Inghams

2.9.1. Ground and Building Monitoring Results

Ground and building surveys have been conducted in accordance with the Management Plan. The locations of monitoring lines relative to Longwall 25 and the Inghams infrastructure are shown in Drawing No. MSEC497-01 and a summary of maximum observed subsidence parameters for each monitoring line is provided in Table 2.7.

Table 2.7 Summary of Maximum Observed Subsidence Parameters along Inghams Monitoring Lines

Monitoring Line		Maximum Observed Subsidence (mm)	Maximum Observed Tilt (mm)	Maximum Observed Tensile Strain (mm/m)	Maximum Observed Compressive Strain (mm/m)
Dam Line	LW 25 Inc Total	108 869	0.8 5.2	0.4 0.8	-0.5 -1.1
East-West Line	LW 25 Inc Total	74 677	0.9 6.9	0.4 1.1	-0.5 -0.4
North-South Line	LW 25 Inc Total	63 234	0.7 0.6	0.4 0.2	-0.5 -0.7
High-Rise Freezer Line	LW 25 Inc Total	380 1364	3.1 12.7	0.3 1.1	-0.8 -2.8
Plant Perimeter Line	LW 25 Inc Total	53 171	Please refer for differential vertical and horizontal movements		
Pipe Support Line	LW 25 Inc Total	48 155	Please refer for differential vertical and horizontal movements		

2.9.2. Ammonia Pipes

The Management Plan includes planned procedures that are triggered from results of monitoring in relation to ammonia pipes. The triggers for the blue trigger level are:

- *Ground survey*: Differential vertical or horizontal movement of 10 mm between adjacent survey marks on the Plant Perimeter and Pipe Support Monitoring Lines
- *Displacement transducers*: 10 mm movement since re-commencement of Longwall 24A
- *Pipe Stress Transducers*: 82.8 MPa for low temp pipes and 112.5 MPa for high temp pipes

Ground survey

A summary of maximum observed differential vertical and horizontal movements along these monitoring lines is shown in Table 2.8.

Table 2.8 Summary of Maximum Observed Differential Movements along Plant Perimeter and Pipe Support Monitoring Lines

Monitoring Line		Maximum Observed Subsidence (mm)	Maximum Observed Differential Vertical Movement (mm)	Maximum Observed Differential Horizontal Movement (mm)	Was BLUE trigger exceeded?
Plant Perimeter Line	LW 25 Inc Total	53 171	-4.1 to 3.4 -14.4 to 12.1	-8.0 to 7.0 -5.0 to 7.0	Yes
Pipe Support Line	LW 25 Inc Total	48 155	-8.7 to 1.2 -8.7 to 3.8	-3.0 to 13.0[1] -4.0 to 15.0[1]	No[1]

[1] Construction work has disturbed Mark PS6.

Differential vertical movements had exceeded the BLUE trigger between survey marks Plant 3 and Plant 4 (north side of High-Rise Freezer), between survey marks Plant 5 and Plant 6 (south side of High-Rise Freezer), and between survey marks Plant 11 and Plant 12 (south side of Carton Tunnel). The pegs are spaced approximately 20 metres, 14 metres and 21 metres apart, respectively. The corresponding ground tilts are therefore 0.9 mm/m, 0.9 mm/m and 0.7 mm/m, respectively. These tilts are small and have not resulted in any impacts to the ammonia pipes.

Displacement transducers

The measured displacements for Sensors 2 and 3 exceeded the BLUE trigger on a number of occasions. However, the sensors were later found to be faulty. It is considered that the actual mining-induced displacements did not exceed the trigger levels.

Pipe Stress Transducers (PSTs)

While some pipe stress transducers showed slight changes in stress, the majority of stress gauges did not reach the trigger level, except for intermittent spikes that were considered to be due to either electrical interference or influence of compressor operation. Only one gauge was observed to experience an increase in pipe stress and this occurred during the mining of Longwall 24A. The pipe supports were adjusted during mining and the stresses were subsequently reduced at this time.

2.9.3. Discussion

The subsidence associated with the Inghams Plant occurred in accordance with predictions. Increased subsidence greater than predictions obtained by the Incremental Profile Model was observed at the Plant during the mining of Longwalls 24A and 25. However, this was expected as the Plant was located above mostly solid, unmined coal reserves that lay between a previously mined area (200 Panels) and the currently mined Longwall 24A. Observations of increased subsidence had been experienced in similar previous mining situations and these are believed to be due to a regional redistribution of the in situ stresses in the overlying strata.

As discussed in the Management Plan, it was expected that this increased subsidence would be accompanied by low tilts and strains at the Plant, and this was observed during the mining of Longwalls 24A and 25. It can be seen from the monitoring results that observed tilts and strains small in magnitude in the vicinity of the Inghams Plant and along nearby monitoring lines (North-South, High-Rise Freezer). For example, a total variation of approximately 60 mm of subsidence was observed among all survey pegs along the Plant Perimeter Monitoring Line.

While subsidence developed as expected at the Plant, increased subsidence was observed at the dams. This was not predicted and discussion on increased subsidence above Longwall 24A was provided in Section 2.1.3.

2.10. Wollondilly Shire Council

2.10.1. Castlereagh Street Bridge

The survey results for Castlereagh Street Bridge show that while the creek sides have closed considerably, the bridge has closed significantly less with the exception of the end of the south-eastern wing wall, as shown in Fig. 2.19. The resistance of the bridge structure to closure has resulted in compressive heaving in the road pavement on the southern side of the bridge and damage to the telecommunications conduit at the north-western abutment. Existing cracks on the southern abutment have been observed to extend slowly during mining, particularly at the interface between the abutment and south-eastern wing wall.

Differential movements between the bridge deck and the abutments have been observed to gradually increase and exceed the BLUE trigger level. The brackets were cut and set back from the southern abutment on Monday, 7 September 2009. Further small movements have been observed since the brackets were removed. There is currently a small air gap between the abutment walls and the bracket supports so that there is no pressure on the brackets, abutments or bridge deck.

