mine subsidence ENGINEERING CONSULTANTS

ILLAWARRA METALLURGICAL COAL:

Appin Colliery – Longwall 709

End of Panel Subsidence Monitoring Report for Appin Longwall 709

DOCUMENT REGISTER

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Previous reports:

MSEC1117 (Rev. B) – Subsidence Predictions and Impact Assessments for the Natural and Built Features due to the Extraction of the Proposed Longwalls 709, 710A, 710B, 711 and 905 at Appin Colliery (in Support of the Extraction Plan Application), dated 18 May 2021.

MSEC1245-01 to MSEC1245-86 – Structures Monitoring Review Reports for Structures, issued during the mining of Longwall 709, between March 2022 and October 2023.

MSEC1287-01 to MSEC1287-18 – Subsidence Monitoring Review Reports for the Main Southern Railway, issued during the mining of Longwall 709 between July 2023 and December 2023.

MSEC1289-01 to MSEC1289-09 – Subsidence Monitoring Review Reports for the M31 Hume Motorway, issued during the mining of Longwall 709 between January 2023 and December 2023.

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)

CONTENTS

Tables

Table numbers are prefixed by the number of the chapter in which they are presented.

Figures

Figure numbers are prefixed by the number of the chapter or the letter of the appendix in which they are presented.

Drawings

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

Drawing No.	*Description*	*Revision*
MSEC1394-01	General layout and ground monitoring lines	A
MSEC1394-02	Natural features	A
MSEC1394-03	Surface infrastructure	A

1.1. Introduction

Illawarra Metallurgical Coal (IMC) has completed the mining of Longwall 709 (LW709) in Area 7 at Appin Colliery, which is located in the Southern Coalfield of New South Wales. The locations of the longwalls in Area 7 are shown in Drawing No. MSEC1394-01, in Appendix B. The commencement and finishing dates for LW709 are provided in Table 1.1.

Table 1.1 Commencement and finishing dates for LW709

Longwall	Commencement date (first shear)	Finishing date (break of chain)
LW709	22 February 2022	8 October 2023

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by IMC to prepare subsidence predictions and impact assessments for Longwalls 709 to 711 and 905 (LW709 to LW711 and LW905) in Appin Areas 7 and 9. Report No. MSEC1117 (Rev. B) was issued in May 2021 and that report supported the Extraction Plan Application for LW709 to LW711 and LW905.

The Department of Planning and Environment (DPE) granted IMC approval for the extraction of LW709 on 29 July 2022.

In accordance with Section 18 of the Extraction Plan Approval Conditions for LW709 to LW711 and LW905, this report provides:

- comparisons between the measured and predicted subsidence effects at the monitoring lines and monitoring points due to the mining of LW709; and
- comparisons between the observed and assessed impacts on the natural and built features due to the mining of LW709.

Further details on the observed and assessed impacts for some natural features due to the mining of LW709 are provided in the reports by other consultants. The discussions provided in this report should be read in conjunction with those and all other relevant reports.

Chapter 2 of this report describes the locations of the ground monitoring lines and points that were measured during the mining of LW709. This chapter also provides comparisons between the measured and predicted movements due to the mining of these longwalls.

Chapter 3 of this report describes the natural and built features near LW709. This chapter also provides comparisons between the observed and assessed impacts for these surface features due to the mining of these longwalls. Further discussions on the observed and assessed impacts for some natural features are provided in the reports by other consultants.

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

1.2. Mining geometry

The layout of the longwalls in Area 7 is shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the as-extracted dimensions for LW702 to LW709 is provided in Table 1.2.

Table 1.2 Mining geometry of the as-extracted longwalls

Location	Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
Area 7	LW702	980	324	-
	LW703	2075	324	45
	LW704	2325	324	45
	LW705	2835	324	45
	LW706	3055	324	45
	LW707A	1035	324	45
	LW707B	2070	324	45
	LW708A	1200	324	45
	LW708B	2260	324	45
	LW709	2615	324	45

The mined lengths of the longwalls excluding the installation headings are approximately 9 m shorter than the overall void lengths provided in Table 1.2. The length of longwall extraction, therefore, is approximately 2606 m for LW709. The longwall face widths excluding the first workings are approximately 314 m.

The longwalls in Area 7 have been extracted from the Bulli Seam. LW709 has been mined from the west towards the east, i.e. towards the Nepean River. The natural surface and seam levels along the centreline of LW709 are illustrated in Fig. 1.1.

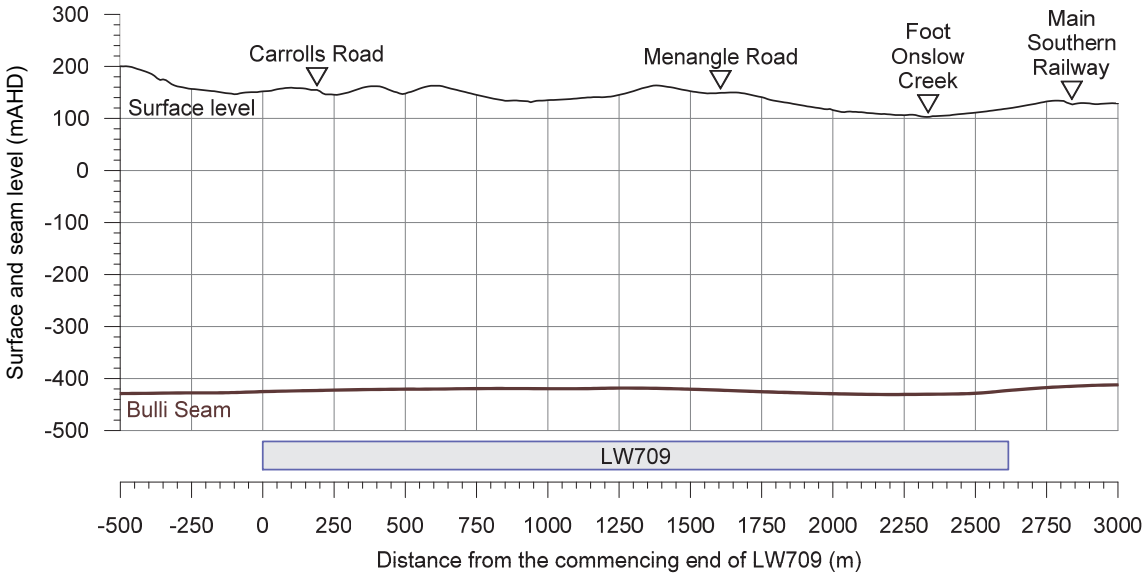


Fig. 1.1 Surface and seam levels along the centreline of LW709

The depth of cover to the Bulli Seam varies between a minimum of 530 m near the finishing (i.e. eastern) end of LW709 and a maximum of 615 m near the commencing (i.e. western) end of the longwall. The seam thickness varies between 2.8 m and 3.3 m within the extents LW709. IMC extracted the full thickness of the Bulli Seam.

2.1. Introduction

The mine subsidence effects due to the mining of LW709 were monitored along several monitoring lines and monitoring points including the:

- Menangle Road monitoring line – refer to Section 2.2;
- Hawkey Road monitoring line – refer to Section 2.3;
- Carrolls Road monitoring line – refer to Section 2.4;
- M31 Hume Motorway East and West Lines – refer to Section 2.5;
- ARTC monitoring line, strain gauges and tilt sensors – refer to Sections 2.6.1 and 2.6.2;
- ARTC embankment and culvert points – refer to Sections 2.6.3 and 2.6.4;
- highway cutting points – refer to Section 2.7;
- Partridge VC Rest Area monitoring points – refer to Section 2.8;
- Far-field 3D marks – refer to Section 2.9;
- absolute and relative 3D monitoring points adjacent to and on the Douglas Park Twin Bridges – refer to Section 2.10;
- absolute and relative 3D monitoring points adjacent to and on the Moreton Park Road Bridge (South) and Moreton Park Road Bridge (North) – refer to Sections 2.11 and 2.12; and
- Light Detecting and Ranging (LiDAR) surveys – refer to Section 2.13.

The locations of these monitoring lines and monitoring points are shown in Drawing No. MSEC1394-01, in Appendix B. Comparisons between the measured and predicted subsidence effects at these monitoring lines and points are provided in the following sections. The predicted subsidence parameters have been obtained using the Incremental Profile Method (IPM). This method was used to predict the subsidence effects that are presented in Report No. MSEC1117.

2.2. Menangle Road monitoring line

The mine subsidence effects along Menangle Road were measured by IMC using a 3D monitoring line. The location of the Menangle Road monitoring line is shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.1.

Table 2.1 Survey dates for the Menangle Road monitoring line during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Weekly during the mining of LW709 and then at the completion of the longwall	7 February 2022 (end of LW708B) 27 July 2022, then approximately weekly to 30 December 2022, 13 January 2023, 27 February 2023, then approximately weekly to 5 September 2023, 19 September 2023 and 5 October 2023 (end of LW709)	As required under the LW710 monitoring program

The profiles of measured and predicted incremental vertical subsidence, tilt and strain along the Menangle Road monitoring line, due to the mining of LW709, are shown in Fig. A.01, in Appendix A. The incremental profiles represent the additional movements due to the mining of LW709 only.

The profile of measured incremental vertical subsidence reasonably matches the predicted profile along the Menangle Road monitoring line; however, the magnitude is less. The measured profile of incremental tilt also reasonably matches the predicted profile. However, the measured tilt locally exceeds the predicted tilt adjacent to the tailgate of LW709 due to a slightly steep profile in this isolated location.

A summary of the maximum measured and predicted incremental vertical subsidence, tilt and strains for the Menangle Road monitoring line is provided in Table 2.2. The values represent the additional movements due to the mining of LW709 only.

Table 2.2 Maximum measured and predicted incremental vertical subsidence, tilt and strain along the Menangle Road monitoring line due to LW709 only

Type	Maximum incremental vertical subsidence (mm)	Maximum incremental tilt (mm/m)	Maximum incremental tensile strain (mm/m)	Maximum incremental comp. strain (mm/m)
Measured	509	4.8	0.7	3.0
Predicted	900	5.5	*- Refer to discussions below -*	

The accuracies of the measured relative eastings, northings and levels along the Menangle Road monitoring line are in the order of ±3 mm to ±5 mm. The accuracies of the measured absolute eastings, northings and levels along monitoring line are in the order of ±15 mm. The accuracies of the measured strains along the monitoring line are in the order of ±0.25 mm/m.

The maximum measured incremental vertical subsidence of 509 mm occurs directly above LW709 and it is less than the maximum predicted value. The ratio of maximum measured to maximum predicted vertical subsidence is 66 %. The monitoring line is located close to the coal blocks located between the adjacent LW708A and LW708B and, therefore, the end effects from these existing longwalls could have reduced the subsidence more than that predicted.

The maximum measured incremental tilt of 4.8 mm/m occurs adjacent to the tailgate of LW709 and it locally exceeds the predicted value in this location. However, it is less than the maximum predicted incremental tilt of 5.5 mm/m which occurs adjacent to the longwall maingate. It appears that locally reduced subsidence near the tailgate chain pillar caused slightly greater tilt than predicted in this location.

The maximum measured incremental strains are 0.7 mm/m tensile and 3.0 mm/m compressive. The predicted incremental strains based on conventional ground movements are 1 mm/m tensile and 2 mm/m compressive. The maximum measured incremental compressive strain is therefore greater than that predicted based on conventional ground movements. Elsewhere, the measured incremental tensile and compressive strains are in the range based on conventional ground movements.

The 95th percentiles for the measured total strains along the Menangle Road monitoring line and above the longwall mining area are 1.0 mm/m tensile and 1.7 mm/m compressive. The maximum predicted total strains for LW709 (refer to Section 4.3.1 of Report No. MSEC1117) are 1.0 mm/m tensile and 1.6 mm/m compressive. The maximum measured total strains based on the 95th percentiles, therefore, are similar to the maximum predicted strains based on the 95 % confidence levels.

It is considered that the ground movements measured using the Menangle Road monitoring line are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

2.3. Hawkey Road monitoring line

The mine subsidence effects along Hawkey Road were measured by IMC using a 2D monitoring line. The location of the Hawkey Road monitoring line is shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.3.

Table 2.3 Survey dates for the Hawkey Road monitoring line during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Fortnightly during the mining of LW709 and then at the completion of the longwall	Initial survey 17 January 2022 14 February 2022, then approximately fortnightly to 20 June 2022, then approximately monthly to 26 October 2022, 3 March 2023 and 10 October 2023 (end of LW709)	As required under the LW710 monitoring program

The profiles of measured and predicted incremental vertical subsidence, tilt and strain along the Hawkey Road monitoring line, due to the mining of LW709, are shown in Fig. A.02, in Appendix A. The incremental profiles represent the additional movements due to the mining of LW709 only.

The profile of measured incremental vertical subsidence along Hawkey Road is relatively consistent and did not increase substantially in magnitude, as predicted. While maximum measured subsidence was less than predicted, low level subsidence was observed to be slightly greater than predicted at the southern end of Hawkey Road. The measured profile of incremental tilt was 0.5 mm/m or less, as predicted.

A summary of the maximum measured and predicted incremental vertical subsidence, tilt and strains for the Hawkey Road monitoring line is provided in Table 2.4. The values represent the additional movements due to the mining of LW709 only.

Table 2.4 Maximum measured and predicted incremental vertical subsidence, tilt and strain along the Hawkey Road monitoring line due to LW709 only

Type	Maximum incremental vertical subsidence (mm)	Maximum incremental tilt (mm/m)	Maximum incremental tensile strain (mm/m)	Maximum incremental comp. strain (mm/m)
Measured	50	0.5	0.4	0.4
Predicted	80	< 0.5	*- Refer to discussions below -*	

The accuracies of the measured strains along the monitoring line are in the order of ±0.25 mm/m.

The maximum measured incremental vertical subsidence of 50 mm occurs at the intersection between Hawkey Road and Carrolls Road to the side of LW710 and it is less than the maximum predicted value. The monitoring line skirts the corner of LW710 near the commencing end.

The maximum measured incremental tilt is 0.5 mm/m and it is very small in magnitude, as expected.

The maximum measured incremental strains are 0.4 mm/m tensile and 0.4 mm/m compressive, which are very small in magnitude and close to survey tolerance, as expected.

The maximum predicted total strains above solid (unmined) coal adjacent to the longwall (refer to Section 4.3.1 of Report No. MSEC1117) are 0.6 mm/m tensile and 0.4 mm/m compressive based on the 95 % confidence levels. The maximum measured total strains, therefore, are similar to or less than the maximum predicted strains based on the 95 % confidence levels.

It is considered that the ground movements measured using the Hawkey Road monitoring line are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

2.4. Carrolls Road monitoring line

The mine subsidence effects along Carrolls Road were measured by IMC using a 2D monitoring line. The location of the Carrolls Road monitoring line is shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.5.

Table 2.5 Survey dates for the Carrolls Road monitoring line during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Fortnightly during the mining of LW709 and then at the completion of the longwall	Initial survey 17 January 2022 14 February 2022, then approximately fortnightly to 7 November 2022, then 2 March 2023 and 10 October 2023 (end of LW709)	As required under the LW710 monitoring program

The profiles of measured and predicted incremental vertical subsidence, tilt and strain along the Carrolls Road monitoring line, due to the mining of LW709, are shown in Fig. A.03, in Appendix A. The incremental profiles represent the additional movements due to the mining of LW709 only.

The profile of measured incremental vertical subsidence reasonably matches the predicted profile along the Carrolls Road monitoring line; however, the magnitude is less. The measured profile of incremental tilt also reasonably matches the predicted profile.

A summary of the maximum measured and predicted incremental vertical subsidence, tilt and strains for the Carrolls Road monitoring line is provided in Table 2.6. The values represent the additional movements due to the mining of LW709 only.

Table 2.6 Maximum measured and predicted incremental vertical subsidence, tilt and strain along the Carrolls Road monitoring line due to LW709 only

Type	Maximum incremental vertical subsidence (mm)	Maximum incremental tilt (mm/m)	Maximum incremental tensile strain (mm/m)	Maximum incremental comp. strain (mm/m)
Measured	423	3.3	0.6	2.2
Predicted	650	3.6	*- Refer to discussions below -*	

The accuracies of the measured strains along the monitoring line are in the order of ±0.25 mm/m.

The maximum measured incremental vertical subsidence of 423 mm occurs directly above LW709 and it is less than the maximum predicted value. The ratio of maximum measured to maximum predicted vertical subsidence is 65 %.

The maximum measured incremental tilt of 3.3 mm/m occurs adjacent to the maingate of LW709 and it compares reasonably well with the predicted maximum value.

The maximum measured incremental strains are 0.6 mm/m tensile and 2.2 mm/m compressive. The predicted incremental strains based on conventional ground movements are 1 mm/m tensile and 2 mm/m compressive. The maximum measured incremental compressive strain is therefore greater than that predicted based on conventional ground movements. Elsewhere, the measured incremental tensile and compressive strains are in the range based on conventional ground movements.

The maximum predicted total strains for LW709 (refer to Section 4.3.1 of Report No. MSEC1117) are 1.0 mm/m tensile and 1.6 mm/m compressive based on the 95 % confidence levels. The maximum measured total tensile strain, therefore, is less than the maximum predicted value based on the 95 % confidence level.

The maximum measured compressive strain occurred due to non-conventional subsidence movements, between Mark CAR36 and CAR37, near a creek crossing. Localised upsidence was observed at this location, accompanied by increased compressive strain at an isolated location. Non-conventional movements were predicted to occur across creeks due to valley-related effects.

It is considered that the ground movements measured using the Carrolls Road monitoring line are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

2.5. M31 Hume Motorway

The M31 Hume Motorway is located to the east of LW709 as shown in Drawings Nos. MSEC1394-01 and MSEC1394-03, in Appendix B. The monitoring associated with the motorway for LW709 included the:

- M31 East and West Lines;
- highway cutting points; and
- Partridge VC Rest Area.

The monitoring results and discussions were provided in the weekly subsidence monitoring review reports for the motorway (MSEC1289-01 to MSEC1289-09), which were issued during the mining of LW709 between January 2023 and December 2023.

A summary of the monitoring results for the M31 Hume Motorway is provided in the following sections.

2.5.1. M31 East and M31 West Lines

The mine subsidence effects along the M31 Hume Motorway were measured by IMC using two 3D monitoring lines, being the M31 East Line and M31 West Line. The locations of these monitoring lines are shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.7.

