SCT Operations Pty Ltd
ABN 23 078 328 953
www.sct.gs

HEAD OFFICE
Cnr Kembla & Beach Streets Wollongong NSW 2500 Australia
PO Box 824 Wollongong NSW 2520 Australia
Telephone: + 61 2 4222 2777 Fax: + 61 2 4226 4884
Email: sctnsw@sct.gs

EMERALD OFFICE
Telephone: +61 7 4987 4000 Fax: +61 7 4987 4035
Email: krixon@sct.gs

MACKAY OFFICE
Telephone/Fax: +61 7 4952 5717
Email: pcartwright@sct.gs

BENDIGO OFFICE
Telephone: +61 3 5443 5941
Email: smacgregor@sct.gs

13 February 2008

Shane Pegg
Technical Services Manager
Ashton Underground Mine
PO Box 699
SINGLETON NSW 2330

Dear Shane,

REVIEW OF LONGWALL 1 SUBSIDENCE MONITORING AND COMPARISON WITH PREDICTIONS

As requested, please find herein our review of the subsidence movements that have been monitored over Longwall 1 at Ashton Coal Mine and a comparison of these movements with the SMP predictions described in SCT Report ASH3084. A more detailed review of the horizontal movement vectors is currently in progress and will be reported separately in due course.

Our review indicates that subsidence behaviour above Longwall 1 at Ashton is consistent with supercritical subsidence behaviour. Subsidence movements have been less than the maximum predicted except for the tensile strains at the start of Longwall 1, which were 49mm/m compared to the 42mm/m predicted. The predicted and measured subsidence values are summarised as follows:

	Maximum Predicted	Maximum Measured	
North End of LW1		**CL2**	**XL8**
Subsidence (mm)	1800	1528	1500
Tilt (mm/m)	244	100	103
Horizontal Movement (mm)	500+	476	500
Tensile strain (mm/m)	73	40	15
Compressive strain (mm/m)	98	28	27
Remainder of LW1		**CL1**	**XL5**
Subsidence (mm)	1700	1318	1377
Tilt (mm/m)	141	60	75
Horizontal Movement (mm)	300-500	480	384
Tensile strain (mm/m)	42	49	24
Compressive strain (mm/m)	56	23	16

This comparison indicates that the vertical subsidence measured is within the range predicted. High levels of tilt and strain predicted at the north end of the panel did not eventuate because the rippling effect that has been observed in shallow cover at other sites did not develop. The measured tilt and strain values are therefore well within the predicted range.

Horizontal movements of up to 500mm were measured within the bounds of Longwall 1. These movements are somewhat unusual in that downslope movement does not appear to be dominating as it typically does. Horizontal movements observed on the subsidence lines located over the northern half of the panel indicate a tendency for movement in a north-easterly direction. This direction is both upslope and up dip. The reasons for this difference in behaviour are not clear, although it is noted that there was a 12m lead on the western side of the longwall face for much of the panel. This lead may be a contributing factor.

Horizontal movements outside of the longwall panel are generally less than 10-20mm. The largest horizontal movements (120mm) outside the goaf occurred over the start of Longwall 1, a phenomenon that is commonly observed at other sites. There does not appear to be any significant horizontal movement outside the longwall panels between Longwall 1 and Glennies Creek. Some movements that were observed at the eastern ends of several of the cross-lines (XL2-4) appear to be a result of survey error or localised ground movement in the very steep terrain in this area. These results do not indicate mass movement of the barrier between Glennies Creek and Longwall 1.

1. Introduction

Ashton Coal Mine has monitored the subsidence movements on the surface during the retreat of Longwall 1 on two longitudinal subsidence lines over the start and finish of the panel, seven cross-lines, mainly along the tailgate site of the panel, and a diagonal line extending from the corner of Longwall 1 to the New England Highway. This report presents the results of the subsidence monitoring and a comparison with predictions provided in Table 1 of SCT Report ASH3084 suitable to meet the end of panel reporting requirements of the Department of Primary Industries.

The report is structured to provide a brief description of the site, the monitoring undertaken, the key results and comparison with predicted behaviour. A more detailed presentation of the horizontal ground movements is currently being prepared and will be forwarded in due course.

2. Site Description

Figure 1 shows a plan of Longwall 1 and the location of the subsidence lines superimposed onto a 1:25,000 topographic series map of the area (updated with a diversion to the New England Highway and changes to minor roads made after the map was produced in 1982).

