SIMEC Mining:

Tahmoor South Project – Extraction Plan for Longwalls S1A to S6A

Subsidence ground movement predictions and subsidence impact assessments for natural features and surface infrastructure

DOCUMENT REGISTER

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Report produced to:- Support the Tahmoor South Project Extraction Plan, prepared by Tahmoor Coal for submission to the NSW Department of Planning, Industry and Environment (DPIE).

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)

EXECUTIVE SUMMARY

Tahmoor Coal Pty Ltd, (Tahmoor Coal), owns and operates Tahmoor Mine, an existing underground coal mine that is located approximately 80 km south-west of Sydney in the Southern Coalfield of New South Wales (NSW). Tahmoor Coal is a wholly owned entity within the SIMEC Mining division of the GFG Alliance group.

Tahmoor Coal received development consent in April 2021 for the Tahmoor South Project, which is an extension of the current Tahmoor Mine underground coal mining within the Bulli seam towards the south of the existing Tahmoor Mine.

Tahmoor Coal is submitting an Extraction Plan for Longwalls S1A to S6A (LWs S1A to S6A), which will be the first longwall panels to be extracted in the Tahmoor South domain. The proposed longwalls are located between Tahmoor's surface facilities to the north and the township of Bargo to the south.

The proposed mine layout for LWs S1A to S6A lies within the approved Extent of Longwalls. Minor changes have been made to the mine layout since development consent was received (approved EIS Layout), as foreshadowed by Tahmoor Coal when it applied for development consent.

MSEC has been commissioned to prepare a subsidence prediction and impact assessment report to provide subsidence predictions and assessments based on the proposed mine layout.

This report should be read in conjunction with the Extraction Plan being prepared by Tahmoor Coal and in conjunction with the reports from the other specialist consultants engaged by the Tahmoor South Project.

MSEC has been commissioned by Tahmoor Coal to:-

- Identify the natural features and items of surface infrastructure that are in the vicinity of the proposed longwalls,
- Provide subsidence predictions at each of these natural features and items of surface infrastructure,
- Provide impact assessments, in conjunction with other specialist consultants, for each of these natural features and items of surface infrastructure, and to
- Provide information on the measures that can be implemented to manage potential impacts.

The proposed mining will affect a broad range of natural features and built infrastructure.

Chapter 1	provides an introduction, outlines the Project, presents the purpose of the report, and provides the base information on the mine layout, surface topography, seam and geological information.
Chapter 2	defines the *Subsidence Study Area* and provides a list of the natural features and items of surface infrastructure that have been identified within the *Subsidence Study Area*.
Chapter 3	includes an overview of conventional and non-conventional subsidence movements and the methods that have been used to predict these movements resulting from the extraction of the proposed longwalls.
Chapter 4	provides the maximum predicted subsidence parameters resulting from the extraction of the proposed longwalls.
Chapters 5 to 11	provide descriptions, predictions and impact assessments for each of the natural features and items of surface infrastructure that have been identified within the *Subsidence Study Area*. Recommendations for each of these features are also provided, which have been based on the predictions and impact assessments.

The overall findings of the assessments undertaken by MSEC are that the levels of impact and damage to all identified natural features and built infrastructure are manageable and can be controlled by the preparation and implementation of Subsidence Management Plans (or Extraction Plans), many of which have been successfully implemented during previous mining at Tahmoor Mine.

These management plans are developed in consultation with the owners of infrastructure and are approved by relevant government agencies. The findings in this report should be read in conjunction with all other associated consultant reports.

Recommended management measures generally include monitoring of ground movements and the condition of surface features. Some mitigation measures are recommended to mitigate or avoid the risk of serious consequences should impacts occur to some critical surface features.

It is recommended that Tahmoor Coal continues to develop management plans to manage the potential impacts for the surface features due to the extraction of the proposed longwalls.

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APPENDIX G. FIGURES COMPARING OBSERVED AND PREDICTED SUBSIDENCE PARAMETERS OVER PREVIOUSLY EXTRACTED LONGWALLS AT TAHMOOR MINE 192

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

Figures

All figures 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 F at the end of this report.

Drawing No.	*Description*	*Revision*
MSEC1192-01	General layout	A
MSEC1192-02	Surface level contours	A
MSEC1192-03	Seam roof contours	A
MSEC1192-04	Extraction height	A
MSEC1192-05	Depth of cover contours	A
MSEC1192-06	Geological structures at seam level	A
MSEC1192-07	Streams – general layout	A
MSEC1192-08	Cliffs and steep slopes – general layout	A
MSEC1192-09	Natural features detail map	A
MSEC1192-10	Railway and associated infrastructure	A
MSEC1192-11	Roads and associated infrastructure	A
MSEC1192-12	Water infrastructure	A
MSEC1192-13	Sewer infrastructure	A
MSEC1192-14	Gas infrastructure	A
MSEC1192-15	Electrical infrastructure	A
MSEC1192-16	Telecommunications infrastructure	A
MSEC1192-17	Archaeological and heritage sites	A
MSEC1192-18	Building structures and dams	A
MSEC1192-19	Public amenities and commercial establishments	A
MSEC1192-20	Tahmoor Mine infrastructure	A
MSEC1192-21	Groundwater bores and survey control marks	A
MSEC1192-22	Predicted total subsidence contours	A
MSEC1192-23	Proposed monitoring plan	A

1.1. Background

Tahmoor Coal Pty Ltd, (Tahmoor Coal), owns and operates Tahmoor Mine, an existing underground coal mine that is located approximately 80 km south-west of Sydney in the Southern Coalfield of New South Wales (NSW). Tahmoor Coal is a wholly owned entity within the SIMEC Mining division of the GFG Alliance group.

Tahmoor Coal received development consent in April 2021 for the Tahmoor South Project, which is an extension of the current Tahmoor Mine underground coal mining within the Bulli seam towards the south of the existing Tahmoor Mine.

Tahmoor Coal is submitting an Extraction Plan for Longwalls S1A to S6A (LWs S1A to S6A), which will be the first longwall panels to be extracted in the Tahmoor South domain. The proposed longwalls are located between Tahmoor's surface facilities to the north and the township of Bargo to the south. The locations of LWs S1A to S6A are shown in Fig. 1.1 and Drawing No. MSEC1192-01, which, together with all other drawings, are included in Appendix F.

The proposed mine layout for LWs S1A to S6A lies within the approved Extent of Longwalls. Minor changes have been made to the mine layout since development consent was received (approved EIS Layout), as foreshadowed by Tahmoor Coal when it applied for development consent. A comparison between mine layouts is shown in Fig. 1.2.

- The layout for LWs S1A to S6A has been shifted approximately 35 metres to the south-west;
- LWs S2A to S6A have been widened by 2 metres (the width of LW S1A is unchanged);
- Chain pillar widths for the tailgates of LWs S3A to S6A have been reduced by 2 metres (the chain pillar between LWs S1A and S2A is unchanged);
- The commencing ends of LWs S1A to S6A have been aligned compared to the previous staggered layout. The outcome of the change is that LWs S2A to S6A have been extended in length. The gap between the A and B series longwalls will be maintained, such that the future B series will be shortened when compared to the mine layout that was submitted for development consent; and
- The planned sequence has been amended, such that the A series longwalls are proposed to be extracted in sequence. When Tahmoor Coal applied for development consent, it had been planned to extract LWs 101A to 103A first, then the B series longwalls and return to extract LWs 104A to 106A. The longwalls have renamed S1A to S6A since the EIS was approved.

Photograph courtesy Nearmap

Fig. 1.1 Proposed longwalls and the Study Area

The Study Area comprises an area adjacent to, and to the south of, the existing Tahmoor Approved Mining Area. The *Subsidence Study Area* for the purposes of this report is defined in Section 2.1 and is shown in Drawing No. 1192-01.

Fig. 1.2 Comparison between mine layouts for LWs S1A to S6A (2022 Extraction Plan) and LWs 101A to 106A (2021 approved EIS Layout)

1.2. Purpose of the report

1.2.1. Scope of Work and Report structure

MSEC has been commissioned by Tahmoor Coal to:-

- Identify the natural features and items of surface infrastructure that are in the vicinity of the proposed longwalls;
- Provide subsidence predictions at each of these natural features and items of surface infrastructure;
- Provide impact assessments, in conjunction with other specialist consultants, for each of these natural features and items of surface infrastructure; and to
- Provide information on the measures that can be implemented to manage potential impacts.

This report is structured as follows:

Chapter 1 provides an introduction, outlines the Project, presents the purpose of the report, and provides the base information on the mine layout, surface topography, seam and geological information.

Chapter 2 defines the *Subsidence Study Area* and provides a list of the natural features and items of surface infrastructure that have been identified within the *Subsidence Study Area*.

Chapter 3 includes an overview of conventional and non-conventional subsidence movements and the methods that have been used to predict these movements resulting from the extraction of the proposed longwalls.

Chapter 4 provides the maximum predicted subsidence parameters resulting from the extraction of the proposed longwalls.

Chapters 5 to 11 provide descriptions, predictions and impact assessments for each of the natural features and items of surface infrastructure that have been identified within the *Subsidence Study Area*. Recommendations for each of these features are also provided, which have been based on the predictions and impact assessments.

1.3. Mining Geometry

The proposed LWs S1A to S6A are shown in Drawing No. MSEC1192-01. A summary of the proposed longwall dimensions is provided in Table 1.1.

Table 1.1 Geometry of the proposed Longwalls S1A to S6A compared to EIS Layout

Layout	Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
Extraction Plan LWs S1A to S6A	LW S1A	1,711	283	-
	LW S2A	1,768	285	38
	LW S3A	1,808	285	36
	LW S4A	1,860	285	36
	LW S5A	1,949	285	36
	LW S6A	1,999	285	36
EIS Layout (MSEC1123)	LW101A	1,715	283	-
	LW102A	1,730	283	38
	LW103A	1,745	283	38
	LW104A	1,760	283	38
	LW105A	1,800	283	38
	LW106A	1,845	283	38

Table 1.1 also compares the proposed mining geometries with the geometries provided in the EIS. The minor changes in panel and pillar widths result in minor changes in predicted subsidence movements, which are discussed in Section 4.2 of this report.

The commencing ends of LWs S1A to S6A have been aligned compared to the previous staggered layout. The outcome of the change is that LWs S2A to S6A have been extended in length by up to 154 metres. The gap between the A and B series longwalls will be maintained, such that the future B series will be shortened when compared to the mine layout that was submitted in the EIS layout.

1.4. Surface topography

The surface level contours in the vicinity of the proposed longwalls are shown in Drawing No. MSEC1192-02. They were generated from 2012 and 2013 airborne laser scans of the area.

The ground surface within the *Subsidence Study Area*, as is defined in Section 2.1, is generally undulating with a fall from the south-west to the north-east. The major topographical feature within the *Subsidence Study Area* is Teatree Hollow. The major topographical feature near the *Subsidence Study Area* is the Bargo River valley, which is located to the north of the *Subsidence Study Area*.

The surface levels near the Subsidence Study Area vary from a low point of approximately 265 metres AHD, in the base of Teatree Hollow, downstream from of the proposed Longwall S1A, to a high point of approximately 345 metres AHD, at the south-western end of the *Subsidence Study Area* to the south-west of the proposed LW S6A.

1.5. Seam information

The seam roof contours, seam thickness contours and depth of cover contours, for the Bulli seam, have been provided by Tahmoor Coal and are shown in Drawing Nos. MSEC1192-03, MSEC1192-04 and MSEC1192-05, respectively.

Fig. 1.3 shows the surface, Bulli seam levels and proposed extraction heights across the proposed mining area along Cross-Section 1. The location of this section is shown in Drawings Nos. MSEC1192-02 and MSEC1192-03.

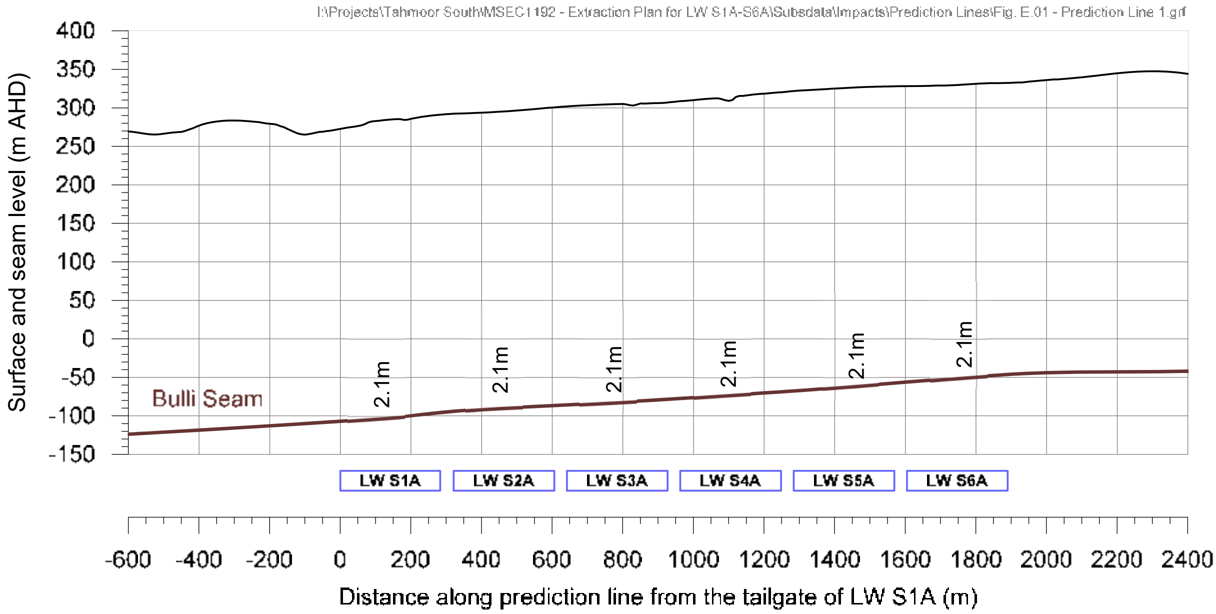

Fig. 1.3 Cross-section 1 through LWs S1A to S6A

The Bulli seam within the Subsidence Study Area generally dips from the south-west to the north-east, as shown by the seam roof contours in Drawing No. MSEC1192-03. The seam roof contours show the presence of several major faults which are discussed further in the next section of this report.

The planned Bulli seam extraction heights, i.e. the height of the Bulli seam that is to be mined, vary from a minimum extraction height of 2.1 metres to a maximum extraction height of 2.2 metres, as is shown in Drawing No. MSEC1192-04. Depending on the strength of floor under the longwall chocks, these extraction heights are planned to include parts of the stone roof, a stone band, a shaly coal layer and some stone floor and, as a result, the subsidence calculations in this report have assumed that these stone partings in both the floor and the roof will be extracted. This planned working section, including the stone partings in the floor and roof, is also shown in Fig. 1.4.

The depth of cover contours to the Bulli seam vary from a minimum of approximately 365 metres beneath a tributary to the Bargo River directly above the proposed LW S5A to a maximum of approximately 410 metres above proposed LW S1A as shown in Drawing No. MSEC1192-05.

1.6. Geological details

Tahmoor Mine lies in the southern part of the Permo-Triassic Sydney Basin, within which the main coal bearing sequence is the Illawarra Coal Measures, of Late Permian age. The Illawarra Coal Measures contain four workable seams, the uppermost of which is the Bulli seam, and it is this seam from which coal is proposed to be extracted as part of the proposed development.

The sediments that form the overburden to the Bulli seam belong to the Hawkesbury Tectonic Stage, which comprises three stratigraphic divisions. The lowest division is the Narrabeen Group, which is subdivided into a series of interbedded sandstone and claystone units. It ranges in age from Lower to Middle Triassic and varies in thickness up to 310 metres. Overlying the Narrabeen Group is the Hawkesbury Sandstone Group, which is a series of bedded sandstone units which dates from the Middle Triassic and has a thickness of up to 185 metres. Above the Hawkesbury is the Wianamatta Group, which consists of shales and siltstones and is poorly represented in this region, having a thickness of only a few tens of metres.

A typical stratigraphic section for the Southern Coalfield area is shown in Fig. 1.4, courtesy of McElroy Bryan Geological Services, (MBGS, 2013) and a west to east stratigraphic geological section is shown in Fig. 1.5 below, which is also available courtesy of MBGS.

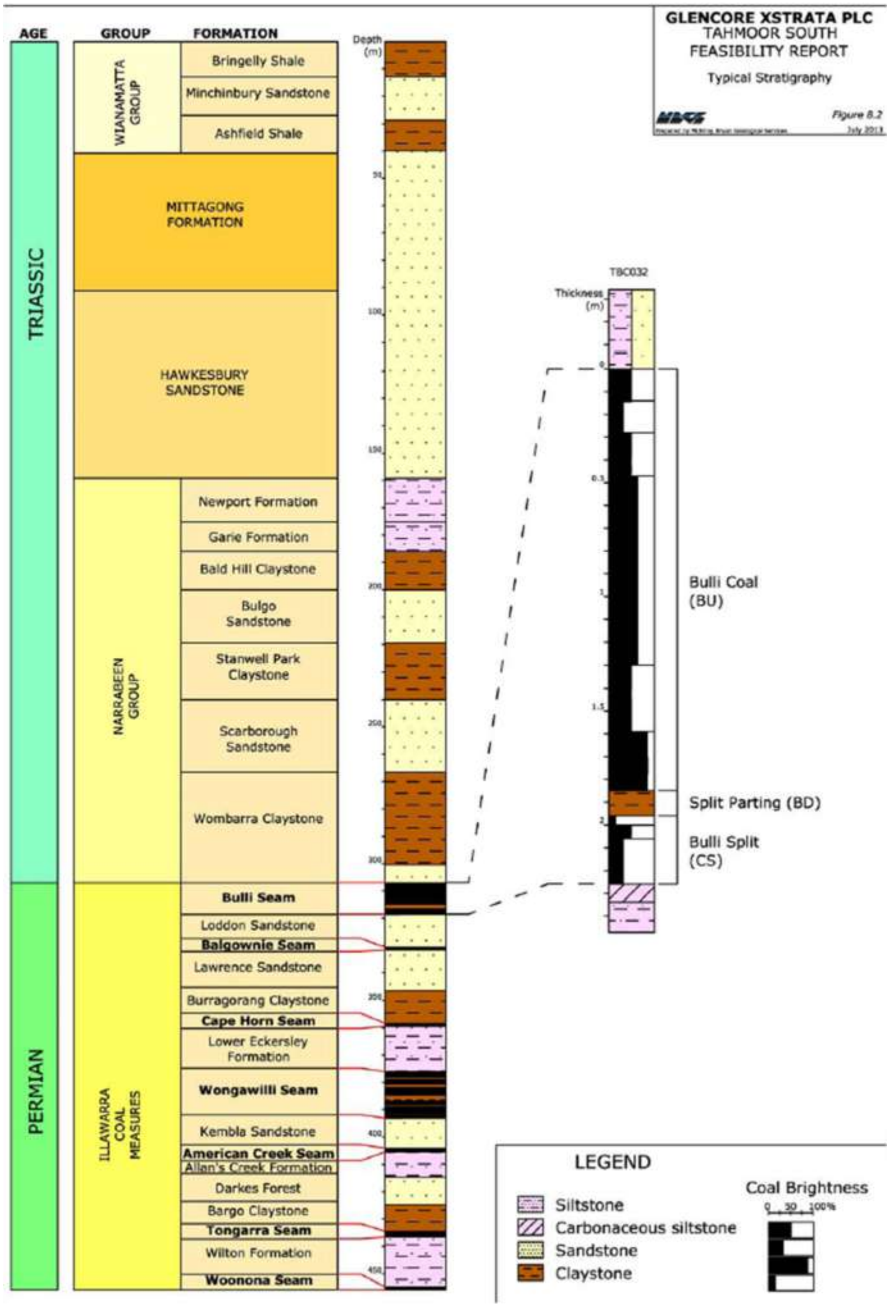

Fig. 1.4 Typical stratigraphic section – Southern Coalfield (MBGS, 2013)

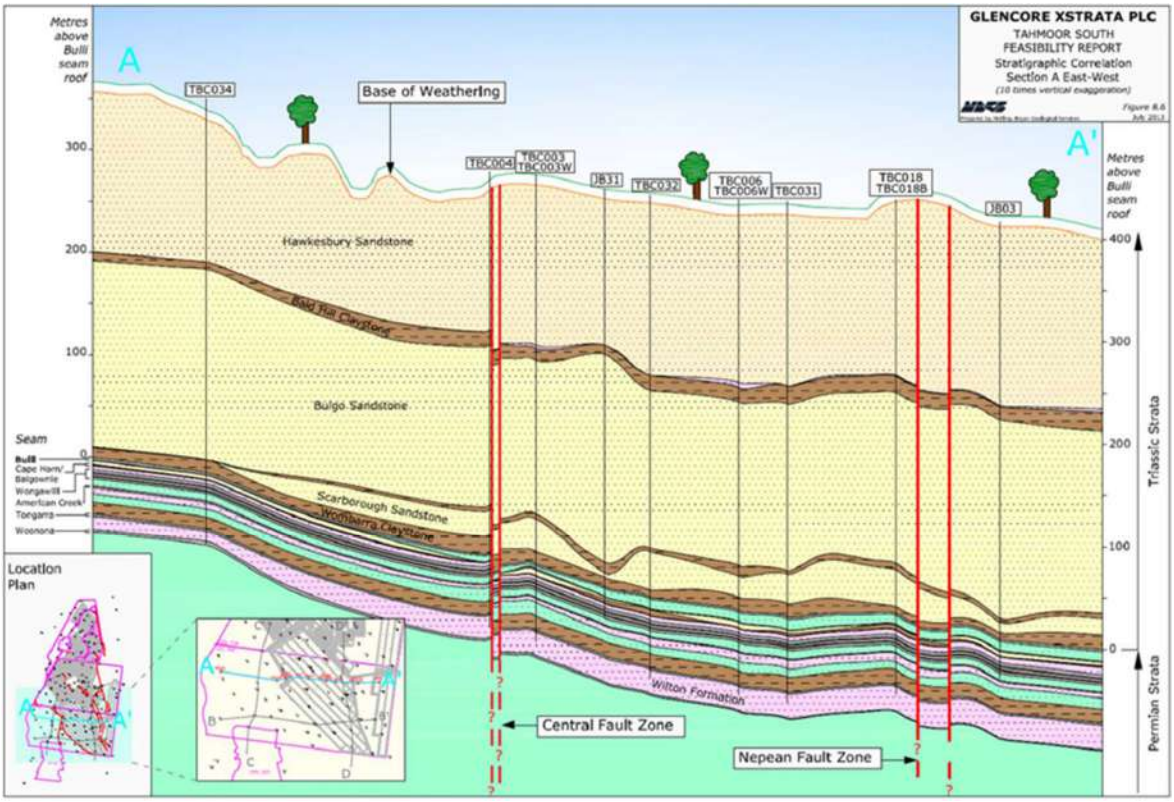

Fig. 1.5 West to east geological cross-section through western, central and eastern domains

The major sandstone units are interbedded with other rocks and, though shales and claystones are quite extensive in places, the sandstone predominates. The major sandstone units are the Scarborough (Narrabeen Group), the Bulgo (Narrabeen Group) and the Hawkesbury Sandstones (Hawkesbury Sandstone Group) and these units vary in thickness from a few metres to as much as 200 metres. The rocks exposed in the river gorges and creek alignments within the *Subsidence Study Area* belong to the Hawkesbury Sandstone Group. The other rocks generally exist in discrete but thinner beds of less than 15 metres thickness or are interbedded as thin bands within the sandstone.