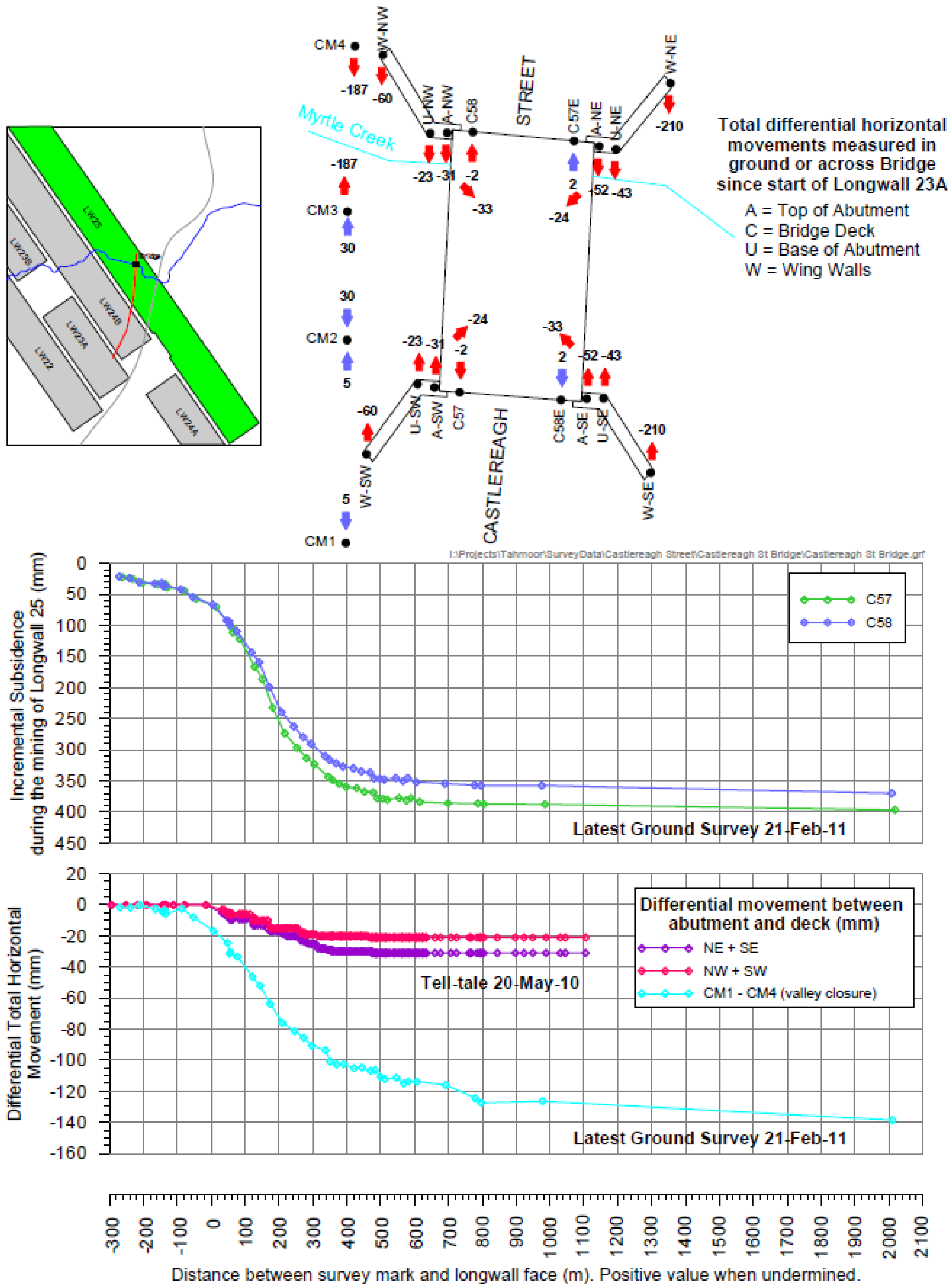


Fig. 2.19 Observed Subsidence and Horizontal Movement at Castlereagh Street Bridge

2.10.2. Remembrance Drive Bridge

A survey of points on the Remembrance Drive Bridge was undertaken at the completion of Longwall 25. The survey showed that the Bridge has subsided approximately 18 mm since the commencement of Longwall 24B, and approximately 13 mm during the mining of Longwall 25.

Differential movements between survey points were very small and within survey tolerance, with the exception of the distance between Marks CN and DS. This bay was measured to have closed approximately 13 mm. The result is inconsistent with the remainder of the survey results, some of which use the same Marks CN and DS. The initial survey is therefore considered to be erroneous and cannot be checked as it was measured by tape.

3.0 SUMMARY OF SURVEYS AND INSPECTIONS

Many surveys and inspections were conducted to meet the requirements of the Surface, Safety and Serviceability Management Plans. Due to the complexities involved, surveys and inspections were managed using a computer database on a weekly basis. A register was also kept, detailing when each survey and inspection had been completed. A timeline showing when each type of survey and inspection was conducted is shown in Fig. 3.1, Fig. 3.2 and Fig. 3.3 below.