Table 2.7 Survey dates for the M31 East Line and M31 West Line during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Survey full length of monitoring lines at start and end of LW709, plus monthly 3D surveys at 2000 m of extraction	15 June 2023 1 November 2023 (end of LW709)	As required under the LW710 monitoring program

The profiles of measured and predicted incremental vertical subsidence, tilt and strain along the M31 East Line and M31 West Line, due to the mining of LW709, are shown in Figs. A.04 and A.05, respectively, in Appendix A.

A summary of the maximum measured and predicted incremental vertical subsidence, tilt and strains along the M31 East Line and M31 West Line is provided in Table 2.8. The values represent the additional movements due to the mining of LW709 only.

Table 2.8 Maximum measured and predicted incremental vertical subsidence, tilt and strain along the M31 East Line and M31 West Line due to LW709 only

Location	Type	Maximum incremental vertical subsidence (mm)	Maximum incremental tilt (mm/m)	Maximum incremental tensile strain (mm/m)	Maximum incremental comp. strain (mm/m)
M31 East Line	Measured	59	1.0	0.6	0.6
	Predicted	< 20	< 0.5	*- Refer to discussions below -*	
M31 West Line	Measured	59	0.8	0.6	1.0
	Predicted	< 20	< 0.5	*- Refer to discussions below -*	

The accuracies of the measured relative eastings, northings and levels along the M31 East and West Lines are in the order of ±5 mm. The accuracies of the measured absolute eastings, northings and levels along the monitoring lines are in the order of ±10 mm. The accuracies of the measured strains along the monitoring lines are in the order of ±0.25 mm/m.

The maximum measured incremental vertical subsidence along the M31 East and M31 West Lines of 59 mm, respectively, are slightly greater than the maximum predicted value of less than 20 mm. The majority of the movements are considered to be due to long-term residual subsidence from the extraction of previous LW708B as the locations of maximum subsidence are located directly above LW708B, near the chain pillar to LW707B. GNSS monitoring in the Motorway corridor also tracked the gradual development of residual subsidence over time, well before the LW709 face approached the Motorway.

The maximum measured incremental tilts of 1.0 mm/m for the M31 East Line and 0.8 mm/m for the M31 West Line are slightly greater than the maximum predicted value of less than 0.5 mm/m. The measured movements are likely to include survey tolerance and possible disturbed marks.

The maximum measured incremental compressive strains along the M31 East Line are 0.6 mm/m tensile and 0.6 mm/m compressive. The maximum measured incremental compressive strains along the M31 West Line are 0.6 mm/m tensile and 1.0 mm/m compressive. The strains appear to be related to environmental effects on the survey marks.

It is considered that the ground movements measured along the M31 East and M31 West monitoring lines are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

2.6. Main Southern Railway

The Main Southern Railway is located immediately adjacent to LW709 as shown in Drawings Nos. MSEC1394-01 and MSEC1394-03, in Appendix B. The monitoring associated with the railway for LW709 included the:

- ARTC 3D ground monitoring line;
- ARTC 3D embankment monitoring points;
- railway cutting points; and
- strain gauges.

The monitoring results and discussions were provided in the weekly subsidence monitoring review reports for the railway (MSEC1287-01 to MSEC1287-18), which were issued during the extraction of LW708B between July 2023 and December 2023.

A summary of the monitoring results for the Main Southern Railway are provided in the following sections.

2.6.1. ARTC Line

The mine subsidence effects along the Main Southern Railway were measured by IMC using a 3D ground monitoring line, referred to as the ARTC Line. The location of the monitoring line is shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.9.

Table 2.9 Survey dates for the ARTC Line during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Start and end of LW709, with monthly 3D surveys after 2200 m of extraction, plus weekly 2D focused surveys after 2400 m of extraction	24 July 2023, 21 August 2023, then weekly to the 4 December 2023, 11 December 2023 (end LW709)	As required under the LW710 monitoring program

The profiles of measured and predicted incremental vertical subsidence, tilt and strain along the ARTC Line, due to the mining of LW709, are shown in Fig. A.06, in Appendix A. The predictions are based on the as-extracted lengths of the longwalls as presented in Report No. MSEC1318.

The profile of measured incremental vertical subsidence reasonably matches the predicted profile; however, the magnitude of vertical subsidence is greater than that predicted.

A summary of the maximum measured and predicted incremental vertical subsidence, tilt and strains along the ARTC Line is provided in Table 2.10. The values represent the additional movements due to the mining of LW709 only.

Table 2.10 Maximum measured and predicted incremental vertical subsidence, tilt and strain along the ARTC Line due to LW709 only

Type	Maximum incremental vertical subsidence (mm)	Maximum incremental tilt (mm/m)	Maximum incremental tensile strain (mm/m)	Maximum incremental comp. strain (mm/m)
Measured	136	0.8	0.3	0.7
Predicted	100	< 0.5	*- Refer to discussions below -*	

The accuracies of the measured relative eastings, northings and levels along the ARTC Line are in the order of ±5 mm. The accuracies of the measured absolute eastings, northings and levels along the monitoring line are in the order of ±10 mm. The accuracies of the measured strains along the monitoring line are in the order of ±0.25 mm/m.

The maximum measured incremental vertical subsidence along the ARTC Line of 136 mm is greater than the maximum predicted value of 100 mm. A portion of the movements are considered to be due to long-term residual subsidence. GNSS monitoring in the Railway corridor also tracked the gradual development of residual subsidence over time, well before the LW709 face approached the Railway.

The maximum measured incremental tilt of 0.8 mm/m is similar to but slightly greater than the maximum predicted value of less than 0.5 mm/m. The maximum measured incremental strains along the ARTC Line are 0.3 mm/m tensile and 0.7 mm/m compressive. The measured tilts and strains are likely to include survey tolerance and possible disturbed survey marks.

It is considered that the ground movements measured using the ARTC Line are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

2.6.2. Automated track monitoring

Rail stress transducers

Rail stress transducers are located along all four rails of the railway track, spaced every 25 m to 60 m. They measured the changes in rail strain every 5 minutes during the extraction of LW709. While some false alarms were triggered during mining, due to malfunction or damage to transducers, the actual stress readings did not exceed the trigger levels.

2.6.3. Embankment monitoring

The mine subsidence effects along and across the Embankment at 69.0 km were measured by IMC during the mining of LW709. A summary of the survey dates during the extraction of LW70 are provided in Table 2.11.

Table 2.11 Survey dates for the Embankment at 69.0 km during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Start and end of LW709, with monthly 3D surveys after 2200 m of extraction, plus weekly 2D focused surveys after 2400 m of extraction	24 July 2023, 21 August 2023, then weekly to the 4 December 2023, 11 December 2023 (end LW709)	As required under the LW710 monitoring program

The profiles of measured incremental vertical subsidence, tilt and strain along the Embankment at 69.0 km, due to the mining of LW709, are shown in Figs. A.07 to A.10, in Appendix A.

The accuracies of the measured relative eastings, northings and levels along the Embankment lines are in the order of ±5 mm. The accuracies of the measured absolute eastings, northings and levels along the monitoring lines are in the order of ±10 mm. The accuracies of the measured strains along the monitoring lines are typically in the order of ±0.15 mm/m, where bay lengths are around 20 m.

The findings are similar to those for the ARTC Line, which are discussed in Section 2.6.1. The main ground monitoring line along the railway corridor is located on the crest of the embankment on the Down side.

2.6.4. Culverts

The mine subsidence effects along the railway culvert at 69.0 km were measured by IMC using a 3D ground monitoring line, referred to as the ARTC 69.0 km Culvert. The location of the monitoring line is shown in Drawing No. MSEC1394-01, in Appendix B. The measured changes in horizontal distance along the invert of the ARTC 69.0 km Culvert are shown in Fig. 2.1.

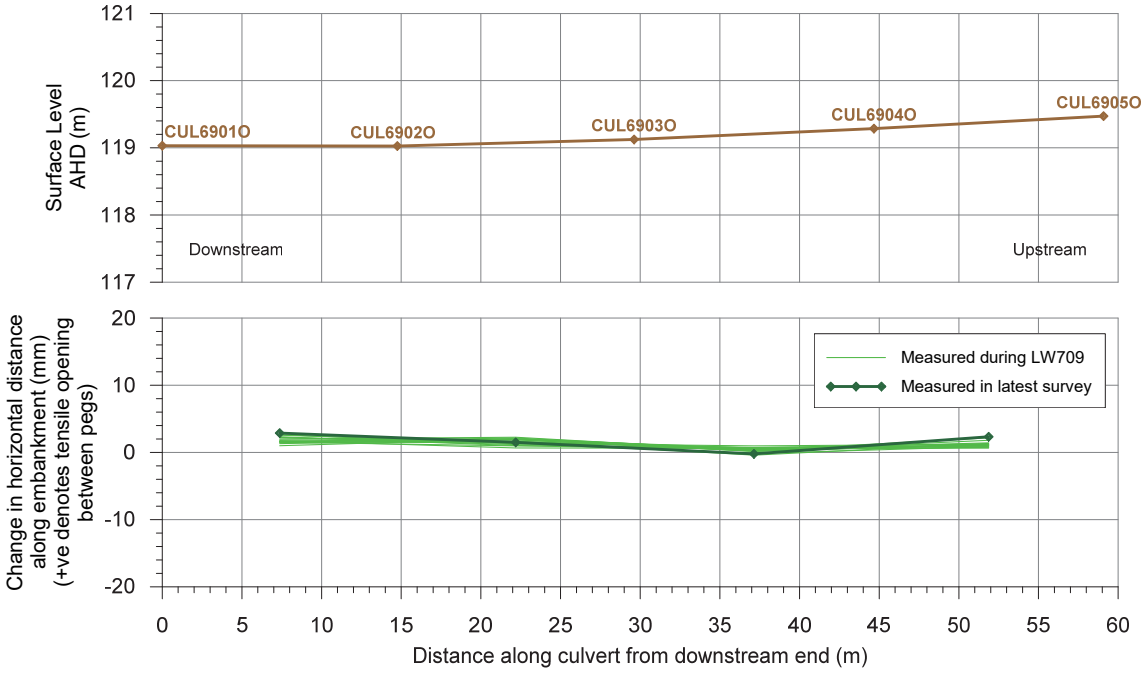


Fig. 2.1 Measured incremental changes in horizontal distance along the invert of the ARTC 69.0 km Culvert due to LW709 only

2.7. Highway Cutting 2

The Highway Cutting 2 Points were measured by IMC during the extraction of LW709. The 3D monitoring points are located on the cuttings along the M31 Hume Motorway. The locations of these monitoring points are shown in Drawing No. MSEC1394-01 in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.12.

Table 2.12 Survey dates for the Highway Cutting 2 Points during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Survey monitoring points at start and end of LW709, plus monthly 3D surveys at 2000 m of extraction	15 June 2023 1 November 2023 (end of LW709)	Surveys have ceased for this monitoring site

The final measured absolute incremental horizontal movements at the Highway Cutting 2 Points, after the completion of LW709, are shown in Fig. 2.2.

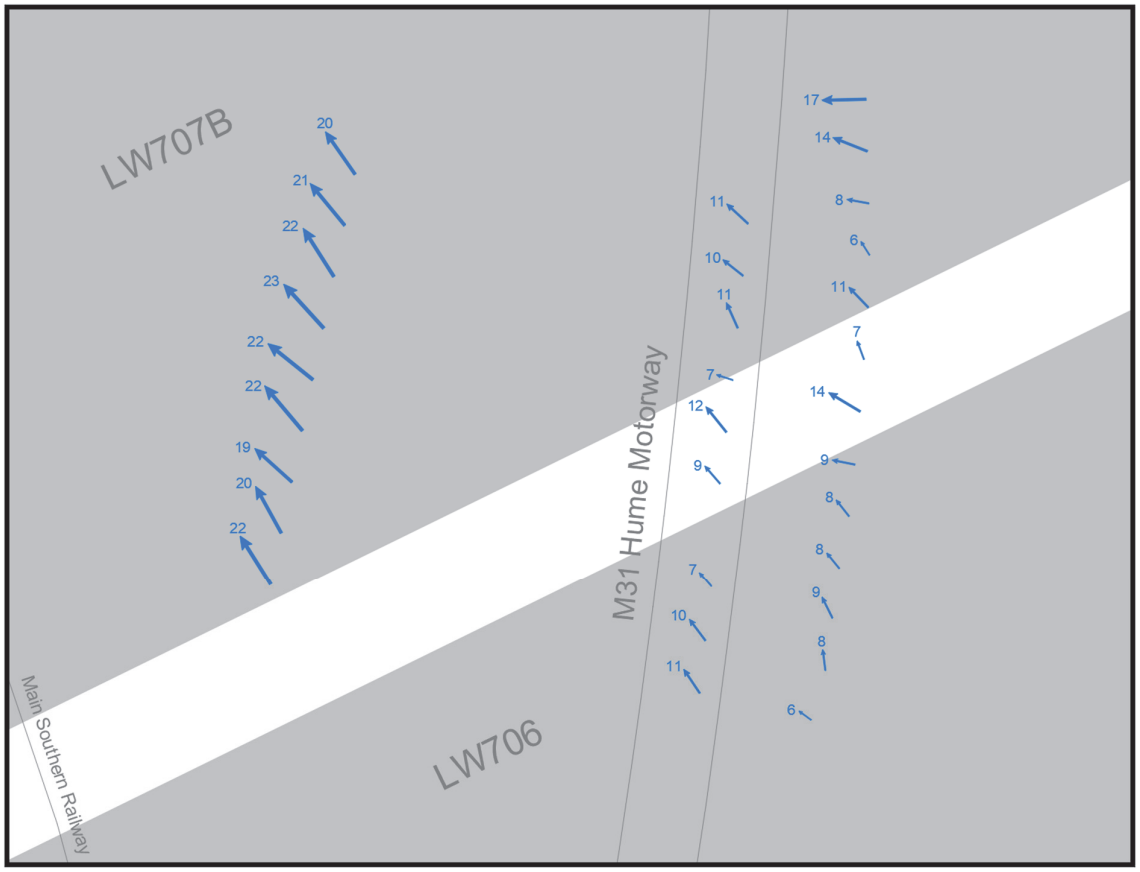


Fig. 2.2 Measured absolute incremental horizontal movements at the Highway Cutting 2 Points due to LW709

A summary of the maximum measured absolute incremental horizontal movements at the cutting monitoring points is provided in Table 2.13. The values represent the additional movements due to the mining of LW709 only.

Table 2.13 Maximum measured absolute incremental horizontal movements at the Highway Cutting 2 Points due to LW709 only

Longwall	Location	Maximum measured incremental horizontal movement (mm)
LW709	W144 to W158	23
	G101 to G110	12
	E146R to E160R	17

The accuracies of the measured eastings and northings at the 3D monitoring points are in the order ±5 mm.

The measured incremental horizontal movements are very small and in the order of survey accuracy for absolute position of 25 mm.

2.8. Partridge VC Rest Area

The Partridge VC Rest Area points were measured by IMC during the extraction of LW709. The locations of these monitoring points are shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.14.

Table 2.14 Survey dates for the Partridge VC Rest Area monitoring points during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Survey monitoring points at start and end of LW709, plus monthly 3D surveys at 2000 m of extraction	15 June 2023 1 November 2023 (end of LW709)	Surveys have ceased for this monitoring site

Only minor changes were observed during the mining of LW709.

2.9. Far-field 3D marks

The far-field mine subsidence effects were measured by IMC using a number of 3D marks in the vicinity of LW709. The locations of these monitoring points are shown in Drawing No. MSEC1394-01, in Appendix B. A summary of the survey dates during the extraction of LW709 is provided in Table 2.15.

Table 2.15 Survey dates for the far-field 3D marks during LW709

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Start and end of LW709, with monthly surveys during mining after 300 m of extraction	6 May 2022, then approximate monthly surveys to 2 November 2023 (end of LW709)	As required under the LW710A and LW710B monitoring program

The final measured absolute incremental horizontal movements at the far-field 3D marks due to the mining of LW709 are shown in Fig. 2.3. It is noted that these movements include the effects from the concurrent mining in Area 9.

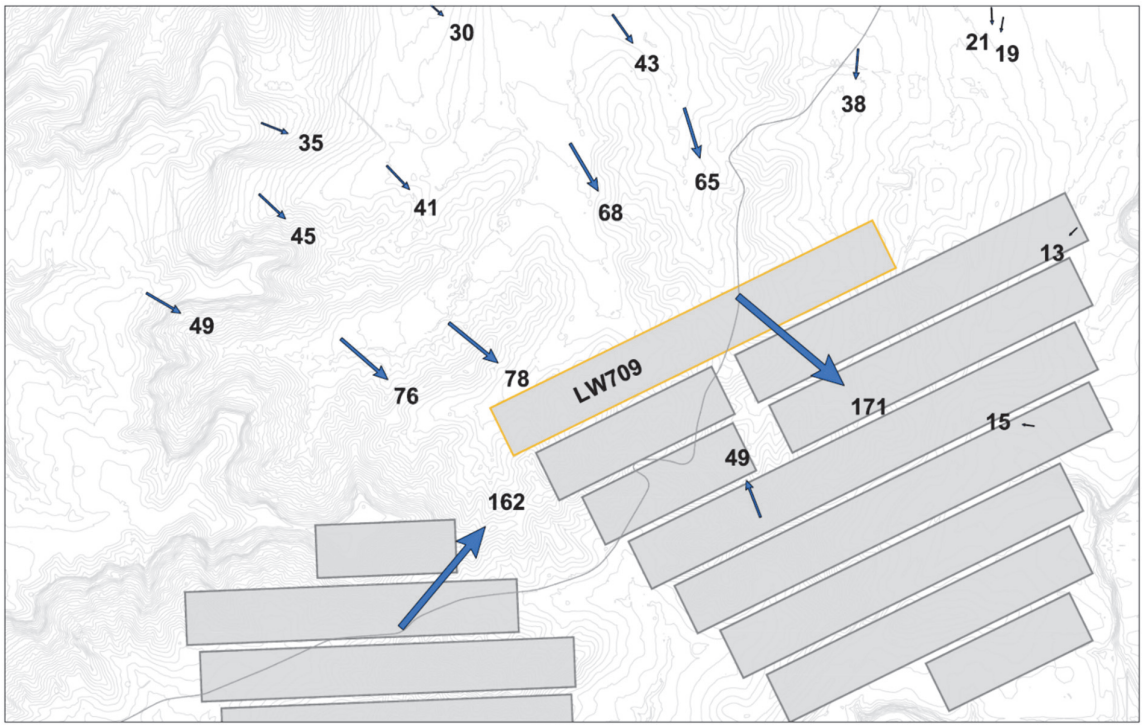


Fig. 2.3 Measured absolute incremental horizontal movements at the far-field 3D marks due to the mining of LW709 and the concurrent mining in Area 9

The accuracies of the measured eastings and northings at the far-field 3D marks are in the order ±5 mm and, therefore, the accuracies of the measured absolute horizontal movements are in the order of ±7 mm.