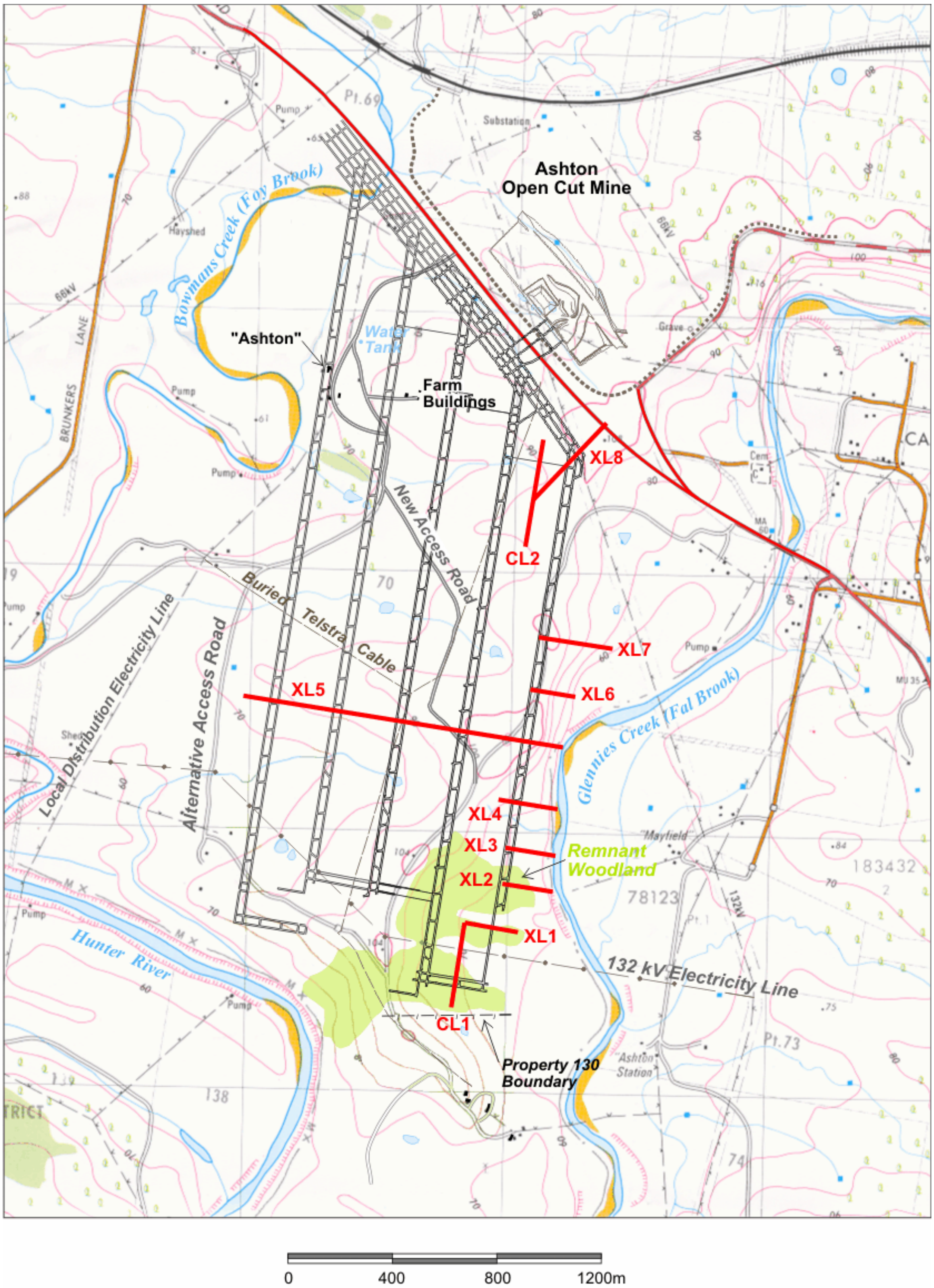


Figure 1 Site plan showing mine plan and location of the subsidence lines superimposed onto 1:25,000 topographic series map updated to reflect current infrastructure.

Figure 2 shows a plan of the overburden depth to the Pikes Gully Seam. The seam section mined ranges along the length of Longwall 1 from 2.6m at the start to 2.7m at the northern end of the panel. The seam dips to the south-west at a grade of up to about 1 in 10. The overburden depth ranges from 65m at the start of Longwall 1 to approximately 85m midway along the panel before decreasing to 35m at the northern end.

Longwall 1 created a final void that is nominally 216m wide. The chain pillars are nominally 25m wide rib to rib with cut-throughs at 100m centres.

3. Results of Subsidence Monitoring

In this section, the results of each of the subsidence lines monitored during the retreat of Longwall 1 are presented and discussed.

3.1 XL5

XL5 is the main cross-line over Longwall 1. The line is located midway along the panel. The overburden depth ranges 80-90m across the panel in this area.

Figure 3 shows a summary of the subsidence movements that have been measured. Sixteen resurveys were made, but only three are shown for clarity. Most of the later surveys indicate close to full subsidence.

The vertical subsidence profile measured is typical of the subsidence expected in a supercritical width panel. Maximum subsidence measured in the centre of the panel is 1377mm or 53% of seam thickness. Goaf edge subsidence is 2mm on the eastern side of the panel and 63mm on the western side. Angle of draw is -5° on the eastern side of the panel and 13° on the western side.

Maximum tilts measured were 75mm/m on the eastern side of the panel and 53mm/m on the western side.

Horizontal movements occur initially toward the approaching longwall face and then, soon after the face passes, the horizontal movements reverse direction causing a final offset in the direction of mining of approximately 250mm. Somewhat contrary to experience at other sites, the direction of the horizontal movements is partly upslope. The magnitude of the upslope cross-panel movement is approximately 250mm over the central part of the panel. The longwall face had up to 12m of lead on the western (maingate) side of the panel which may have contributed to some bias, but the reason for, or mechanics of, this behaviour is not clear.

Maximum strains are 24mm/m in tension and 17mm/m in compression with the peak tensile strain on the downslope side of the panel.