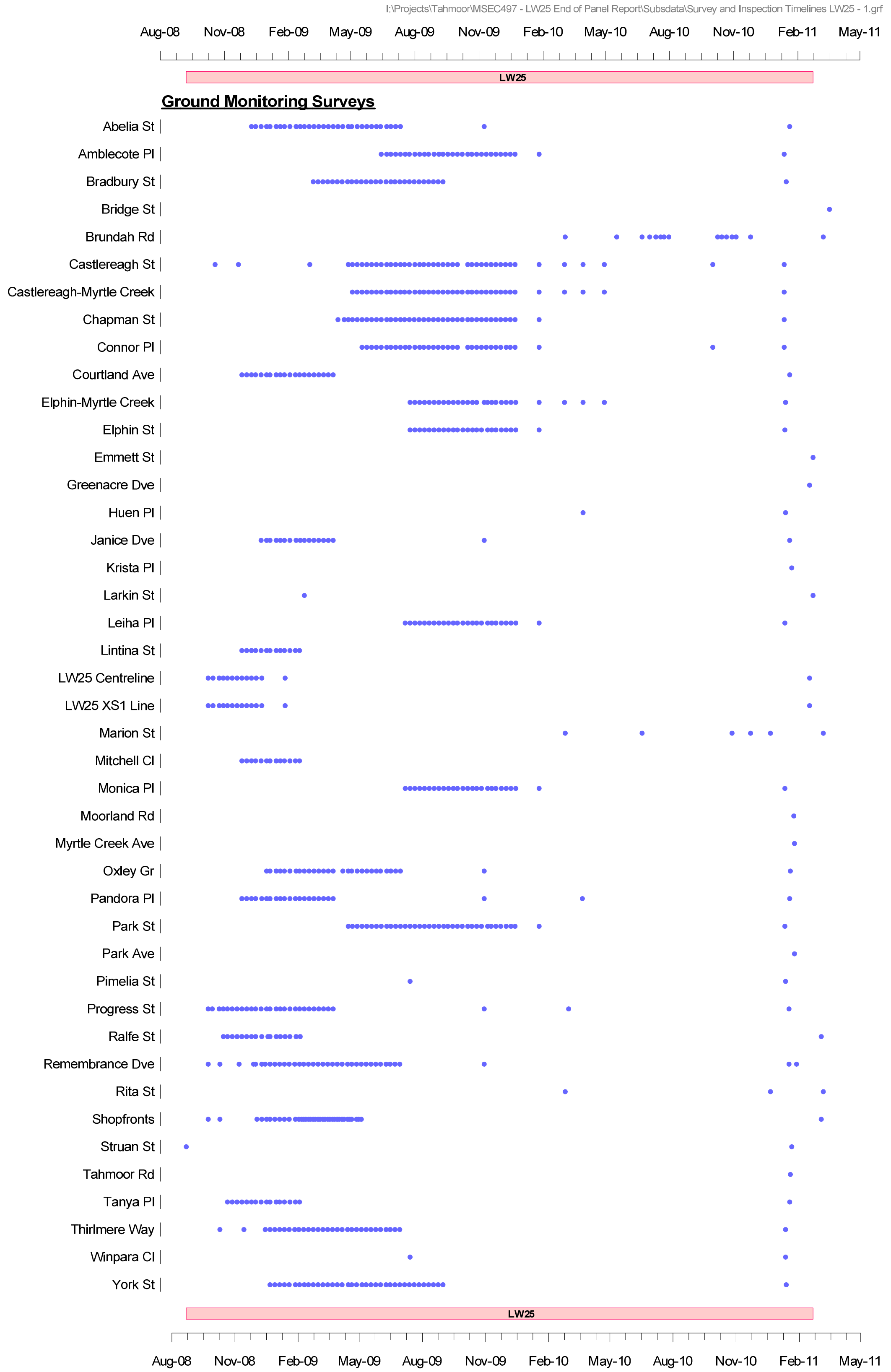


Fig. 3.1 Timeline of Surveys and Inspections during Longwall 25

Fig. 3.2 Timeline of Surveys and Inspections during Longwall 25

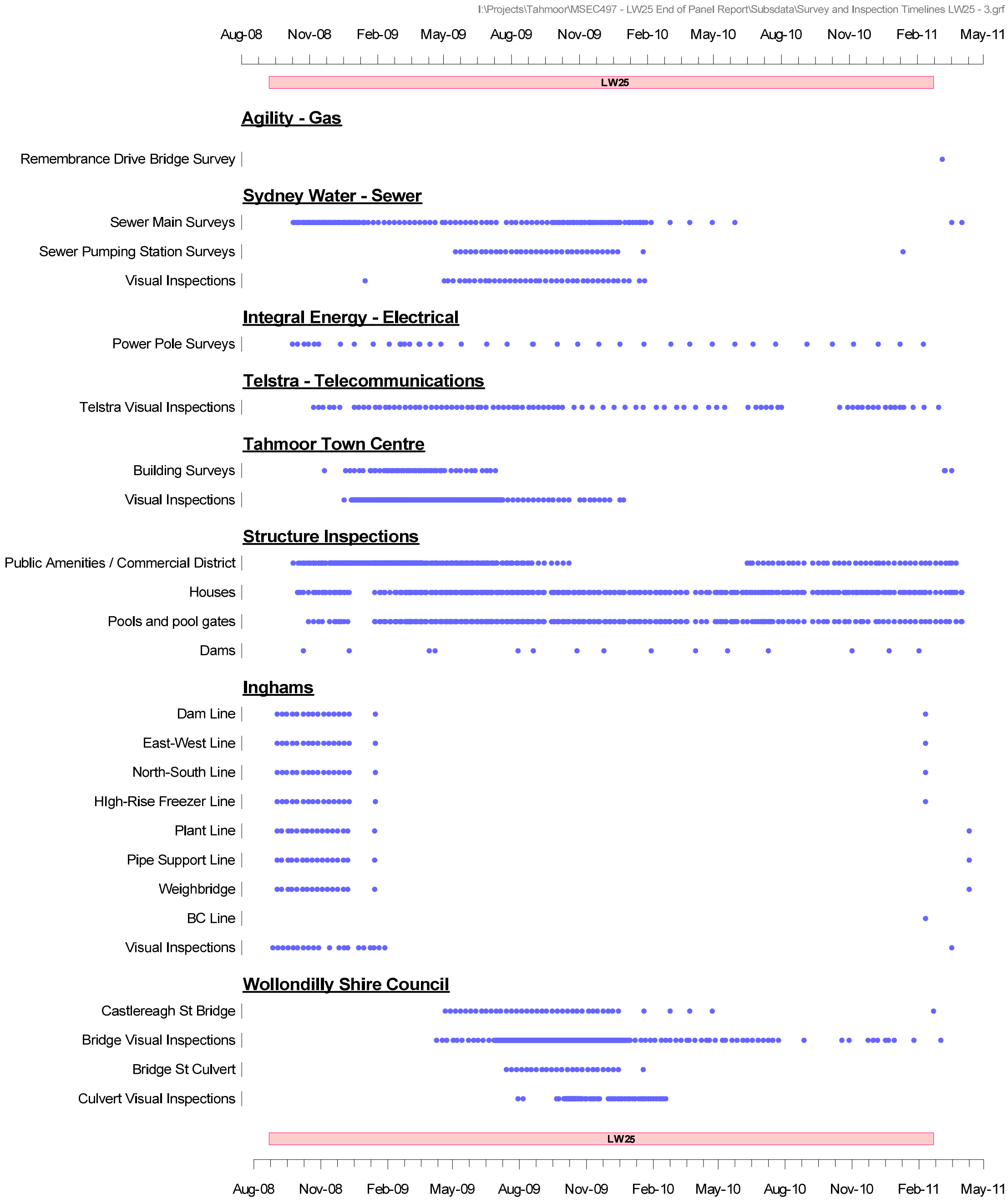


Fig. 3.3 Timeline of Surveys and Inspections during Longwall 25

A count of the total numbers of surveys and inspections is provided in Table 3.1

Table 3.1 Number of Surveys and Inspections conducted during Longwall 25

Inspection / Survey	Responsibility	Number of Inspections / Surveys
Ground Monitoring Surveys		
	Lean & Hayward	796
Sub-Total		**796**
Natural Features		
Bargo River Water Monitoring	HCS / GeoTerra	31
Bargo River Angle of Draw Surveys	Lean & Hayward	4
Bargo River Rockbar Surveys	Lean & Hayward	5
Myrtle Creek Water Monitoring	GeoTerra	17
Redbank Creek Water Monitoring	GeoTerra	17
Groundwater Monitoring	GeoTerra	17
Sub-Total		**91**
Main Southern Railway		
Ground Surveys	Meadows Consulting	136
Rail Creep Surveys	Meadows Consulting	38
Long Bay Surveys	Meadows Consulting	53
Track Geometry Surveys	Railcon	290
Platform Clearance Surveys	Meadows Consulting	32
Thirlmere Way Overbridge Surveys	Meadows Consulting	31
Thirlmere Way Overbridge Visual Inspections	SBPS	66
Myrtle Creek Culvert Surveys	Meadows Consulting	51
Myrtle Creek Culvert Visual Inspections	SBPS	46
Tiltmeter and Extensometer Surveys	GHD	53
Sub-Total		**796**
Agility - Gas		
Remembrance Drive Bridge Surveys	Lean & Hayward	1
Sub-Total		**1**
Sydney Water - Sewer		
Sewer Main Surveys	Lean & Hayward	121
Sewer Pumping Station Surveys	Lean & Hayward	35
Visual Inspections	SBPS	40
Sub-Total		**196**
Integral Energy - Electrical		
Power Pole Surveys	Lean & Hayward	40
Sub-Total		**40**
Telstra - Telecommunications		
Visual Inspections	Colin Dove	87
Sub-Total		**87**
Tahmoor Town Centre		
Building Surveys	Lean & Hayward	49
Visual Inspections	SBPS	232
Sub-Total		**281**
Structure Inspections		
Public Amenities / Commercial District	SBPS	1054
Houses and Units	SBPS	3664
Pools and Pool Gates	SBPS	1879
Dams	GeoTerra	49
Sub-Total		**6646**
Inghams		
Ground Surveys	Lean & Hayward	120
Visual Inspections	SBPS	21
Sub-Total		**141**
Wollondilly Shire Council		
Castleregah St Bridge	Lean & Hayward	40
Castleregah St Bridge Visual Inspections	SBPS	239
Bridge St Culvert	Lean & Hayward	24
Bridge St Culvert Visual Inspections	SBPS	61
Sub-Total		**364**
Total		**9439**

4.1. Summary of Impacts to Surface Features

A comparison between assessed and observed impacts to surface features is summarised in Table 4.1 below. The assessed and observed impacts to surface features compare reasonably well, with the exception of locations where non-systematic movements have occurred.