The maximum measured incremental horizontal movements are 171 mm and 162 mm at Marks MR2 and MR1 along Menangle Road located above LW709 and LW904, respectively. Elsewhere, low level horizontal movements have been measured which are generally orientated towards the active longwall.

The maximum measured incremental horizontal movement outside the mining areas is 78 mm at Mark BURRELL1 located downslope of Razorback Range.

Horizontal movements were also measured along the Menangle Road line, the Hawkey Road line, the Carrolls Road line, the ARTC line, M31 West Line, M31 East Line and the cutting marks during the mining of LW709. The results for these monitoring lines are discussed in separate sections of this report.

Fig. 2.4 shows the final measured incremental horizontal movements for the far-field 3D marks (i.e. black diamonds), Menangle Road line (i.e. purple diamonds), Hawkey Road line (i.e. pink diamonds), Carrolls Road line (i.e. brown diamonds), ARTC line (i.e. green diamonds), M31 West Line (i.e. cyan diamonds), M31 East Line (i.e. blue diamonds) and the cutting marks (i.e. orange diamonds) due to the mining of LW709 versus their distances from the active longwall. The measured incremental horizontal movements elsewhere in the Southern Coalfield (i.e. grey triangles) are also shown in this figure for comparison.

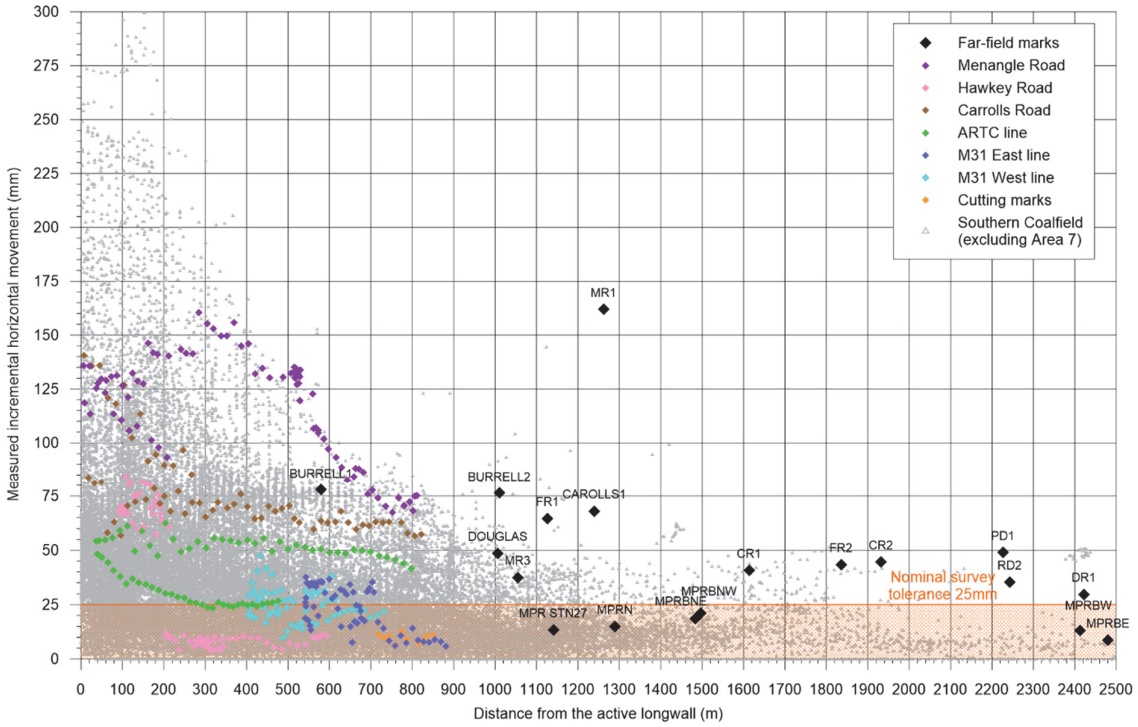


Fig. 2.4 Measured incremental horizontal movements versus distance from LW709

The incremental horizontal movement measured at MR1 is greater than those typically measured at similar distances from the active longwall elsewhere in the Southern Coalfield. However, this mark is located in Area 9 and therefore its movement was affected by the concurrent mining of LW905. Elsewhere, the measured incremental horizontal movements at the other far-field 3D marks and monitoring lines are similar to those typically measured in the Southern Coalfield.

2.10. Douglas Park Twin Bridges over the Nepean River

The Douglas Park Twin Bridges are located approximately 3.1 km south of the commencing (i.e. western) end of LW709. The monitoring associated with the Douglas Park Twin Bridges for LW709 included the:

- absolute 3D bridge monitoring points;
- relative 3D bridge monitoring points;
- bridge joint monitoring; and
- visual inspections.

Descriptions of the monitoring results are provided in the following sections.

2.10.1. Absolute 3D monitoring for the Douglas Park Twin Bridges

The absolute 3D horizontal movements at the Douglas Park Twin Bridges were monitored by IMC at Marks DPBN and DPBS. These two marks are located at the northern and southern ends of the bridges.

A summary of the maximum measured incremental and total absolute horizontal movements at Marks DPBN and DPBS is provided in Table 2.16.

Table 2.16 Maximum measured absolute horizontal movements at Marks DPBN and DPBS

Mark	Maximum measured incremental horizontal movement due to LW709 (mm)	Maximum measured total horizontal movement due to LW701 to LW708B (mm)
DPBN	16	66
DPBS	15	92

The development of the total absolute horizontal movements at Marks DPBN and DPBS, during the mining of LW703 to LW709 and concurrent mining in the adjacent Area 9, is shown in Fig. 2.5. The development of the relative horizontal distance between these two marks is illustrated in Fig. 2.6.

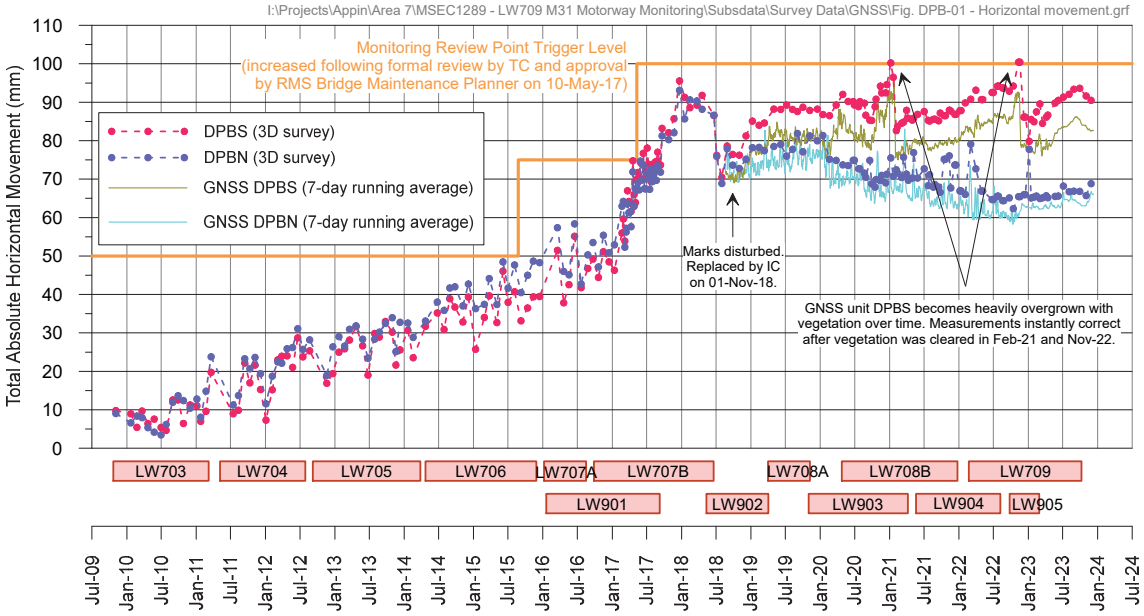


Fig. 2.5 Development of the absolute horizontal movements at Marks DPBN and DPBS

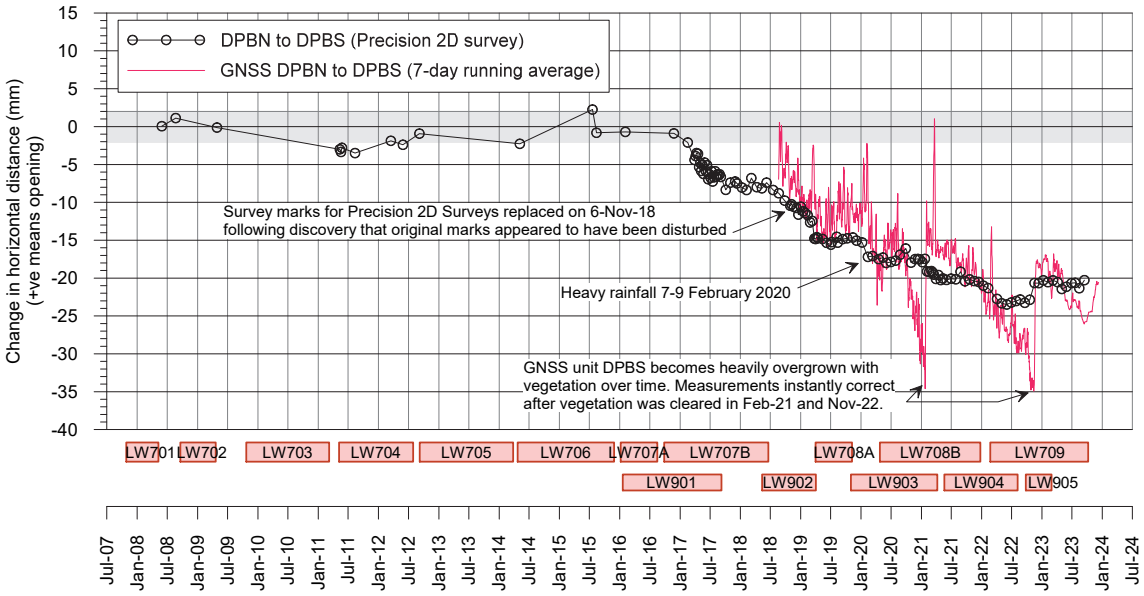


Fig. 2.6 Development of the relative horizontal movement between Marks DPBN and DPBS

The Trigger Action Response Plan (TARP) for the Douglas Park Twin Bridges, developed by the RMS chaired Technical Committee, provided triggers for absolute and relative horizontal movements of Marks DPBN and DPBS.

The Level 1 trigger of 100 mm for the absolute total horizontal movement, was agreed by the Technical Committee on the 10 May 2017, during the extraction of LW707B. No changes were made to the Level 1 trigger during the mining of LW709. Very little change in horizontal distance was observed between the ends of the Bridges during the mining of LW709.

A summary of the measured horizontal movements at Marks DPBN and DPBS, during the mining of LW709, and the Level 1 triggers is provided in Table 2.17.

Table 2.17 Maximum measured horizontal movements at Marks DPBN and DPBS during the extraction of LW709 and the Level 1 triggers

Type	Maximum measured horizontal movement (mm)	Level 1 trigger (mm)
Absolute horizontal movement of Marks DPBN and DPBS	92	100

The maximum measured total horizontal movements of Marks DPBN and DPBS were less than the Level 1 trigger during the extraction of LW709.

2.10.2. Relative 3D monitoring for the Douglas Park Twin Bridges

The mine subsidence effects at the Douglas Park Twin Bridges were measured by IMC using relative 3D marks fixed directly to the bridge structure. The locations of the monitoring points on the Southbound and Northbound carriageways of the bridges are shown in Fig. 2.7 and Fig. 2.8 (Source: IMC).

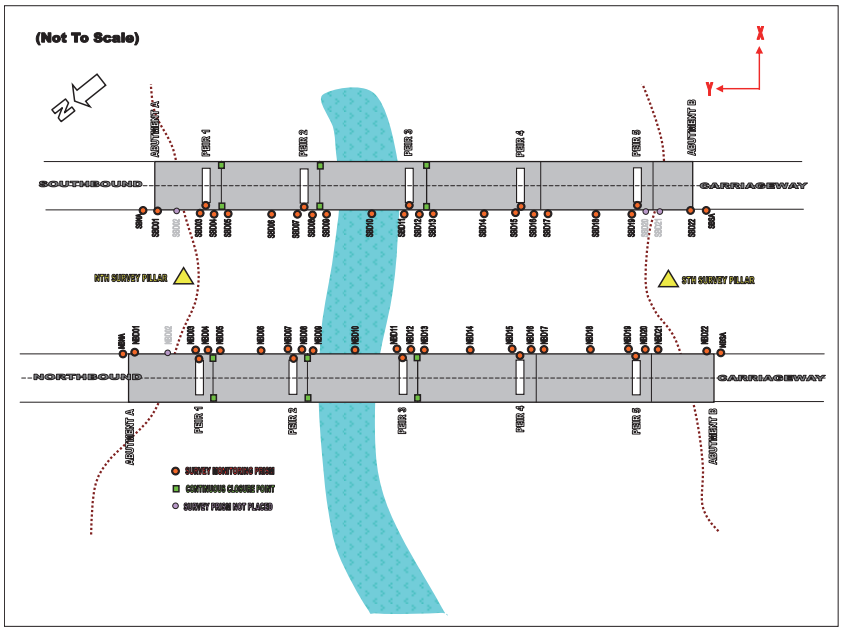


Fig. 2.7 Plan of the relative 3D monitoring points on the Douglas Park Twin Bridges (Source: IMC)

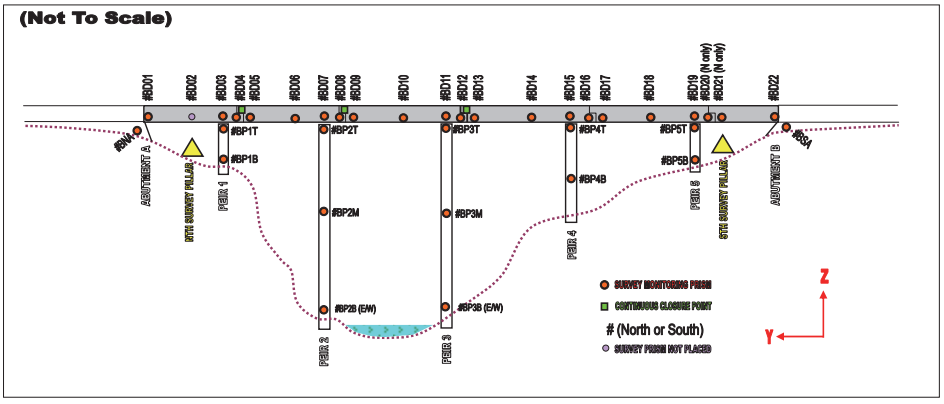


Fig. 2.8 Elevation of the relative 3D monitoring points on the Douglas Park Twin Bridges (Source: IMC)

The changes in horizontal distance between the piers and abutments of the Douglas Park Twin Bridges have been measured during mining in Area 7, since the 15 October 2007, and during the concurrent mining in Area 9. The development of the total changes in horizontal distance between the marks, plotted from the commencement of LW701, is shown in Fig. 2.9. The nominal survey accuracy is ±2 mm.

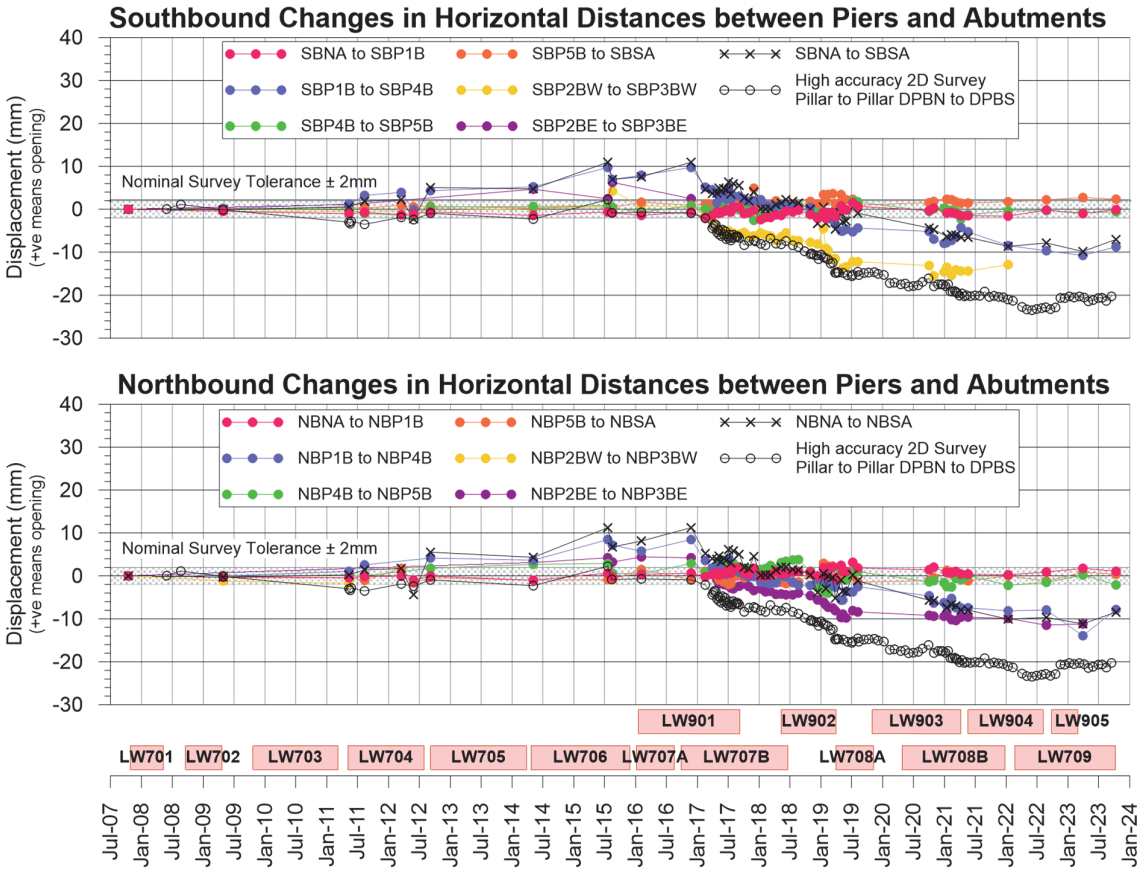


Fig. 2.9 Measured total changes in horizontal distance between the piers and abutments of the Douglas Park Twin Bridges

The total changes in horizontal distance between the abutments and piers at the completion of LW709 were generally less than ±5 mm and, therefore, were similar to the order of survey tolerance.