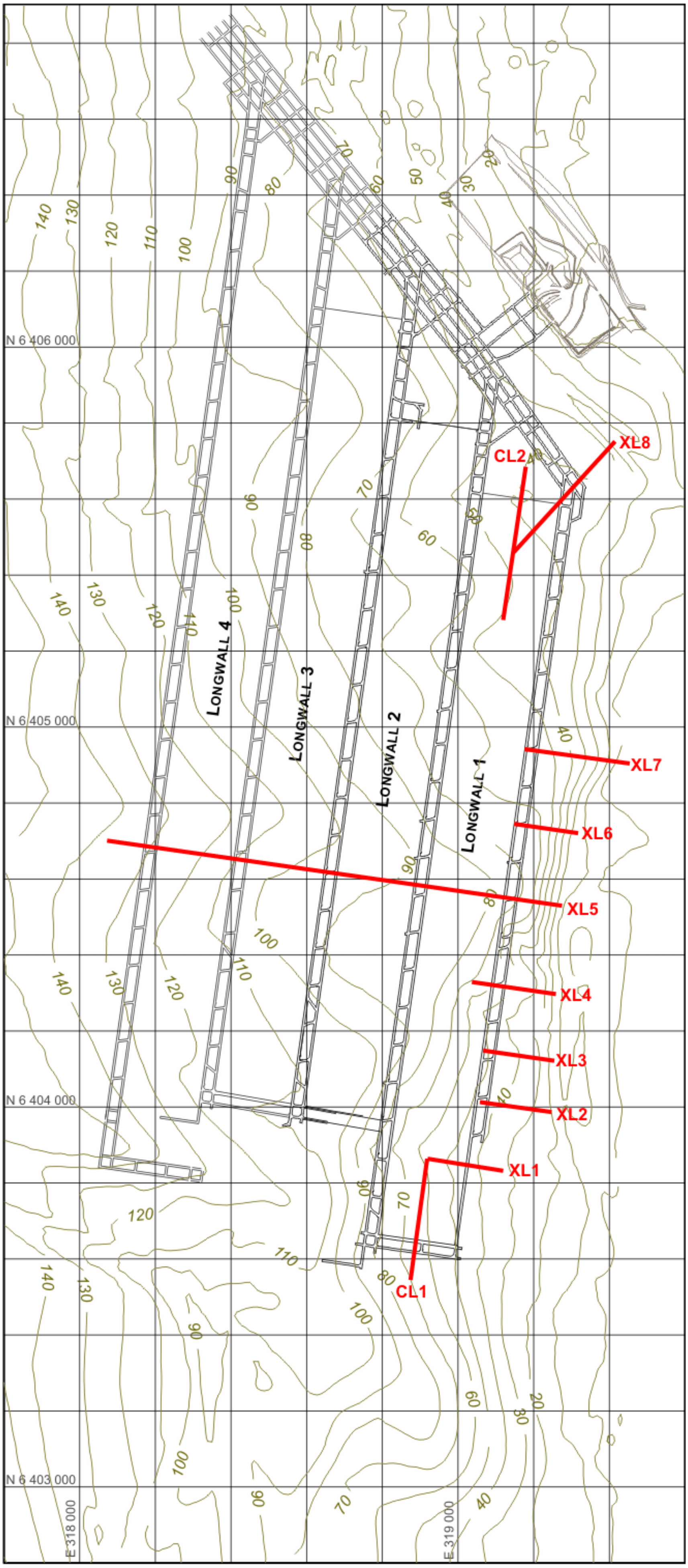


Figure 2 Overburden depth to the Pikes Gully Seam.

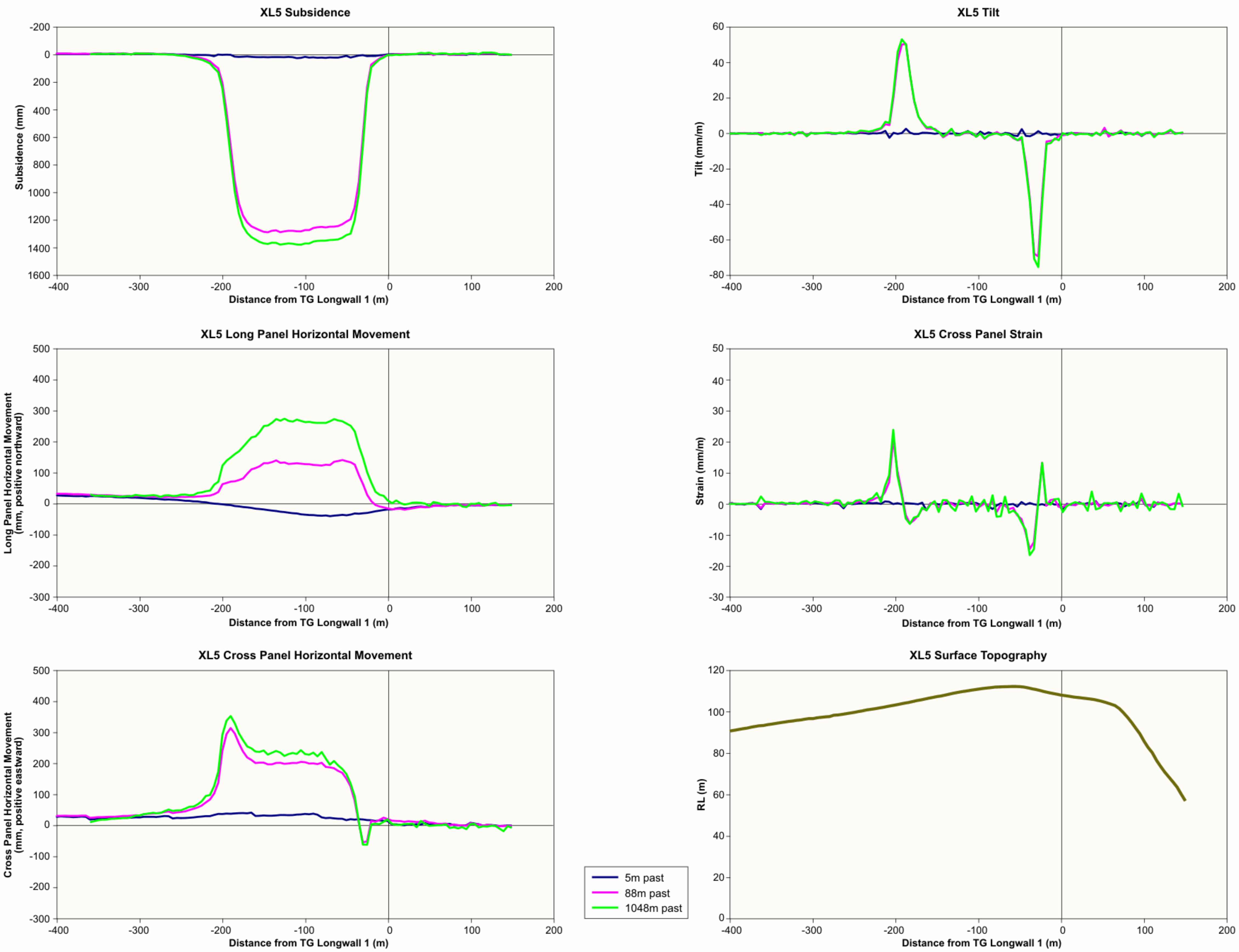


Figure 3 Summary of subsidence movements on Subsidence Line XL5.

3.2 CL1

Figure 4 shows a summary of the subsidence movements measured on the centreline subsidence line CL1 located over the start of the panel.

Vertical subsidence develops as the longwall panel commences and provides an indication of the caving characteristics of the overburden strata. This relationship is discussed in more detail in Section 5 of this report. The maximum subsidence measured on CL1 is 1318mm or 51% seam thickness. Goaf edge subsidence is 56mm and the angle of draw is 12°.

Maximum tilt occurs over the start line and reaches a peak of 60mm/m. Over the moving longwall face, the tilt peaks in the range 35-45mm/m.