The major claystone unit is the Bald Hill Claystone, which lies above the Bulgo Sandstone and at the base of the Hawkesbury Sandstone. As shown in Fig. 1.5 above, the base of the Bald Hill Claystone is between 180 metres to 220 metres above the Bulli Seam. This claystone unit varies in thickness and is, in some places, more than 25 metres thick. The Bald Hill Claystone has been described in the literature as an aquitard (e.g. the Independent Inquiry report entitled "*Strategic Review of Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield*", (Southern Coalfield Inquiry Report), which was published in July 2008, (NSW DPIE, 2008), and detailed information on this claystone and other claystone and siltstone units within the overburden are provided in the reports by SCT (2013a) and SLR (2022a).

1.7. Geological structures

Tahmoor Mine has undertaken comprehensive geological exploration of the overburden and the Illawarra Coal Measures within the *Subsidence Study Area* using several geological and geotechnical consultants (MBGS, 2013; Gordon Geotechniques, 2013; SCT, 2013a) and a number of geological structures have been identified.

Several fault structures were identified and the two main structures that separate the mining domains are the Nepean Fault zone and the Central Fault zone. These and other identified faults and igneous intrusions are shown in Drawing No. MSEC1192-06. MBGS (2013) reviewed 205 drill holes in the Tahmoor area for Tahmoor Coal of which 72 drill holes were in Tahmoor South. Additionally, an extensive array of seismic survey lines (140 km) were completed over recent years and combined this data provides sufficient data to have a sound understanding of overall deposit geometry, structural features likely to impact on mining, seam gas and raw coal quality characteristics within the Bulli Seam.

The Nepean Fault zone is the major structural feature in the Tahmoor complex and it marks the eastern boundary to the existing mining operations at Tahmoor Mine. The MBGS (2013) advises that the Nepean Fault zone runs in an approximate North-South direction and is a normal fault system which appears to exhibit en echelon style. Seismic surveys indicate the fault zone within the Tahmoor South area comprises many near vertical faults with overall displacement in the order of 10 metres to 15 metres and has a varying width of approximately 350 metres wide. A report by Gordon Geotechniques (2013), quoted two other reports, Lohe, et al., (1992), advising that the Nepean Fault was a high angle westerly dipping reverse fault and SEA, (2002), advising that the Nepean Fault was a series of reverse and normal faults. Gordon Geotechniques noted that the Nepean Fault zone was up to 200 metres wide with the western side of the fault being more disturbed than the eastern side. The proposed LWs S1A to S6A are not located near the Nepean Fault complex.

The Central Fault zone, which lies to the west and south of the proposed longwalls, was described by MBGS as a normal fault trending northwest with vertical displacement up to 20 metres, east side up. This fault was identified in the 2D seismic lines and was also intercepted in one drill hole (JB06) where the Wongawilli Seam has been displaced. The Gordon Geotechniques report advised that this Central Fault zone was associated with a number of features including a change in Bulli Seam fluidity and thinning of the Balgownie to Bulli Seam interburden. The Central Fault has a surface expression which affects Hornes Creek as it flows into the Bargo River.

It is noted that while comprehensive drilling and seismic exploration has been carried out, further in-seam drilling is planned to be undertaken and additional smaller geological structures may be discovered at that time. Further discussion on the influence of faulting on mining induced subsidence movements is presented in Chapters 3, 4 and 6.

The surface geology within the Study Area, as is defined in Section 2.1, is shown in Fig. 1.6, which presents the proposed longwalls overlaid on Geological Series Sheet 9029, (Geological Survey of NSW, NSW Government, 1999).

It can be seen from Fig. 1.6 that the majority of surface geology within the Study Area comprises the Hawkesbury Sandstone Group (Rh), with the Wianamatta Group, (Rw) located near the finishing ends of LWs S1A and S2A.

Hawkesbury Sandstone Group (Rh) is exposed along the majority of streams within the *Subsidence Study Area*.

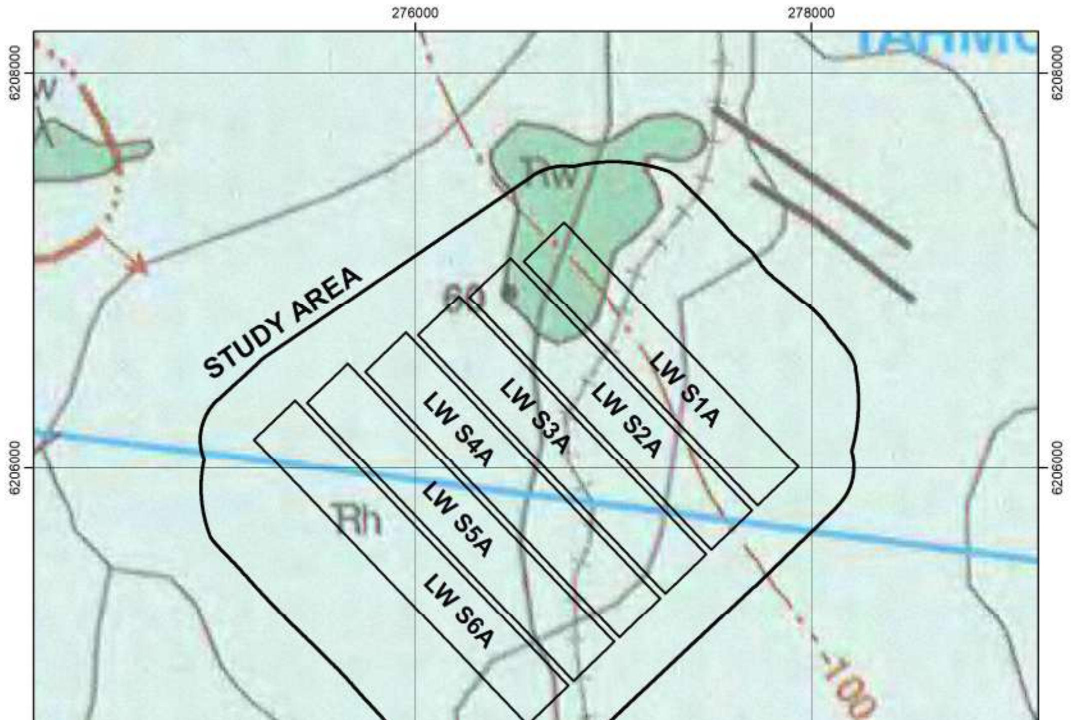

Fig. 1.6 Surface geology within the Study Area (DTIRIS, Geological Series Sheet 9029-9129)

2.1. Definition of the Subsidence Study Area

The *Subsidence Study Area* is the surface area within which natural surface features and items of infrastructure have been identified and assessed for their potential to experience mine subsidence impacts as a result of the proposed extraction of LWs S1A to S6A.

The extent of the *Subsidence Study Area* has been conservatively defined by combining the areas bounded by the following limits:-

- A 35° angle of draw from the extents of LWs S1A to S6A;
- The predicted limit of vertical subsidence, taken as the 20 mm subsidence contour, resulting from the extraction of LWs S1A to S6A; and
- Features that could experience far-field or valley-related movements and could be sensitive to such movements.
- For natural features, the *Subsidence Study Area* has been extended to a minimum of 600 metres from the extents of LWs S1A to S6A, as recommended in the independent inquiry report titled "Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield – Strategic Review" (NSW Department of Planning(DoP), 2008).

The depths of cover contours for the Bulli Seam are shown in Drawing No. MSEC1192-05. The depths of cover directly above LWs S1A to S6A vary between 375 m and 410 m. The 35° angle of draw, therefore, has been determined by drawing a line that is a horizontal distance varying between 260 m and 290 m around the extent of the longwall mining area.

The predicted limit of vertical subsidence, taken as the predicted total 20 mm subsidence contour, has been determined using the Incremental Profile Method, which is described in Chapter 3. The predicted 20 mm subsidence contour has been calibrated to account for measured subsidence in the northern areas of the existing Tahmoor Mine and the measured values were based on detailed ground surveys that were carried out using remote stable datum points. In some cases, the predicted 20 mm subsidence contour extends to 600 metres from the nearest edge of longwalls.

The extent of the *Subsidence Study Area* has therefore been drawn with a line around the longwalls based on whichever of the above limits extended the furthest from the proposed mining area. The extent of the *Subsidence Study Area* is shown in Drawings MSEC1192-01.

Additionally, it was found that there may be areas that are outside this line showing the extent of the *Subsidence Study Area* that could experience either far-field movements, or valley-related upsidence and closure movements. Some surface features have been identified that may be sensitive to such movements and, hence, impact assessments have been provided in this report for all the surface features or items of infrastructure that are outside the *Subsidence Study Area* and could be impacted by these far-field movements, or valley-related upsidence and closure movements.

The features that are located beyond the *Subsidence Study Area* for LWs S1A to S6A that could be sensitive to impacts from such movements are shown in Drawing MSEC1192-01 and are listed below. The descriptions and impact assessments for each of these natural features or items of infrastructure are provided in later sections of the report:-

- The Main Southern Railway viaduct over the Bargo River, located 1,755 metres from LW S1A;
- The Remembrance Drive Bridge over the Bargo River and Main Southern Railway, located 1,690 metres from LW S1A;
- The Picton Weir, (or Bargo Weir), on Bargo River, located 940 metres from LW S6A;
- Streams, within the predicted limits of 20 mm total upsidence and 20 mm total closure;
- Groundwater bores; and
- Survey control marks.

2.2. Natural Features and items of surface infrastructure within the Subsidence Study Area

The major natural features and items of surface infrastructure within the *Subsidence Study Area* can be seen in the 1:25,000 Topographic Maps of the area, published by the Central Mapping Authority (CMA), numbered PICTON 9029-4-S and BARGO 9029-3-N. The proposed longwalls and the *Subsidence Study Area* have been overlaid on an extract of this CMA map in Fig. 2.1.

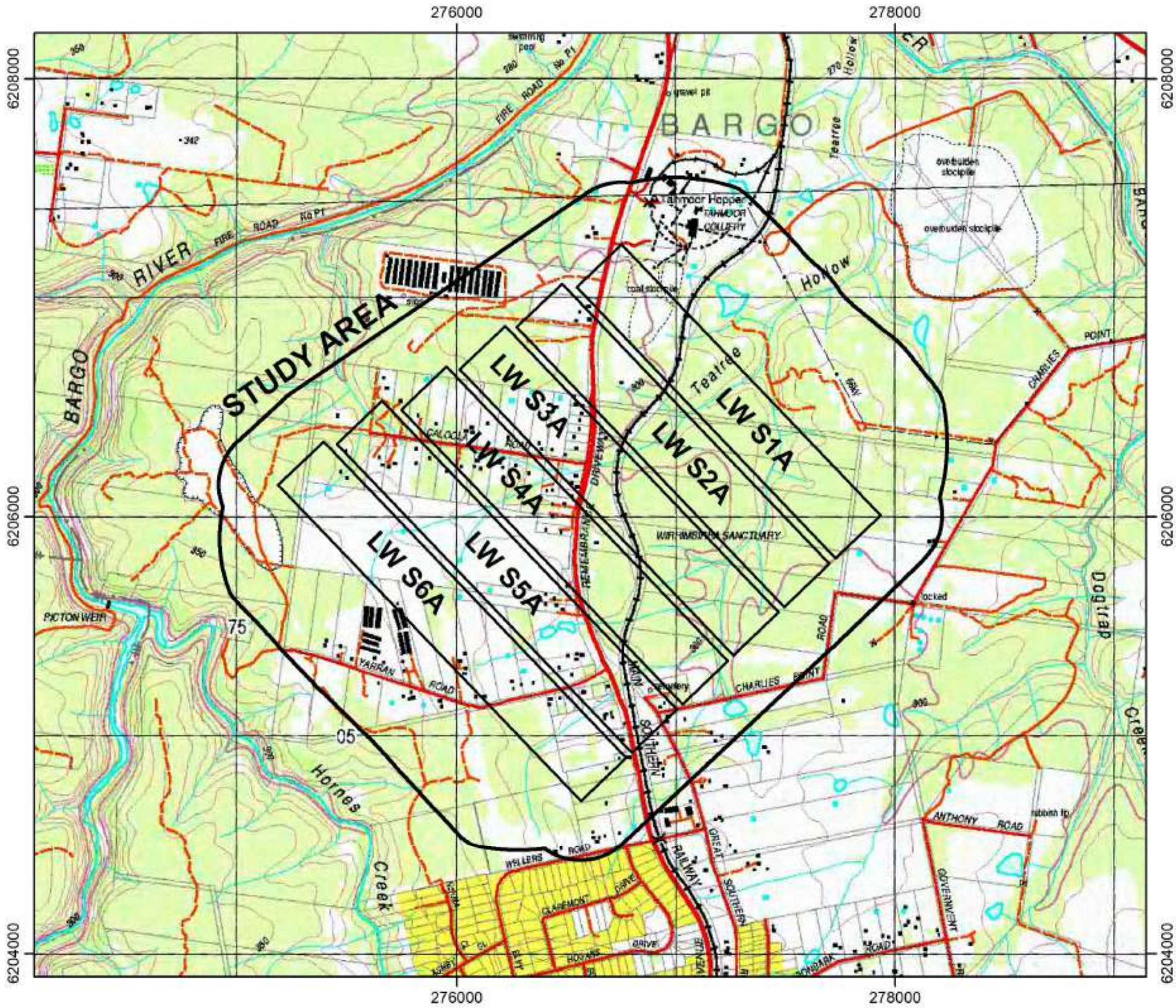

Fig. 2.1 The proposed longwalls and the Subsidence Study Area overlaid on CMA Map No. Bargo 9029-3-N

A summary of the natural features and items of surface infrastructure within the *Subsidence Study Area* is provided in Table 2.1. The locations of these features are shown in Drawing Nos. MSEC1192-07 to MSEC1192-21, in Appendix F.

Descriptions, predictions and impact assessments for the natural features and items of surface infrastructure are provided in Chapters 5 though to 11. The relevant chapter and section number references in this report that address these features and items are provided in Table 2.1.

Table 2.1 Natural features and surface infrastructure

Item	Within *Study Area*	Section Number Reference
NATURAL FEATURES		
Catchment Areas or Declared Special Areas	×	
Rivers or Creeks	✓	5.2 & 5.3
Aquifers or Known Groundwater Resources	✓	8.11
Springs	×	
Sea or Lake	×	
Shorelines	×	
Natural Dams	×	
Cliffs or Pagodas	✓	5.4
Steep Slopes	✓	5.5
Escarpments	×	
Land Prone to Flooding or Inundation	✓	5.7
Swamps, Wetlands or Water Related Ecosystems	×	
Threatened or Protected Species	✓	5.9
National Parks	×	
State Forests	×	
State Conservation Areas	×	
Natural Vegetation	✓	5.12
Areas of Significant Geological Interest	×	
Any Other Natural Features Considered Significant	✓	5.14
PUBLIC UTILITIES		
Railways	✓	6.1
Roads (All Types)	✓	0
Bridges	✓	6.4
Tunnels	×	
Culverts	✓	6.1 & 0
Water, Gas or Sewerage Infrastructure	✓	0, 6.7 & 6.8
Liquid Fuel Pipelines	×	
Electricity Transmission Lines or Associated Plants	✓	6.9
Telecommunication Lines or Associated Plants	✓	6.10
Water Tanks, Water or Sewage Treatment Works	✓	0
Dams, Reservoirs or Associated Works	✓	6.11
Air Strips	×	
Any Other Public Utilities	×	
PUBLIC AMENITIES		
Hospitals	×	
Places of Worship	✓	7.4
Schools	✓	0
Shopping Centres	×	
Community Centres	×	
Office Buildings	×	
Swimming Pools	×	
Bowling Greens	×	
Ovals or Cricket Grounds	✓	7.11
Race Courses	×	
Golf Courses	×	
Tennis Courts	✓	7.14
Any Other Public Amenities	✓	7.15

Item	Within *Study Area*	Section Number Reference
FARM LAND AND FACILITIES		
Agricultural Utilisation or Agricultural Suitability of Farm Land	✓	8.1
Farm Buildings or Sheds	✓	8.2
Tanks	✓	8.3
Gas or Fuel Storages	✓	8.4
Poultry Sheds	✓	0
Glass Houses	×	
Hydroponic Systems	✓	8.7
Irrigation Systems	✓	8.8
Fences	✓	8.9
Farm Dams	✓	8.10
Wells or Bores	✓	8.11
Any Other Farm Features	×	
INDUSTRIAL, COMMERCIAL AND BUSINESS ESTABLISHMENTS	×	
Factories	×	
Workshops	✓	9.1
Business or Commercial Establishments or Improvements	✓	9.1
Gas or Fuel Storages or Associated Plants	✓	9.2
Waste Storages or Associated Plants	×	
Buildings, Equipment or Operations that are Sensitive to Surface Movements	×	
Surface Mining (Open Cut) Voids or Rehabilitated Areas	×	
Mine Infrastructure Including Tailings Dams or Emplacement Areas	✓	9.3
Any Other Industrial, Commercial or Business Features	×	
AREAS OF ARCHAEOLOGICAL OR HERITAGE SIGNIFICANCE	✓	10.1 & 0
ITEMS OF ARCHITECTURAL SIGNIFICANCE	×	
PERMANENT SURVEY CONTROL MARKS	✓	6.12
RESIDENTIAL ESTABLISHMENTS		
Houses	✓	11.1
Flats or Units	✓	11.2
Caravan Parks	✓	0
Retirement or Aged Care Villages	×	
Associated Structures such as Workshops, Garages, On-Site Waste Water Systems, Water or Gas Tanks, Swimming Pools or Tennis Courts	✓	11.5 11.5.6 9.3 11.5.8
Any Other Residential Features	×	
ANY OTHER ITEM OF SIGNIFICANCE	×	
ANY KNOWN FUTURE DEVELOPMENTS	×	

2.3. Bargo Mine Subsidence District and the role of Subsidence Advisory NSW

The *Subsidence Study Area* is located within the Bargo Mine Subsidence District as proclaimed in 1975 and 1994.

Subsidence Advisory NSW (SA NSW) is the NSW Government agency responsible for administering the *Coal Mine Subsidence Compensation Act 2017.* SA NSW has two core functions:

1. To provide compensation or manage the provision of compensation where surface developments are damaged by mine subsidence following extraction of coal or shale in NSW; and
2. To regulate surface development within mine subsidence districts to reduce the risk of mine subsidence damage.

SA NSW provides expert advice to property owners, government departments, councils, community organisations and industries within coal mining areas of NSW. This advice aims to provide compatibility between surface development and underground mining.

The owners of buildings or other surface improvements damaged by mine subsidence can lodge claims for compensation through SA NSW. Currently, under the Coal Mine Subsidence Compensation Act 2017, any claim for mine subsidence damage needs to be lodged with SA NSW. SA NSW staff will arrange for the damage to be assessed by an independent specialist assessor. If the damage is attributable to mine subsidence, a scope of repairs will be prepared and compensation will be determined.

Proposed development in mine subsidence districts requires SA NSW approval. SA NSW sets building and construction requirements to protect buildings and other surface improvements from subsidence damage. These requirements cover the nature and class of improvements, including height, type of building materials used and the construction method.

SA NSW has the power to issue stop work notices to prevent illegal construction in mine subsidence districts, and any improvements erected without SA NSW's approval, or contrary to an approval are not eligible for compensation.

Further information about SA NSW's services is available at www.subsidenceadvisory.nsw.gov.au.