2.10.3. Joint monitoring for the Douglas Park Twin Bridges

The differential movements across the movement joints in the Douglas Park Twin Bridges were measured by PSM during the extraction of LW709. The bridge movement joints are referred to as Joint 1 (adjacent to Pier 1), Joint 2 (adjacent to Pier 2) and Joint 3 (main expansion joint adjacent to Pier 3). The locations of these joints are shown in Fig. 2.7.

The bridge joint monitoring readings commenced on the 29 November 2007 (during the mining of LW701) and measurements have since been taken at 5 or 10 minute intervals. Further details on the bridge joint monitoring and the results are provided in the monitoring reports by PSM numbers PSM883-472L through PSM883-478L.

The TARP for the Douglas Park Twin Bridges, which was developed by the RMS chaired Technical Committee, provided a trigger for the differential movements across the bridge movement joints. A summary of the maximum measured differential movements across the bridge movement joints, during the extraction of LW709, and the Level 1 triggers is provided in Table 2.18.

Table 2.18 Measured differential movements and triggers for the Douglas Park Twin Bridges joints

Location	Maximum measured differential movement across bridge joint (mm)	Level 1 trigger (mm)
Joint 1 (Northern joint)	< +0.05 (Northbound Carriageway) +0.4 (Southbound Carriageway)	2
Joint 2 (Middle joint)	-0.7 (Northbound Carriageway) -0.5 (Southbound Carriageway)	2
Joint 3 (Main expansion joint)	-3.8 (Northbound Carriageway) -0.6 (Southbound Carriageway)	10

The measured differential movements at the bridge joints did not exceed the Level 1 triggers during the extraction of LW709.

2.11. Moreton Park Road Bridge (South) monitoring points

Moreton Park Road Bridge (South) is located approximately 2.5 km southeast of the commencing (i.e. western) end of LW709. The monitoring associated with Moreton Park Road Bridge (South) for LW709 included the:

- absolute 3D bridge monitoring points;
- relative 3D bridge monitoring points; and
- visual inspections.

The descriptions of the monitoring results are provided in the following sections.

2.11.1. Absolute 3D monitoring points for the Moreton Park Road Bridge (South)

The absolute 3D horizontal movements at the Moreton Park Road Bridge (South) were monitored by IMC at Marks MPBE and MPBW. These two marks are located adjacent to the eastern and western ends of the bridge.

The TARP for the Moreton Park Road Bridge (South), which was developed by the RMS chaired Technical Committee, provided triggers for the absolute horizontal movements of the far-field 3D Points MPBE and MPBW.

The Level 1 trigger of 150 mm for the total absolute horizontal movement, was agreed by the Technical Committee on the 30 May 2017, during the extraction of LW707B. No changes were made to the Level 1 trigger during the mining of LW709.

The development of the total absolute horizontal movement at Marks MPBE and MPBW is shown in Fig. 2.10.

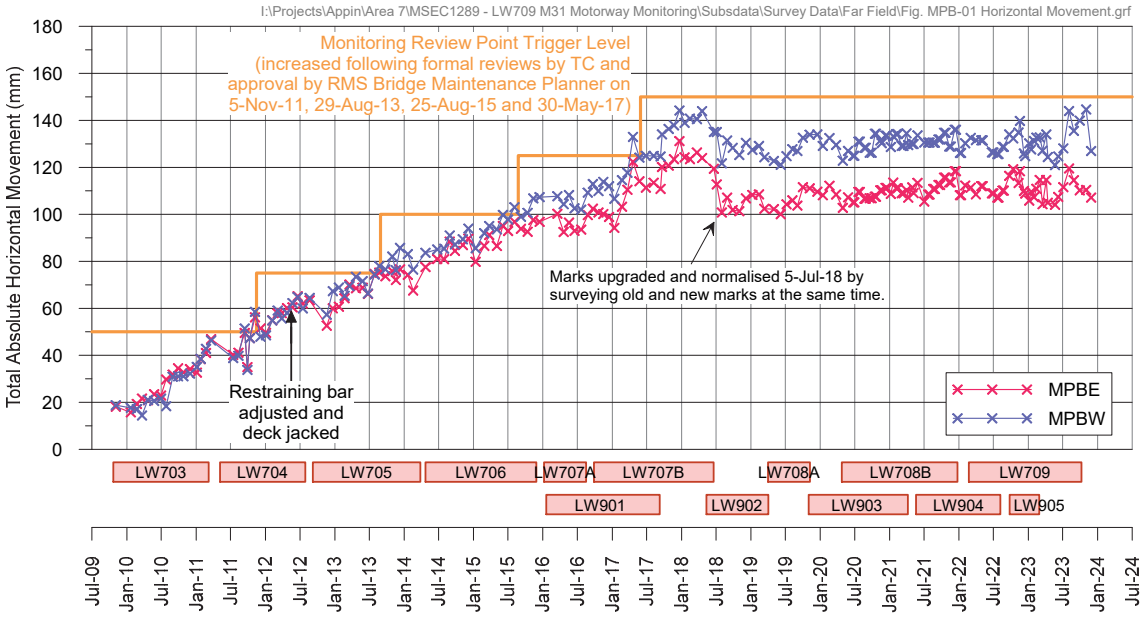


Fig. 2.10 Development of absolute horizontal movement at Marks MPBE and MPBW

A summary of the maximum measured total absolute horizontal movements at Marks MPBE and MPBW, during the extraction of LW709, and the Level 1 trigger is provided in Table 2.19.

Table 2.19 Maximum measured total absolute horizontal movements at Marks MPBE and MPBW during LW709 and the Level 1 trigger

Location	Maximum measured absolute horizontal movement (mm)	Level 1 Trigger (mm)
Marks MPBE and MPBW	110 (MPBE) 145 (MPBW)	150

The maximum measured total absolute horizontal movements at Marks MPBE and MPBW were less than the Level 1 trigger at the completion of LW709.

2.11.2. Relative 3D monitoring points for the Moreton Park Road Bridge (South)

The mine subsidence effects of the Moreton Park Road Bridge (South) were measured by IMC using relative 3D marks fixed directly to the bridge structure. The locations of the monitoring points on the bridges are shown in Fig. 2.11 and Fig. 2.12 (Source: IMC).

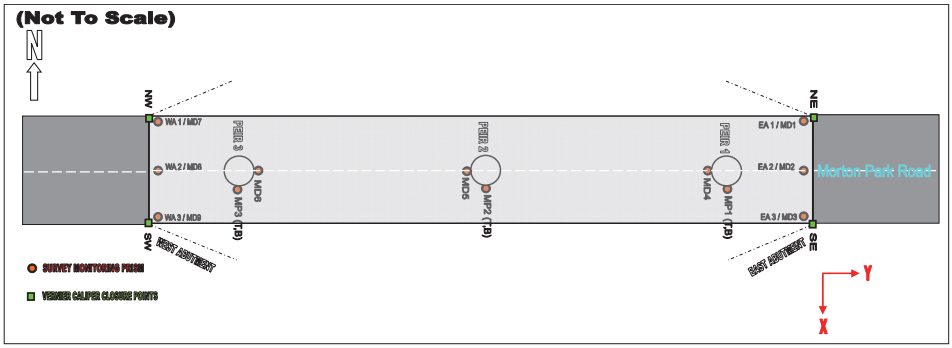


Fig. 2.11 Plan of the relative 3D monitoring points on Moreton Park Road Bridge (South) (Source: IMC)

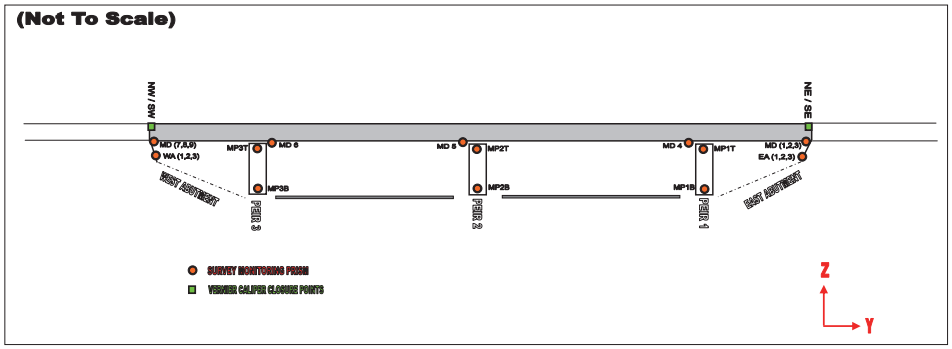


Fig. 2.12 Elevation of the relative 3D monitoring points on Moreton Park Road Bridge (South) (Source: IMC)

The changes in horizontal distance between the bridge abutments have been measured during mining in Area 7, since 15 October 2007, and during the concurrent mining in Area 9. Marks have been established on the eastern abutment (EA1 to EA3) and on the western abutment (WA1 to WA3). Mark EA2 was destroyed in May 2017. The development of the total changes in the horizontal distance between the abutments, during the extraction of LW701 to LW709, are illustrated in Fig. 2.13. The nominal survey accuracy is ±2 mm.

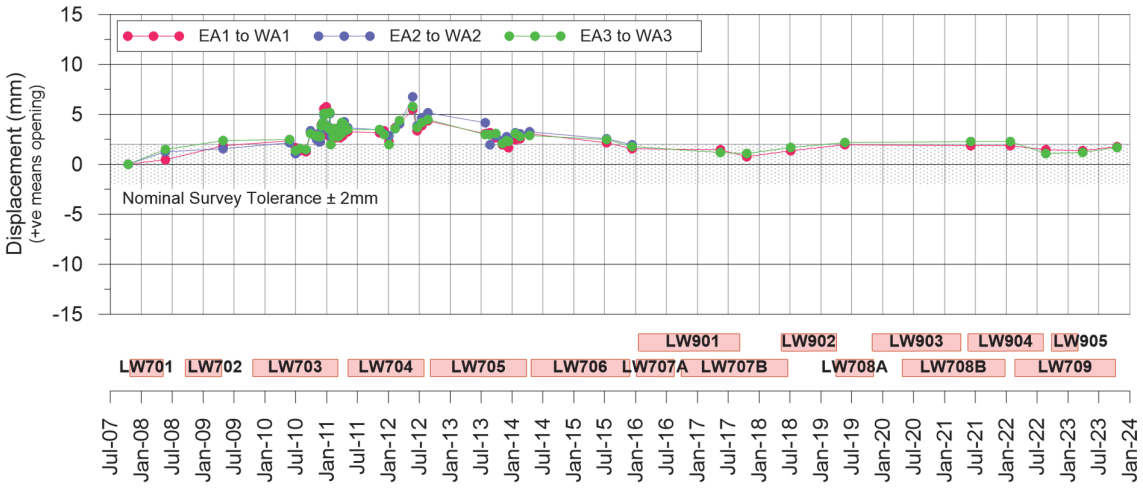


Fig. 2.13 Measured changes in the total horizontal distances between the abutments

There was a small amount of abutment spreading, in the order of +5 mm, that developed during the previous extraction of LW703 to LW705. The results vary slightly between surveys and the cause is thought to be related to changes in moisture and/or temperature. Minor changes have been observed during LW706 to LW709.

The measured total changes in horizontal distance between the bridge abutments were less than+2 mm at the completion of LW709. The total measured movements, therefore, were within the order of survey tolerance.

2.12. Moreton Park Road Bridge (North) monitoring points

Moreton Park Road Bridge (North) is located approximately 1.5 km northeast of the finishing (i.e. eastern) end of LW709. The monitoring associated with Moreton Park Road Bridge (North) for LW709 included the:

- absolute 3D bridge monitoring points;
- 2D bridge monitoring points; and
- visual inspections.

The descriptions of the monitoring results are provided in the following sections.

2.12.1. Absolute 3D monitoring points for the Moreton Park Road Bridge (North)

The absolute 3D horizontal movements at the Moreton Park Road Bridge (North) were monitored by IMC at Marks MPRBNE and MPRBNW. These two marks are located adjacent to the eastern and western ends of the bridge.

The TARP for the Moreton Park Road Bridge (North), which was developed by the RMS chaired Technical Committee, provided triggers for the absolute horizontal movements of the far-field 3D Points MPRBNE and MPRBNW.

The Level 1 trigger of 50 mm for the total absolute horizontal movement, was originally set in the Subsidence Management Plan. The Level 1 trigger was revised during the mining of LW709 to 90 mm, as agreed by the Technical Committee on the 5 September 2023.

The development of the total absolute horizontal movement at Marks MPRBNE and MPRBNW is shown in Fig. 2.10.

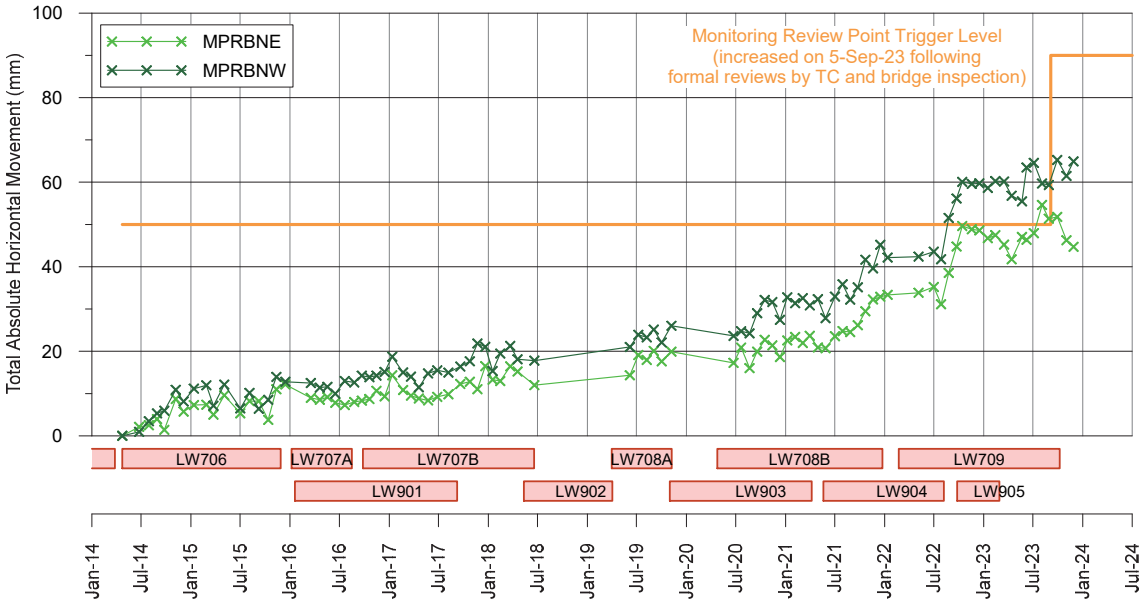


Fig. 2.14 Development of absolute horizontal movement at Marks MPRBNE and MPRBNW

A summary of the maximum measured total absolute horizontal movements at Marks MPRBNE and MPRBNW, during the extraction of LW709, and the Level 1 trigger is provided in Table 2.19.

Table 2.20 Maximum measured total absolute horizontal movements at Marks MPRBNE and MPRBNW during LW709 and the Level 1 trigger

Location	Maximum measured absolute horizontal movement (mm)	Level 1 Trigger (mm)
Marks MPRBNE and MPRBNW	46 (MPBE) 62 (MPBW)	90

The maximum measured total absolute horizontal movements at Marks MPRBNE and MPRBNW were less than the revised Level 1 trigger at the completion of LW709.

The survey pegs have recorded a gradual movement to the south, particularly during the mining of LW708B. The movements at the Bridge are consistent with measured horizontal movements at Far Field Peg MR3, which is located nearby.

The changes in horizontal distance between the bridge abutments have been measured during mining in Area 7, since 30 July 2014, and during the concurrent mining in Area 9. Marks were established on the eastern abutment (MPRBNE) and on the western abutment (MPRBNW). The nominal survey accuracy is ±5 mm.

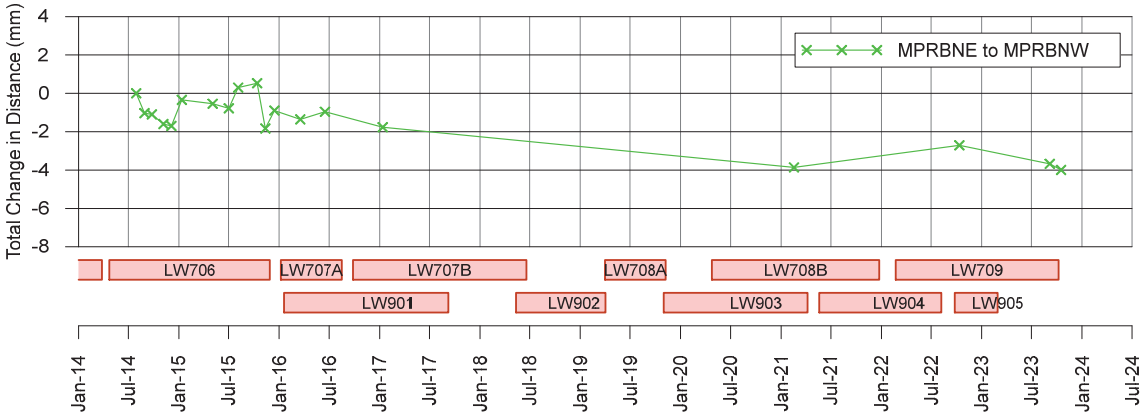


Fig. 2.15 Measured changes in the total horizontal distances between the abutments

The measured total changes in horizontal distance between the bridge abutments were less than 4 mm at the completion of LW709. The total measured movements, therefore, were within the order of survey tolerance.