Horizontal subsidence movements across the panel are relatively uniform with a magnitude of 200-250mm in an easterly and downslope direction. During the early stages of caving, the cross panel subsidence movements develop in proportion to the magnitude of vertical subsidence suggesting a correlation between the two. The long panel subsidence movements are initially symmetrical about the goaf. When the goaf is fully developed, initial movement is toward the void and then a reversal occurs leaving a final offset in the direction of mining of 150-250mm. Peak horizontal movement is approximately 450mm in the direction of mining. The horizontal movements extend back over the solid starting rib more than on any of the other goaf edge subsidence profiles. This behaviour is also observed over starting ribs at other sites.

Maximum horizontal strain along the panel reaches 49mm/m adjacent to the starting rib. Surface cracking and horizontal strains are typically highest in this area. Further along the panel, horizontal strain peaks are typically less than 10-20mm/m in both tension and compression.

3.3 CL2

Figure 5 shows a summary of the subsidence movements measured on CL2, a longitudinal subsidence line located on the centreline of Longwall 1 at the northern end of the panel.

Maximum vertical subsidence measured on CL2 is 1528mm. The vertical subsidence profiles develop regularly behind the longwall face, although there is significant variability in the shape of the individual profiles indicating that there is a local blockiness within the overburden strata. The goaf edge subsidence measured over the finish line is -14mm and the angle of draw is -8°. Such behaviour is commonly observed at shallow depth and is not readily transferable to locations where the overburden depth is greater.

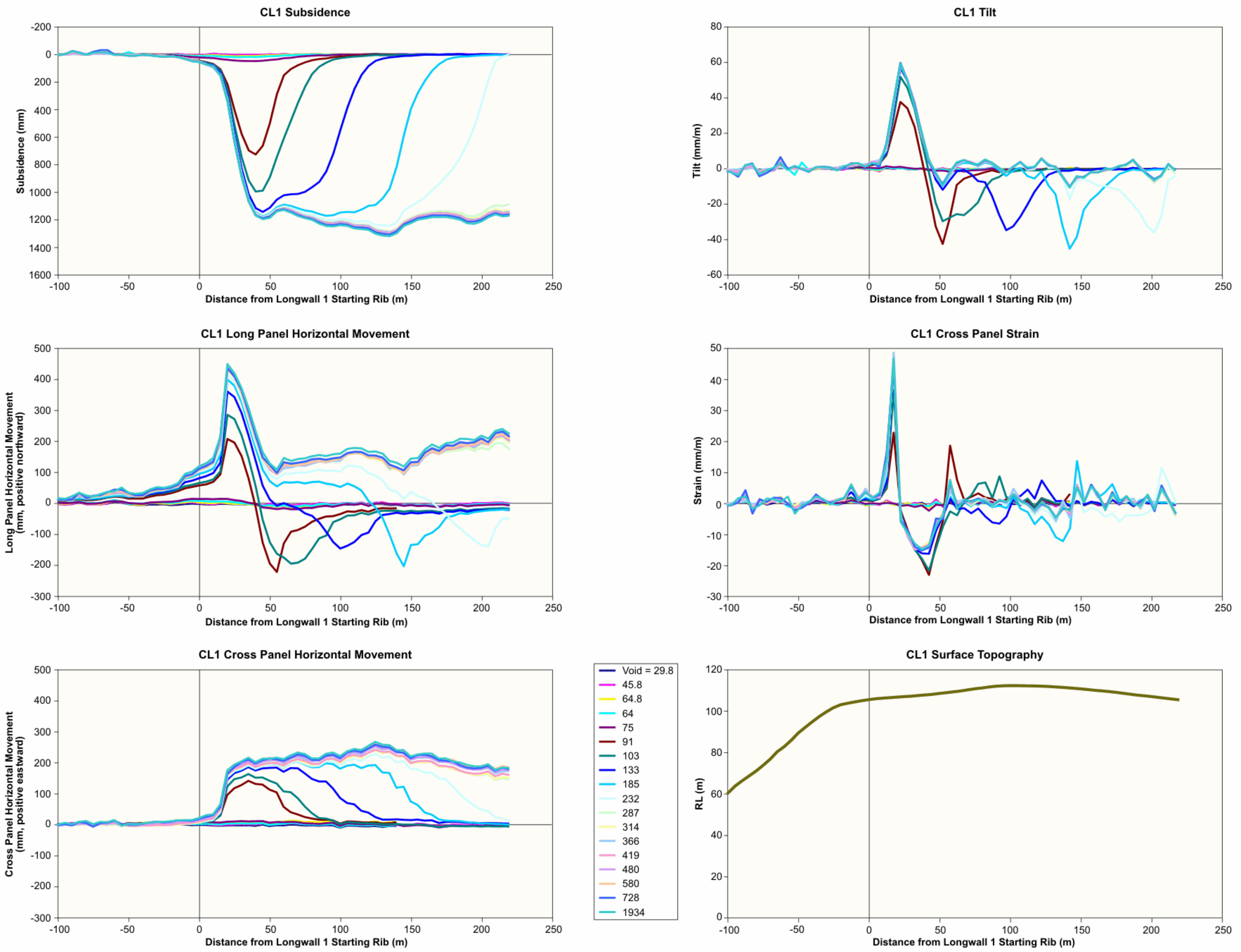


Figure 4 Summary of subsidence movements on Subsidence Line CL1.