Table 4.1 Summary of Predicted and Observed Impacts during Longwall 25

Surface Feature	Predicted Impacts	Observed Impacts
Natural Features		
Bargo River	Potential cracking and uplift of river bed. Potential for observable loss of flow and pool level reduction Potential reduction in water quality Potential for transfer of water to shallow groundwater system Please refer report by Geoterra.	No cracks or uplift observed. No loss of stream flow or pool level reductions observed. No observable reduction in quality No transfer of water to shallow groundwater observed. Please refer report by Geoterra and Section 4.2.
Myrtle Creek and Redbank Creek	Potential cracking in creek bed. Potential surface flow diversion. Potential reduction in water quality during times of low flow. Potential increase in ponding.	Localised cracking and limited short term surface flow diversion observed in bedrock in Myrtle Creek at four locations. No increased ponding or impacts to water quality observed. Limited short term surface flow diversion observed in bedrock in Redbank Creek at one location. No increased ponding or impacts to water quality observed. Please refer report by Geoterra and Section 4.3.
Aquifers or known groundwater resources	Potential for enhanced groundwater seepage from the cliffs Temporary lowering of piezometric surface by up to 10m which may stay at that level until maximum subsidence develops Groundwater levels should recover with no permanent post mining reduction in water levels in bores on the plateau unless a new outflow path develops No permanent reduction in groundwater levels under the Bargo River Please refer report by Geoterra.	No subsidence effects have been observed in bores during the mining of Longwall 25. Most of the bores are located outside of the limit of vertical subsidence, though P3 is located over the LW25/26 chain pillar. No indication of any adverse breaching or interconnection between the Hawkesbury Sandstone and Bulgo Sandstone, through the Bald Hill Claystone or any other aquitards during the extraction of Longwalls 22 to 25. No generation or alteration of groundwater seep flow volumes or water quality in Myrtle or Redbank Creek has been observed. No adverse change to groundwater quality has been observed, along with no distinctive increase in salinity, iron or manganese. Please refer report by Geoterra.
Steep slopes and cliffs	Potential soil slippage and cracking to slopes. Large scale slope failures or cliff instabilities unlikely.	No impacts observed during Longwall 25.
Natural vegetation	No impacts anticipated	No impacts observed during Longwall 25.
Public Utilities		
Railway	Bridges will remain safe and serviceable with management plans in place.	Railway maintained in safe and serviceable condition during mining. Refer to Section 4.4 for further details.

Surface Feature	Predicted Impacts	Observed Impacts
Roads and Bridges (all types)	Minor cracking and buckling may occur in isolated locations. Bridges will remain safe and serviceable with management plans in place.	Cracks and buckling in pavement and kerbs in isolated locations along most streets located directly above the longwall. A hump formed on Abelia St and roundabout at the intersection of Remembrance Drive and Thirlmere Way. These impacts were greater than previously experienced. Refer Section 4.5 for further details.
Water pipelines	Minor impacts possible to pipelines, particularly older cast iron pipes with lead joints.	A water leak occurred on York St opposite the Tahmoor Town Centre. Refer Section 4.6 for further details.
Gas pipelines	Ground movements unlikely to adversely impact pipelines if systematic movement occurs.	No impacts observed during Longwall 25. Refer Section 4.7 for further details.
Sewer pipelines	Mining induced tilt may reduce grade of some pipes to less than that required for self-cleansing. Cracking to pipes and joints is unlikely if systematic movement occurs. Potential impacts at creek crossings where non-systematic movement is expected.	No blockages or reversals of grade observed. Physical damage to pipes on Abelia St, Remembrance Dr and horizontal bore behind Amblecote Pl. No impacts to rising mains, pumping station or creek crossings. Refer Section 4.8 for further details.
Electricity transmission lines or associated plants	Ground movements unlikely to adversely impact electrical infrastructure if systematic movement occurs.	Adjustment to tension of aerial power cables on Abelia St and Janice St. Refer Section 4.9 for further details.
Telecommunication lines or associated plants	Ground movements unlikely to adversely impact telecommunications infrastructure if systematic movement occurs. Most vulnerable cables are older cables such as air pressurised lead sheathed cables. Strains may be higher where cables connect to support structures or where affected by tree roots.	Adjustment to tension of aerial telecommunications cables on Abelia St and Janice St. Damage to conduit on north-western abutment of the Castlereagh St Bridge. Refer Section 4.10 for further details.
Public Amenities	Potential impacts to public amenities, particularly to shops along Remembrance Drive. All public amenities expected to remain safe and serviceable due to the mining of Longwall 25.	All public amenities remained safe and serviceable due to the mining of Longwall 25. Impacts to 10 public amenity buildings, mainly consisting of shops along Remembrance Dr plus one place of worship. Refer Section 4.13 for further details.
Farmland and Facilities		
Farm buildings or sheds	Negligible to slight impacts predicted for all farm buildings and sheds if systematic movement occurs.	No impacts observed during Longwall 25.
Fences	Potential for impacts to fences and gates.	Impacts reported to fences on three farm properties during Longwall 25.
Farm dams	Potential adverse effects on dam walls and storage capacity. Please refer report by Geoterra.	No impacts observed during Longwall 25. Please refer report by Geoterra.
Wells or bores	No registered usage within SMP Area. Please refer report by Geoterra.	No impacts observed during Longwall 25. Please refer report by Geoterra
Industrial, Commercial or Business Establishments	Negligible to slight impacts predicted for all business and commercial establishments.	All industrial, commercial and business establishments remained safe and serviceable due to the mining of Longwall 25. Impacts reported to shops during Longwall 25. Refer Section 4.14 for further details.

Areas of Archaeological or Heritage Significance	Negligible to very slight impacts predicted for items of heritage significance.	No impacts observed during Longwall 25.

Surface Feature	Predicted Impacts	Observed Impacts
Permanent Survey Control Marks	Ground movement predicted at identified survey marks.	Ground movement occurred.
Residential Establishments		
Houses, flats or units	All houses expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some houses. Refer Section 4.12 for details.	All houses were safe, serviceable and repairable during Longwall 25. In six cases, however, it was agreed to rebuild the house as the cost of repair exceeded the cost of rebuilding. Refer Section 4.12 for details.
Retirement or aged care villages	All dwellings expected to remain safe, serviceable and repairable provided that they are in sound condition prior to mining. Impacts predicted to some dwellings.	No new impacts reported to dwellings during Longwall 25, though two impacts reported in relation to external pavements.
Swimming pools	While predicted tilts are not expected to cause a loss in capacity, tilts are more readily noticeable in pools as the height of the freeboard will vary along the length of the pool. While predicted strain impacts are low, many of the pools are inground, which are more susceptible.	Impacts to 18 pools during the mining of Longwalls 22 to 25, of which 7 pools were reported with impacts during the mining of Longwall 25.
Associated structures such as workshops, garages, on-site wastewater systems, water or gas tanks or tennis courts	Potential impact to pipes connected to inground septic tanks. Negligible impacts predicted for non-residential domestic structures, including sheds and tanks.	Impacts to associated structures were reported by four properties during Longwall 25.
External residential pavements	Cracking and buckling likely to occur, though majority minor.	Impacts to external pavements were reported by 27 properties during Longwall 25.
Fences in urban areas	Some fences and gates could be slightly damaged. Most vulnerable are Colorbond fences.	Impacts to fences reported by 12 urban properties during Longwall 25

4.2. Bargo River Gorge

4.2.1. Water Quality and Flow Impacts

Geoterra undertook an investigation into the effects of Longwall 25 on surface and ground waters in the area (Geoterra, 2011). Geoterra reported no observed subsidence effects in regard to stream bed cracking, changes in pool depth or storage, groundwater seeps or river flow up to the extraction of Longwall 25.

Geoterra advises that there has been no observable adverse effect on stream water quality due to subsidence following extraction of Longwall 24A and Longwall 25 have been observed in the Bargo River.

Field inspections, monitoring and laboratory analyses conducted to date have shown no increase in the seepage volume, iron hydroxide precipitation or changes in other monitored water quality parameters within any pool containing a ferruginous groundwater seep within or outside the SMP area, either before or since Longwall 24A and Longwall 25 was extracted.

No rock falls were observed during the mining of Longwall 25.

4.3. Creeks

4.3.1. Myrtle Creek

Geoterra undertook an investigation into the effects of Longwall 25 on surface and ground waters in the area (Geoterra, 2011).