2.13. LiDAR surveys

Changes in surface level due to the mining in Area 7 have been measured using Light Detection and Ranging (LiDAR) surveys.

The initial or base surface level contours have been determined from the survey carried out in 2007 before the commencement of LW702. The post-mining surface level contours have been determined from the subsequent surveys carried out in March 2022 shortly after the commencement of LW709 and again in November 2023 after the completion of LW709.

The measured incremental changes in surface level due to the mining of LW709 only are shown in Fig. 2.16. These contours have been determined by taking the differences between the surface levels measured in March 2022 and November 2023. The data located outside the predicted incremental 20 mm subsidence contour due to the mining of LW709 have been removed for clarity.

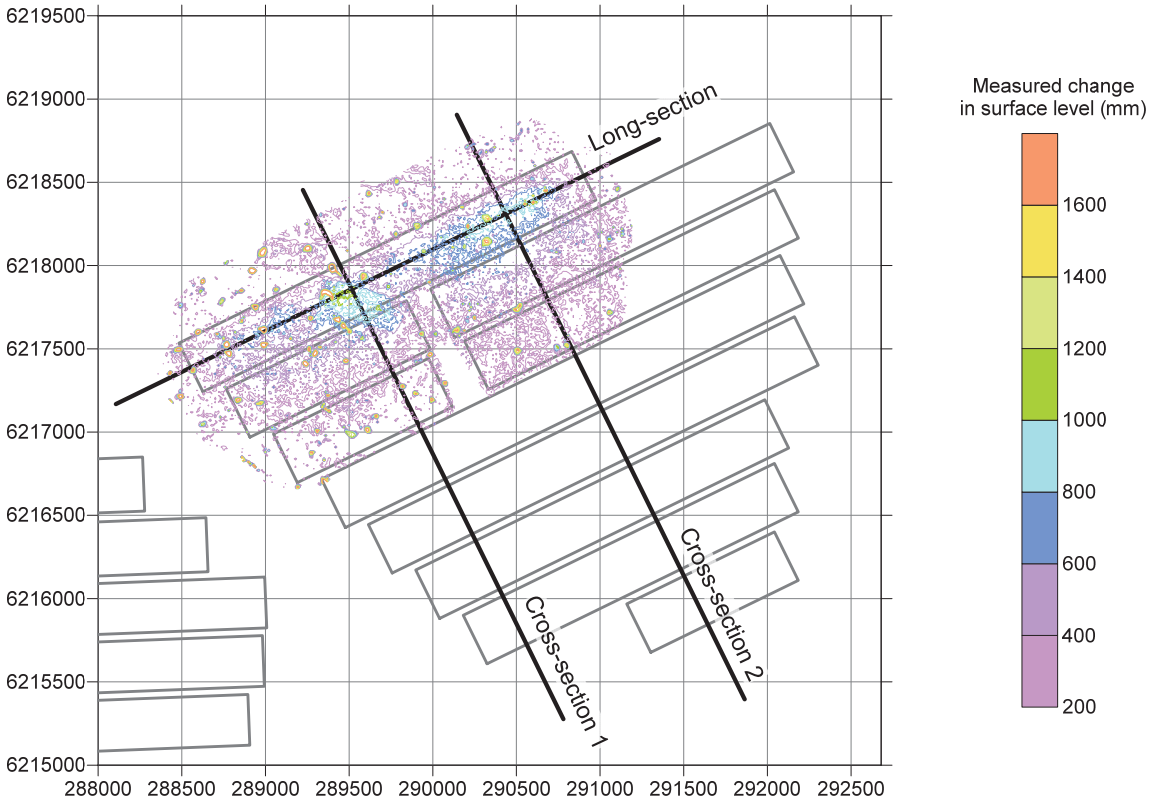


Fig. 2.16 Measured incremental changes in surface level due to the mining LW709 only

The measured total changes in surface level due to the mining of LW702 to LW709 are shown in Fig. 2.17. These contours have been determined by taking the differences between the surface levels measured in 2007 and November 2023. The data located outside the predicted total 20 mm subsidence contour due to the mining of LW702 to LW709 have been removed for clarity.

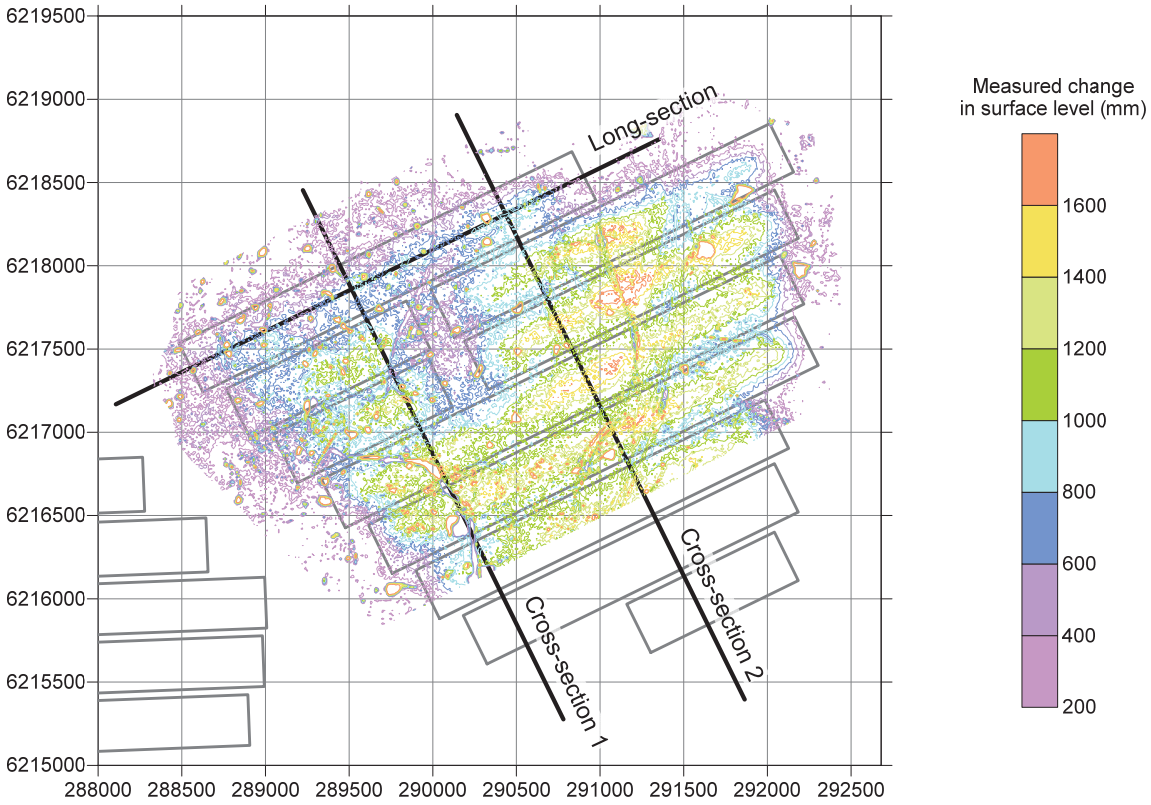


Fig. 2.17 Measured total changes in surface level due to the mining LW702 to LW709

The LiDAR surveys have an accuracy for absolute level in the order of ±100 mm. The accuracy of the measured changes in surface level (i.e. the difference between two surveys), therefore, is in the order of ±200 mm.

The contours of the measured changes in surface level, developed from the LiDAR surveys, show the changes in the heights of points at fixed positions in space (i.e. eastings and northings). This differs from traditional subsidence contours that include both the vertical and horizontal components of the movements of points fixed to the surface. Horizontal movements are usually included in the subsidence profiles, as traditional ground monitoring data is based on the movements of survey marks that are fixed to the ground.

The contours can contain artefacts (i.e. locally increased or decreased movements), particularly in the locations of steeply incised terrain, such as at the cliffs and steep slopes. These artefacts can be seen in Fig. 2.16 and Fig. 2.17 as the localised areas of red contours above the longwalls and the lower level subsidence outside the extents of the longwalls.

The change in surface level at a fixed position in space (i.e. easting and northing), therefore, can be large in the locations of steep terrain and does not provide a true indication of the actual vertical subsidence at a point on the ground. However, where the ground is reasonably flat, the contours of the measured changes in surface level should provide a good indication of the actual vertical subsidence.

Comparisons of the measured changes in surface level and the predicted vertical subsidence along Cross-section 1, Cross-section 2 and the Long-section are provided in Fig. 2.18 to Fig. 2.20, respectively. The locations of these sections are indicated in Fig. 2.16 and Fig. 2.17. The predicted profiles of vertical subsidence have been derived from the predicted subsidence contours illustrated in Report No. MSEC1117.

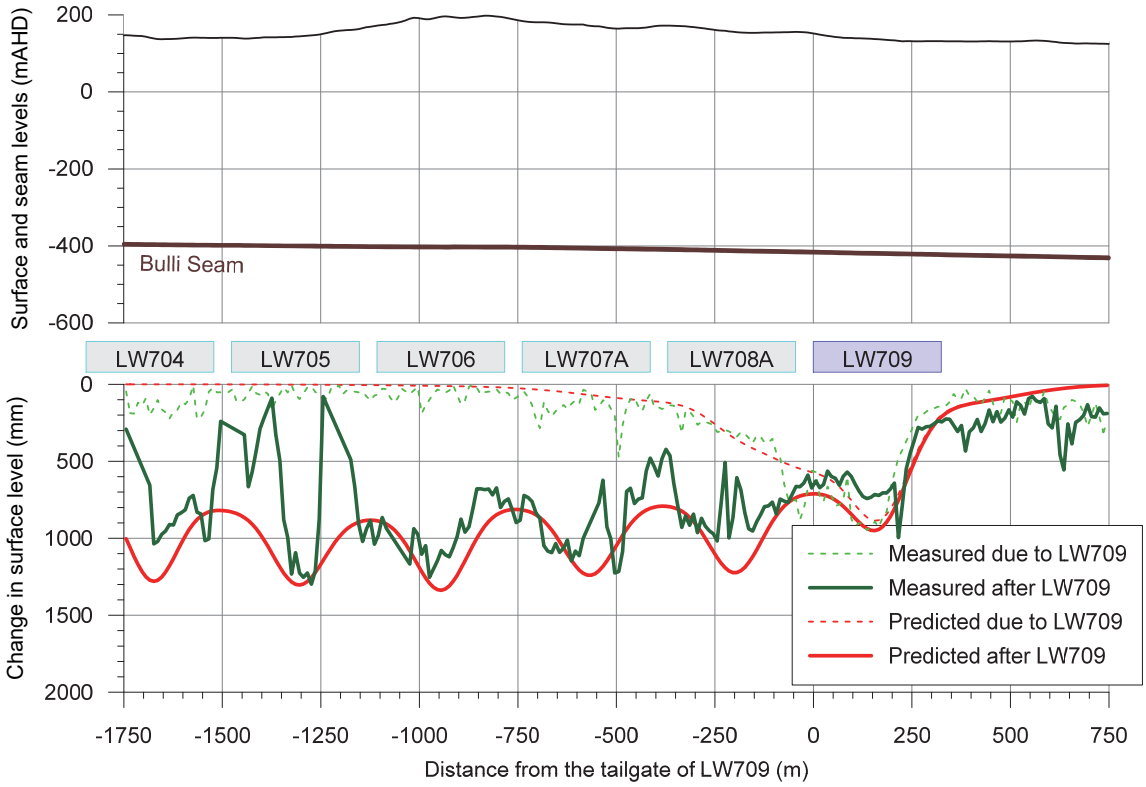


Fig. 2.18 Measured changes in surface level and predicted vertical subsidence for the Cross-section 1 across LW704 to LW709

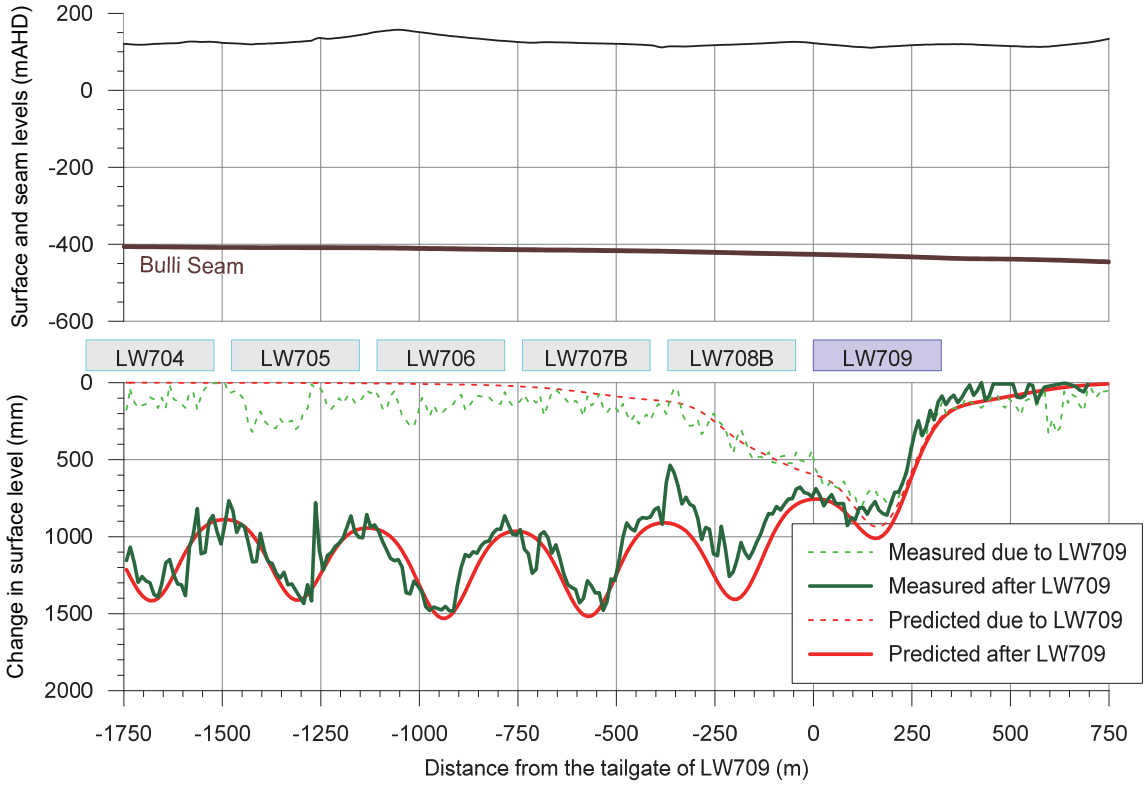


Fig. 2.19 Measured changes in surface level and predicted vertical subsidence for Cross-section 2 across LW704 to LW709

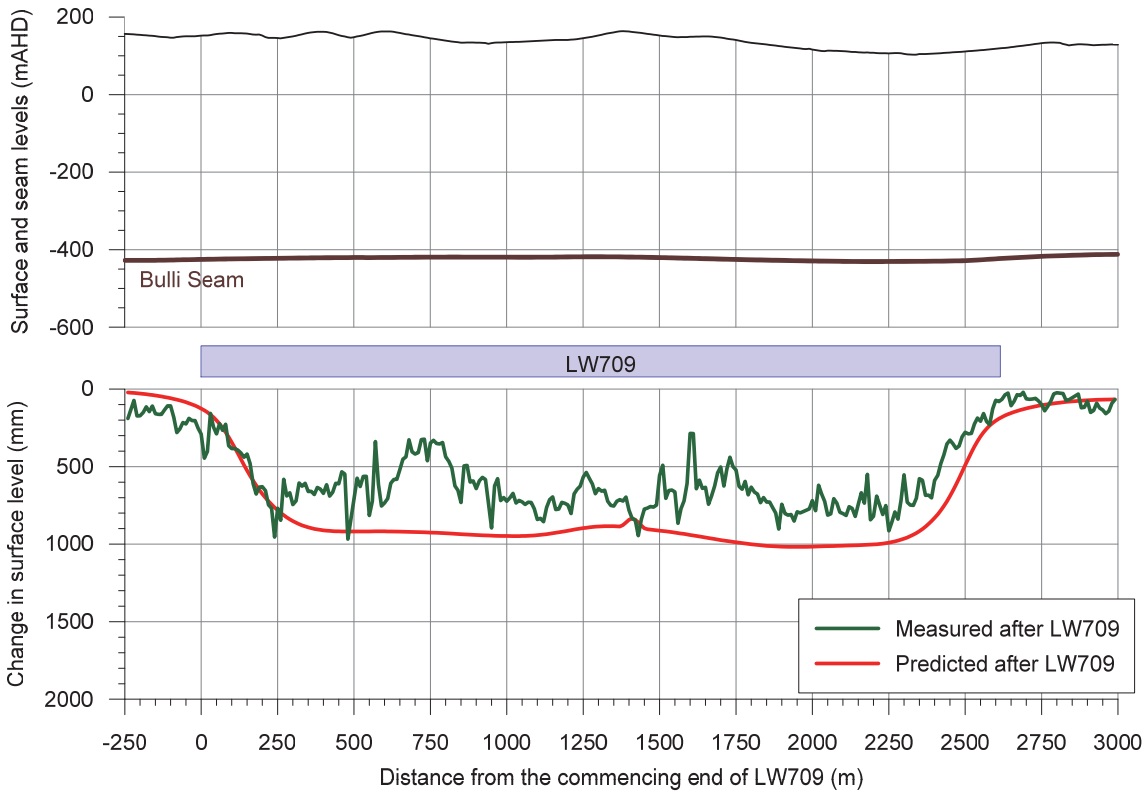


Fig. 2.20 Measured changes in surface level and predicted vertical subsidence for the Long-section along the centreline of LW709

The profiles of the measured change in surface level reasonably match the predicted profiles of vertical subsidence along the two cross-sections and long-section. The maximum measured changes in surface level above the longwalls are typically less than the maximum predicted values. The measured change in surface level locally exceeds the predicted vertical subsidence in some locations; however, these are likely to be localised effects partly due to the measurement tolerance.