3.0 OVERVIEW OF CONVENTIONAL AND NON-CONVENTIONAL SUBSIDENCE MOVEMENTS AND THE METHODS USED TO PREDICT THESE MOVEMENTS FOR THE PROPOSED LONGWALLS

3.1. Introduction

This chapter provides a brief overview of; longwall mining; the development of mine subsidence and the methods that have been used to predict the mine subsidence movements resulting from the extraction of the longwalls. Further details on longwall mining, the development of subsidence and the methods used to predict mine subsidence movements can be obtained in the background reports entitled *Introduction to Longwall Mining and Subsidence* and *General Discussion on Mine Subsidence Ground Movements* which can be obtained from *www.minesubsidence.com*.

3.2. Overview of longwall mining

The proposed development at Tahmoor Mine is to continue mining coal using the longwall mining method. A typical cross-section at a coal face showing a typical longwall shearer and roof supports and showing typical immediate floor and roof strata, is sketched in Fig. 3.1.

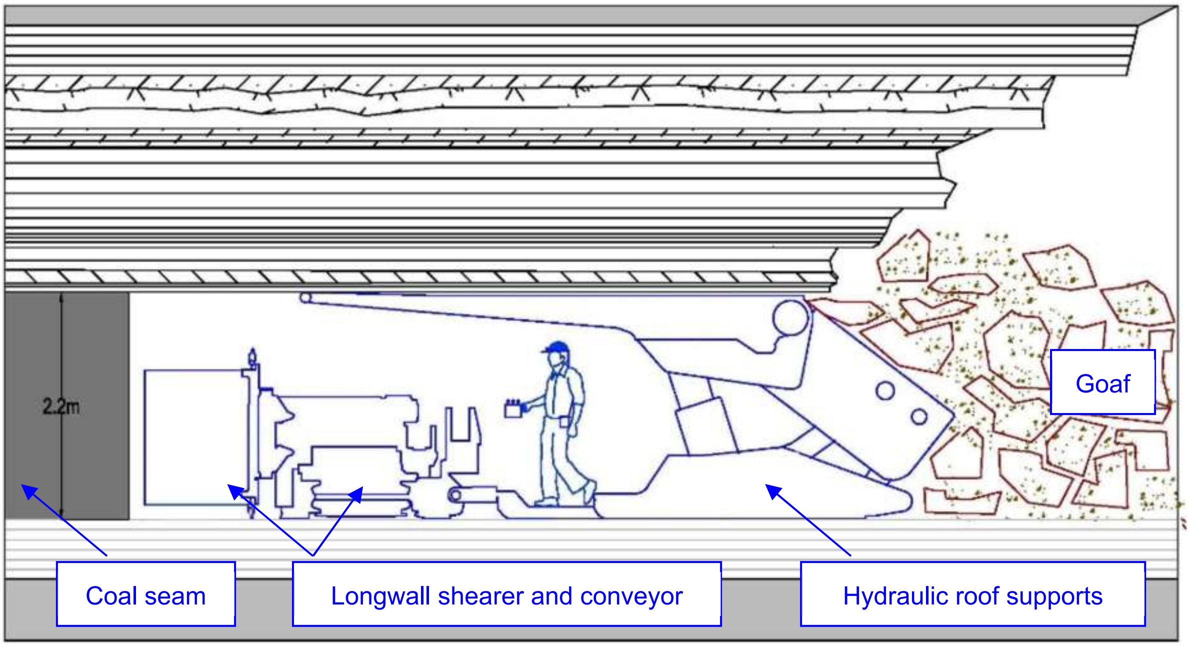

Fig. 3.1 Cross-section along the length of a typical longwall at the coal face

The coal is removed by a shearer, which cuts the coal from the coal face on each pass as it traverses the width of the longwall. The roof at the coal face is supported by a series of hydraulic roof supports, which temporarily hold up the roof strata, and provide a secure working space at the coal face. The coal is then transported by a face conveyor belt which is located behind and beneath the shearer. As the coal is removed from each section of the coal face, the hydraulic supports are stepped forward, and the coal face progresses (retreats) along the length of the longwall.

The strata directly behind the hydraulic supports, immediately above the coal seam, collapses into the void that is left as the coal face retreats. The collapsed zone, often called the goaf, comprises loose blocks and can contain large voids. Immediately above this collapsed zone, the strata remain relatively intact and bends into the goaf, resulting in new vertical factures and the opening up of existing vertical fractures and creation of bed openings or separations. The amount of fracturing, strata sagging and bedding plan separation reduces for the overlying strata that are higher up again that is up towards the surface.

At the surface, the ground subsides vertically and moves horizontally towards the centre of the mined goaf area. The maximum subsidence at the surface varies, depending on a number of factors including longwall geometry, depth of cover, extracted seam thickness, extent and proximity of previously extracted panels and seams and the overburden geology. The maximum subsidence in the Southern Coalfield, within a single seam and for a single panel of supercritical critical width of extraction, that is the panel width is much wider than the depth of cover, is generally about 65 % of the extracted seam thickness.

3.3. Overview of conventional subsidence parameters

The normal ground movements resulting from the extraction of longwalls are referred to as conventional or systematic subsidence movements. These movements are described by the following parameters:-

- **Subsidence** usually refers to vertical displacement of a point, but subsidence of the ground includes both vertical and horizontal displacements. These horizontal displacements in some cases, where the subsidence is small beyond the longwall goaf edges, can be greater than the vertical subsidence.
- Unlike mining induced vertical subsidence, which has a magnitude only, **Horizontal Displacements** have both a magnitude and a direction, i.e. they can be referred to as a vector. Early researchers generally only measured and predicted vertical subsidence and ground strains and rarely measured or predicted the horizontal displacements of points. Subsidence and horizontal movements are usually expressed in units of *millimetres (mm)*.
- **Tilt** is the change in the slope of the ground as a result of differential subsidence and is calculated as the change in subsidence between two points divided by the distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.
- **Curvature** is the bending of the ground as a result of differential subsidence and is calculated as the change in tilt between two adjacent sections of the tilt profile divided by the average length of those sections. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km^{-1})*, but the values of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*.
- **Strain** is the relative differential horizontal movements of the ground. **Normal strain** is calculated as the change in horizontal distance between two points on the ground, divided by the original horizontal distance between them. Strain is typically expressed in units of *millimetres per metre (mm/m)*. **Tensile strains** occur where the distance between two points increases and **Compressive strains** occur when the distance between two points decreases. So that ground strains can be compared between different locations, they are typically measured over bay lengths that are equal to the depth of cover between the surface and seam divided by 20. When strains are measured over longer bay lengths lower averaged values are generally observed.

  Whilst mining induced normal strains are measured along monitoring lines, **ground shearing** can also occur both vertically and horizontally across the directions of monitoring lines. Most of the published mine subsidence literature discusses the differential ground movements that are measured along subsidence monitoring lines, however, differential ground movements can also be measured across monitoring lines using 3D survey monitoring techniques.
- **Horizontal shear deformation** across monitoring lines can be described by various parameters including horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index. However, is not possible to determine the horizontal shear strain across a monitoring line using standard 2D or 3D monitoring techniques. High deformations along monitoring lines (i.e. normal strains) are generally measured where high deformations have been measured across the monitoring line (i.e. shear deformations) and vice versa.

High resolution surveying techniques using GPS technology and satellite based differential interferometry are providing far more data and a much better basis for understanding the extent and the mechanics of the mining induced vertical and horizontal ground movements. Modern surveyors now provide the current easting, northing and reduced level of each installed peg from which three-dimensional subsidence and mining induced horizontal movements and directions can be derived for each epoch. Because of these improvements in subsidence surveying our understanding of both the magnitude and direction of mining induced vertical and horizontal ground movements and the lateral extent of these mining induced ground movements has improved substantially.

The **total** subsidence, tilts, curvatures and strains are the accumulated parameters which result from the extraction of a series of longwalls. **Incremental** subsidence, tilts, curvatures and strains are the additional movements due to the extraction of each longwall and are determined from monitored data by subtracting the movements monitored before a longwall was mined from the movements monitored after that longwall was mined. The **travelling** tilts, curvatures and strains are the transient movements as the longwall extraction face mines directly beneath a given point.

Residual subsidence is defined as the additional, time-dependent subsidence that develops after active mining has been completed or has moved sufficiently far enough away from the affected area to no longer have an immediate influence. As the amount of subsidence being measured reduces asymptotically to smaller and smaller levels, the shrinking and swelling of the soil due to changes in moisture content and the survey accuracy can form a large proportion of the measured subsidence.

3.4. Overview of conventional and non-conventional subsidence movements

Some subsidence terms and definitions were first published in an Independent Inquiry report entitled "*Strategic Review of Impacts of Underground Coal Mining on Natural Features in the Southern Coalfield*", (Southern Coalfield Inquiry Report), which was published in July 2008, (NSW DP, 2008). The terms and definitions draw a distinction between subsidence effects, subsidence impacts, environmental consequences, consequences, secondary consequences, conventional effects and non-conventional effects.

Conventional subsidence profiles are typically smooth in shape and can be explained by the expected caving mechanisms associated with overlying strata spanning the extracted void. Normal conventional subsidence movements due to longwall extraction are easy to identify where longwalls are regular in shape, the extracted coal seams are relatively uniform in thickness, the geological conditions are consistent and surface topography is relatively flat.

As a general rule, the smoothness of the profile is governed by the depth of cover and lithology of the overburden, particularly the near surface strata layers. Where the depth of cover is greater than 400 metres, such as the case within the Study Area, the observed subsidence profiles along monitoring survey lines are generally smooth. Where the depth of cover is less than 100 metres, the observed subsidence profiles along monitoring lines are generally irregular. Very irregular subsidence movements are observed with much higher tilts, curvatures and strains at very shallow depths of cover where the collapsed zone above the extracted longwalls extends up to or near to the surface.

Irregular subsidence movements are occasionally observed at the deeper depths of cover along an otherwise smooth subsidence profile. The cause of these irregular subsidence movements can be associated with:-

- sudden or abrupt changes in geological conditions;
- steep topography; and
- valley related mechanisms.

Non-conventional movements due to geological conditions, steep topography and valley related movements are discussed in the following sections.

3.4.1. Non-conventional subsidence movements due to changes in geological conditions

For those sites where the depth of cover is less than 100 metres, the observed subsidence profiles along monitoring lines are generally irregular with much higher tilts, curvatures and strains principally because the collapsed zone has extended up to or near to the surface. Where the depth of cover is around 400 metres, as is the case over most of the *Subsidence Study Area*, the observed subsidence profiles along monitoring survey lines will generally be smooth as is typical in the Southern Coalfields. However, irregular subsidence movements can occasionally be observed at these deeper depths of cover along an otherwise smooth subsidence profile and these localised irregular subsidence movements, that are called non-conventional subsidence movements, are often associated with sudden or abrupt changes in geological conditions, steep topography, and valley related mechanisms.

Accordingly, non-conventional subsidence movements may occur or could be expected within the river and creek valleys, near the major fault zones, near the outcrop of the interface between sandstone and shale strata layers. It is believed that most the unexpected irregular subsidence movements, i.e. the non-conventional ground movements, are a result of the reaction of near surface strata to increased horizontal compressive stresses due to mining operations. Some of the geological conditions that are believed to influence these irregular subsidence movements are the blocky nature of near surface sedimentary strata layers and the possible presence of unknown faults, dykes or other geological structures, cross bedded strata, thin and brittle near surface strata layers and pre-existing natural joints. The presence of these geological features near the surface can result in bumps in an otherwise smooth subsidence profile which are usually accompanied by locally increased tilts, curvatures and strains.

Even though it may be possible to attribute a reason behind many of the observed non-conventional ground movements, there remain some observed irregular ground movements that still cannot be explained with the available geological information. The term "anomaly" is therefore reserved for those non-conventional ground movement cases that were not expected to occur and cannot be explained by any of the above possible causes.

It is not possible to predict the locations and magnitudes of non-conventional anomalous movements. In some cases, approximate predictions for the non-conventional ground movements can be made where the underlying geological or topographic conditions are known in advance. It is expected that these methods will improve as further knowledge is gained through ongoing research and investigation.

In this report, the analyses of non-conventional ground movements have been carried out statistically in the predictions and impact assessments, by basing these on the frequency of past occurrence of both the conventional and non-conventional ground movements and impacts. The analysis of strains provided in Section 4.3 includes those resulting from both conventional and non-conventional anomalous movements.

An analysis of observations during the mining of Tahmoor Longwalls 22 to 31 provides an indication of the spatial frequency of non-conventional movements, which is discussed in Section 4.7. The impact assessments for the natural features and items of surface infrastructure, which are provided in Chapters 5 through to 11, include a discussion of historical impacts resulting from previous longwall mining which have occurred as the result of both conventional and non-conventional subsidence movements.

3.4.2. Non-conventional subsidence movements due to valley related Movements

Valley bulging movements are a natural phenomenon, resulting from the formation and ongoing weathering, erosion and development of valleys, as illustrated in Fig. 3.2. These naturally occurring valley bulging movements include inward movement of the valley sides and the bulging or upwards movement of the valley floor. The potential for these natural movements are influenced by the geomorphology of valleys.

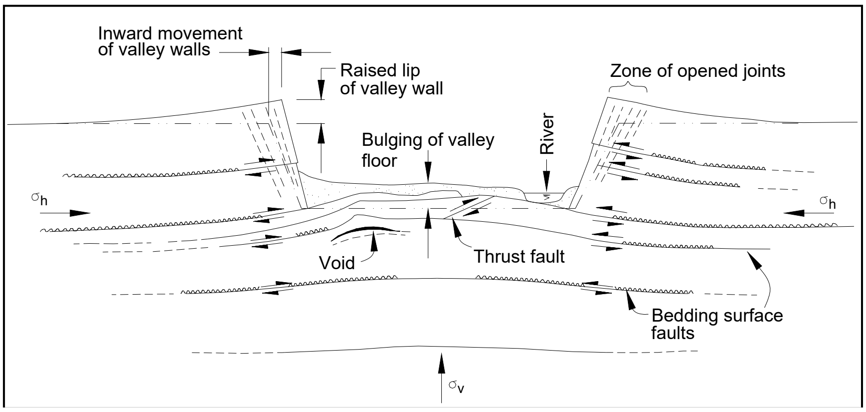

Fig. 3.2 Valley formation in flat-lying sedimentary rocks (after Patton and Hendren 1972)

The streams within the *Subsidence Study Area* may also be subjected to mining induced valley related movements, which result in similar consequences to the naturally occurring valley bulging movements that are discussed above. These mining induced valley closure result in closure movements across the valley and upsidence in the floor of the valley. The potential for these mining induced movements are influenced by the geomorphology of the valleys and the proximity and magnitude of the mining induced subsidence movements. As discussed in Section 3.4 and in the Southern Coalfield Inquiry Report (DPIE 2008), mining induced valley related movements are commonly observed across river and creek alignments in the Southern Coalfield and extensive studies have been carried out to predict the extent of these valley related movements.

As stated in the peer review by SCT (2014), a number of explanations of the mechanics of valley closure have been provided in the literature. Valley related movements are believed to be caused by the mining process through a number of different complex mechanisms and the relative contribution from each mechanism is expected to vary from case to case.

Valley related movements are normally described by the following parameters:-

- **Upsidence** is the reduced subsidence, or the relative uplift within a valley which results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

- **Closure** is the reduction in the horizontal distances across the valley sides. The magnitude of maximum valley closure, which is typically expressed in the units of *millimetres (mm)* and is defined as the greatest reduction in distance between any two points on the opposing valley sides, is generally measured from pegs located at the top of the sides of the valley, however, sometimes the greatest closure is observed between pegs located in the base of the valley.

- **Compressive valley closure strains** occur within the bases of valleys as a result of valley closure and upsidence movements. **Tensile strains** tend occur in the sides and near the tops of the valleys as a result of valley closure movements. The magnitudes of these strains, which are typically expressed in the units of *millimetres per metre (mm/m)*, are calculated as the changes in horizontal distance over a standard bay length, divided by the original bay length.

The predicted valley related movements resulting from the extraction of the proposed longwalls were made using the empirical method outlined in Australian Coal Association Research Programme (ACARP) Research Project No. C9067 (Waddington and Kay, 2002). Further details can be obtained from the background report entitled *General Discussion on Mine Subsidence Ground Movements* which can be found at *www.minesubsidence.com*.

3.4.3. Non-conventional subsidence movements due to steep topography

Non-conventional movements can also result from slope instability movements where longwalls are extracted beneath steep slopes. In these cases, elevated tensile strains develop near the tops of the steep slopes and elevated compressive strains develop near the bases of the steep slopes. The potential impacts resulting from slope instability movements include the development of tension cracks at the tops and the sides of the steep slopes and compression ridges at the bottoms of the steep slopes. The term 'slope instability movements' is not intended to be confused with horizontal movements in a downslope direction, as correctly raised in the peer review by SCT (2014).

Further discussions on the potential for slope instability movements for the steep slopes within the *Subsidence Study Area* are provided in Section 5.5.

3.5. Far-field movements

The measured horizontal movements at survey marks which are located beyond the longwall goaf edges and over solid unmined coal areas are often much greater than the observed vertical movements at those marks. These movements are often referred to as *far-field movements*.

Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain. These movements generally do not result in impacts on natural features or surface infrastructure, except where they are experienced by large structures which are very sensitive to differential horizontal movements.

These observed far field horizontal movements appear to occur as a result of a number of mechanisms or components, however, the main mechanism thought to be responsible for the observed far-field movements in flat terrain is the partial relief or relaxation of the in situ horizontal stresses of the immediate strata around the goaf towards the goaf areas. For the strata around the goaf to expand towards the collapsed zone there has to be slippage along some bedding planes. It is agreed with the statements in the peer review by SCT (2014) that the shear horizon or horizons on which movement occurs is not necessarily at the level of the coal seam and may occur at one or many horizons within the overburden.

The extent to which a particular stratum can expand into the goaf is dependent on the height of the void formation, the dilation in the neighbouring strata and the elastic properties of each stratum, and hence, the horizontal expansion varies from stratum to stratum with the greatest expansion occurring near, or just above, seam level. The measured far-field horizontal movements on the surface would, therefore, be expected to increase wherever the in situ compressive stresses are higher and where the height and extent of the goaf is more extensive, i.e. where the mining activity is more extensive.

Where narrow sub-critical panels are being mined and the height of collapse may only extend part of the way up to the surface, the strata that is overlying the collapsed zone may be able accommodate increased horizontal stresses. However, around wide supercritical panels where the cracking and goafing can extend up to the surface, there would be greater disturbance to the strata over the goaf and less stiffness within the collapsed strata to accommodate increased horizontal stresses. It is likely therefore that greater redistribution of in situ horizontal stresses would occur under and around these supercritical panels, greater stress relief and far field movements can occur towards these supercritical panels and these far field movements would extend well beyond a mined area before equilibrium is regained in the rock mass.

An empirical database of observed incremental far-field horizontal movements has been compiled using monitoring data from the NSW Coalfields, but predominately the database includes measurements from the Southern Coalfield. The far-field horizontal movements resulting from longwall mining are generally observed to be orientated towards the extracted longwall. At very low levels of far-field horizontal movements, however, there was a higher scatter in the orientation of the observed movements.

Far-field horizontal movements can be predicted with reasonable accuracy and the method used to predict such movements are described further in Section 4.6.

3.6. The Incremental Profile Method (IPM)

The predicted conventional subsidence parameters due to the extraction of the proposed longwalls were determined using the Incremental Profile Method (IPM), which was developed by MSEC in 1994, when formally known as Waddington Kay and Associates. This method is an empirical model based on a large database of observed subsidence monitoring data from previous mining within the Southern, Newcastle, Hunter and Western Coalfields of New South Wales and the Bowen Basin in Queensland.

The database of detailed subsidence monitoring data from various coalfields includes data from the following Collieries or Mines: Abel, Angus Place, Appin, Ashton, Awaba, Austar, Baal Bone, Bellambi, Beltana, Blakefield South, Bulga, Bulli, Burwood, Carborough Downs, Chain Valley, Clarence, Coalcliff, Cook, Cooranbong, Cordeaux, Corrimal, Crinum, Cumnock, Dartbrook, Delta, Dendrobium, Donaldson, Eastern Main, Ellalong, Elouera, Fernbrook, Glennies Creek, Grasstree, Gretley, Grosvenor, Invincible, John Darling, Kenmare, Kemira, Kestrel, Lambton, Liddell, Mandalong, Metropolitan, Moranbah North, Mt. Kembla, Munmorah, Narrabri, Nardell, Newpac, Newstan, Newvale, Newvale 2, NRE Wongawilli, Oaky Creek, Ravensworth, South Bulga, South Bulli, Southern, Springvale, Stockton Borehole, Tasman, Teralba, Tahmoor, Tower, Wambo, Wallarah, Western Main, Ulan, United, West Cliff, West Wallsend, and Wyee.

Observed incremental subsidence profiles show the additional subsidence that resulted from the extraction of an individual longwall panel and these can be derived by subtracting the observed subsidence profiles of points along monitoring lines before mining from the observed subsidence profiles after mining. Reviews of the available incremental and total subsidence profiles showed that, whilst the final observed total subsidence profiles measured over a series of longwalls were irregular, the observed incremental subsidence profiles due to the extraction of individual longwalls were more consistent in both shape and magnitude.

The observed incremental subsidence at a point has been shown to vary according to local geology, depth of cover, panel width, the pillar widths, the extracted seam thickness, the extent and proximity of adjacent previously mined panels in the currently mined seam and/or in the overlying or underlying seams, the stability of the chain pillars, the strength of the coal seams and the overburden strata and a time-related subsidence component.