Overall, there has been no adverse effect on stream flow, water quality and bed or bank stability in Myrtle Creek or the small unnamed gullies over the subsided longwalls during the monitoring period.

Subsidence within the creek has generated limited short term exposed sandstone stream bed cracking or isolated exposed sandstone through flow in four locations over Longwalls 22, 23B and 25, along with soil cracks in the upper banks and flanks over Longwall 23B. Three areas of isolated cracking of exposed sandstone in the base or sides of generally dry pools were observed above Longwall 25.

To date, outside of the isolated, limited and short term effects on pooled water in the exposed, cracked sandstone sites, no adverse effect on stream flow in Myrtle Creek has been observed, and no new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 25. No observable adverse effects on stream water quality due to subsidence following extraction of Longwalls 22 to 25 have been observed in Myrtle Creek.

4.3.2. Redbank Creek

Geoterra (2011) reports that overall, there has been no adverse effect on stream bed stability, steam bank stability or water quality in Redbank Creek during the monitoring period.

Subsidence within the creek has generated limited short term flow diversion through exposed sandstone at one location above Longwall 25. One isolated, 6 metre long section of exposed sandstone in Redbank Creek was observed to have a short term reach of through flow, however, no cracks were observed in the sandstone and no change in water quality or generation of ferruginous seepage has been observed.

4.4. Main Southern Railway

4.4.1. Railway track

While changes were observed, the Main Southern Railway remained serviceable at all times during the mining of Longwall 25. No reductions in speed limits were required. The track condition has deteriorated slightly as a result of mining and resurfacing will likely be required in the future.

During the mining of Longwall 25 some of the triggers associated with the *Tahmoor Colliery Longwall 25, Surface Safety Serviceability and Management Plan for Longwall Mining under the Main Southern Railway (Rev 5.2, February 2009)* were exceeded.

With respect to rail stress triggers, while some low level (Blue) alarms were triggered during mining, the causes of the alarms were mainly associated with rail maintenance issues or high rail temperatures with nil or only minor contributions from subsidence movement.

With respect to switch displacement triggers, while some low level (Blue) alarms were triggered as a result of subsidence, responses had already been planned in anticipation of the alarm.

4.4.2. Myrtle Creek Culvert

While changes were observed, the Myrtle Creek Culvert remained serviceable at all times during the mining of Longwall 25. The culvert structure has moved largely as a rigid body during mining.

During the mining of Longwall 25 some of the triggers associated with the *Tahmoor Colliery Longwall 25, Surface Safety Serviceability and Management Plan for Longwall Mining under the Main Southern Railway (Rev 5.2, February 2009)* were exceeded.

The low level (Blue) trigger for more than 2 mm vertical opening of the culvert was exceeded during mining. This trigger was revised by the Rail Management Group to 4 mm in light of the observation of seasonal changes of the ribs over time.

4.4.3. Thirlmere Way Overbridge

No impacts were observed to the Bridge, as expected, following extensive strengthening works undertaken by Tahmoor Colliery prior to commencement of Longwall 24B. No triggers were exceeded.

4.5. Roads and Bridges

4.5.1. Roads

Approximately 16.7 kilometres of asphaltic pavement lie directly above the extracted longwalls and a total of 33 impact sites have been observed. The observed rate of impact equates to an average of one impact for every 500 metres of pavement.

The impacts to road pavement and kerbs were generally similar to previous experiences during the mining of Longwalls 22 to 24 in frequency and extent. It is noted, however, that the severity of impacts at Abelia Street (hump in pavement) and at the corner of Remembrance Drive and Thirlmere Way (hump in roundabout) were greater than previously experienced. The impacts have been recorded by the MSB and have been repaired.

Abelia Street

Remembrance Drive

Progress Street

Tickle Drive

Photographs courtesy of Colin Dove

Fig. 4.1 Photographs of Impacts to Road Pavements and Kerbs during Longwall 25

4.5.2. Castlereagh Street Bridge

Valley closure across Castlereagh Street Bridge was greater than predicted. Prior to reaching the Blue trigger for the bridge brackets, adjustments were made to the brackets to reduce the load on the brackets and deck. There is currently a small air gap between the abutment walls and the bracket supports so that there is no pressure on the brackets, abutments or bridge deck.

The resistance of the bridge structure to closure has resulted in compressive heaving in the road pavement on the southern side of the bridge. Existing cracks on the southern abutment have been observed to extend slowly during mining, particularly at the interface between the abutment and south-eastern wing wall. These impacts have been repaired.

4.6. Potable Water Infrastructure

Longwalls 22 to 25 have directly mined beneath approximately 3 kilometres of DICL pipe and 7.2 kilometres of CICL pipe, with only one noticeable impact recorded. This was a leak in a cast iron water main on Glenanne Place in June 2007 during the mining of Longwall 24A. A very small number of minor leaks have been observed to consumer connection pipes on private properties

A water leak was also observed on York Street opposite the Tahmoor Town Centre during the mining of Longwall 25. The cause of the leak is currently unknown. While no impacts were reported to the road pavement and no elevated ground strain was observed at the leak, a bump was observed in the subsidence profile near the location of the leak.

4.7. Gas Infrastructure

It is noted that Longwalls 22 to 25 have directly mined beneath approximately 10.3 kilometres of gas pipes and no impacts have been recorded so far.

In response to the observation of increased subsidence and curvature along Remembrance Drive, subsidence monitoring and enhanced gas patrols were undertaken along the streets during mining in accordance with the *Tahmoor Colliery Longwalls 25 to 26 Jemena Asset Management Surface Safety Serviceability and Management Plan (Rev F).*

4.8. Sewer Infrastructure

Longwalls 22 to 25 have directly mined beneath approximately 12.4 kilometres of sewer pipes. The following observations have been made:

- *Changes to grades of self-cleansing gravity sewers*
  While changes in sewer grades have occurred as a result of mine subsidence, no blockages or reversals of grade have been observed.
- *Physical damage to pipes*
  There were no observations of damage during the mining of Longwalls 22 to 24. Physical damage has been observed during the mining of Longwall 25. Damage was observed in three locations. In each case the pipes have remained serviceable, though repairs are required at each location.
    - Crushing and vertical bending of 150 mm diameter pipe at Abelia Street, at the location shown in Fig. 4.2. The impacts coincide with a large measured ground strain of 4.6 mm/m (over a 22 metre bay length) between Pegs A12 and A13, a measured vertical bump in the subsidence profile and an observed hump in the road pavement.
    - Crushing and vertical bending of 150 mm diameter pipe at Remembrance Drive, at the location shown in Fig. 4.2. The impacts coincide with a large measured ground strain of 2.8 mm/m (over a 37 metre bay length) between Pegs R1 and RE1, a measured vertical bump in the subsidence profile and an observed hump in the road pavement and roundabout.
    - Crushing and vertical bending of the 225 mm diameter horizontal bore between Amblecote Place and Myrtle Creek, at the location shown in Fig. 4.3. There is no monitoring line above this bore.
- *Rising mains*
  No impacts have been observed to rising mains. This includes the rising main that runs from the pumping station SP1045 at Castlereagh Street, which is located directly above Longwall 25.
- *Sewer Pumping Station SP1045 at Castlereagh Street*
  Longwall 25 has mined directly beneath the pumping station. No impacts were observed. While the pumping station experienced differential movements, they were well below trigger levels.
- *Sewer Creek Crossings at Myrtle Creek*
  A 225 mm diameter sewer main crosses Myrtle Creek at two locations directly above Longwall 24B. While closure between the pit lids has been measured, no impacts have been observed from CCTV investigations of the pipes.