It can be inferred from the slopes of the profiles along Cross-section 1, Cross-section 2 and the Long-section that the measured changes in grade are similar to the predicted tilts along and across the longwalls. It is not possible to derive the curvature nor the horizontal movements from the LiDAR surveys.

The measured changes in surface level are greater than the predicted vertical subsidence outside the mining area for each of the cross-sections and long-section. However, this is due to the measurement tolerance and the effects of the horizontal movements and sloping terrain on the LiDAR surveys. The differences between the measured and predicted movements above solid coal are generally in the order of accuracy of the LiDAR surveys of ±200 mm. There are localised areas where these differences exceed the measurement tolerance; however, these are artefacts of the LiDAR surveys and are not real movements.

It is considered that the ground movements measured using the LiDAR surveys are consistent with the predictions provided in Report No. MSEC1117 which supported the Extraction Plan Application for LW709 to LW711 and LW905.

3.1. Natural Features

The natural features located near LW709 are shown in Drawing No. MSEC1394-02, in Appendix B. These features include the:

- Nepean River;
- creeks;
- cliffs and rock outcrops;
- steep slopes; and
- archaeological sites.

The MSEC assessments for the natural features due to the mining of LW709 to LW711 and LW905 are provided in Report No. MSEC1117. More detailed assessments for some natural features are also provided in other consultant's reports. Comparisons between the MSEC assessments and the observed impacts for the natural features, as listed above, are provided in Table 3.1. The observed impacts are based on those recorded by IMC Environmental Field Team and are described in the report entitled *Appin Mine Longwall 709 End of Panel Landscape Report*, dated November 2023.

Table 3.1 Summary of the MSEC assessments and the observed impacts for the natural features due to the mining of LW709

Natural feature	MSEC assessed impacts	Observed impacts
The Nepean River	**Minor fracturing** could occur in the bed of the river	No fracturing observed; however, the flooded valley and sediment profile limits observations of the riverbed
	The potential for **surface water flow diversion** assessed as very low	No observable loss or diversion of water from the Nepean River. Refer to the accompanying Surface Water Report by HGEO for further details
	The **surface water level** is expected to remain essentially unchanged. Uplift of the banks could result in some desiccation of the banks	No observed changes in water level apart from the normal fluctuations associated with rainfall and WaterNSW discharges
	Possible that mining-induced **springs** could occur	No iron staining or iron seeps were observed in the Nepean River during the mining of LW709
	Possible that isolated **gas emissions** could occur	No new gas releases. One existing gas release zone was active during the inspection carried out on 4 October 2023. See Table 1 in Landscape Report by IMC
	Water quality – Refer to the accompanying Surface Water Report by HGEO **Terrestrial ecology** – No impacts or changes to terrestrial ecology were observed during the mining of LW709. Refer to the accompanying Landscape Report by IMC	
Creeks	Potential for some **ponding**, **flooding** and **desiccation** above the longwalls	No observed adverse impacts in the monitored streams
	Fracturing could occur in the beds of the smaller creeks above the longwalls	No observed adverse impacts in the monitored streams
Cliffs and rock outcrops	Potential for **cliff instabilities** assessed as very low	No observed adverse impacts
Steep slopes	Potential for **soil slippage**	No observed adverse impacts
Aboriginal heritage sites	Low likelihood of impacts on open sites, scarred tree and shelters.	There are no applicable Aboriginal heritage sites on the Aboriginal Heritage Information Management System (AIHMS) within or adjacent to the LW709 mining area

There were no observed adverse impacts on the natural features due to the mining of LW709. Three previously reported Appin Area 7 gas release zones had active gas release at some stage during the LW709 extraction period. Further assessments of natural features have been provided by other specialist consultants on the project, which are described in the relevant reports accompanying the *End of Panel* report.

3.2. Built features

The built features located near LW709 are shown in Drawings No. MSEC1394-03, in Appendix B. The features considered in this *End of Panel* report include those located within either the 35° angle of draw line from LW709 and/or the predicted 20 mm incremental subsidence contour due to the mining of these longwalls. The built features expected to experience far-field or valley-related movements and which could be sensitive to these movements have also been considered. The built features include:

- Moreton Park Road and drainage culverts;
- Menangle Road and drainage culverts;
- Carrolls Road and drainage culverts;
- Hawkey Road and drainage culverts;
- M31 Hume Motorway and associated infrastructure;
- Main Southern Railway and associated infrastructure;
- Douglas Park Twin Bridges;
- Moreton Park Road Bridge (South);
- low voltage powerlines;
- copper telecommunications cables;
- optical fibre cables;
- building structures, pools, tanks and farm dams; and
- survey control marks.

The MSEC assessments for the built features, due to the mining of LW709 to LW711 and LW905 are provided in Report No. MSEC1117. Comparisons between the assessed and observed impacts for the built features located near LW709, as listed above, are provided in Table 3.2. The observed impacts are based on those recorded by IMC Environmental Field Team.

Table 3.2 Summary of the MSEC assessed and observed impacts for built features due to the mining of LW709

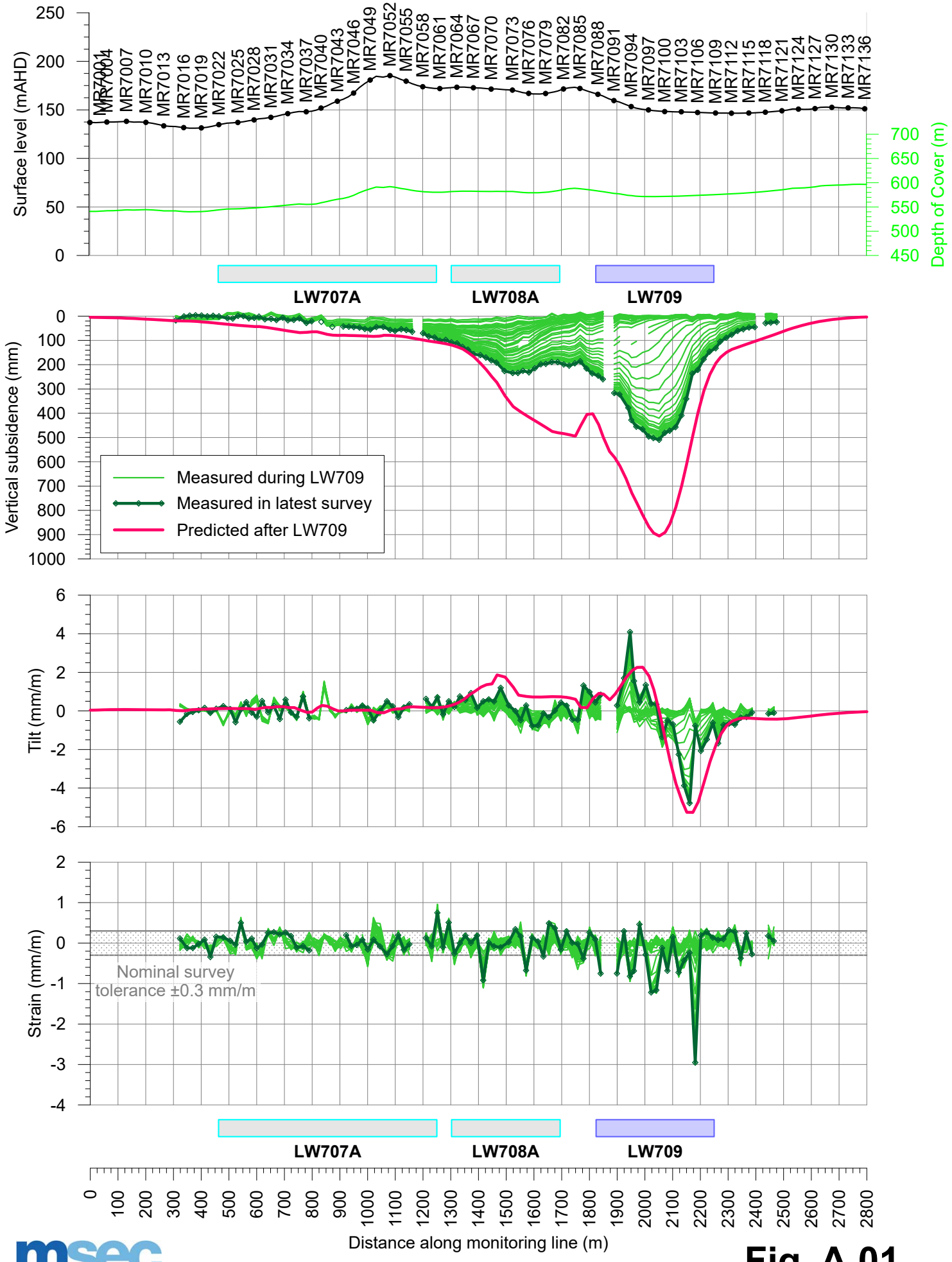
Built feature	MSEC assessed impacts	Observed impacts
Menangle Road, Carrolls Road and Hawkey Road	Minor cracking and localised heaving of the road surface may occur in some locations above the longwalls	Roads remained safe and serviceable. Localised heaving and cracking occurred in the road pavements between Marks MR7105 and MR7106 along Menangle Road and between Marks CAR36 to CAR37 along Carrolls Road. The road pavement along Menangle Road was resurfaced during the mining of LW709.
M31 Hume Motorway	No impacts on the safety or serviceability of the motorway after the implementation of the management strategies	Road remained safe and serviceable. No adverse impacts to safety or serviceability
Main Southern Railway	No impacts on the safety or serviceability of the railway after the implementation of the management strategies	Track remained safe and serviceable. Changes in track geometry recorded during the mining of LW709 and these were remediated in accordance with the Management Plan
Douglas Park Twin Bridges	Impacts unlikely after the implementation of the TARP	No adverse impacts observed due to the mining of LW709
Moreton Park Road Bridge (South)	Impacts unlikely after the detailed investigation, analysis and implementation of the TARP	No adverse impacts observed due to the mining of LW709
Moreton Park Road Bridge (North)	Impacts unlikely after the detailed investigation, analysis and implementation of the TARP	No adverse impacts observed due to the mining of LW709
Low voltage powerlines	Impacts unlikely, but minor mitigation measures may be required	No adverse impacts observed due to the mining of LW709

Built feature	MSEC assessed impacts	Observed impacts
Copper telecommunications cables	Impacts unlikely	No adverse impacts observed due to the mining of LW709
Optical fibre cables	Impacts unlikely with the implementation of the management strategies including OTDR monitoring and mitigation	No adverse impacts observed due to the mining of LW709
Building structures	Assess that approximately 17 % to 23 % of houses will experience Category R1 or R2 impacts, approximately 7 % to 11 % will experience Category R3 or R4 impacts and approximately 2 % to 3 % will experience Category R5 impacts	Building structures remained in safe and serviceable conditions. Impacts observed to houses during the mining of LW709 comprise very slight to slight impacts (Category R1 or R2) at 7 houses (Refs. D33, D35, D50, D52, F08, F32 and F33) and moderate or greater impacts (Category R3) at 3 houses (Refs. A24, C09 and D38). Claims that have been lodged are being managed by Subsidence Advisory (SA) NSW through the relevant legislation
Pools	Inground pools could be more susceptible to ground strains causing cracking and/or loss of water	Impacts observed to pools during the mining of LW709 comprise cracking of the shells or surrounds or loss of water at 4 locations (Refs. C09, D18, D41 and F32). Claims that have been lodged are being managed by SA NSW through the relevant legislation Pool gates not closing or latching correctly at several properties (Refs. A24, D26, D33, D41, D44, D45, F06 and F32) which were remediated by IMC or the property owner
Water tanks	Impacts unlikely	No adverse impacts observed due to the mining of LW709
Farm dams	Potential for minor cracking or leakage	No adverse impacts observed due to the mining of LW709
Heritage structures	No heritage structures located near LW709	No adverse impacts observed due to the mining of LW709
Groundwater bores	Potential for blockage or reduction in the capacity of the groundwater bores	No adverse impacts observed to groundwater bores due to the mining of LW709. Refer to the accompanying Groundwater Report by HGEO
Survey control marks	Small fair-field horizontal movements which could require re-establishment	Small far-field horizontal movements

The observed impacts on the built features due to the mining of LW709 were similar to or less than the assessed (i.e. predicted) impacts.

APPENDIX A. FIGURES

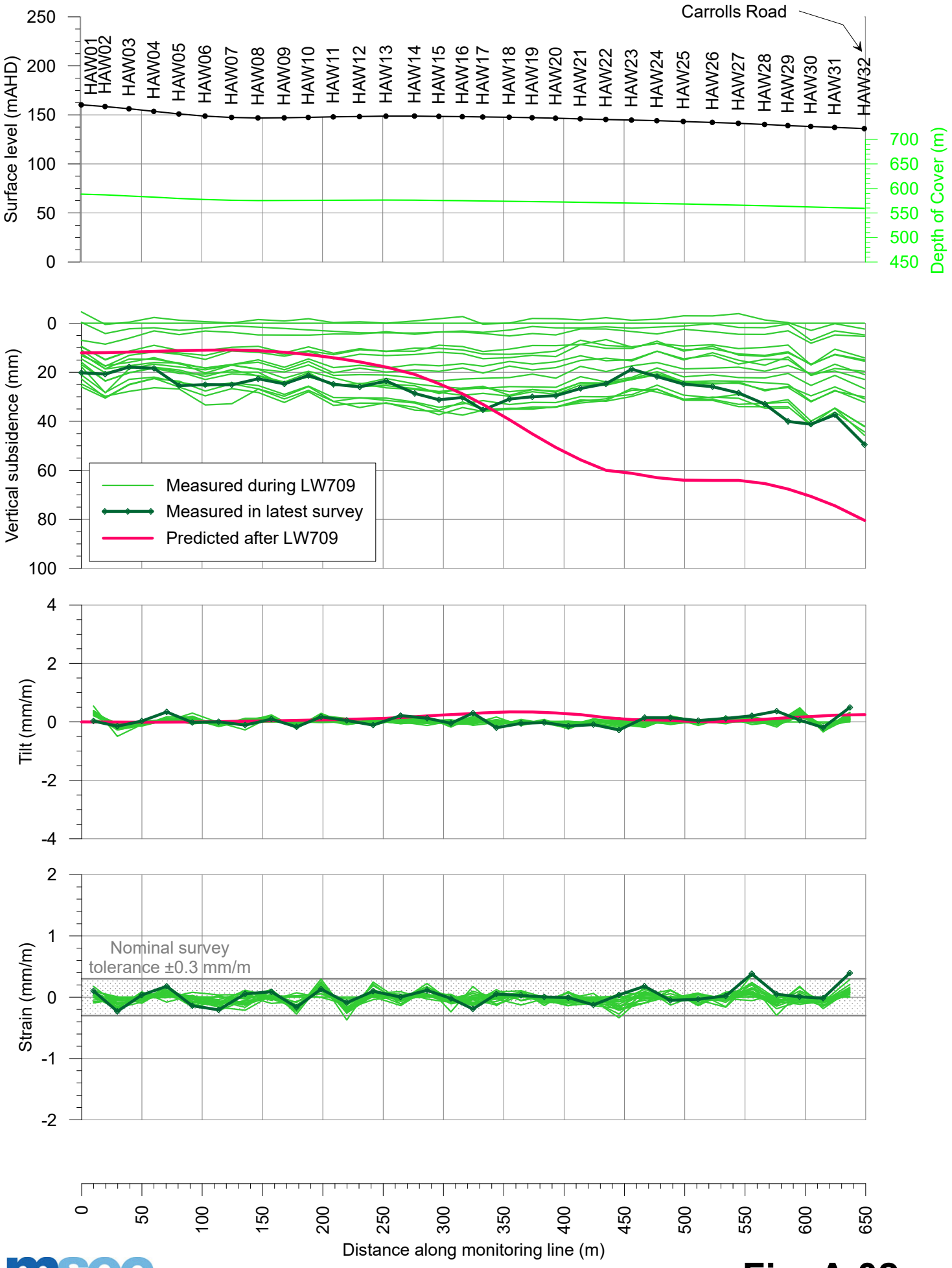
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along the Menangle Road monitoring line due to LW709



msec

Fig. A.01

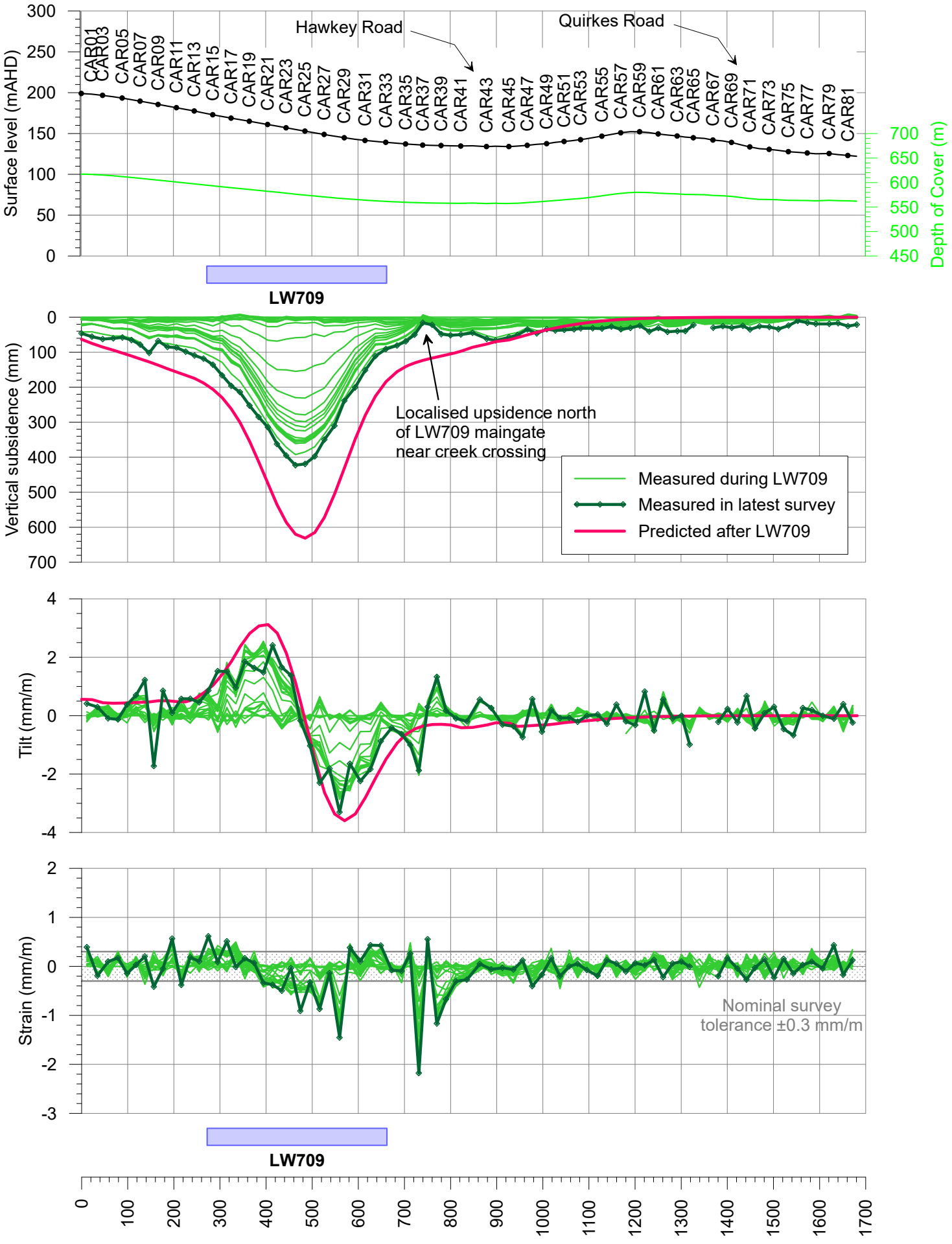
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along the Hawkey Road monitoring line due to LW709