The regularity in shape between observed incremental subsidence profiles was first noticed whilst carrying out an empirical study in the Southern Coalfields of NSW using monitoring data from more than 72 longwall panels. A prediction model was then developed to predict the incremental subsidence at points for each of the longwalls in a series of longwalls and then adding together the appropriate subsidence values to derive the total subsidence at each point. MSEC then developed standard subsidence prediction curves and shapes of predicted incremental subsidence profiles using observed profiles from monitoring lines with similar mining geometry and overburden geology. This IPM subsidence prediction model has been continually developed, revised and updated since 1994, as the new additional monitoring data became available, to suite specific local geology and conditions.

The prediction of subsidence using the IPM is now fully automated and subsidence predictions can be made anywhere above or outside the extracted longwalls, based on the local surface and seam information. Details as to how this model was developed have been outlined in various published papers, which include information that would allow others to use this method to predict mine subsidence ground movements resulting from underground coal mining operations, based on local observed data. MSEC can use the current IPM model to predict subsidence contours over complex underground mine layouts within days of receiving the necessary data.

MSEC has used this IPM for almost 1,000 studies for proposed mines and numerous comparisons have been provided between the predicted subsidence movements and the subsequently monitored ground movements. The results of these comparisons have been included in many prediction reports, government inquiry reports and end of panel monitoring reports, and these comparisons and reviews confirm the use of this IPM subsidence prediction model provides reasonable, if not, slightly conservative predictions for both single seam and multi-seam conditions in NSW and QLD for those cases where the mining geometry and overburden geology are similar to and within the range of the empirical data from which the IPM model was developed. When the mining geometry and overburden geology are outside the ranges of the empirical data from which the IPM model was developed then additional advice is sought from relevant mathematical models.

For this Tahmoor South Project, the IPM has been based on the Southern Coalfield predictive curves with calibrations for the local conditions, based on the extensive ground monitoring data from Tahmoor Mine as discussed in Section 3.7.

Further details on the IPM are provided in the background report entitled General Discussion on Mine Subsidence Ground Movements which can be obtained from *www.minesubsidence.com*. The following section describes the calibration of the IPM for local single-seam conditions.

3.7. Calibration of Incremental Profile Method, outside the increased subsidence area

The extraction of longwalls at Tahmoor Mine has generally resulted in observed mine subsidence movements that are typical of those observed above other collieries in the Southern Coalfield of NSW at comparable depths of cover. However, during the mining of Longwall 24A at Tahmoor Mine substantially increased subsidence was observed over the predicted subsidence levels and then similar increased subsidence movements were also observed above the southern ends of Longwalls 25 to 27 and Longwall 32. This was a very unusual event for the Southern Coalfield and is discussed further in Section 3.8.

This section of the report describes the calibration and testing of the IPM above the majority of the previously extracted longwalls at Tahmoor Mine and does not include observations in the areas of increased subsidence, which is addressed separately in Section 3.8.

The IPM was previously refined or calibrated using the extensive monitoring data that had been collected during the extraction of Longwalls 22 to 25 at Tahmoor to predict the subsidence parameters for Longwalls 27 to 30 at Tahmoor Mine, and the details of this calibration were provided in Section 3.6 of Report No. MSEC355 (Revision B, July 2009).

The IPM prediction curves from that report are the latest calibration of the IPM and this model was tested against the latest available subsidence data in the Tahmoor North area, plus, the available subsidence data from monitoring lines above the previously extracted Tahmoor Longwalls 1 to 19 since these later longwalls were located closer to the proposed Tahmoor South longwalls.

The reliability of the IPM prediction curves is illustrated by comparing the observed movements with those predicted for the following monitoring lines, which are shown in Appendix G of this report. The results have been extended to include measured subsidence after the mining of Longwall 30, where they have been measured. The locations of the monitoring lines are shown in Fig. 3.3 :-

- Fig. G.01 – 100-Line for Tahmoor Longwalls 1 and 2;
- Fig. G.02 – 200-Line for Tahmoor Longwall 2;
- Fig. G.03 – 300-Line for Tahmoor Longwalls 3 to 7;
- Fig. G.04 – 800-Line for Tahmoor Longwalls 8 to12;
- Fig. G.05 – 900-Line for Tahmoor Longwalls 10A to 13;
- Fig. G.06 – 1000-Line for Tahmoor Longwalls 14B to 19;
- Fig. G.07 – Brundah Road Line for Tahmoor North Longwalls 23B to 28;
- Fig. G.08 – Castlereagh Street Line for Tahmoor North Longwalls 22 to 28;
- Fig. G.09 – Remembrance Drive Line for Tahmoor North Longwalls 23A to 30;
- Fig. G.10 – Thirlmere Way Line for Tahmoor North Longwalls 23A to 27;
- Fig. G.11 – York Street Line for Tahmoor North Longwalls 24A to 28;
- Fig. G.12 – HRF Line for Tahmoor North Longwalls 23 to 26;
- Fig. G.13 – LW25 XS1 Line for Tahmoor North Longwalls 25 to 26;
- Fig. G.14 – LW24A Draw Line for Tahmoor North Longwalls 24A to 26; and
- Fig. G.15 – LW25 Centreline for Tahmoor North Longwalls 25 to 26.

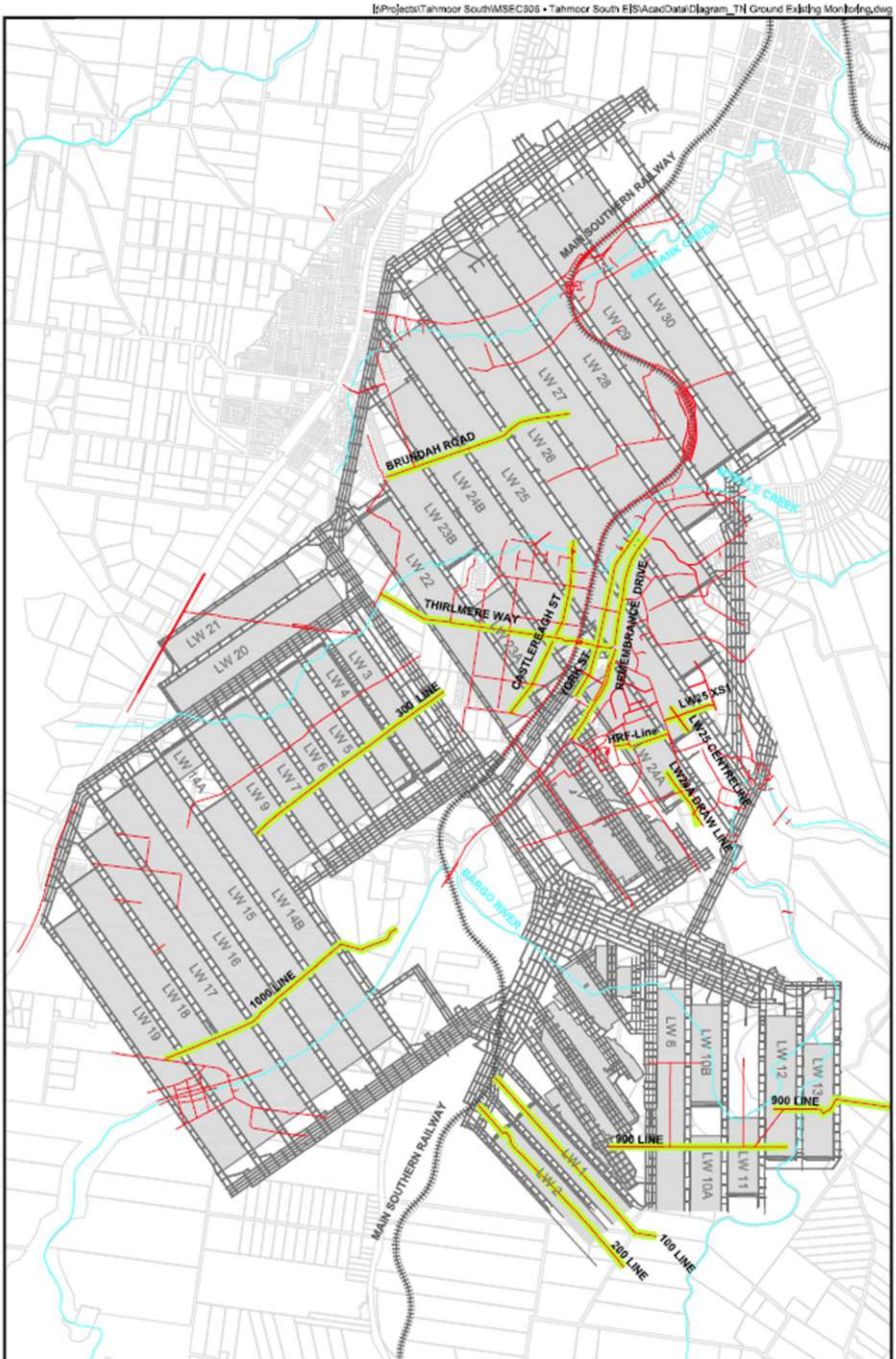

Fig. 3.3 Tahmoor North monitoring lines used in testing calibration of the IPM model

The following observations can be seen from the above figures:

- Predicted maximum subsidence has been greater, for all the monitoring lines over Longwalls 1 to 7, over Longwalls 14 to 23 and over the northern western ends of Longwalls 24B to 26, than the observed maximum subsidence.
- The observed subsidence profiles, for all the monitoring lines over Longwalls 1 to 7, Longwalls 14 to 19, Longwalls 20 to 21 and over Longwalls 21 to 24B, reasonably match those predicted using the calibrated prediction curves with the observed subsidence generally being greater than the observed subsidence. While there is reasonable correlation, it is highlighted that, in some locations away from the points of maxima and, in particular, beyond the longwall goaf edges, the observed subsidence has exceeded that predicted. In these locations beyond the longwall goaf edges, however, the magnitude of subsidence is low and there were very low associated tilts, curvatures and strains.
- Greater maximum subsidence of up to 670 mm has been observed, along some of the lines over Longwalls 24A and above the south eastern ends of Longwalls 25 to 27, than the predicted maximum subsidence as discussed in detail in Section 3.8.
- Greater subsidence was observed compared to predictions along the 800-Line above the centre of Longwall 8 where several small faults and dykes were located. The observed incremental subsidence of 420 mm was 50% greater at that location than the predicted value of 280 mm. The centre of this panel is within 500 metres of the Bargo River, where the valley depth, measured using a one half a depth of cover basis, is 40 metres and this location was within 1,400 m of the Nepean Fault.
- Greater subsidence was observed compared to predictions along the 900-Line above Longwall 13. At this location where the 900-Line crosses Longwall 13 and the Nepean Fault zone, the Nepean Fault zone runs almost parallel to Longwall 13 and the maingate edge of Longwall 13 is within 170 metres of the fault zone. The observed incremental subsidence of 820 mm was approximately 30% greater at that location than the predicted value of 550 mm. The centre of this panel is also within 300 metres of the Bargo River, where the valley depth, measured using a one half a depth of cover basis, is 25 metres and this location was within 300 m of the Nepean Fault.
- Slightly greater subsidence was observed along Castlereagh Street compared to predictions above Longwalls 22 and 23A. This street runs across the south eastern ends of these longwall panels and near the railway corridor.
- Slightly greater subsidence was observed compared to predictions along Remembrance Drive above Longwalls 24A and the southern parts of Longwall 25 and Longwall 26. This area is located on the edge of the zone of increased subsidence.
- Slightly greater subsidence was observed compared to predictions along Thirlmere Way above the southern end of Longwall 24B and the south eastern parts of Longwall 25. This area is located near the zone of increased subsidence.
- Slightly greater subsidence was observed compared to predictions along York Street above Longwalls 24A and the south eastern parts of Longwall 25. This area is located along the edge of the zone of increased subsidence.
- Greater subsidence of up to 600 mm was also observed compared to predictions along the HRF-Line and LW25 XS1 Line, which are within the zone of increased subsidence, as is discussed in more detail in Section 3.8.
- The observed tilt and curvature profiles over all these monitoring lines also reasonably matched the predicted profiles using the calibrated prediction curves. The observed curvatures were derived from the smoothed subsidence profiles, to obtain overall levels of curvature, rather than the localised curvatures at each survey mark. Please see Section 3.7.1 for further discussion on curvature.
- The maximum observed tilts and curvatures were, in most cases, similar to the maximums predicted using the standard Bulli seam prediction curves. The observed tilts and curvatures exceeded those predicted at the tributary crossings, at the locations of the upsidence movements, as the predicted profiles did not include non-conventional valley related movements. There was also some scatter in the observed tilt and curvature profiles.

A comparison between the observed and predicted total subsidence at the individual survey marks from the 100-Line, 200-Line, 300-Line, 800-Line, 900-Line and the 1000-Line after the extraction of Longwalls 1 to 19 at Tahmoor Mine is provided in Fig. 3.4. That is, this analysis includes the occasions when the observed total subsidence exceeded the predicted total subsidence over Longwalls 1 to 19, which were along the 800-Line and 900-Line as shown in Fig. G.04 and Fig. G.05.

The observed subsidence at individual survey pegs, i.e. at a point, for pegs located over Tahmoor Longwalls 1 to 19 exceeded the predicted subsidence by more than +15 % by a small margin at some of the survey marks along the 100-Line, 300-Line, and by much higher margins at surveys marks along the 800-Line and 900-Line. It can be seen from Fig. 3.4 that the observed total subsidence at the other individual survey marks were generally less than the predicted total subsidence plus 15 %, or less than the predicted total subsidence plus 50 mm, which is generally considered acceptable for subsidence prediction methods.

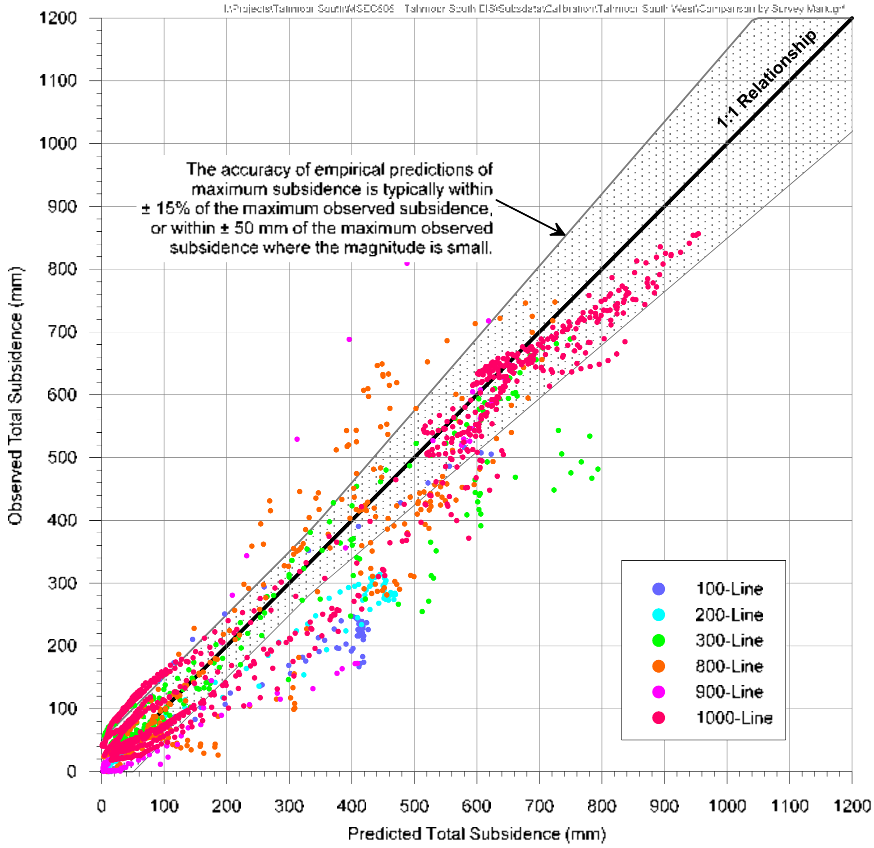

Fig. 3.4 Comparison between observed and predicted total subsidence at individual survey marks for the Tahmoor Longwalls 1 to 19

The further comparison between the observed and predicted total subsidence at all of the individual survey marks over the northern areas of the Tahmoor Mine, at the completion of each of the Longwalls 22 to 26, is provided in Fig. 3.5. These results in Fig. 3.5 have only been provided for the monitoring lines that are located outside the zone of increased subsidence, as is discussed separately in Section 3.8, i.e. these plots do not including pegs located above Longwall 24A and above the south eastern ends of Longwalls 25 and 26. However this analysis does include the monitored data from those parts of Remembrance Drive and Castlereagh Street that are close to or near the zone of increased subsidence, i.e. within a transition zone.

It can be seen from Fig. 3.5, that the observed total subsidence at the individual survey marks at Tahmoor North, due to the extraction of Tahmoor Longwalls 22 to 26, for these monitoring lines that are generally located outside the zone of increased subsidence and outside the transition zone, were generally less than the predicted total subsidence plus 15 %, or less than the predicted total subsidence plus 50 mm, which is generally considered acceptable for subsidence prediction methods. There are several exceedances, however, and these generally occurred along the monitoring lines in those parts of Remembrance Drive and Castlereagh Street that are located close to or near the zone of increased subsidence and from those with lower levels of subsidence.

Instead of plotting the results for all survey marks along a line, a further comparison is provided in Fig. 3.6 between the observed and predicted maximum total subsidence along monitoring lines at the northern parts of the Tahmoor Mine for these monitoring lines that are located outside the zone of increased subsidence, due to the extraction of Tahmoor Longwalls 22 to 26.

It can be seen by comparing Fig. 3.4 and Fig. 3.5 that the maximum observed subsidence values anywhere along the whole monitoring lines are generally less than the predicted total subsidence plus 15 %, or less than the predicted total subsidence plus 50 mm, except where the magnitudes are small. There are some exceedances at the Railway Line (2D) and Larkin St, however, these lines are also located close to or near the zone of increased subsidence and are generally occurred along the monitoring lines with lower levels of subsidence.

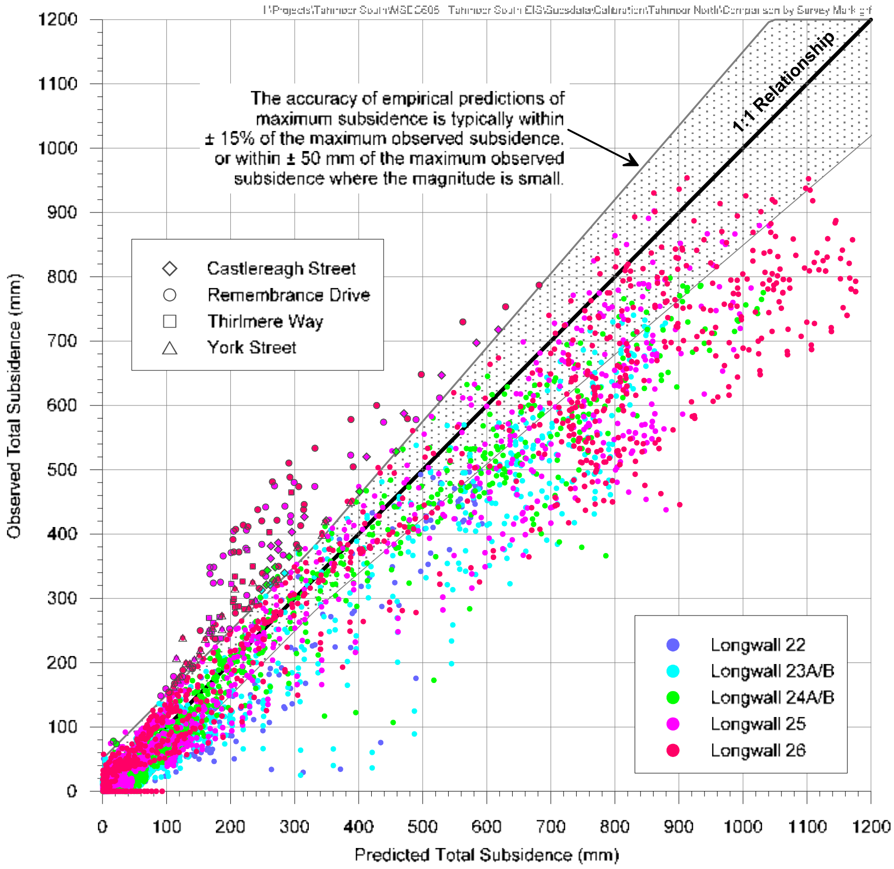

Fig. 3.5 Comparison between observed and predicted total subsidence at individual survey marks for the Tahmoor North longwalls 22 to 26

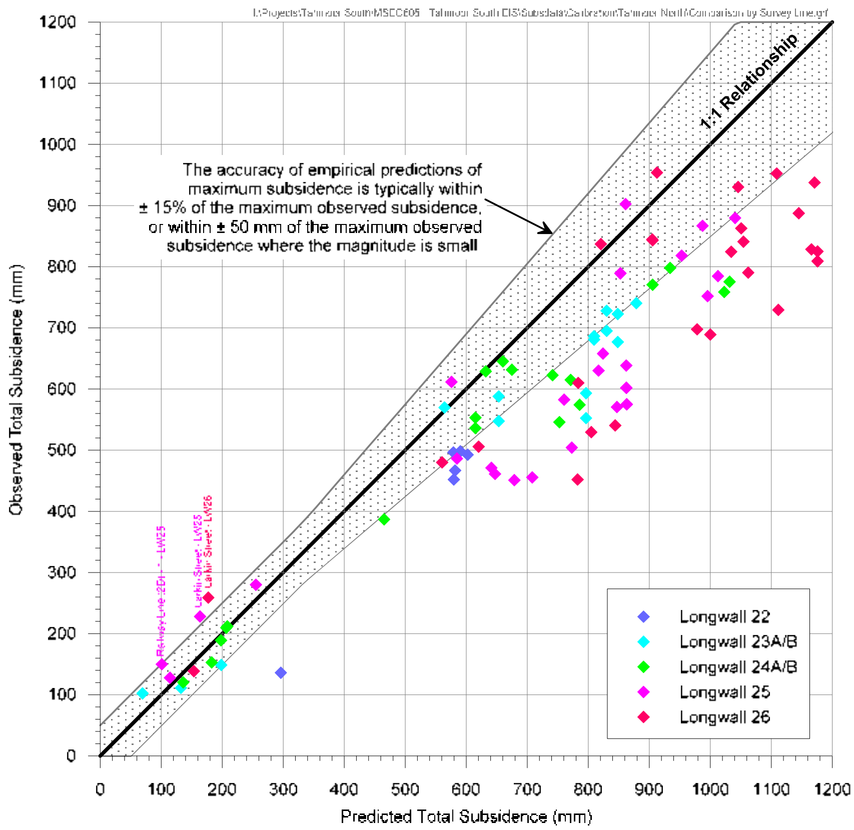

Fig. 3.6 Comparison between observed and predicted maximum total subsidence along whole monitoring lines for the Tahmoor North longwalls 22 to 26

A further statistical review of these maximum subsidence values along monitoring lines has been undertaken. The distribution of the ratio of the maximum observed to maximum predicted total subsidence, for the monitoring lines near Longwalls 22 to 26 located outside the zone of increased subsidence at Tahmoor Mine with maximum values greater than 200 mm, is illustrated in Fig. 3.7 (left). A gamma distribution has been fitted to the results and this is also shown in this figure. The resulting probabilities of exceedance have been determined, based on this gamma distribution, which is shown on the right of Fig. 3.7.