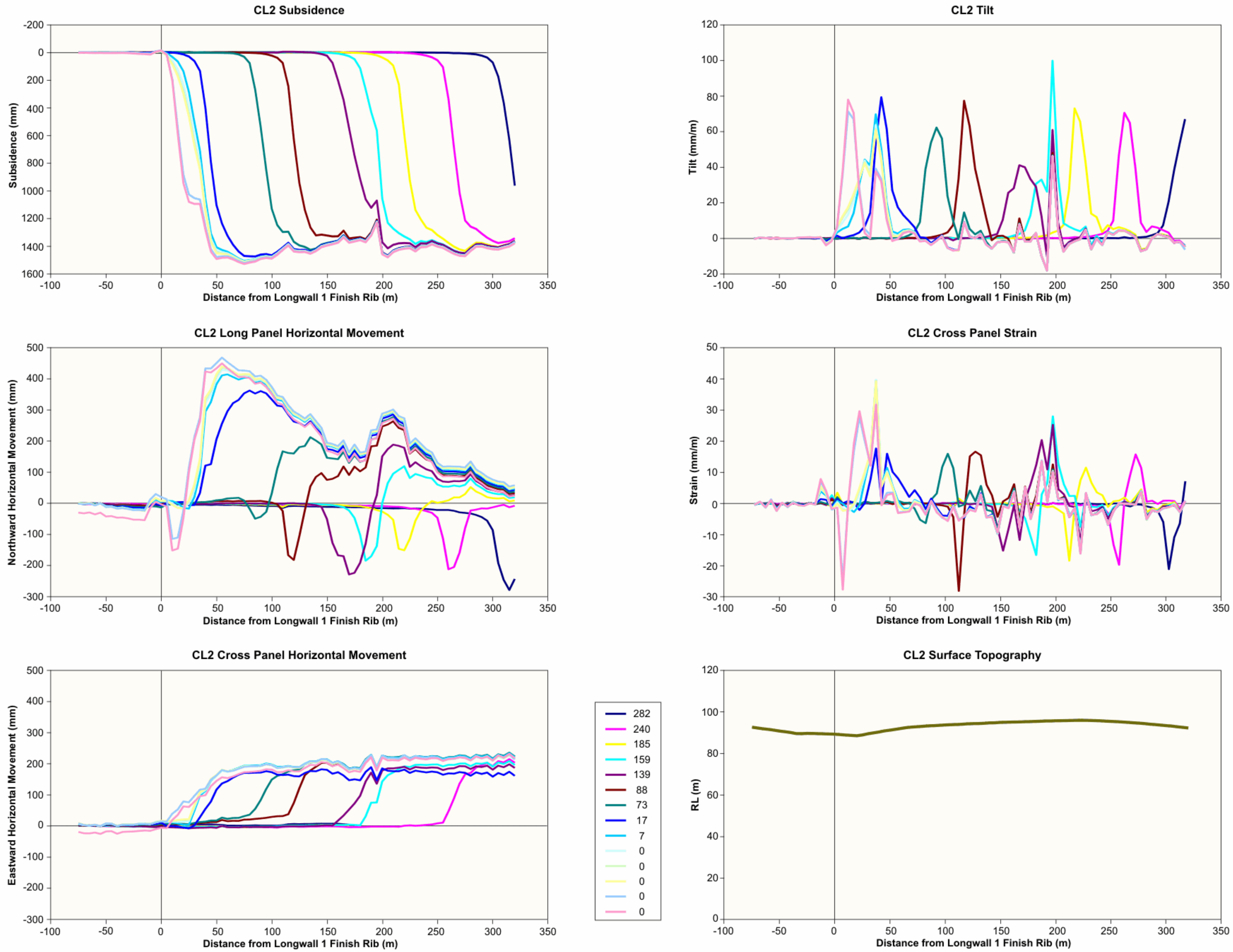


Figure 5 Summary of subsidence movements on Subsidence Line CL2.

Maximum tilt measured along CL2 is typically about 80mm/m, but there is a single peak of 100mm/m at approximately 200m from the end of the panel. This peak may be a result of a local geological structure or topographic effect such as a compression override.

Horizontal movements peak at 476mm. The cross-panel component is uniform at approximately 200mm. Surprising though, the direction of cross-panel movement is eastward, which is in a direction opposite to the ground slope. The longitudinal movements are more variable, with approximately 200mm initial movement toward the approaching longwall face and from 200mm to 500mm in a northerly direction when the longwall face has passed.

Maximum horizontal strains of 10-20mm/m in compression and 15-40mm/m in tension are measured.

3.4 XL8

XL8 is located diagonally off the north-east corner of Longwall 1. This line is intended to monitor any horizontal subsidence movements that may have potential to impact on the New England Highway. Figure 6 shows a summary of the subsidence movements measured on XL8.

The monitoring on XL8 indicates that, within the 10mm accuracy of the surveying, no movements have occurred outside the boundary of the Longwall 1 goaf. Figure 7 shows the horizontal movements monitored on this line outside of the goaf. A single survey on 7 November 2007 showed a uniform 20mm horizontal movement along the full length of the line after the longwall had finished, but five subsequent resurveys indicate that this result is anomalous, and it has been disregarded. Monitoring on XL8 indicates that no significant movement occurred outside the longwall panel and there was no movement at the New England Highway.

Maximum vertical subsidence of 1500mm is measured on XL8 over the longwall panel. Maximum tilt is 103mm/m, maximum tensile strain is 15mm/m, and maximum compressive strain is 27mm/m. The horizontal movements measured over the longwall goaf reach a maximum of 500mm, approximately 100m from the end of the panel. The direction of movement is slightly west of north.

3.5 XL1-7

Seven subsidence lines were set up perpendicular to Longwall 1 over the barrier between the panel and Glennies Creek. These lines were intended to monitor any horizontal movements that would indicate mass movement of the overburden strata and by implication formation of shear planes with potential to cause a change in the hydraulic conductivity of the barrier.