The observed impacts to date have been within expectations.

Fig. 4.2 Location of Sewer Impacts at Abelia Street and Remembrance Drive

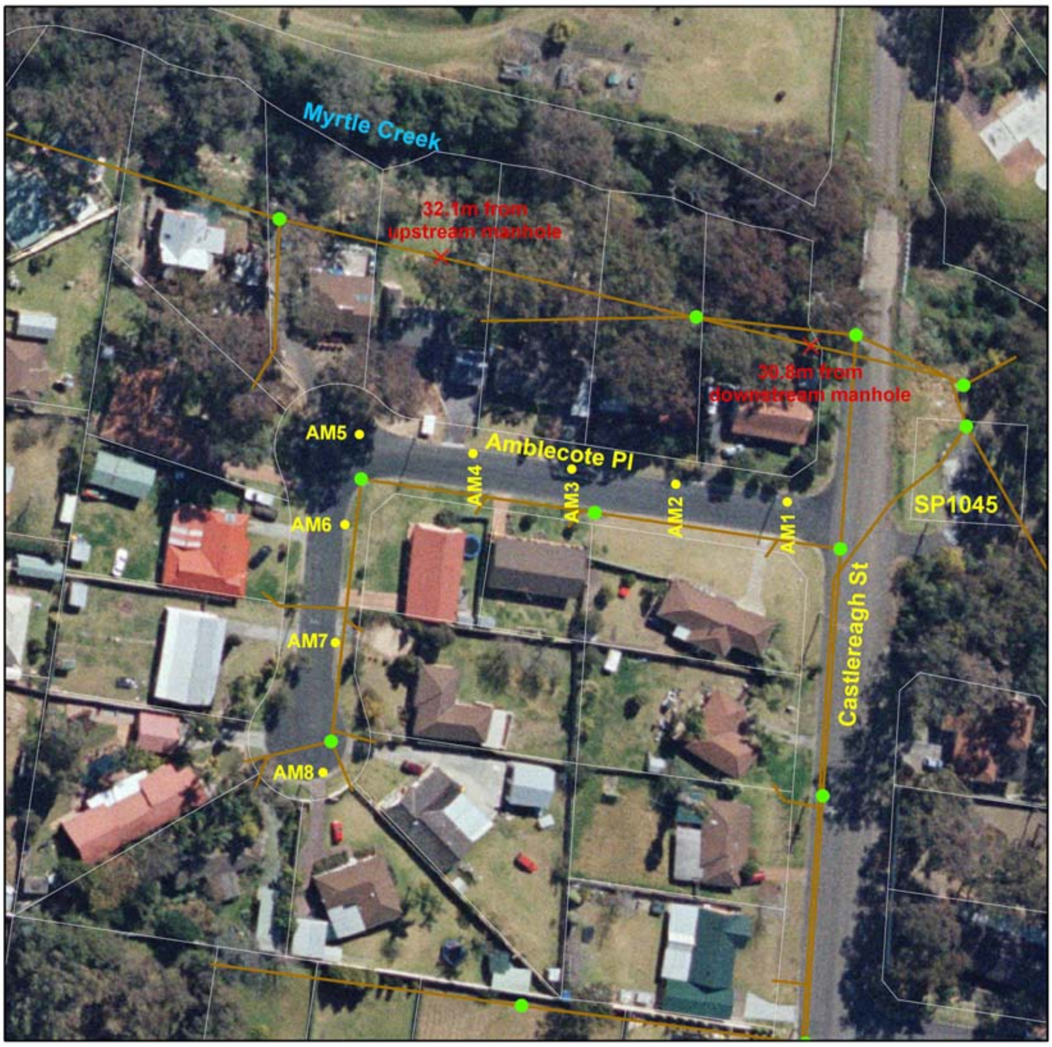


Fig. 4.3 Location of Sewer Impacts along Horizontal Bore near Amblecote Place

4.8.1. Exceedance of Defined Triggers

During the mining of Longwall 25 a number of the triggers associated with the *Tahmoor Colliery Longwall 25 to 26, Sydney Water Sewer Infrastructure, Surface Safety Serviceability and Management Plan (Rev F, September 2008)* were exceeded. These were:

- Observation of physical impacts to pipes on Abelia Street, Remembrance Drive and Amblecote Place
- Closure between pits across Myrtle Creek

Actions were undertaken in accordance with the management plans, usually before the triggers were exceeded.

4.9. Electrical Infrastructure

Longwalls 22 to 25 have directly mined beneath approximately 22.4 kilometres of electrical cables and 667 power poles and no impacts have been recorded to electrical supply so far. However, tension adjustments have been made by Integral Energy to some aerial services connections to houses, including along Abelia St and Janice St during the mining of Longwall 25. This is understandable as the overhead cables are typically pulled tight between each house and power pole.

4.10. Telecommunications Infrastructure

Longwalls 22 to 25 have directly mined beneath approximately 30.2 kilometres of buried copper cable and 1.2 kilometres of buried optical fibre cable and 3.3 kilometres of aerial cable and no impacts have been recorded to telecommunications services so far.

During the mining of Longwalls 22 to 24B some aerial consumer lines were retensioned as a precautionary measure and air leakage occurred on an old lead main copper cable in conduit at two locations on Thirlmere Way during the mining of Longwall 22. The impacts on the old lead cable are only the second known impact to such a cable during mining in the Southern Coalfield.

During the mining of Longwall 24A there was tilting of poles supporting the aerial cable network in the residential area of Tahmoor, around Courtland Avenue, Pandora Place, Tanya Place, Lintina Street and Mitchell Close. The movement of the poles created excess sag and tension within the aerial distribution network. Telstra, in consultation with the MSB, adjusted the cable tensions where necessary, to prevent loss of service, and where aerial cables crossed streets, reduce hazard to traffic.

Similar adjustments were required during the mining of Longwall 25 along Abelia St and Janice St. Damage was also observed to a conduit on the north-western abutment of the Castlereagh St Bridge. The major Inter Exchange Network optical fibre and main copper cables were not impacted by Longwall 25.

4.11. Inghams Infrastructure

No impacts were reported to Inghams Infrastructure during the mining of Longwall 25.

4.12. Residential Establishments and Public Amenities

All structures remained safe and serviceable during the mining of Longwall 25. In six cases, however, it was agreed to rebuild the house as the cost of repair exceeded the cost of rebuilding. In some cases, works were undertaken by the Mine Subsidence Board (MSB) to maintain safety and serviceability during mining.

A register of observed impacts is based on claims received from the MSB. Information on the nature of the impacts was provided by the MSB and Sunrise Property Building Services, who inspect impacted structures on behalf Tahmoor Colliery. The register was updated on a weekly basis and the statistics provided in this report are based on impacts recorded up to the week ending 27 March 2011, three days before the commencement of Longwall 26.

Information on the nature of impacts to each structure has been collected in the following manner:

- Initial details of claim as supplied by the MSB on a weekly basis
- Photographs taken during claim inspections by the MSB
- Site visits to selected properties in company with MSB representatives
- Inspection contained in claim files held by the MSB

A summary of reported impacts following the completion of Longwall 25 is provided in Table 4.2. The count of residential structures and public amenities includes only those structures that were predicted to experience more than 20 mm of subsidence due to the extraction of Longwalls 22 to 25.

Table 4.2 Summary of Observed Impacts to Structures

	Total after Longwalls 22 to 25	Increment during Longwall 25
Number of structures within zone of influence (predicted subsidence > 20 mm)	1366	1238
Number of properties with reported impacts (not including refused claims)	331	182
Number of properties with reported impacts that relate to main structures (e.g. house or shop)	298	162
Number of properties with reported impacts that only relate to associated structures	33	20

The above information can be misleading as almost a third of claims received during the mining of Longwall 25 were associated with the previous mining of Longwalls 22 to 24A. This is due to time lag between the actual impact and the claim of an impact by residents to the Mine Subsidence Board.