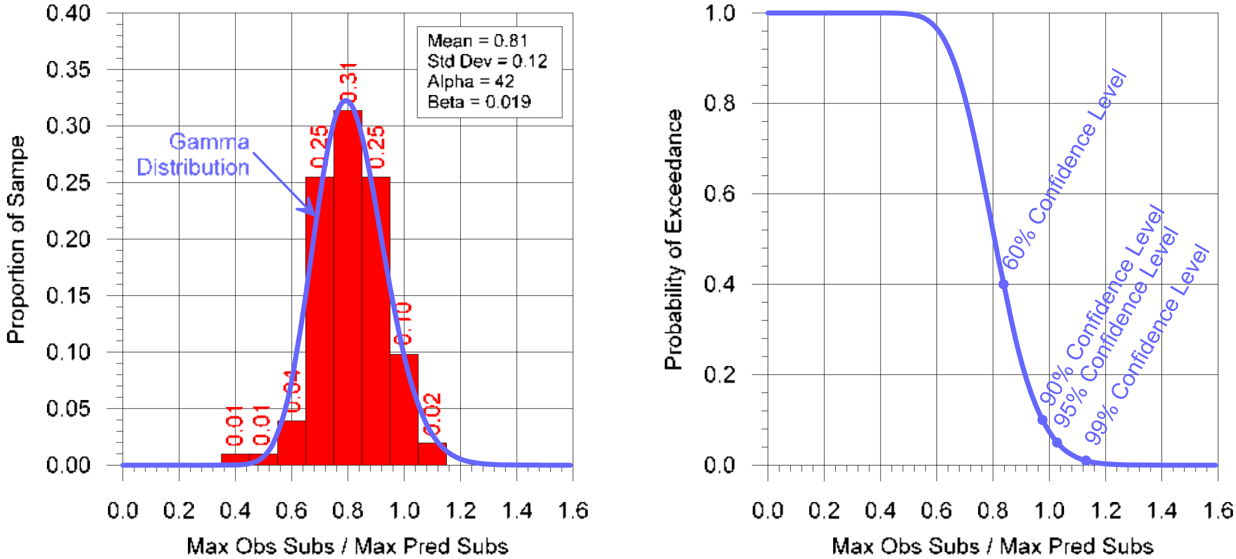

Fig. 3.7 Distribution of the ratio of the maximum observed to maximum predicted total subsidence for monitoring lines at Tahmoor Mine

It can be seen on the left side of the above figure that the maximum observed total subsidence along the monitoring lines at Tahmoor Mine was, on average, 81 % of the maximum predicted total subsidence. The maximum observed total subsidence along the monitoring lines was, at most, 10 % greater than the maximum predicted total subsidence.

It can be seen on the right side of the above figure that, based on the monitoring data, there is approximately a 93 % confidence level that the maximum observed total subsidence would be less than the maximum predicted total subsidence. That is, there is an approximate 7 % probability that the maximum observed total subsidence would exceed the maximum predicted subsidence anywhere along a monitoring line.

The subsidence predictions for the proposed Tahmoor South longwalls using this calibrated IPM model are provided in Section 4.2. Based on the statistical review of the accuracy of this calibrated IPM model, it is expected, therefore, that the calibrated IPM should generally provide reasonable, if not, slightly conservative predictions for conventional subsidence resulting from the extraction of the proposed Tahmoor South longwalls.

However, because of the increased subsidence that has been observed in parts of Tahmoor Mine, consideration should, however, be made for the observed movements exceeding those predicted as the result of anomalous or non-conventional movements, or for increased subsidence which is discussed in Section 3.8.

3.7.1. Comparisons between the observed and predicted tilt and curvature for previously extracted longwalls in the Southern Coalfield

It can be seen from Fig. G.01 to G.11 that there has generally been a reasonable correlation between predicted and observed tilt profiles at Tahmoor Mine. A reasonable correlation has also been found at surrounding collieries in the Southern Coalfield where the depths of cover are similar to those at Tahmoor Mine. Where increased subsidence has been observed at Tahmoor Mine, however, higher than predicted tilts have been observed, and this is discussed further in Section 3.8.

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

To make meaningful curvature comparisons, the observed curvatures have been derived from smoothed observed subsidence profiles, which removes the small deviations resulting from, amongst other things, survey tolerance. The subsidence profile has been smoothed using either the Savitzky-Golay or Loess algorithm, which removes the localised deviations, but does not reduce the overall maxima. This is illustrated in Fig. 3.8 along the Moreton Park Road Line in Area 7, which shows the raw observed subsidence profile, the smoothed subsidence profile, the raw observed curvature profile and the curvature profile derived from the smoothed subsidence.

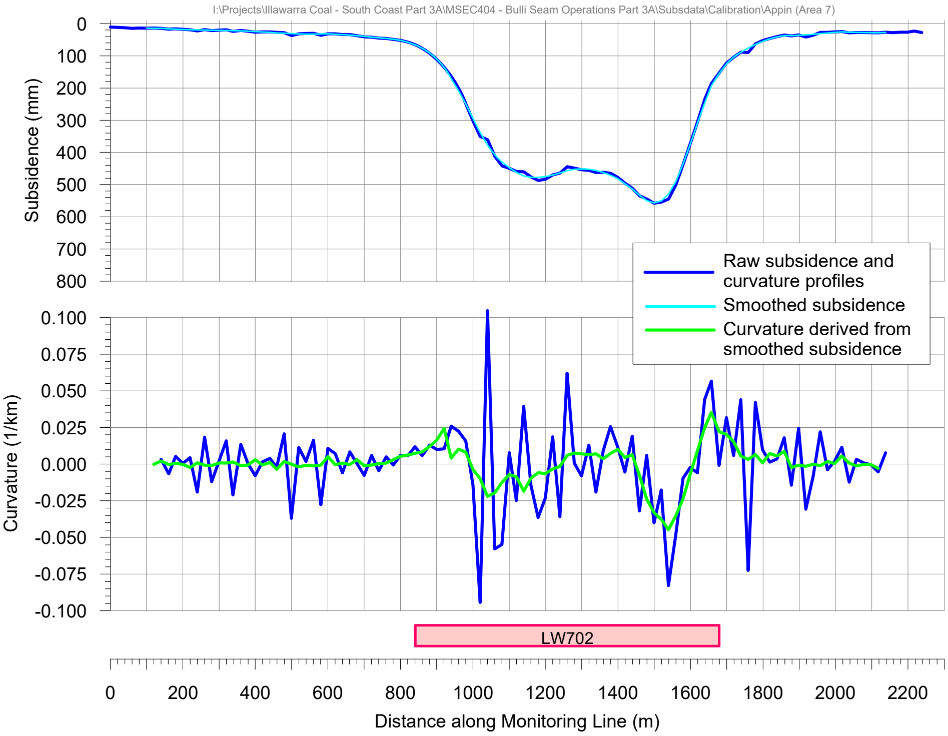

Fig. 3.8 Comparisons of raw observed curvature with curvature derived from smoothed subsidence along the Moreton Park Road line due to Appin Colliery Longwall 702

It can be seen from the above figure, that the smoothed subsidence profile reasonably matches the raw subsidence profile, but the small deviations have been removed. It can also be seen that the raw observed curvatures are very irregular, due to the small deviations in the raw observed subsidence profile. The curvature derived from the smoothed subsidence profile, however, more clearly shows the locations of overall hogging curvature and overall sagging curvature, rather than the localised curvatures at each mark.

Comparisons between the profiles of observed subsidence, tilt and curvature derived from smoothed subsidence profiles with predicted subsidence, tilt and curvature have been provided along the following monitoring lines at Tahmoor Mine:-

- Fig. G.07 – Brundah Road;
- Fig. G.09 – Remembrance Drive; and
- Fig. G.11 – York Street

The comparisons show that when observed curvature has been derived from smoothed subsidence profiles, a reasonable correlation between predicted and observed profiles can be found. A reasonable correlation has also been found at surrounding collieries in the Southern Coalfield where the depths of cover are similar to those at Tahmoor Mine. Where increased subsidence has been observed at Tahmoor Mine, however, higher than predicted curvatures have been observed, and this is discussed further in Section 3.8.

3.8. Areas where increased subsidence, compared to predictions, have been observed

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

However, the locations where greater subsidence was observed compared to the predicted values were identified, in Section 3.7, were:

- over Longwalls 24A and the southern parts of Longwalls 25 to 27;
- over the commencing end of Longwall 32; and
- over Longwall 8 and along the 800-Line, and over Longwall 13 and along the 900-Line.

It is not a coincidence that there are many faults and dykes at these locations, that these locations are near the Nepean Fault and these locations are near major river valleys or gorges. The extents of these zones of increased subsidence are discussed in detail in Report No. MSEC1123, which was submitted by Tahmoor Coal in support of the EIS application for the Tahmoor South Project.

While the proposed LWs S1A to S6A are not located near the Nepean Fault, the experiences are a reminder that increased subsidence movements can occur. Tahmoor Coal has extensive experience in successfully managing potential subsidence impacts on surface features, even when actual subsidence is substantially greater than the magnitudes that have been predicted above LWs S1A to S6A. It is recommended that subsidence management plans be developed to manage potential impacts that could occur if greater than predicted subsidence occurs.

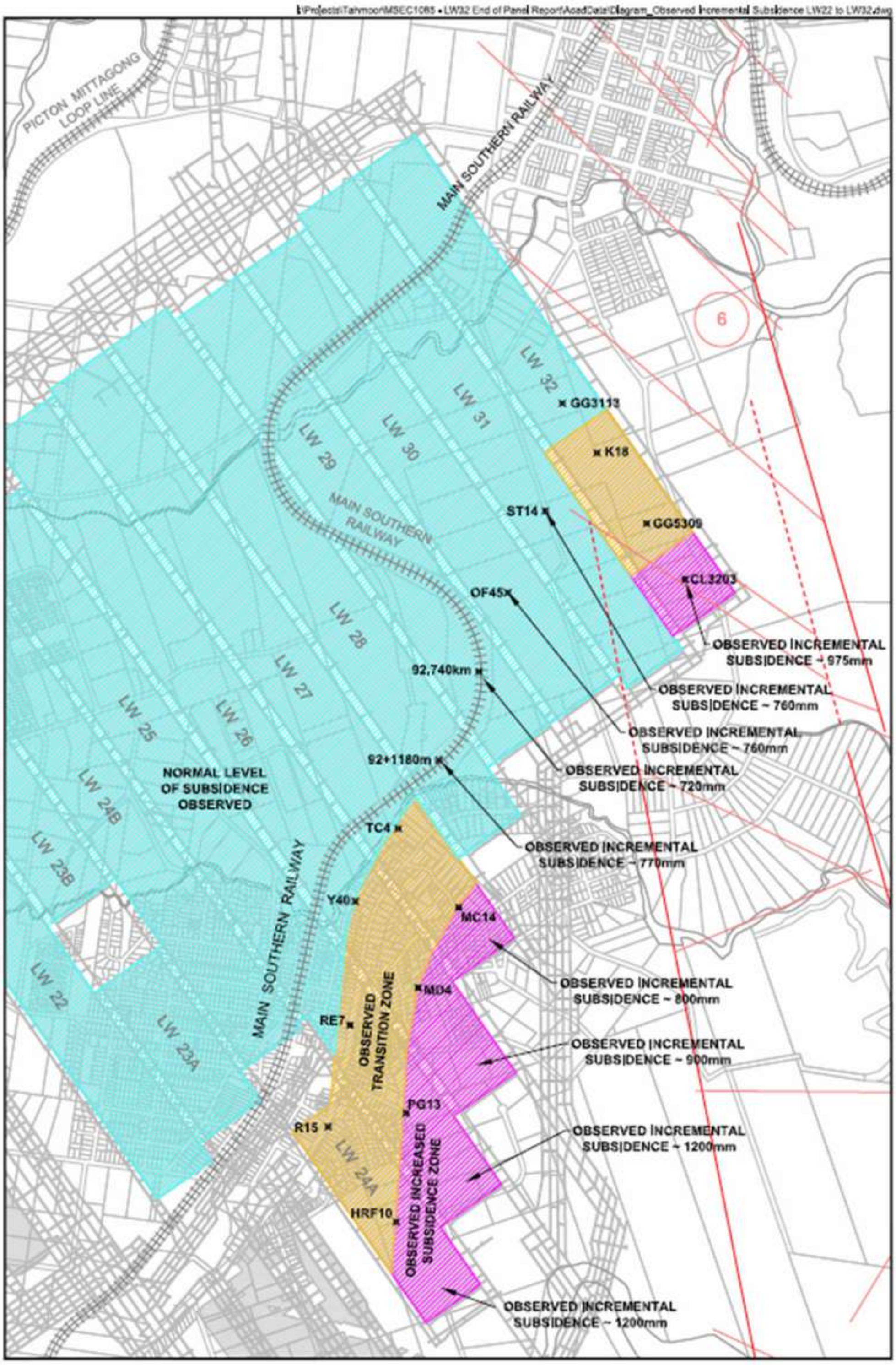

Fig. 3.9 Zones of increased subsidence over Longwalls 22 to 32

3.9. Review of the measured and predicted valley-related effects at Tahmoor

The predicted upsidence and closure movements for the longwalls at Tahmoor Mine have been obtained using the empirical method outlined in Australian Coal Association Research Program (ACARP) Research Project No. C9067 (Waddington and Kay, 2002), referred to as the 2002 ACARP method. Comparisons between the measured and predicted valley-related effects for the previously extracted longwalls at Tahmoor Mine have been provided in the following sections.

3.9.1. Myrtle Creek and the Skew Culvert

Detailed ground monitoring was undertaken where Myrtle Creek and a tributary to this creek (referred to as the Skew Culvert) crosses beneath the Main Southern Railway above Longwalls 26 and 27. A map showing the monitoring lines in these locations is shown in Fig. 3.10.

Fig. 3.10 Monitoring lines across Myrtle Creek and the Skew Culvert

The development of valley closure at each of the monitoring lines across the Myrtle Creek, during the extraction of Longwalls 24B to 27, are illustrated in Fig. 3.11.

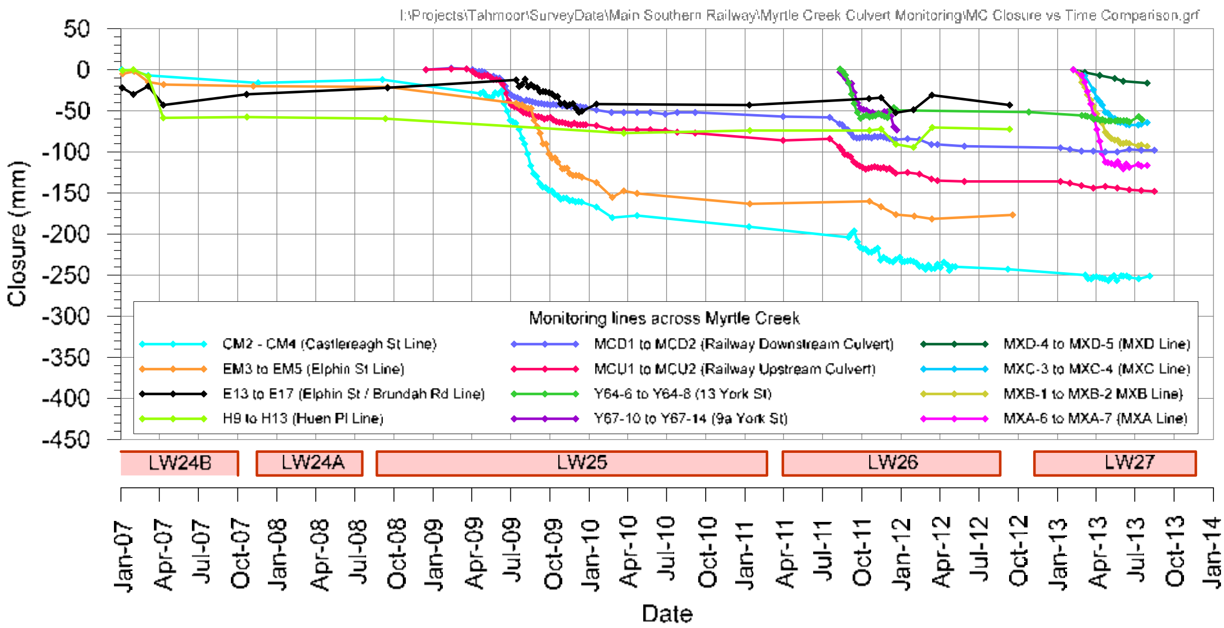

Fig. 3.11 Development of closure across Myrtle Creek during LW24B to LW27

The development of valley closure at each of the monitoring lines across the creek at the Skew Culvert, during the extraction of LW26 and LW27, are shown in Fig. 3.12.

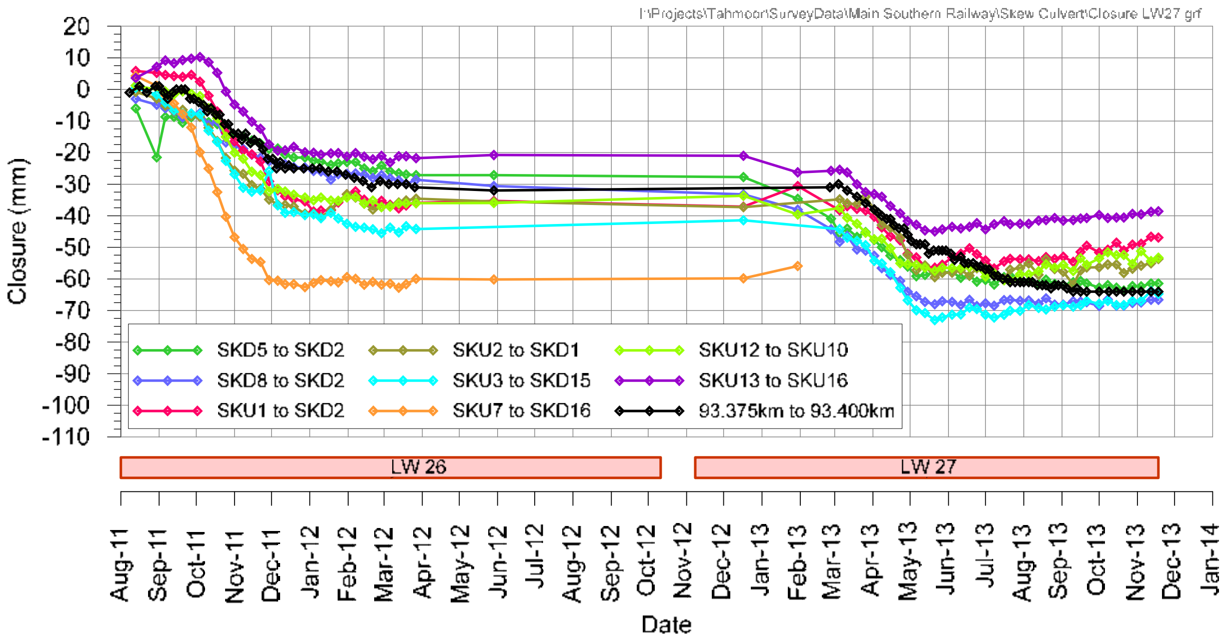

Fig. 3.12 Development of closure across the Skew Culvert during LW26 and LW27

A summary of the predicted and measured incremental closure across Myrtle Creek and the Skew Culvert is provided in Table 3.1. The predictions are consistent with those provided in Report No. MSEC355, which supported the SMP Application for Tahmoor LW27 to LW30.