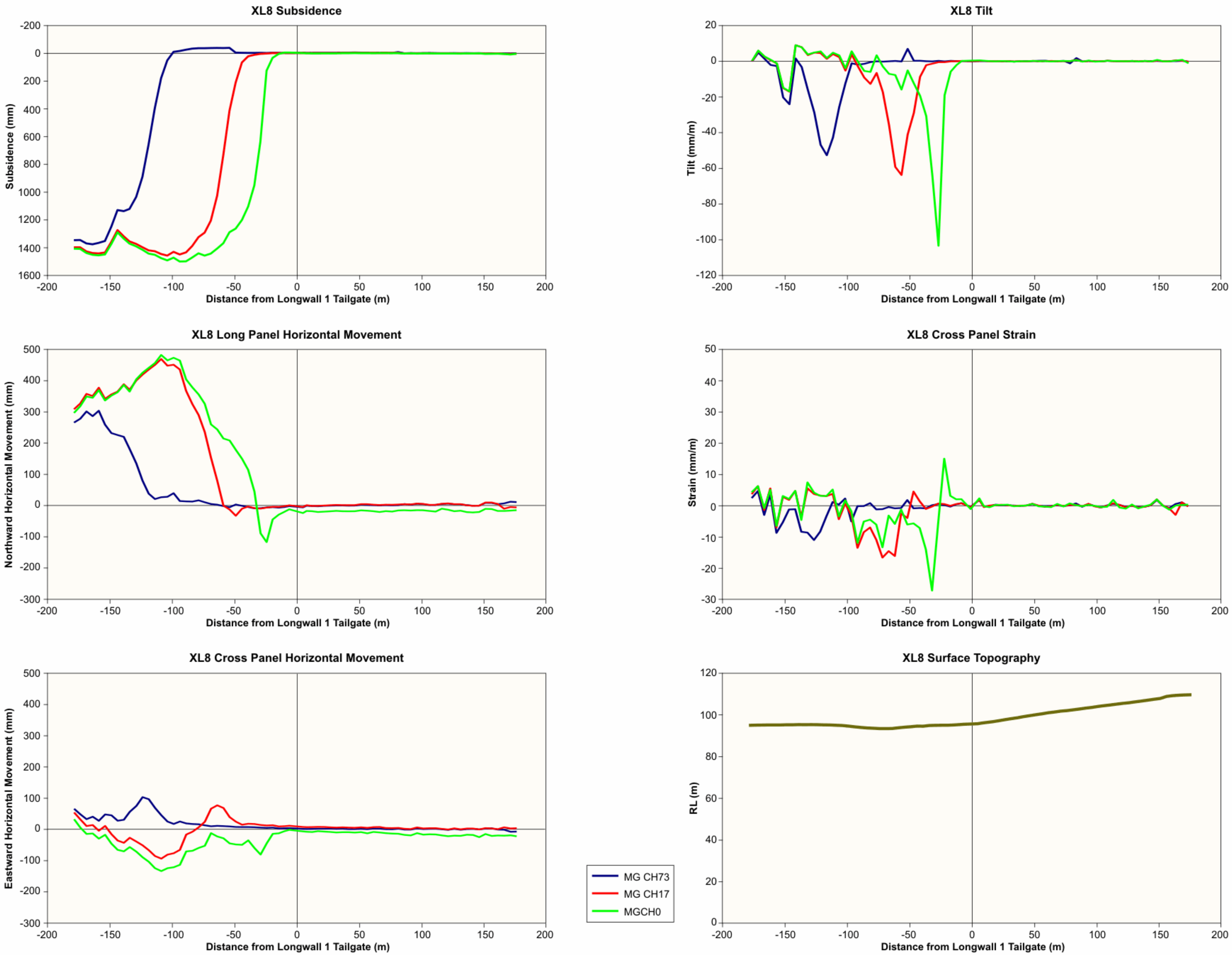


Figure 6 Summary of subsidence movements on Subsidence Line XL8.

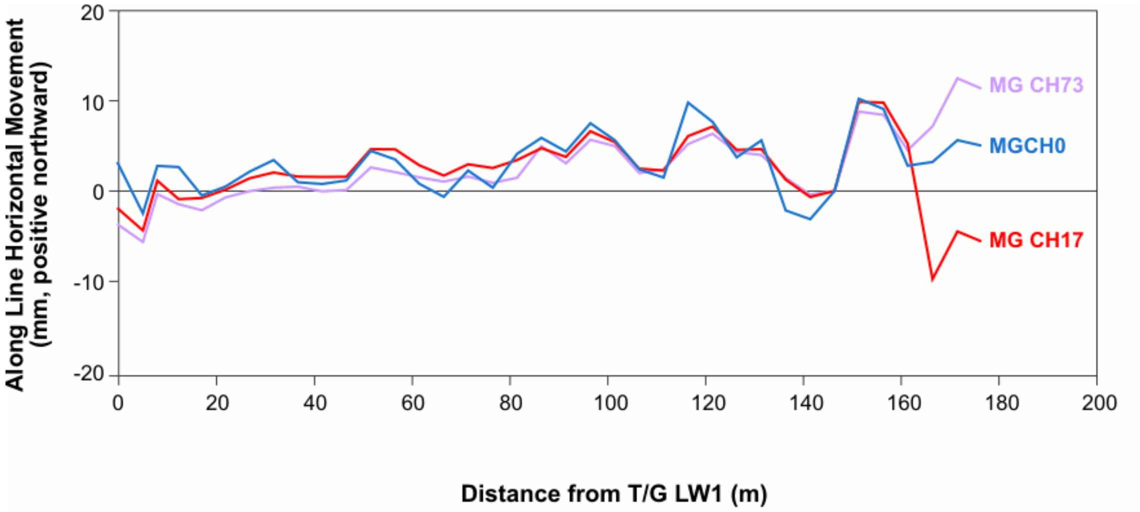


Figure 7 Horizontal movements outside of Longwall 1 on Subsidence Line XL8.

Figure 8 shows a summary of the three components of subsidence movement measured on each of the seven subsidence lines. In general, subsidence movements outside of the goaf are consistently of low magnitude. Movements greater than the 10-20mm survey accuracy, include some eastward and upward movement at the eastern end of XL2, XL3 and XL4 and some northward movement within 80-100m of the goaf edge on XL6 and XL7.

On XL2, XL3 and XL4, there are spikes in the vertical and horizontal subsidence profiles that indicate some 20-50mm of eastward movement and 30mm of upward movement just in from the eastern end of the line. The points where these higher movements become perceptible are all located at approximately the same reduced level on the southern bluff adjacent to Glennies Creek some 15m vertically above the creek level. The terrain in the area is steep. The movements seem to diminish again closer to the creek.

Only the surveys on XL5 were controlled from the eastern side of Glennies Creek, so it is possible that the steep terrain has contributed to a degradation in survey accuracy near the eastern end of these other lines. While the alignment of the higher movements at the same reduced level suggests the possibility of the movements correlating along a geological horizon rather than random survey inaccuracy, any such movement is not likely to be significant from a hydrogeological perspective because it has occurred some 15m above the level of Glennies Creek. The peaks of movement are not in the right place to be upsidence related.

A further survey is planned along all these lines to link back into the survey control on the eastern side of Glennies Creek to confirm that there has not been any large scale movement.