This is illustrated by a spatial plot of locations of impacts reported during the mining of Longwall 25 in Fig. 4.4. A total of 59 of 182 claims related to the mining of Longwalls 22 to 24A, rather than the active Longwall 25.

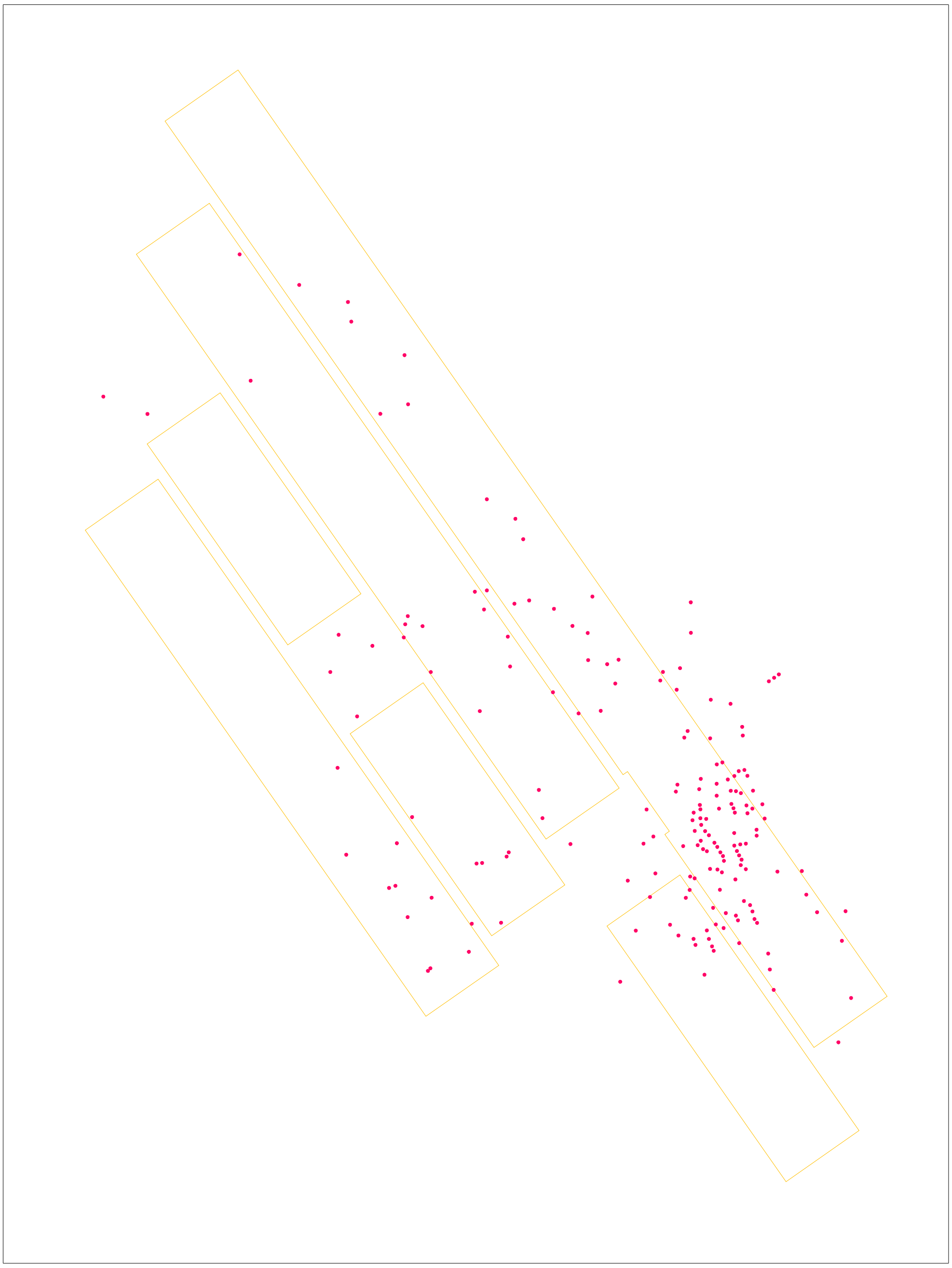


Fig. 4.4 Locations of Impacts Reported during the Mining of Longwall 25

Observed impacts have been classified in accordance with the impact classification tables provided in the SMP Report. Strain impacts are classified generally in accordance with Table C.1 of the Australian Standard AS2870 – 1996, although the classification was extended to include a Category 5, which corresponds to the Very Severe Damage Category of the UK National Coal Board Classification.

Australian Standards AS2870 advises that crack width is the main factor by which damage to walls is categorised. Predicted crack width was also the method by which impact assessments were conducted. Crack width has therefore been used for the purposes of classifying strain impacts to residential structures.

Predictions and impact assessments for residential structures and public amenities were provided in the SMP Report No. MSEC157. Predictions and assessments focussed on two separate types of subsidence movements: normal systematic subsidence movements and non-systematic movements. Detailed impact assessments were provided for each individual house on the basis that normal systematic movements would occur. The potential for impacts from non-systematic subsidence movements were discussed separately and no specific predictions were provided. Areas that are considered to have experienced non-systematic movements were identified in Section 2.1.4.

4.12.1. Comparison in General

A comparison between observed and assessed impacts is provided in Table 4.3.

Table 4.3 Comparison between Observed and Assessed Impacts in General

	Assessed Total No. of Structures	Observed Total No. of Structures
	Tilt Impacts	
No impact to house or civil structure	0	1068
Tilt Impact Category A	1351 systematic +/- unspecified non-systematic	290
Tilt Impact Category B	15 systematic +/- unspecified non-systematic	6
Tilt Impact Category C	0 systematic +/- unspecified non-systematic	1
Tilt Impact Category D	0 systematic +/- unspecified non-systematic	1
Total	**1366**	**1366**
	Strain Impacts	
No impact to house or civil structure	0	1068
Strain Impact Category 0	738 systematic +/- unspecified non-systematic	187
Strain Impact Category 1	578 systematic +/- unspecified non-systematic	50
Strain Impact Category 2	50 systematic +/- unspecified non-systematic	32
Strain Impact Category 3	0 systematic +/- unspecified non-systematic	12
Strain Impact Category 4	0 systematic +/- unspecified non-systematic	7
Strain Impact Category 5	0 systematic +/- unspecified non-systematic	10
Total	**1366**	**1366**

Notes:
"Systematic" refers to impacts assessed based on predictions of systematic subsidence movements, as described in Section 3.17.1.1 of SMP Report No. MSEC157.
"Non-systematic" refers to the predicted potential for impacts to structures from non-systematic subsidence movements, as described in Section 3.17.1.4 of SMP Report No. MSEC157.

A discussion of the above comparison is provided in Section 4.12.3.

4.12.2. Comparison Based on Predicted Impact Categories

A comparison has been made between observed and assessed impacts on a structure by structure basis for Strain Impacts only. The comparison is based on assessed up to 27 March 2011. A summary is provided in Table 4.4.