msec

Fig. A.02

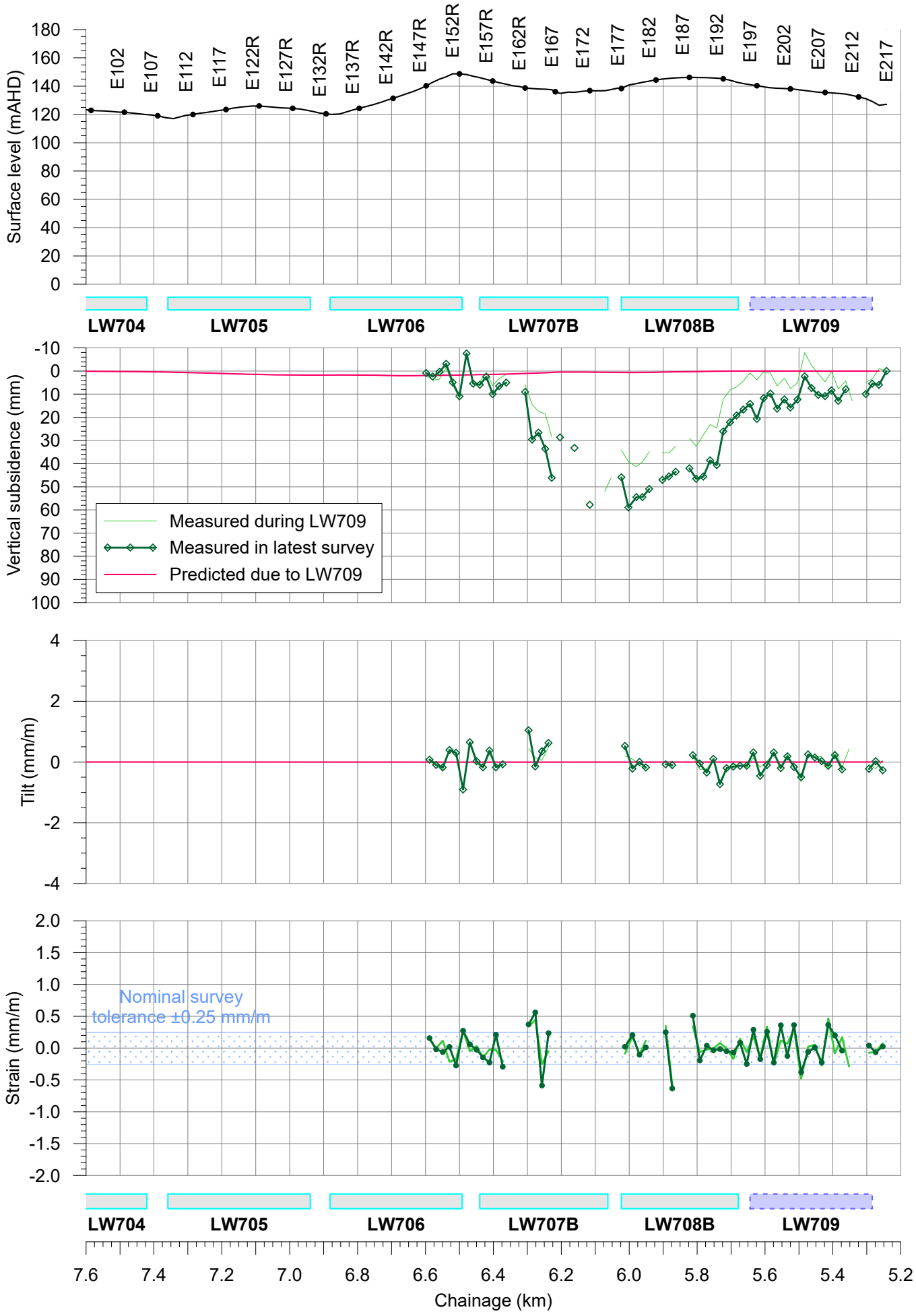
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along the Carrolls Road monitoring line due to LW709



msec

Fig. A.03

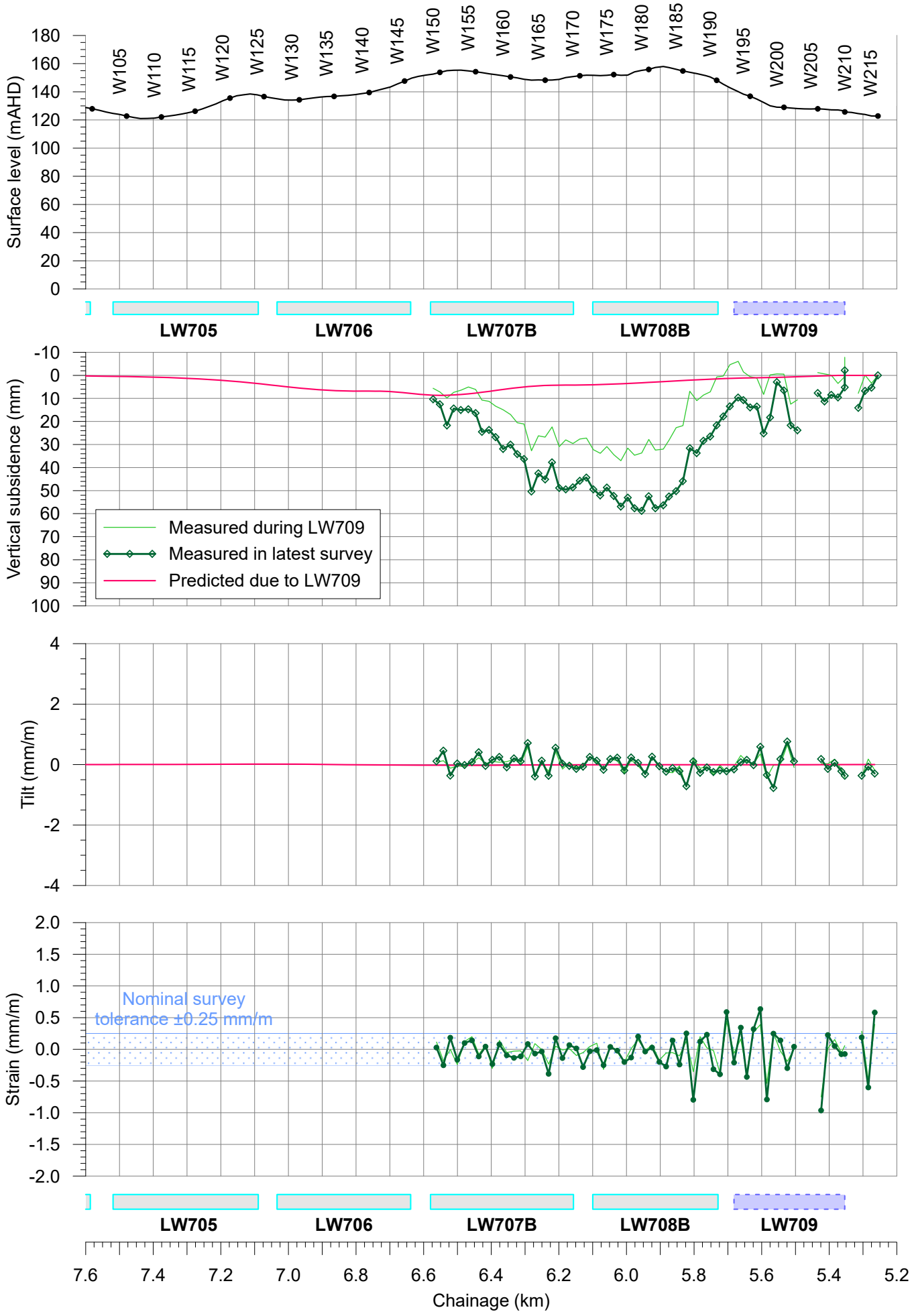
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along M31 East Line due to LW709



msec

Fig. A.04

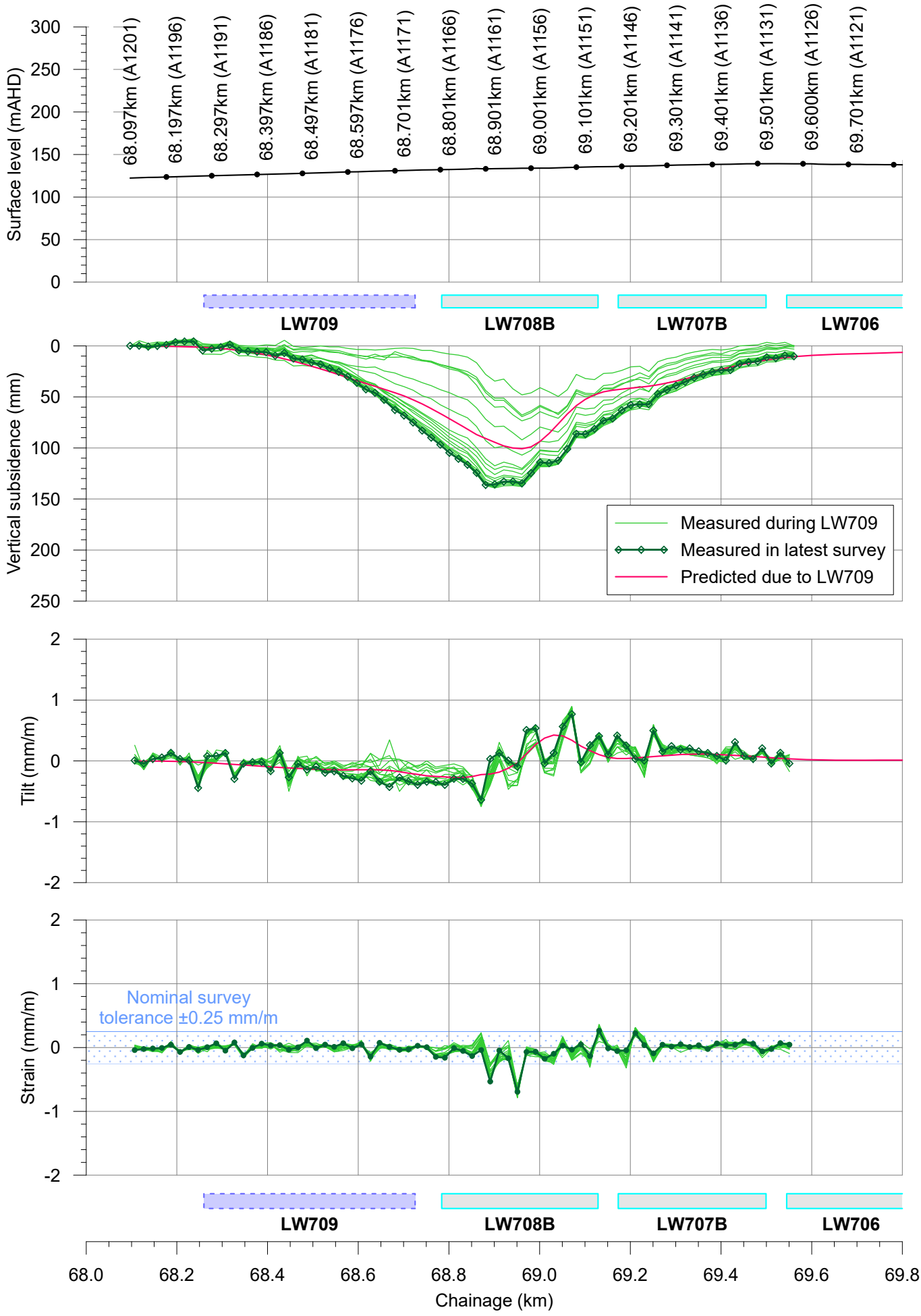
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along M31 West Line due to LW709



msec

Fig. A.05

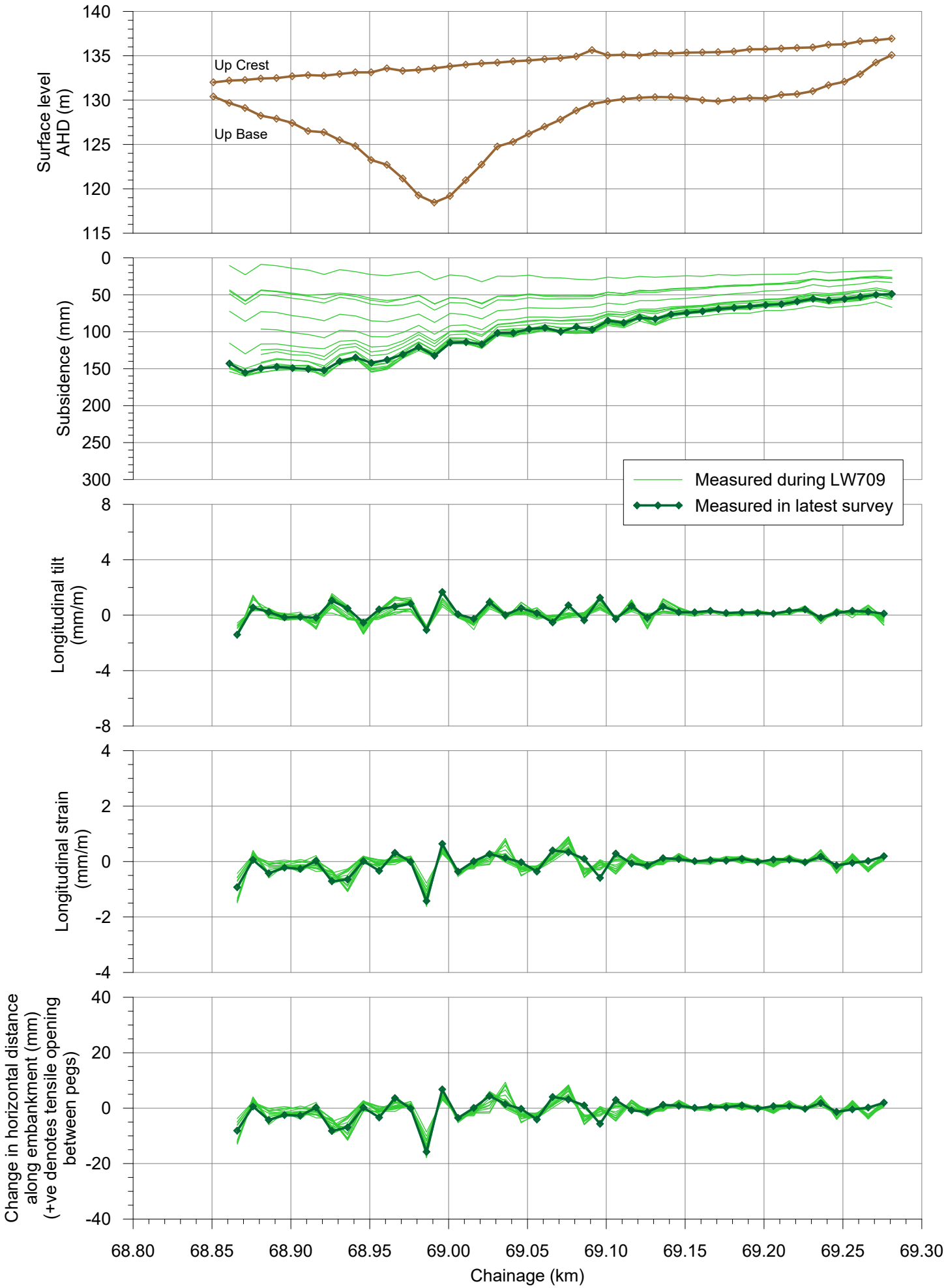
Measured and predicted profiles of incremental vertical subsidence, tilt and strain along the ARTC Line due to LW709