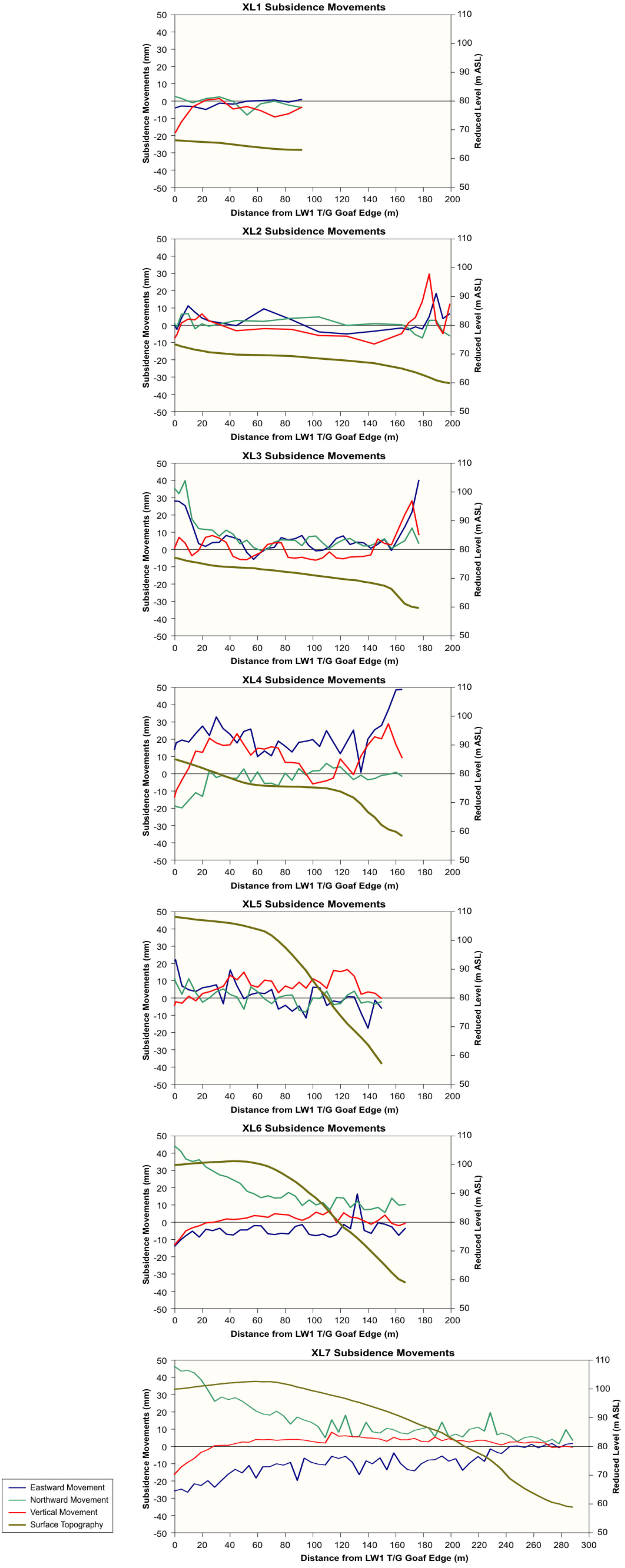


Figure 8 Subsidence movements measured on XL1-7 between Longwall 1 and Glennies Creek.

It should be noted that movement observed on XL2, XL3 and XL4 is not observed on any of the other lines. If the movement horizon is controlled by geological outcrop as suggested by the alignment of the zones of movement on these three lines, the rise of the bedded coal measure strata to the north and east would mean that any such geological outcrop would intersect XL5, XL6 and XL7. The absence of any step change in subsidence movements on these northern lines suggests that the movement zone is localised to the southern bluff area.

The form of the horizontal movements observed outside the goaf changes in the vicinity of XL6 and XL7 with a stronger northward component and movement to the west toward the longwall goaf increasing in magnitude with proximity to the goaf. The movements are still very small, but they have a different characteristic to the movements observed on the earlier cross-lines.

The horizontal movements on XL7 near the goaf edge indicate up to 50mm of northward movement and approximately 25mm of westward movement. The westward nature of this movement is unusual because although it is down dip, it is upslope. It is more common to see downslope movement in this situation.

4. Comparison with Predictions

The magnitude of subsidence movements above Longwalls 1-4 at Ashton Coal Mine was predicted in Table 1 of SCT Report ASH3084 as part of the SMP approval process.

The predicted and measured subsidence values are summarised in Table 1.

Table 1: Summary of Predicted and Measured Subsidence

	Maximum Predicted	**Maximum Measured**	
North End of LW1		**CL2**	**XL8**
Subsidence (mm)	1800	1528	1500
Tilt (mm/m)	244	100	103
Horizontal Movement (mm)	500+	476	500
Tensile strain (mm/m)	73	40	15
Compressive strain (mm/m)	98	28	27
Remainder of LW1		**CL1**	**XL5**
Subsidence (mm)	1700	1318	1377
Tilt (mm/m)	141	60	75
Horizontal Movement (mm)	300-500	480	384
Tensile strain (mm/m)	42	49	24
Compressive strain (mm/m)	56	23	16

In general the subsidence movements measured are less than predicted, except for the tensile strains at the start of Longwall 1 measured on CL1, which were 49mm/m compared to the 42mm/m maximum predicted.

The vertical subsidence measured was within the range predicted at all locations. High levels of tilt and strain predicted at the north end of the panel did not eventuate because the rippling effect that has been observed in shallow cover at other sites did not develop. The measured strains and tilts are therefore well within the predicted range.

Horizontal movements of up to 500mm were measured within the bounds of Longwall 1. These movements are somewhat unusual in that downslope movement does not appear to be dominating as much as it typically does. There appears to be a strong tendency for movement to occur in a north-easterly direction, which is both upslope and up dip. The mechanics of this process are not clear. A more detailed study of the relationship between horizontal movements observed and surface topography is currently being conducted and will be reported separately.

Horizontal movements outside of the longwall panel are generally less than 10-20mm. The largest horizontal movements (120mm) outside the goaf occurred over the start of Longwall 1, a phenomenon that is commonly observed at other sites. Some horizontal movement is evident at the eastern ends of several of the cross-lines (XL2-4).