Table 3.1 Predicted and measured incremental closure at the monitoring lines across Myrtle Creek and the Skew Culvert

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

It can be seen from the above table, that the measured valley closure has substantially exceeded predictions at the Castlereagh Street crossing, at the crossing of the Elphin-Myrtle monitoring line and, to a lesser extent, the crossing of the Main Southern Railway during the mining of LW25. It is considered that the reason for the differences in observations may be linked to the change in orientation of Myrtle Creek as the three above-mentioned monitoring lines are located along the same stretch of Myrtle Creek. It is noted, however, that substantially less closure has developed at Castlereagh Street than predicted during the mining of LW27.

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

The measured valley closure across Myrtle Creek where it flows directly above LW27 (MXA to MXC lines) has been less than predicted, but greater in magnitude than that measured across monitoring lines upstream of LW27. This was expected because the valley is deeper compared to sections further upstream.

3.9.2. Redbank Creek

Detailed ground monitoring has been undertaken along Redbank Creek during the extraction of LWs 26 to 31. The ability to survey valley closure across the creek was constrained as access was not provided by some landowners located adjacent to the creek. There was no access to the creek from the northern bank and limited access on the southern bank of the Redbank Creek.

Ground surveys were undertaken in relative 3D from Bridge Street to a monitoring line that is located in cleared pasture land along the top of the valley, as shown in Fig. 3.13. This has provided measurements of total valley closure. Some survey pegs have been installed along a fenceline on the southern side to a point where surveyors can sight a survey peg on Bridge Street. Despite the best efforts of the survey team, the accuracy of the survey is challenged by the lack of cross lines across Redbank Creek. Baseline monitoring indicates that the valley closure measurements were accurate to approximately 20 mm to 30 mm.

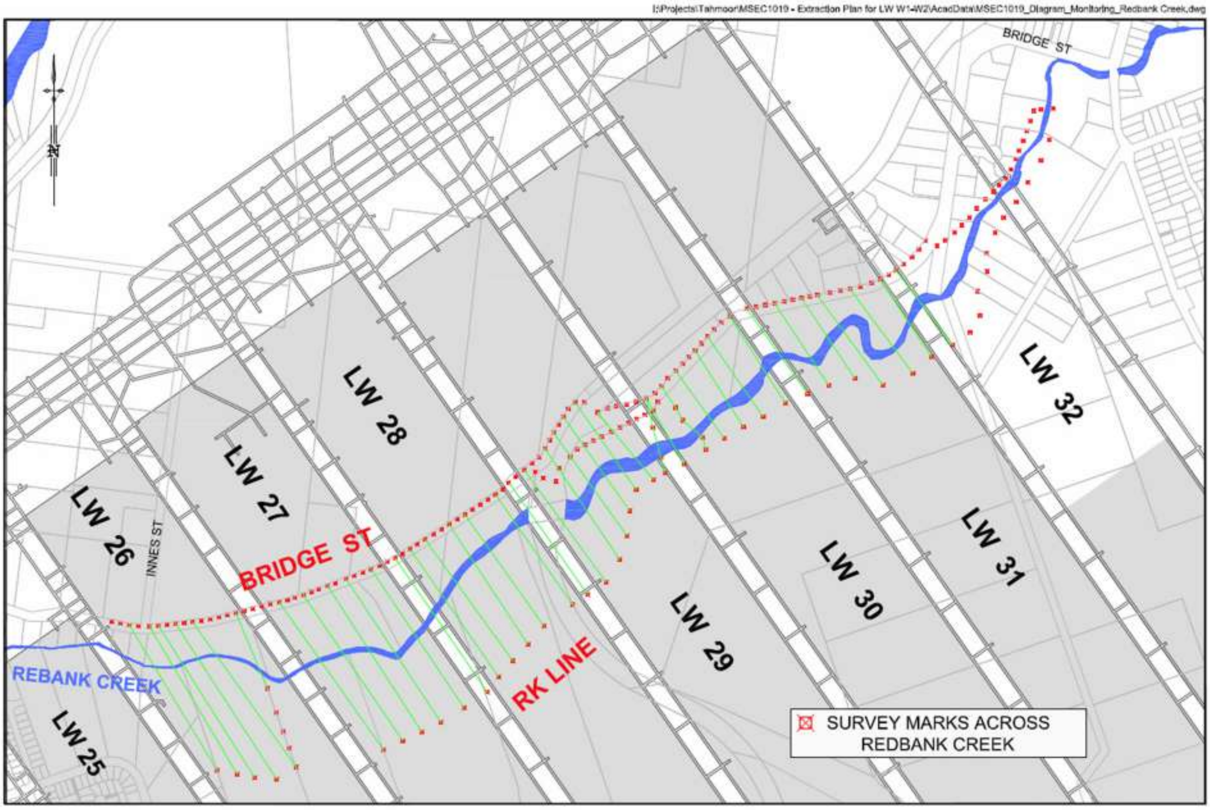

Fig. 3.13 Location of survey marks across Redbank Creek

A comparison between observed and predicted total valley closure along Redbank Creek after the mining of Longwall 31 is shown in Fig. 3.14. A comparison between observed and predicted incremental closure along Redbank Creek is also provided.

The closures are based on calculating changes in horizontal distance between pegs located across the valley in an orientation that is approximately parallel to the longwall panel. This orientation was chosen as Redbank Creek flows approximately at right angles across the panel.

Different results can be derived if the calculations were based on different pairs of pegs, though it is considered that if different pairs were chosen, such calculations would include an additional component of conventional and non-conventional ground shortening that occurs across the panel in both plateau areas or valleys. This is particularly the case if the pegs are located across the width of the longwall panel from each other. When comparing the results against predictions of valley closure, it was considered simpler to choose pegs that are approximately aligned with longwall direction so as not to make allowances for the additional effects of conventional lateral ground closure movements.

A number of observations are made from the monitoring data:

- There has been a reasonable correlation between predicted and observed incremental closure at the completion of Longwall 31. Valley closure was slightly greater for a temporary period of time, when the transient effects of the subsidence travelling wave passed through the valley; and
- Observed total closure from the mining of Longwalls 26 to 31 is less than predicted.

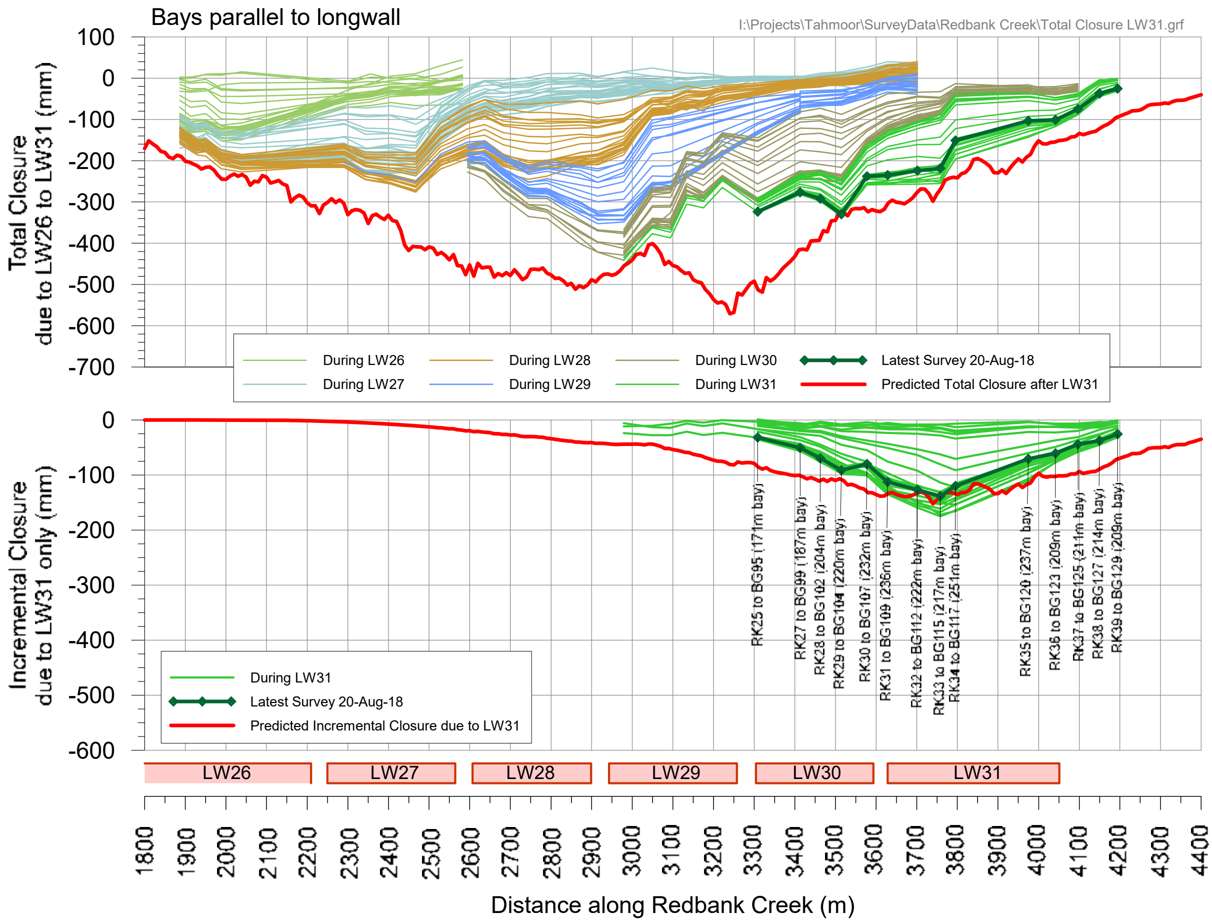

Fig. 3.14 Comparison between observed and predicted valley closure along Redbank Creek

3.9.3. Creek crossings directly above LW W1-W2

Very minor closure of approximately 20 mm was measured across the creek crossing at 88.400 km on the Picton to Mittagong Loop Line during the mining of LW W1, which is less than predicted. Closure is, however, currently developing during the mining of LW W2, with total closure likely to be a similar order of magnitude to the prediction of 125 mm.

Surveys across other creeks above LW W1 have measured very little to no measurable valley closure. As at March 2021, LW W2 has not yet mined directly beneath or adjacent to other creek crossings.

The results show that while the prediction of valley closure is not an exact science, there is a reasonable correlation between measured and predicted subsidence when measured across the width of the valley.

3.9.4. Reliability of the predicted valley-related movements

The review of the observed movements at Myrtle and Redbank Creeks and the observed movements directly above and adjacent to LW W1 indicate that the ACARP Method provides reasonable predictions for valley closure at Tahmoor Mine. It is noted, however, the measured closures substantially exceeded those predicted in three locations along Myrtle Creek, due to the extraction of LW25, but these all occurred along the same section of creek. Elsewhere, the measured closures were typically similar to or less than those predicted.

Whilst the major factors that determine the levels of movement have been identified, there are some factors that are difficult to isolate. One factor that is thought to influence the upsidence and closure movements is the level of in-situ horizontal stress that exists within the strata. In-situ stresses are difficult to obtain and not regularly measured and the limited availability of data makes it impossible to be definitive about the influence of the in-situ stress on the upsidence and closure values. The methods are, however, based predominantly upon the measured data from Tower Colliery in the Southern Coalfield, where the in-situ stresses are high. The methods should, therefore, tend to over-predict the movements in areas of lower stress.

Variations in local geology can affect the way in which the near surface rocks are displaced as subsidence occurs. In the compression zone, the surface strata can buckle upwards or can fail by shearing and sliding over their neighbours. If localised cross bedding exists, this shearing can occur at relatively low values of stress. This can result in fluctuations in the local strains, which can range from tensile to compressive. In the tensile zone, existing joints can be opened up and new fractures can be formed at random, leading to localised concentrations of tensile strain.

Another factor that is thought to influence the movements is the characteristics of near surface geology, particularly in stream beds. Upsidence in particular is considered to be sensitive to the way in which the bedrock responds, since thin strata layers may respond differently to thicker ones. The location of the point of maximum upsidence is also considered to be strongly influenced by the characteristics of near surface geology.

Another factor that is thought to influence upsidence and closure movements is the presence of geomorphological features. Recent monitoring along a deeper and more incised valley has shown variable measurements around bends. There tended to be less movement at the apex of the bend than in the straight sections.

Notwithstanding the abovementioned limitations, the 2002 ACARP method is the most thoroughly used and tested prediction method for upsidence and closure movements in the Southern Coalfield. It is expected in most cases to provide reasonable, if not, slightly conservative predictions of the valley-related movements for the proposed longwalls.

More recently, the empirical prediction method has been refined based on further research undertaken as part of ACARP Research Project No. 18015 (Kay and Waddington, 2014). The 2014 ACARP method only provides predictions for valley closure and not for upsidence.

The predictions based on the 2002 ACARP method can be directly compared with the predictions provided in previous MSEC subsidence reports for Tahmoor Mine and with other case studies. This method has also been more widely used and tested than the more recent 2014 ACARP method. The assessments provided in this report, therefore, have been based on the predictions obtained using the 2002 ACARP method.

3.10. Rate of subsidence development and timing required for remedial actions

Monitoring of subsidence movements during the mining of previously extracted longwalls at Tahmoor Mine and other surrounding mines in the Southern Coalfield at similar depths of cover have shown that subsidence movements develop gradually over time, with no obvious indication of large and sudden step changes.

The subsidence effect at a point on the surface can be likened to a form of a wave. This wave moves across the ground at approximately the same speed as the longwall face retreats within the longwall panel but the impact of the surface subsidence wave is modified by the depth of cover and the overburden geology.

When the extraction of coal from a panel first commences, there is no immediate surface subsidence, but as the coal within the panel is extracted and the resulting void increases in size, subsidence develops gradually above the goaf area. As mining approaches and before a point is undermined, subsidence movements start to develop and then, after the longwall face passes beyond the point, the maximum value of subsidence is reached and despite further mining occurring within the panel, this level of subsidence is not exceeded except for some small time based residual movements.

An example of the gradual development of subsidence is shown in Fig. 3.15, which shows the development of subsidence of survey pegs that are located along the centreline of Tahmoor Mine's Longwall 27. The development of subsidence is plotted against the distance of each survey peg to the longwall face at the time of each survey. It shows that subsidence at a point above Longwall 27 typically did not commence until the longwall face had approached to within 200 metres of the point and that the majority of the subsidence movements had developed after the longwall face had passed each point by a distance of approximately 400 to 600 metres. The average extraction rate of Longwall 27 was approximately 40 metres per week, so it can be seen that subsidence typically developed over a period of approximately 15 to 20 weeks.

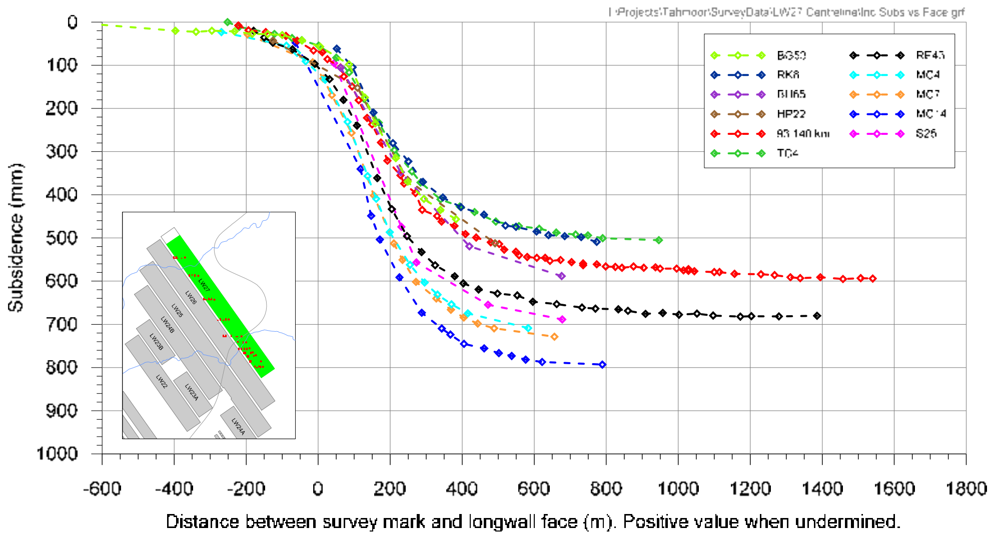

Fig. 3.15 Observed Development of subsidence along Longwall 27 centreline versus distance to longwall face

As further adjacent panels are extracted, additional subsidence can be experienced above the previously mined panel or panels. However, a point is reached where a maximum value of subsidence occurs over the series of panels irrespective of whether more panels are later extracted.

Differential vertical and horizontal subsidence movements, such as tilt, curvature, strain and valley closure and upsidence are also observed to develop gradually as mining progresses.

The gradual development of subsidence movements allows potential impacts on surface features to be managed effectively. This is because with the implementation of an effective monitoring program, unexpected or anomalous subsidence ground movements can be detected early and actions taken in response well before potentially severe impacts occur.

4.1. Introduction

The following sections provide details on the maximum predicted conventional subsidence parameters resulting from the extraction of the proposed mine layout for LWs S1A to S6A using the calibrated IPM model.

The predicted subsidence parameters and the impact assessments for the natural features and surface infrastructure are provided in Chapters 5 through to 11.

The predicted subsidence, tilt and curvature have been obtained using the Incremental Profile Method, which was calibrated for local conditions as described in Section 3.7. The predicted strains have been determined by analysing the strains measured during the previous extraction of longwalls at Tahmoor Mine, as well as at other nearby collieries.

The maximum predicted subsidence parameters and the predicted subsidence contours provided in this Chapter describe and show the conventional movements and do not include the valley-related upsidence and closure movements, nor the effects of faults and other geological structures. Such effects have been addressed separately in the impact assessments for each feature provided in Chapter 5 through to 11.

4.2. Maximum predicted conventional subsidence, tilt and curvature

The maximum predicted conventional subsidence parameters resulting from the extraction of the proposed longwalls were determined using the calibrated Incremental Profile Method, which was described in Chapter 3.

A summary of the maximum predicted values of incremental conventional subsidence, tilt and curvature, due to the extraction of each of the proposed amended longwalls, is provided in Table 4.1. The predicted ground strains are discussed in Section 4.3. The predicted tilts provided in this table are the maxima after the completion of each of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of each of the proposed longwalls.

Table 4.1 Maximum predicted incremental conventional subsidence, tilt and curvature resulting from the extraction of each of the proposed longwalls

Longwall	Maximum predicted incremental conventional subsidence (mm)	Maximum predicted incremental conventional tilt (mm/m)	Maximum predicted incremental conventional hogging curvature (km^{-1})	Maximum predicted incremental conventional sagging curvature (km^{-1})
LW S1A	800	7.0	0.08	0.22
LW S2A	950	7.5	0.08	0.22
LW S3A	950	8.0	0.09	0.22
LW S4A	950	8.0	0.09	0.22
LW S5A	950	8.0	0.10	0.22
LW S6A	975	8.3	0.09	0.23

The predicted total conventional subsidence contours, using the calibrated IPM model for Tahmoor Mine, resulting from the extraction of the proposed LWs S1A to S6A are shown in Drawing No MSEC1192-22.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature, after the extraction of each of the proposed amended longwall series, is provided in Table 4.2.

Table 4.2 Maximum predicted total conventional subsidence, tilt and curvature after the extraction of each of the proposed longwalls

Longwalls	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
LW S1A	800	7.0	0.08	0.22
LW S2A	1,000	8.0	0.10	0.22
LW S3A	1,200	8.0	0.10	0.22
LW S4A	1,250	8.5	0.13	0.22
LW S5A	1,350	9.0	0.14	0.22
LW S6A	1,350	9.5	0.14	0.24

The maximum predicted total subsidence, after the completion of the proposed longwalls, is 1,350 mm which represents around 61 % of the extraction height. The maximum predicted total conventional tilt is 9.5 mm/m (i.e. 0.95 %), which represents a change in grade of 1 in 95. The maximum predicted total conventional curvatures are 0.14 km^{-1} hogging and 0.24 km^{-1} sagging, which represent minimum radii of curvature of 7.1 kilometres and 4.2 kilometres, respectively.

The predicted conventional subsidence parameters vary across the *Subsidence Study Area* as the result of, amongst other factors, variations in the depths of cover, longwall geometry and extraction heights. To illustrate this variation, the predicted profiles of conventional subsidence, tilt and curvature have been prepared along a prediction line, the locations of which is shown in Drawing No. MSEC1192-22.

The predicted profiles of conventional subsidence, tilt and curvature along Prediction Line 1, resulting from the extraction of the proposed LWs S1A to S6A, are shown in Fig. E.01 in Appendix E. The predicted incremental profiles, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profile, after the extraction of each of the proposed amended longwalls, are shown as solid blue lines with the final predicted total profiles being shown in a thicker solid blue line. The range of predicted curvatures in any direction to the prediction lines, at any time during or after the extraction of the proposed longwalls, is shown by the grey shading.

The reliability of the predictions of subsidence, tilt and curvature, obtained using the Incremental Profile Method, is discussed in Section 3.4 to Section 3.8 and Section 4.4 to Section 4.6.

4.2.1. Comparison between predictions based on proposed LWs S1A to S6A with predictions based on the approved EIS layout

Minor changes have been made to the mine layout for proposed LWs S1A to S6A since development consent was received (EIS Layout). The potential for changes was foreshadowed by Tahmoor Coal when it applied for development consent. A comparison between mine layouts was previously shown in Fig. 1.2 and further details are provided.