Table 4.4 Summary of Comparison between Observed and Assessed Impacts for each Structure

Strain Impact Category	Total No. of Observed Impacts for Structures assessed to be Strain Impacts Category 0	Total No. of Observed Impacts for Structures assessed to be Strain Impacts Category 1	Total No. of Observed Impacts for Structures assessed to be Strain Impacts Category 2	Total
No Impact	631	405	32	**1068**
Cat 0	61	117	9	**187**
Cat 1	20	27	3	**50**
Cat 2	16	13	3	**32**
Cat 3	2	8	2	**12**
Cat 4	4	2	1	**7**
Cat 5	4	6	0	**10**
Total	**738**	**578**	**50**	**1366**
% Claim	**14.8**	**29.76**	**36**	
% Obs > Pred	**6.2**	**5.0**	**6.0**	
% Obs < = Pred	**93.8**	**95.0**	**94.0**	

Note: Predicted impacts due to systematic subsidence only, as per Section 3.1.7.1.1 of SMP Report No. MSEC157.

4.12.3. Discussion of Results

Given that observed impacts were less than or equal to predicted impacts in 94 % of cases, it is considered that the current methods are generally conservative even though non-systematic movements were not taken into account in the predictions and assessments. However, when compared on a house by house basis, the predictions have been substantially exceeded in a small proportion of cases.

The majority, if not all, of the houses that have experienced Category 3, 4 or 5 impacts are considered to have experienced substantial non-systematic subsidence movements. The consideration is based on nearby ground survey results, where upsidence bumps are observed in subsidence profiles and high localised strain is observed. The potential for impact from non-systematic movements were discussed generally but not included in the specific impact assessments for each structure.

The inability to specify the number or probability of impacts due to the potential for non-systematic movements is a shortcoming of the current method. It is considered that there is significant room for improvement in this area and recommendations have been provided in a report following a review of predicted impacts on dwellings (Report No. MSEC361).

The comparison shows a favourable observation that the overall proportion of claims increased for increasing predicted impact categories. This suggests that the main parameters currently used to make impact assessments (namely predicted systematic strain derived from predicted curvature and maximum plan dimension of each structure) are credible.

The overall claim rate for main structures during the mining of Longwalls 22 to 25 was 22%.

Importantly, all structures have remained safe and serviceable throughout the mining period.

4.12.4. Swimming Pools

Impacts have been observed to seven swimming pools during to the mining of Longwall 25.

4.12.5. Associated Structures

Minor impacts have been observed on four structures during to the mining of Longwall 25.

4.12.6. Fences

The potential for impacts to fences was raised in the SMP Report and a total of 12 properties in urban areas have claimed impacts to gates and fences above Longwall 25.

4.13. Public Amenities

All public amenities have remained safe and serviceable throughout the mining period. A total of 10 public amenity structures experienced mine subsidence movements due to the mining of Longwall 25. All of the structures were located along Remembrance Drive. The majority of the structures comprise of relatively small shopfronts though one place of worship also experienced impacts. The large shopping centre, Tahmoor Town Centre, also experienced subsidence movements and discussion is provided separately in Section 4.14.

4.14. Tahmoor Town Centre

Tahmoor Town Centre remained safe and serviceable during the mining period. In some cases, works were undertaken by the Mine Subsidence Board (MSB) to maintain safety and serviceability during mining.

While the observed impacts were more numerous than were expected, the majority of the impacts were minor in nature and none seriously affected the structural integrity of the TTC buildings.

The columns of the petrol station awning experienced differential horizontal movements, resulting in unsightly bending of the columns. The awning location is roughly aligned with the measured increased compressive ground strains and surface bumps on Abelia Street and at the roundabout at the corner of Thirlmere Way and Remembrance Drive. The columns were re-set at their bases and this work resulted in the greatest inconvenience to the shopping centre.

5.0 SUMMARY OF RESULTS

There is generally a good correlation between observed and predicted subsidence, tilt and curvature for areas located between Remembrance Drive in Tahmoor and Thirlmere. Observed subsidence was generally slighter greater than predicted in areas that were located directly above previously extracted longwalls and areas of low level subsidence (typically less than 100 mm) where the subsidence was observed to extend further than predicted.

As anticipated following the mining of Longwall 24A, substantially increased subsidence has been observed above the southern end of Longwall 25. This was a very unusual event for the Southern Coalfield.

Maximum observed incremental subsidence from the mining of Longwall 25 was 1234 mm, which was almost double the maximum predicted subsidence of approximately 740 mm. While observed tilts and curvature were also substantially greater than predicted, observed ground strains were generally within the normal range.

Tahmoor Colliery has engaged a specialist in strata mechanics (SCT) to provide advice on possible causes of the increased subsidence. Current advice suggests a link with groundwater flows towards either the Bargo River or Nepean Fault.

Once it became apparent that increased subsidence had developed, Tahmoor Colliery revised its management plans prior to the extraction of LW25 to manage potential increased impacts to surface infrastructure before the longwall extracted beneath the urban area of Tahmoor.

While subsidence has substantially exceeded predictions in most locations at the commencing end of Longwall 25, there remains a reasonable correlation between observed and predicted impacts, particularly in relation to public infrastructure such as sewer mains, water mains, gas mains, and electrical and telecommunications infrastructure. Impacts to road pavements were similar in frequency compared to those observed during the mining of previous longwalls. The impacts to the road pavement on Abelia Street and at the roundabout at the intersection of Remembrance Drive and Thirlmere Way were, however, more severe than had been observed previously.

All structures remained safe and serviceable during the mining of Longwall 25. In six cases, however, it was agreed to rebuild the house as the cost of repair exceeded the cost of rebuilding. In some cases, works were undertaken by the Mine Subsidence Board (MSB) to maintain safety and serviceability during mining. The overall claim rate for main structures during the mining of Longwalls 22 to 25 was 22 %.

Given that observed impacts to structures were less than or equal to predicted impacts in 94 % of cases, it is considered that the current methods are generally conservative even though non-systematic movements were not taken into account in the predictions and assessments. However, when compared on a house by house basis, the predictions have been substantially exceeded in a small proportion of cases.

In relation to the Bargo Gorge, little to no measureable upsidence or closure has occurred across any of the monitoring lines across the Bargo Gorge during the mining of Longwall 25. The Gorge has experienced a small amount of subsidence in the order of 20 mm since the commencement of Longwall 24A. No physical, hydrological or water quality impacts were observed to the Bargo River.

In relation to Myrtle Creek, observed incremental valley closure movements due to the mining of Longwall 25 have exceeded predictions, particularly along the Elphin-Myrtle and Castlereagh-Myrtle monitoring lines. Observed upsidence is generally less than prediction, with substantial upsidence only detected along the Elphin-Myrtle monitoring line. While the exceedances of the predicted incremental closure during the mining of Longwall 25 are significant, observed total closures are much closer to prediction.

Overall, there has been no adverse effect on stream flow, water quality and bed or bank stability in Myrtle Creek or the small unnamed gullies over the subsided longwalls during the monitoring period. Cracks were observed in the bedrock of Myrtle Creek at isolated locations, three of which developed above Longwall 25. To date, outside of the isolated, limited and short term effects on pooled water in the exposed, cracked sandstone sites, no adverse effect on stream flow in Myrtle Creek has been observed, and no new springs have been generated, or reduced, due to subsidence due to the mining of Longwalls 22 to 25. No observable adverse effects on stream water quality due to subsidence following extraction of Longwalls 22 to 25 have been observed in Myrtle Creek.

There has been no adverse effect on stream bed stability, steam bank stability or water quality in Redbank Creek during the monitoring period. Subsidence within the creek has generated limited short term flow diversion through exposed sandstone at one location above Longwall 25. One isolated, 6 metre long section of exposed sandstone in Redbank Creek was observed to have a short term reach of through flow, however, no cracks were observed in the sandstone and no change in water quality or generation of ferruginous seepage has been observed.