5. Discussion of Results

The subsidence monitoring results from Longwall 1 provide a good indication of the subsidence behaviour that can be expected over future longwall panels at the mine. The subsidence behaviour observed is consistent with the supercritical width subsidence behaviour.

The magnitude of subsidence movements observed appears to be generally less than predicted magnitudes, although because rippling of the surface observed at other sites where the overburden depth is less than about 60m has not developed, the measured strains and tilts are generally much lower than predicted values. The exception is the higher tensile strains measured at the start of Longwall 1. Higher values of horizontal movement and tensile strains are commonly observed at the start of longwall panels, so it is not surprising that higher levels of strain have been observed in this area.

There does not appear to have been any significant far-field horizontal movements involving mass movement of the overburden strata. Horizontal movements outside of the goaf have generally been less than 20mm, although at the start of Longwall 1 horizontal movement is 120mm at the goaf edge and at several locations near the northern end of the panel, horizontal movements of up to 50mm are measured. There have been no indications of horizontal movements with capacity to impact the New England highway.

The cross-lines over the barrier to Glennies Creek have indicated that there is no mass movement of the overburden strata either toward or away from Glennies Creek. There appears to be a localised zone of movement at a horizon located well above the level of Glennies Creek on the southern bluff. The movements do not appear to be a result of mass movement of the overburden strata, but a further survey of points on these cross-lines to tie them back into control points on the eastern side of Glennies Creek is planned to confirm this.

The horizontal movements generally have not followed a pattern that is consistent with general experience of downslope movement dominating horizontal subsidence movements. The magnitude of horizontal movements has been consistently in the range 300-500mm as expected at relatively shallow overburden depth, but the direction of movement is not consistent with downslope movement and seems to have a strong north and east component. The reason for this tendency is not clear. A 12m lead on the western end of the longwall face may be a factor, but the mechanics of this process are not apparent.

During the early stages of mining before the panel becomes square, the minimum width of the panel is the distance between the longwall face and the back rib of the goaf. By measuring the subsidence repeatedly as this distance increases, the relationship between panel width and surface subsidence can be determined for a range of panel widths. The subsidence is dynamic and relationship observed is likely to be a best case scenario, with less bridging and more subsidence expected in the longer term under static loading conditions.

Monitoring at the start of Longwall 1 on CL1 provides an indication of the sag subsidence behaviour and caving characteristics of the overburden strata. Figure 9 shows the ratio of maximum subsidence to seam thickness plotted against the ratio of effective panel width to overburden depth as the void width increased during the early stages of mining Longwall 1. The range of observations of similar measurements made at other sites is also shown.

The results from the start of Longwall 1 indicate that the dynamic bridging of the overburden strata at the start of the panel was significantly greater than is typical of the Southern, Hunter, and Western Coalfields. Subsidence movements of less than 50mm were observed when the effective panel width to overburden depth ratio was more than 1.0. Normally subsidence of greater than several hundred millimetres is apparent when the panel width to depth ratio increases above about 0.7.

The magnitude of the final subsidence is less than would be expected. At the start of Longwall 1, the maximum subsidence is approximately 1.2m for a nominal seam height extracted of 2.6m, giving a ratio of S_{max} to seam thickness of 46%, a value that is much lower than the 55-65% typically observed at other sites. At the northern end of Longwall 1, the ratio increases to 53% of seam thickness.

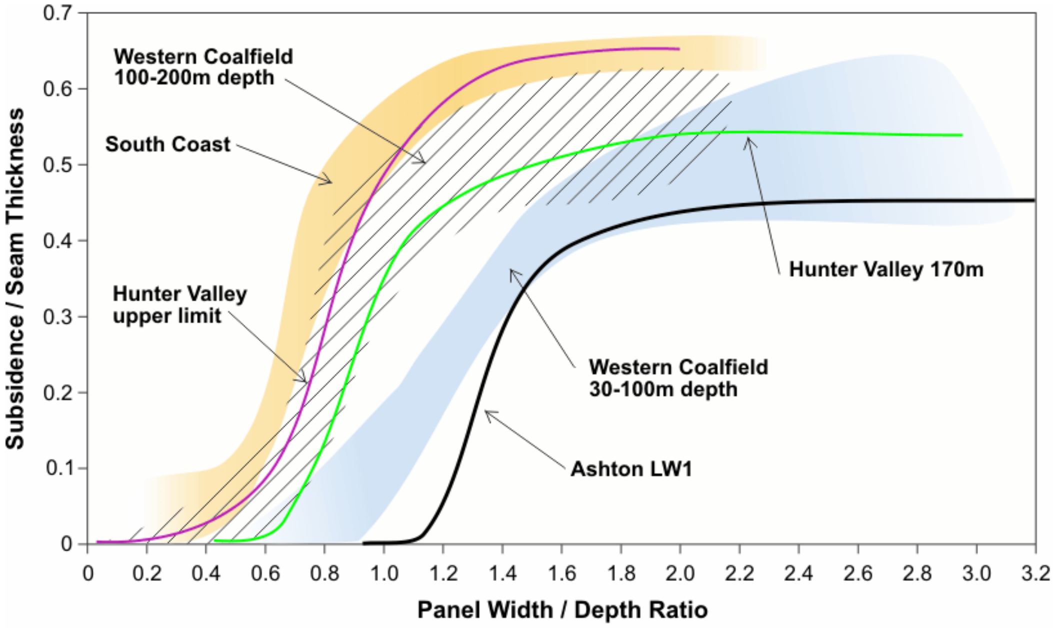
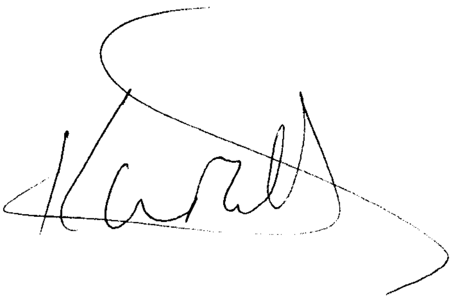


Figure 9 Dynamic Smax/T versus panel width to depth ratio measured at the start of Longwall 1.

If you have any queries, or would like further clarification of any of these results, please do not hesitate to contact our office.

Regards



Ken Mills
Senior Geotechnical Engineer