- The layout for LWs S1A to S6A has been shifted approximately 35 metres to the south-west;
- LWs S2A to S6A have been widened by 2 metres (the width of LW S1A is unchanged);
- Chain pillar widths for the tailgates of LWs S3A to S6A have been reduced by 2 metres (the chain pillar between LWs S1A and S2A is unchanged);
- The commencing ends of LWs S1A to S6A have been aligned compared to the previous staggered layout. The outcome of the change is that LWs S2A to S6A have been extended in length. The gap between the A and B series longwalls will be maintained, such that the future B series will be shortened when compared to the mine layout that was submitted for development consent; and
- The planned sequence has been amended, such that the A series longwalls are proposed to be extracted in sequence. When Tahmoor Coal applied for development consent, it had been planned to extract LWs 101A to 103A first, then the B series longwalls and return to extract LWs 104A to 106A.

A comparison between predictions based on proposed LWs S1A to S6A with predictions based on the approved EIS layout is shown in Fig. 4.1. A comparison between maximum predicted incremental and total conventional subsidence, tilt and curvature between the EIS Layout and the First Amended Layout is shown in Table 4.3 and Table 4.4.

The proposed increases in panel width by 2 metres are very small compared to the overall depth of cover (0.5%) and panel width (0.7%). The chain pillar widths have been reduced by 5%, the 2 metre reduction from 38 metres to 36 metres represents a 0.5% reduction as a proportion of the depth of cover. Both proposed changes are predicted to result in very small increases in predicted maximum subsidence, tilt and curvature, as shown in Fig. 4.1. The predicted changes are within the accuracy of the subsidence prediction model.

The proposed offset in the layout by 35 metres has resulted in a shift of the predicted subsidence profiles across the panels. As shown in Fig. 4.1, some points on the surface are predicted to experience greater subsidence, tilt and curvature as a result of the change, while other points on the surface are predicted to experience greater subsidence, tilt and curvature.

For linear features such as streams, railways, roads and pipelines, the overall predicted maximum subsidence, tilts and curvatures are similar but shifted slightly. For discrete surface features such as building structures, the proposed changes will result in higher predicted values for some features and lower predicted values for other features but the overall spread across the Subsidence Study Area is expected to be similar. It is further noted that subsidence predictions for discrete surface features have been provided in this Extraction Plan report and the previous EIS report as the maximum predicted values within 20 metres of each feature, in recognition of the accuracy of the prediction method. This conservative approach is expected to buffer the effects of the 35 metre shift in mine layout.

The proposed change to the alignment of the central mains between the A and B series longwalls has been proposed to improve efficiencies in resource recovery and mining operations. The gap between the A and B series longwalls will be maintained, such that the future B series will be shortened when compared to the mine layout that was submitted for development consent. Some points on the surface are predicted to experience greater subsidence, tilt and curvature as a result of the change, while other points on the surface are predicted to experience greater subsidence, tilt and curvature as a result of the change.

The proposed changes to the sequencing of longwall extraction is expected to be beneficial to the community in the sense that the effects of extraction of the A series will occur over a shorter duration. Under the previously proposed sequencing in the EIS, the ground surface above LWs S3A and S4A in particular would have experienced a delay in the order of 5 years between active subsidence events while the B series was extracted.

It is also worthwhile noting that the points on the surface where maximum subsidence, tilt and curvatures were predicted for the approved EIS layout are located above the longwall panels in the B series. While the proposed changes to the mine layout in the A series are predicted to result in very small increases in predicted maximum subsidence, tilt and curvature over the A series, the predicted maxima remain less than the maximum subsidence, tilt and curvatures that were predicted for the approved EIS layout.

Specific subsidence predictions have been provided for identified surface and sub-surface features in this report. Comparisons to previously provided predictions for the EIS Layout have generally not been provided for reasons of brevity. Detailed comparisons can be made for each feature by comparing the findings in Report No. MSEC1123 for the EIS Layout.

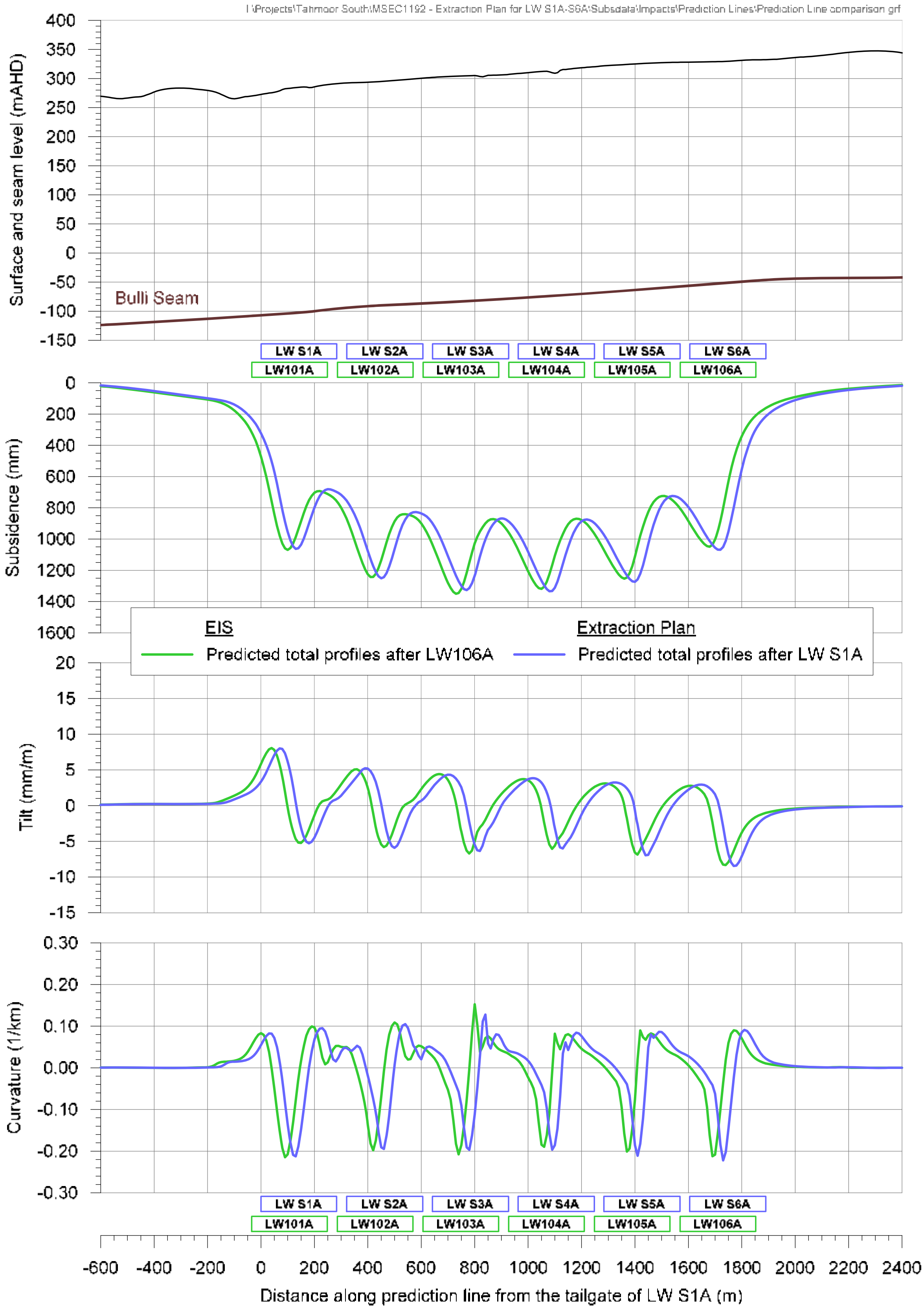

Fig. 4.1 Comparison of predictions between proposed Extraction Layout and approved EIS Layout

Table 4.3 Maximum predicted incremental conventional subsidence, tilt and curvature resulting from the extraction of the Extraction Plan Layout and the EIS Layout

Layout	Longwall	Maximum predicted incremental conventional subsidence (mm)	Maximum predicted incremental conventional tilt (mm/m)	Maximum predicted incremental conventional hogging curvature (km^{-1})	Maximum predicted incremental conventional sagging curvature (km^{-1})
Proposed Extraction Plan LWs S1A to S6A	LW S1A	800	7.0	0.08	0.22
	LW S2A	950	7.5	0.08	0.22
	LW S3A	950	8.0	0.09	0.22
	LW S4A	950	8.0	0.09	0.22
	LW S5A	950	8.0	0.10	0.22
	LW S6A	975	8.3	0.09	0.23
EIS Layout (MSEC1123)	LW101A	800	7.0	0.08	0.22
	LW102A	950	7.5	0.08	0.21
	LW103A	950	7.5	0.08	0.21
	LW104A	950	8.0	0.09	0.21
	LW105A	950	8.0	0.09	0.21
	LW106A	950	8.0	0.09	0.22

Table 4.4 Maximum predicted total conventional subsidence, tilt and curvature resulting from the extraction of the Extraction Plan Layout and the EIS Layout

Layout	Longwall	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Proposed Extraction Plan LWs S1A to S6A	LW S1A	800	7.0	0.08	0.22
	LW S2A	1,000	8.0	0.10	0.22
	LW S3A	1,200	8.0	0.10	0.22
	LW S4A	1,250	8.5	0.13	0.22
	LW S5A	1,350	9.0	0.14	0.22
	LW S6A	1,350	9.5	0.14	0.24
EIS Layout (MSEC1123)	LW101A	800	7.0	0.08	0.22
	LW102A	1000	8.0	0.10	0.22
	LW103A	1200	8.5	0.11	0.22
	LW104A	1300	8.5	0.16	0.22
	LW105A	1350	8.5	0.16	0.22
	LW106A	1350	8.7	0.16	0.23

4.3. Predicted strains

It is important to appreciate that the extraction of coal not only results in subsidence, but, it also induces horizontal ground movements and ground strains, and, unlike subsidence, which is measured vertically, it is important to appreciate that these parameters have both a magnitude and a direction. The magnitude of the measured ground strains can be sensitive to the ground distances over which they were measured, and, both the measured ground strains and horizontal movements are very sensitive to the direction in which they were measured. Hence, strain and horizontal movements are more complex, and they are more difficult to predict than subsidence, tilt and curvature.

The profiles of observed strain along monitoring lines, therefore, were often irregular in shape even when the profiles of observed subsidence, tilt and curvature were relatively smooth.

Early researchers noticed the similarity between the observed curvature and strain profiles and the similarity between the observed tilt and horizontal movement profiles. Hence, it was logical that the early strain prediction methods were based on linear relationships with predicted conventional curvature and the early horizontal ground movement prediction methods were based on linear relationships with predicted conventional tilt.

The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and the locations that are predicted to experience sagging or concave curvature are expected to be net compressive strain zones and adopting a linear relationship between curvature and strain provided a reasonable prediction for the maximum conventional tensile and compressive strains.

In the Southern Coalfield, it was found that a curvature to conventional strain conversion factor of 15 provided a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains. Similarly, a tilt to conventional horizontal movement conversion factor of 15 was found to provide a reasonable relationship between the maximum predicted tilt and the maximum predicted conventional horizontal movement.

However, it was noticed that, whilst these correlations were reasonable for the maximum values of these parameters over some areas of the mined panels, they were not as reliable in many other areas, particularly in those locations that were beyond the edges of the mined panels that were near changes in geological conditions. It was also noted that survey tolerance and valley related movements can represent a high proportion of measured ground strains and horizontal displacements.

The limited accuracy of strain and horizontal movement predictions at locations away from the point of maximum strain and horizontal movement was discussed in later subsidence prediction reports where it was stated that the measured strains and horizontal ground movements at a point can vary considerably from the predicted conventional values. It was noted that the locations that were predicted to experience hogging or convex curvature experienced net tensile strain zones and the locations that were predicted to experience sagging or concave curvature experienced net compressive strain zones, but, it was highlighted that the observed strain and horizontal movement profiles along monitoring lines were irregular in shape, with an occasional spike, compared to the observed subsidence, tilt and curvature profiles which were relatively smooth. Hence, it was concluded that, whilst the prediction of vertical subsidence and tilt at a point could be carried out with reasonable accuracy and reliability, the prediction of mining-induced ground strains and horizontal movements at a point was far less accurate, especially when those predictions used linear conversion factors that were based on predicted conventional curvature and tilt.

Furthermore, the horizontal movement predictions at a point were rarely provided and the predictions of ground strains are usually provided based on statistical basis, as is detailed in Section 4.3.1.

However, strain is one of the most important parameters for assessing the likelihood of mine subsidence damage to natural features and built features on the surface. Recent research has resulted in some improved understanding and methods for predicting ground strains and relative horizontal movements in zones across mined panels at the surface, (Barbato, 2016, 2017). These new methods for predicting strain have been developed dependent on the mining geometry, surface topography, surface geology and the likelihood of irregular anomalous movements.

The predicted distribution of strains using this new method also provides guidance on the magnitudes of localised spikes and the likelihoods of exceeding strain thresholds based on previously measured ground monitoring data (Barbato et al., 2016 and 2017).

The reasons why ground strains and horizontal movements are more complex and difficult to predict than subsidence, tilt and curvature are partly associated with the observation that, while the strata has only one direction to move,(i.e. vertically downwards), it can be moved in two directions horizontally and it has been observed that the ground will move wherever it is easiest to go. Additionally, studies have noted that ground strains and horizontal movements are influenced/affected by many multiple factors and a complex interaction of many mechanisms, including the:

- magnitude of the vertical subsidence, tilt and the depth of cover;
- steepness and direction of the surface topography;
- steepness and direction of the seam dip;
- direction of mining in relation to both the surface and seam slope;
- geology, geomechanical properties and thicknesses of the near surface strata, as well as, all the overburden strata layers, the seam and the strata layers immediately under the seam;
- presence of geological faults, pre-existing natural joints and igneous intrusions;
- magnitude and principal direction of the in situ horizontal compressive stresses in the strata layers around the mined goaf and the surface strata layers;
- presence and proximity of previously extracted panels in the currently mined seam and previously extracted panels in other seams;
- behaviour of blocky sandstone environments where initial ground movements occur predominantly along pre-existing natural joints, the location of which would not be known;
- limited ability of opened joints to close fully during the following compression phases after the initial shearing and tensile movements;
- reversing component that seems to initially move surveyed surface pegs towards the longwall face as the face approaches and, then, after the face extracts under and away from this peg, the surface is moved back towards its initial position and often it is moved further past that position as it follows the mining face; and
- other contributing factors such as the degree of surface roughness and frictional resistance along the bedding planes, survey accuracy or survey tolerance (especially where the strains are of a low order of magnitude), the presence of groundwater flows along the bedding planes and its influence on the slippage along bedding planes, etc.

Nevertheless, it has been concluded that the curvature to conventional strain conversion factor and the tilt to horizontal movement conversion factor can be used to provide a reasonable indication of the maximum conventional strains and horizontal movements over extracted panels.

Using the maximum predicted conventional curvatures of 0.14 km^{-1} hogging and 0.24 km^{-1} sagging curvature and the conventional strain conversion factor of 15, the maximum predicted conventional strains for the proposed LWs S1A to S6A, are approximately 2.1 mm/m tensile and 3.4 mm/m compressive.

At specific points around the mined panels, however, there can be considerable variation from this linear curvature to conventional strain relationship, resulting from non-conventional movements and a wide range of scatter is observed between the predicted and observed strain profiles. When expressed as a percentage, observed strains can be many times greater than the predicted conventional strain for low magnitudes of curvature. In this report, therefore, MSEC has provided a statistical approach to predict observed strain and hence account for this variability, instead of just providing a single predicted conventional strain.

The range of potential strains above the proposed longwalls has been determined using monitoring data from the previously extracted longwalls at Tahmoor Mine, as well as from other nearby collieries, including Appin and West Cliff, where the regional geology and mining geometries are reasonably similar to that for the proposed longwalls. A summary of the monitoring lines that were used in the strain analysis is provided in Table 4.5 and Table 4.6 shows the mining geometry for the proposed longwalls.

Table 4.5 Monitoring lines used in the strain analysis

Location	Monitoring Lines	Longwall Widths (m)	Depths of Cover (m)	Width-to-Depth Ratios	Extraction Heights (m)
Early longwall areas at Tahmoor Mine	100-Line	190	410	0.47	2.0
	200-Line	190	410	0.46	1.9
	300-Line	190 ~ 240	430	0.47	2.2
	800-Line	235	420	0.56	2.1
	900-Line	235	420	0.56	2.0
	1000-Line	190 ~ 240	400	0.57	1.8
Northern areas over Tahmoor	40 monitoring lines located outside the area of '*increased subsidence*'	285	425 ~ 470 *(440 average)*	0.60 ~ 0.67 *(0.64 average)*	1.7 ~ 2.3 *(2.1 average)*
Appin Area 3	M-Line	260	480 ~ 520 *(500 average)*	0.50 ~ 0.54 *(0.52 average)*	2.6 ~ 3.0 *(2.8 average)*
Appin Area 7	HW2 East, HW2 West, ARTC and Moreton Park Road	305	500 ~ 560 *(530 average)*	0.54 ~ 0.61 *(0.58 average)*	2.8 ~ 3.2 *(3.0 average)*
West Cliff Area 5	B-Line	305	490 ~ 530 *(510 average)*	0.58 ~ 0.62 *(0.60 average)*	2.4 ~ 3.0 *(2.6 average)*

Table 4.6 Mining geometry for the proposed LWs S1A to S6A

Location	Longwall Widths (m)	Depths of Cover (m)	Width-to-Depth Ratios	Extraction Heights (m)
LW S1A to LW S6A	283-285	375 ~ 410 *(390 average)*	0.69 ~ 0.76 *(0.73 average)*	2.1 ~ 2.2 *(2.1 average)*

It can be seen from the above tables, that the extraction heights for the proposed longwalls vary between 2.1 metres and 2.2 metres, which similar to those for the previously extracted longwalls at Tahmoor Mine, which varied between 1.7 metres and 2.3 metres, but is less on average than those for the previously extracted longwalls at Appin and West Cliff Collieries, which varied between 2.4 metres and 3.2 metres. That is, the extraction heights for the proposed longwalls are within the ranges of those for the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries.

The width-to-depth ratios for the proposed longwalls varies between 0.69 and 0.76, which are slightly greater than those for the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries, which varied between 0.46 and 0.67. Unfortunately, there is limited available ground monitoring data from previously extracted longwalls in the Southern Coalfield where the width-to-depth ratios are exactly similar to the proposed longwalls.

There is, however, extensive ground monitoring data available from previously extracted longwalls in the Newcastle, Hunter and Western Coalfields where the width-to-depth ratios were similar and much greater than those for the proposed longwalls. This data was not included in the strain analyses, since the overburden geology is different to that in the Southern Coalfield and since the width-to-depth ratios for the proposed longwalls are only slightly higher than the available Southern Coalfields data that has similar overburden geology.

A review of the available data from the Newcastle, Hunter and Western Coalfields indicates that the observed strains for previously extracted longwalls having width-to-depth ratios between 0.70 and 0.85, i.e. slightly greater when compared to the proposed amended longwalls, were on average, around 20 % to 40 % greater than the observed strains for previously extracted longwalls in the Newcastle, Hunter and Western Coalfields having width-to-depth ratios between 0.50 and 0.70, i.e. similar to Tahmoor North, Appin and West Cliff Collieries.

It could be expected, therefore, that the observed strains resulting from the extraction of the proposed longwalls would be, on average, around 20 % to 40 % greater than those previously experienced at Tahmoor, Appin and West Cliff Collieries and, hence, the predicted strains for the proposed longwalls have been determined from the analyses of strain from the previously extracted longwalls at Tahmoor, Appin and West Cliff Collieries, with the magnitudes increased by 20 % to 40 % to account for the higher width-to-depth ratios based on the observations from the Newcastle, Hunter and Western Coalfields.

The data used in the analysis of observed strains included those resulting from both conventional and non-conventional anomalous movements but did not include those resulting from valley related movements, which are addressed separately in this report. The strains resulting from damaged or disturbed survey marks have also been excluded.

A number of probability distribution functions were fitted to the empirical monitored strain data. It was found that a *Generalised Pareto Distribution (GPD)* provided a good fit to the raw strain data. Confidence levels have been determined from the empirical strain data using the fitted GPDs. In the cases where survey bays were measured multiple times during a longwall extraction, the maximum tensile strain and the maximum compressive strain were used in the analysis (i.e. single tensile strain and single compressive strain measurement per survey bay).

4.3.1. Analysis of strains measured in survey bays

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

Predictions of strain above goaf

The survey database has been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls, which has been referred to as "*above goaf*".

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for monitoring lines at Tahmoor, Appin Area and West Cliff Collieries, is provided in Fig. 4.2. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

The 95 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and 1.6 mm/m compressive. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above goaf* would be less than 1.3 mm/m tensile and 2.2 mm/m compressive.

The 99 % confidence levels for the maximum total strains that the individual survey bays *above goaf* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 1.4 mm/m tensile and 3.1 mm/m compressive. Similarly, it is expected that 99 % of the strains measured *above goaf* for the proposed longwalls would be less than 2.0 mm/m tensile and 4.3 mm/m compressive.