msec

Fig. A.06

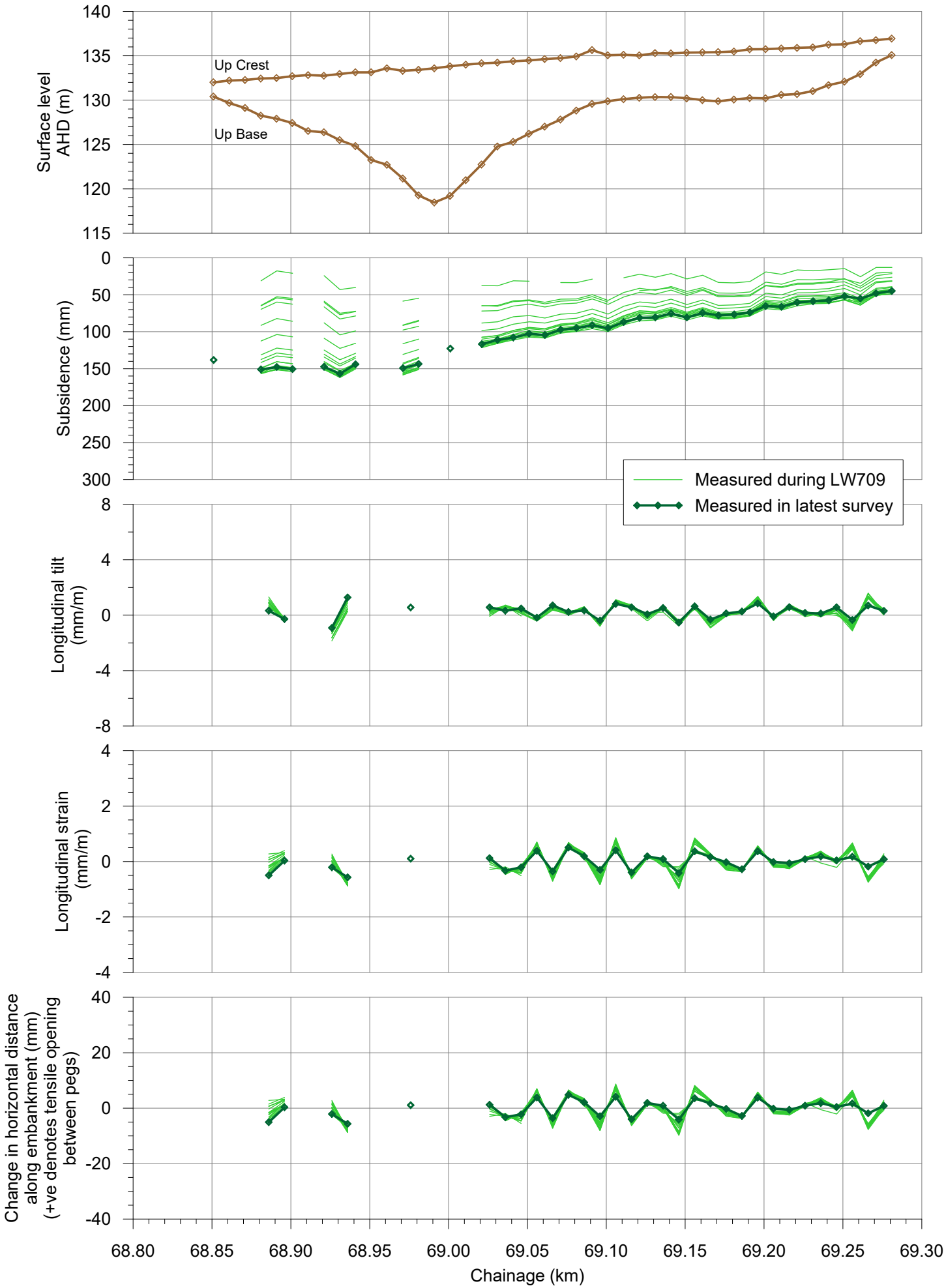
Appin Colliery - LW709 - Embankment at 69.0km
Incremental Subsidence Profiles along Up Base



msec

Fig. A.07

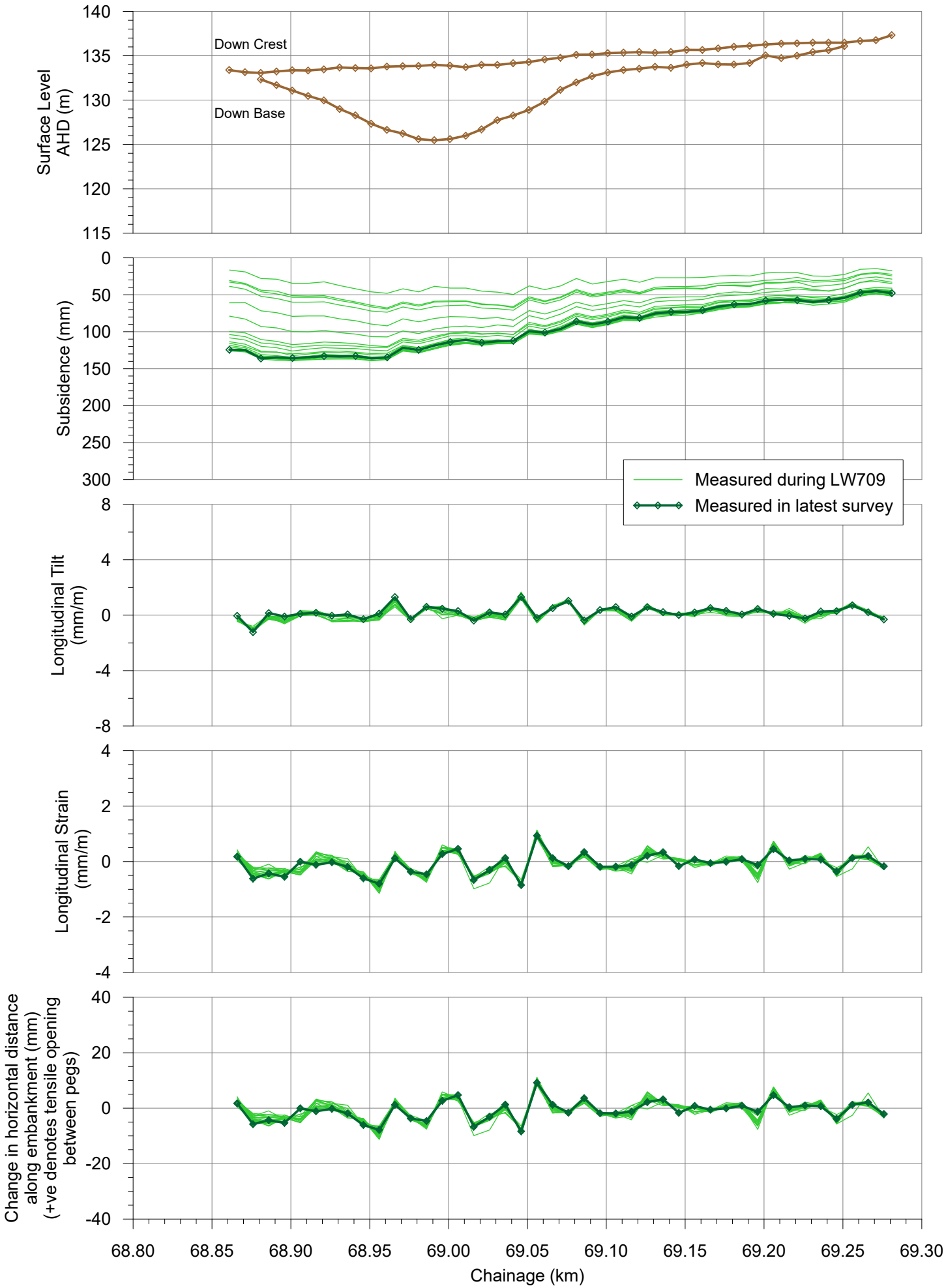
Appin Colliery - LW709 - Embankment at 69.0km
Incremental Subsidence Profiles along Up Crest



msec

Fig. A.08

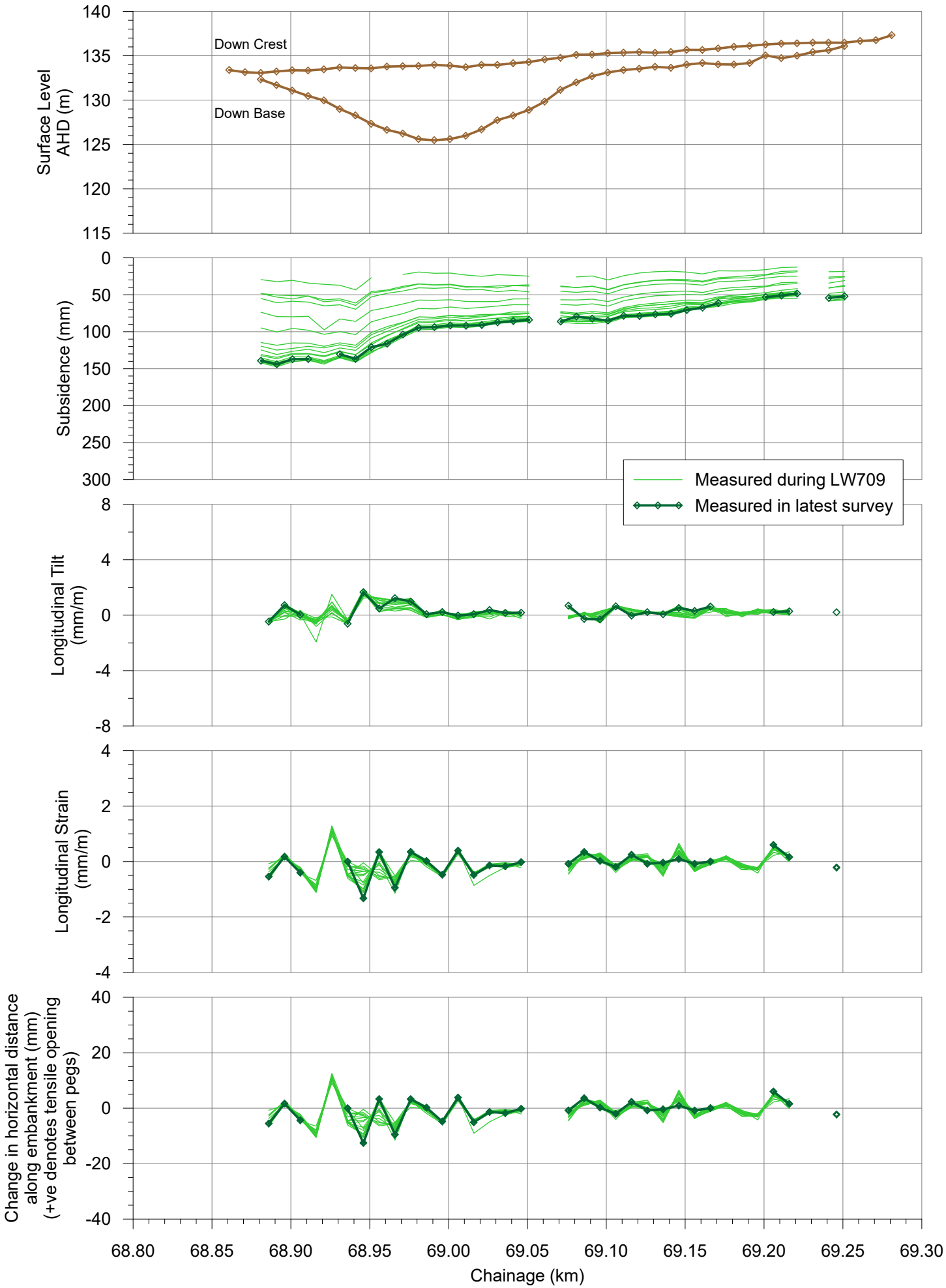
Appin Colliery - LW709 - Embankment at 69.0km
Incremental Subsidence Profiles along Down Crest



msec

Fig. A.09

Appin Colliery - LW709 - Embankment at 69.0km
Incremental Subsidence Profiles along Down Base



msec

Fig. A.10

APPENDIX B. DRAWINGS

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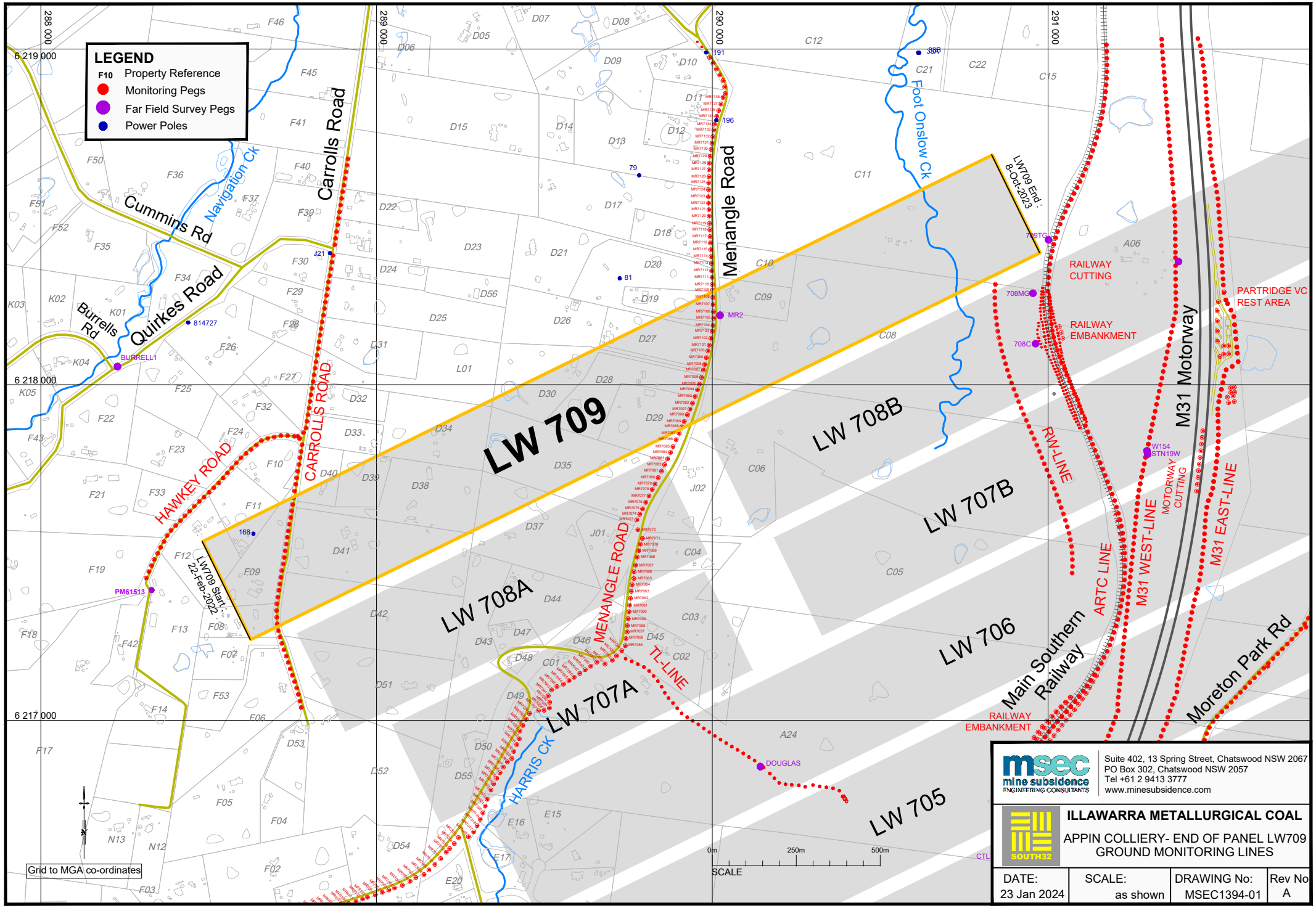

msec mine subsidence ENGINEERING CONSULTANTS
Suite 402, 13 Spring Street, Chatswood NSW 2067
PO Box 302, Chatswood NSW 2057
Tel +61 2 9413 3777
www.minesubsidence.com

ILLAWARRA METALLURGICAL COAL

APPIN COLLIERY- END OF PANEL LW709 GROUND MONITORING LINES

DATE:	SCALE:	DRAWING No:	Rev No
23 Jan 2024	as shown	MSEC1394-01	A

I:\Projects\Appin\Area 7\MSEC1394 - LW709 End of Panel Report\AcadData\MSEC1394-02 Natural Features.dwg

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Suite 402, 13 Spring Street, Chatswood NSW 2067
PO Box 302, Chatswood NSW 2057
Tel +61 2 9413 3777
www.minesubsidence.com

SOUTH32

ILLAWARRA METALLURGICAL COAL
LW709 END OF PANEL NATURAL FEATURES

DATE:	SCALE:	DRAWING No:	Rev No
23 Jan 2024	as shown	MSEC1394-02	A

289 000
290 000
291 000
6 219 000
6 218 000
6 217 000
288 000

Navigation Ck
Foot Onslow Ck
HARRIS CK
MENANGLE ROAD
MAIN SOUTHERN RAILWAY
M31 HUME MOTORWAY
MORETON PARK RD

LW709 End: 8-Oct-2028
LW709 Start: 22-Feb-2022

LW 709
LW 708A
LW 708B
LW 707A
LW 707B
LW 706
LW 705

Foot Onslow Creek IA 1
Foot Onslow Creek IA 2
Foot Onslow Creek IA 3
Foot Onslow Creek IA 4
Foot Onslow Creek AS 1
Foot Onslow Creek IA 5
Foot Onslow Creek IA 6
52-2-1213

LEGEND:
- CLIFFS
- STEEP SLOPES
- WATERCOURSES
- ARCHAEOLOGICAL SITES
- GEOLOGICAL STRUCTURES AT SEAM

N

Grid to MGA co-ordinates

I:\Projects\Appin\Area 7\MSEC1394 - LW709 End of Panel Report\AcadData\MSEC1394-03 Surface Infrastructure.dwg

msec mine subsidence ENGINEERING CONSULTANTS
Suite 402, 13 Spring Street, Chatswood NSW 2067
PO Box 302, Chatswood NSW 2057
Tel +61 2 9413 3777
www.minesubsidence.com

SOUTH32

ILLAWARRA METALLURGICAL COAL
LW709 END OF PANEL SURFACE INFRASTRUCTURE

DATE:	SCALE:		
23 Jan 2024	as shown	MSEC1394-03	A

289 000 290 000 291 000 288 000

6 218 000 6 217 000

CUMMINS RD CARROLLS RD MENANGLE ROAD BURRELLS QUIRKES RD HAWKEY ROAD MAIN SOUTHERN RAILWAY M31 HUME MOTORWAY MORETON PARK RD

LW709 End: 8-Oct-2023

LW709 Start: 22-Feb-2022

LW 709 LW 708B LW 708A LW 707B LW 707A LW 706 LW 705

PM 87187 PM 87186 PM 87183 PM 61513 PM 25150 PM 60540 PM 60539 PM 60538 PM 60537 PM 25153 PM 67986

SS 97734 SS 67659 SS 16320

TS 10421

Mountbatten 2

PARTRIDGE VC REST AREA

LEGEND

- Heritage Sites
- Building Structures & Farm Dams
- Roads & Roads Culverts
- Railway & Rail Culverts
- Survey Marks
- Telecommunications
  - Optical Fibre Cables
  - Copper Cables
- Electrical Infrastructure
  - Low Voltage Lines
  - 66kV Line
  - Power Poles

Grid to MGA co-ordinates