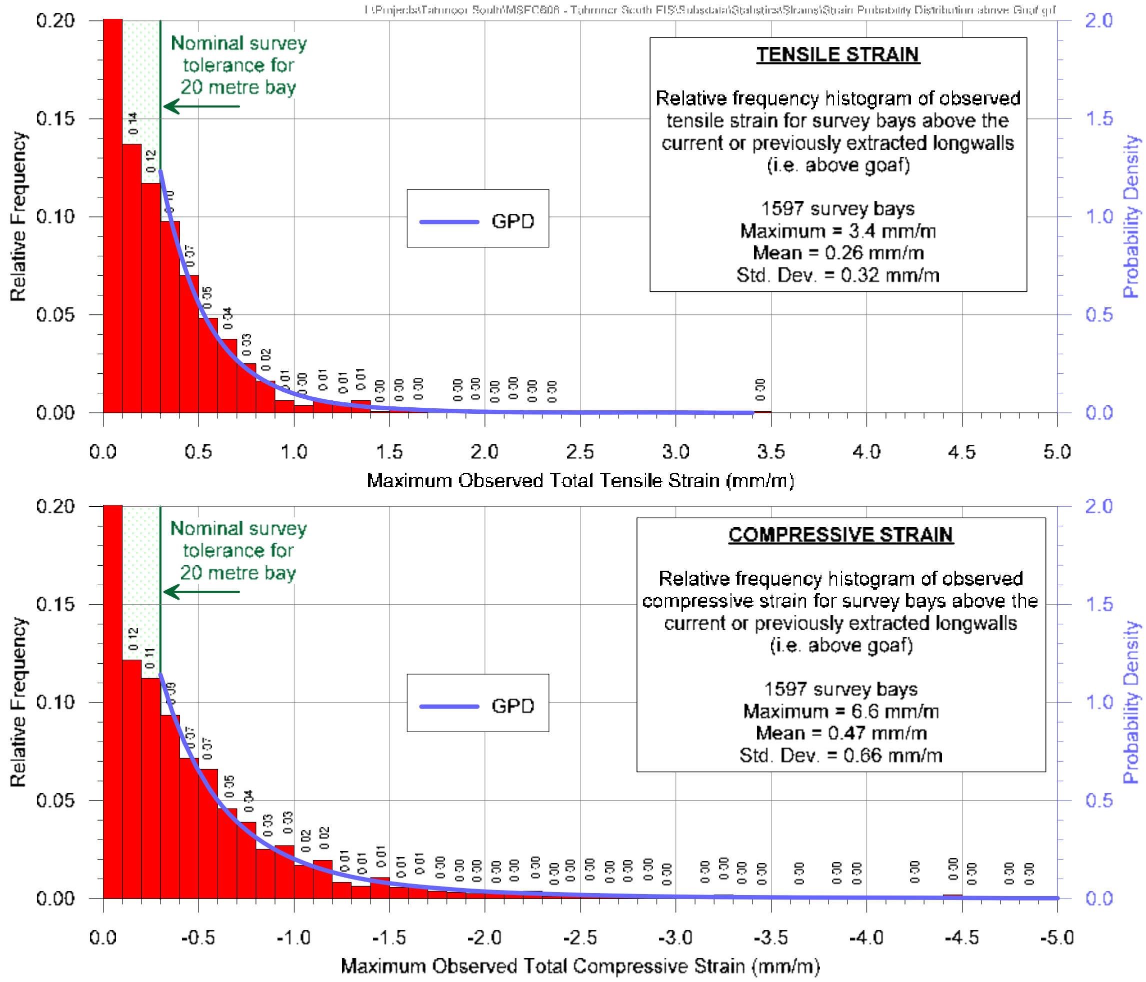

Fig. 4.2 Distributions of the measured maximum tensile and compressive strains for surveys bays located *above goaf* at Tahmoor, Appin and West Cliff Collieries

Predictions of strain above solid coal

The survey database has also been analysed to extract the maximum tensile and compressive strains that have been measured at any time during the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, for survey bays that were located beyond the goaf edges of the mined panels and positioned on unmined areas of coal, i.e. outside panels but within 200 metres of the nearest longwall goaf edge, which has been referred to as "*above solid coal*".

The histogram of the maximum observed tensile and compressive strains measured in survey bays above solid coal, for monitoring lines at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 4.3. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

The 95 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.6 mm/m tensile and 0.5 mm/m compressive. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 95 % of the strains measured *above solid coal* would be less than 1.0 mm/m tensile and compressive.

The 99 % confidence levels for the maximum total strains that the individual survey bays *above solid coal* experienced at any time during mining at Tahmoor, Appin and West Cliff Collieries were 0.9 mm/m tensile and compressive. Similarly, it is expected that 99 % of the strains measured *above solid coal* adjacent to the proposed longwalls would be less than 1.5 mm/m tensile and compressive.

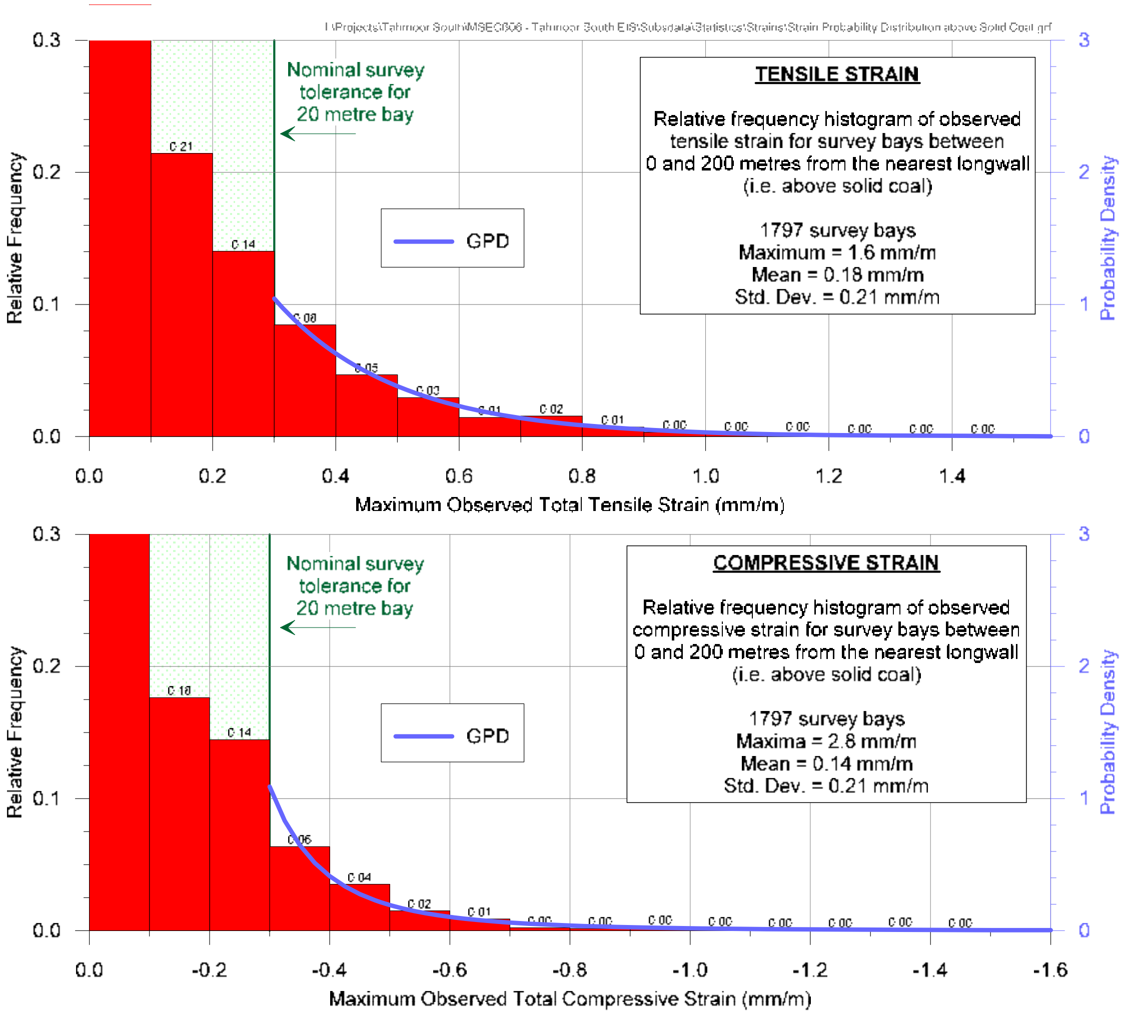

Fig. 4.3 Distributions of the measured maximum tensile and compressive strains for survey bays located *above solid Coal* at Tahmoor, Appin and West Cliff Collieries

4.3.2. Analysis of strains measured along whole monitoring lines

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

The histogram of maximum observed total tensile and compressive strains measured anywhere along the monitoring lines, at any time during or after the extraction of the previous longwalls at Tahmoor, Appin and West Cliff Collieries, is provided in Fig. 4.4.

It can be seen from Fig. 4.4, that 42 of the 52 monitoring lines (i.e. 92 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total tensile strains of 2.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 92 % of the monitoring lines above the proposed longwalls would experience maximum tensile strains of 3.0 mm/m, or less.

It can also be seen, that 45 of the 52 monitoring lines (i.e. 87 % of the total) at Tahmoor, Appin and West Cliff Collieries had recorded maximum total compressive strains of 4.0 mm/m, or less. The strains for the proposed longwalls are predicted to be 20 % to 40 % greater than those previously observed at these collieries and, therefore, it is expected that 87 % of the monitoring lines above the proposed longwalls would experience maximum compressive strains of 5.5 mm/m, or less.

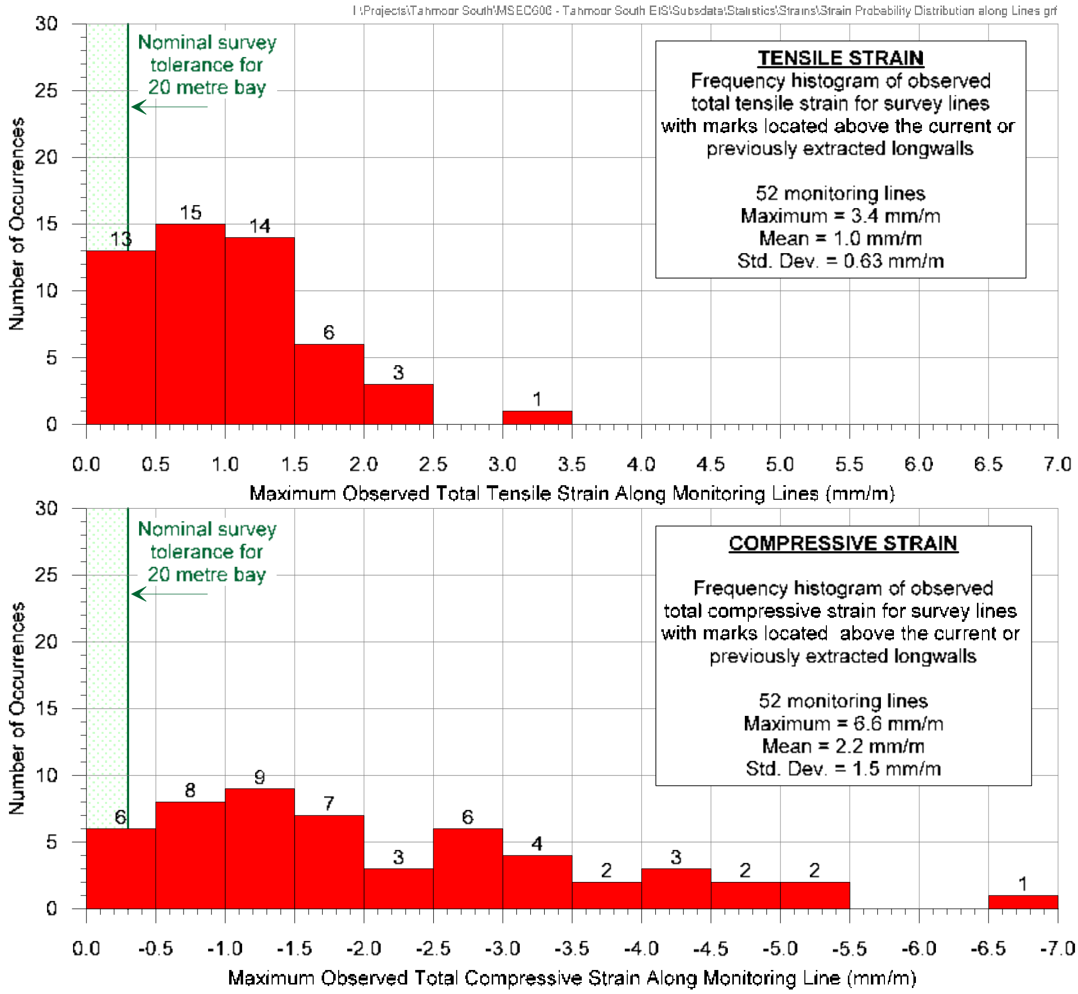

Fig. 4.4 Distributions of measured maximum tensile and compressive strains anywhere along the monitoring lines at Tahmoor, Appin and West Cliff Collieries

4.3.3. Analysis of shear strains

As described in Section 3.3, ground strain comprises two components, being normal strain and shear strain, which can be interrelated using a Mohr's Circle analysis. The magnitudes of the normal strain and shear strain components are, therefore, dependent on the orientation in which they are measured. The maximum normal strains (i.e. principal strains) are those in the direction where the corresponding shear strain is zero.

Normal strains along monitoring lines can be measured using 2D and 3D techniques, by taking the change in horizontal distance between two points on the ground and dividing by the original horizontal distance between them. This provides the magnitude of normal strain along the orientation of the monitoring line but, this strain may not necessarily be the maximum (i.e. principal) strain.

Shear deformations are more difficult to measure, as they are the relative horizontal movements perpendicular to the direction of measurement. However, 3D monitoring techniques provide data on the direction and the absolute displacement of survey marks and, therefore, the shear deformations perpendicular to the monitoring line can be determined. It is possible to gain an understanding of the shear strain along a monitoring line with repeat measurements, but, in accordance with rigorous definitions and the principles of continuum mechanics, (e.g. Jaeger, 1969), it is not possible to accurately determine horizontal shear strains in any direction relative to the monitoring line using 3D monitoring data from a straight line of survey marks.

As described in Section 3.3, shear deformations perpendicular to monitoring lines can be described using various parameters, including horizontal tilt, horizontal curvature, horizontal mid-ordinate deviation, angular distortion and shear index. In this report, horizontal mid-ordinate deviation has been used as the measure for shear deformation, which is defined as the differential horizontal movement of each survey mark, perpendicular to a line drawn between two adjacent survey marks.

The frequency distribution of the maximum total horizontal mid-ordinate deviations measured at survey marks above goaf, for previously extracted longwalls in the Southern Coalfield, is provided in Fig. 4.5. As the typical survey bay length was 20 metres, the calculated mid-ordinate deviations were over a chord length of 40 metres. The probability distribution function, based on the fitted GPD, has also been shown in this figure.

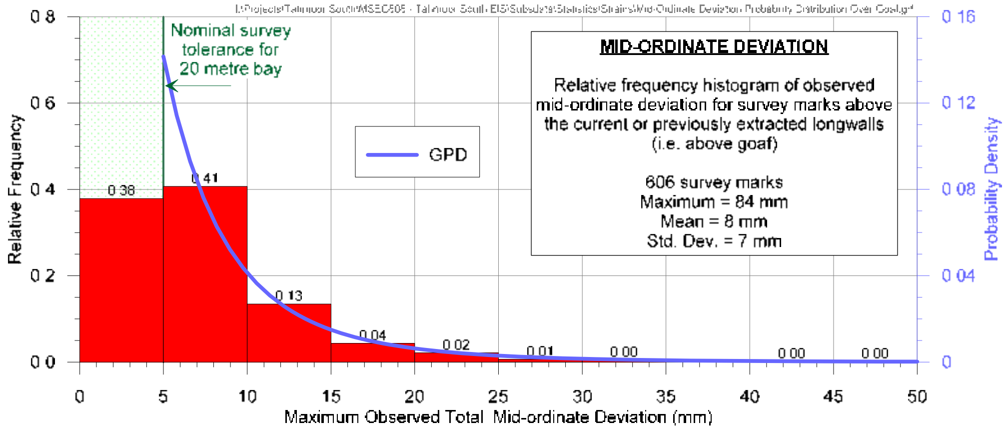

Fig. 4.5 Distribution of measured maximum mid-ordinate deviation during the extraction of previous longwalls in the Southern Coalfield for marks located above goaf

The 95 % and 99 % confidence levels for the maximum total horizontal mid-ordinate deviation that the individual survey marks located above goaf experienced at any time during mining were 20 mm and 35 mm, respectively. The shear deformations for the proposed longwalls are estimated to be 20 % to 40 % greater than those previously observed at Tahmoor, Appin and West Cliff Collieries and, therefore, it is expected that 95 % and 99 % of the horizontal mid-ordinate deviations measured above the proposed longwalls would be less than 30 mm and 50 mm, respectively.

4.4. Potential additional settlement above coal barriers between proposed and previous mine workings

Parts of the proposed longwalls are located close or adjacent to the previously extracted Longwall 2, Longwall 14B and Longwalls 15 to 19 with a proposed barrier of unmined coal being left between the previously extracted panels and the proposed workings, (except for development headings).

Slightly increased levels of subsidence over the predicted levels of subsidence were observed within the following areas at Tahmoor, Appin or Tower Collieries that were also located above similar unmined barriers of coal (with some development headings) between previously extracted areas, such as:

- Between Longwall 3 and Longwall 22 at Tahmoor Mine;
- Between Longwall 23A and 23B at Tahmoor Mine;
- Between Longwall 24A and the 200 Panels at Tahmoor Mine;
- Between Longwalls 22 to 24B and Longwall 24A and the 200 Panels and Longwall 25 (i.e. mining on three sides of a corridor of intact coal) at Tahmoor Mine;
- Between Longwalls 8-12, Longwall 18 and Longwall 408 at Appin Colliery; and
- Between Longwalls 14-18, 301-302 and 401 at Appin Colliery.

The amount of increased subsidence in these areas has generally been between 50 and 150 mm of subsidence above what was predicted using the IPM and generally low levels of tilt and strain were measured within these areas.

These areas of increased subsidence have not always been observed in these situations. For example, it was not observed between Longwalls 3-9 and Longwall 20, nor between Longwalls West 1-2 and Longwalls 30-32 at Tahmoor Mine.

While observed subsidence may exceed predictions above the coal barrier between proposed LW S1A and previously extracted Longwall 2, between proposed LWs S1A to S6A and previously extracted LWs 14B to 19, subsidence monitoring has shown that it is usually accompanied by relatively low systematic tilts, curvature and strains (less than 0.5 mm/m and usually within survey tolerance).

It is noted that the *Subsidence Study Area* encompasses the surface areas located directly above the coal barriers.

4.5. Predicted conventional horizontal movements

Tahmoor Coal commenced surveys of absolute horizontal movement during the mining of Longwall 25. The great majority of the surveys at Tahmoor Mine are now undertaken using 3D surveying techniques, including most of the pegs along the Main Southern Railway and within the monitoring network around the ends of Longwalls 25 to 32.

The maximum measured incremental horizontal movement to date has been 255 mm at Peg RE14 on Remembrance Drive during the mining of Longwall 26. The maximum measured incremental horizontal movement after the completion of Longwall 25 was 175 mm at Peg 25-21 along the Longwall 25 Centreline.

These horizontal movements are within the normal range in the Southern Coalfield at similar depths of cover.

Absolute horizontal movements by themselves do not directly impact on natural and built features, rather impacts occur as the result of differential horizontal movements. Strain is a measure of change of horizontal movement as was discussed in Sections 3.3 and 0. The impacts of strain movements on the natural and built features are addressed in the impact assessments for each feature, which have been provided in Chapters 5 through to 11.

4.6. Predicted far-field horizontal movements

As discussed in Section 3.5, in addition to the conventional subsidence movements that have been predicted above and adjacent to the proposed longwalls, far-field horizontal movements will also be experienced during the extraction of the proposed longwalls.

The observed incremental far-field horizontal movements resulting from the extraction of incremental longwall panels, in any location above goaf, i.e. above the currently mined or previously mined panels, or above solid coal, i.e. unmined areas of coal, are provided in Fig. 4.6. The observed incremental far-field horizontal movements above solid coal only, i.e. outside the extents of extracted longwalls, are provided Fig. 4.7. The confidence levels, based on fitted *Generalised Pareto Distributions* (GPDs), have also been shown in these figures to illustrate the spread of the data. It can be seen from Fig. 4.6 and Fig. 4.7 that the magnitude of the observed far-field horizontal movements over solid unmined areas of coal are lower and more consistent than the observed far-field horizontal movements over previously extracted panels.

A far field monitoring program was conducted by Tahmoor Coal during the extraction of Longwall 32 at key civil structures. The observed horizontal movements were within the normal range. Similar experiences have been observed during the extraction of the Tahmoor West longwalls.

As successive longwalls within a series of longwalls are mined, the magnitudes of the incremental far-field horizontal movements decrease. This is possibly due to the fact that once the in-situ stresses within the strata have been redistributed around the collapsed zones above the first few extracted longwalls, the potential for further movement is reduced. The total far-field horizontal movement may be less, therefore, than the sum of the incremental far-field horizontal movements for the individual longwalls.

The predicted far-field horizontal movements resulting from the extraction of the proposed longwalls are very small and could only be detected by precise surveys. Such movements tend to be bodily movements towards the extracted goaf area, and are accompanied by very low levels of strain, which are generally less than the order of survey tolerance (i.e. less than 0.3 mm/m). The potential impacts of differential far-field horizontal movements on the natural and built features within the vicinity of the proposed longwalls are not expected to be measurable, with possibly the exception of the road and railway bridges, which are discussed in the impact assessments for these features in Chapter 5 through to 11.

No measurable differential movements were observed during the far field monitoring program conducted by Tahmoor Coal during the extraction of Longwall 32 at key civil structures. Some of these structures were located near or across mapped first order faults, including structures within the Picton Water Recycling Plant, the Picton Viaduct, the Victoria Bridge and the Argyle Street Railway Underbridge.

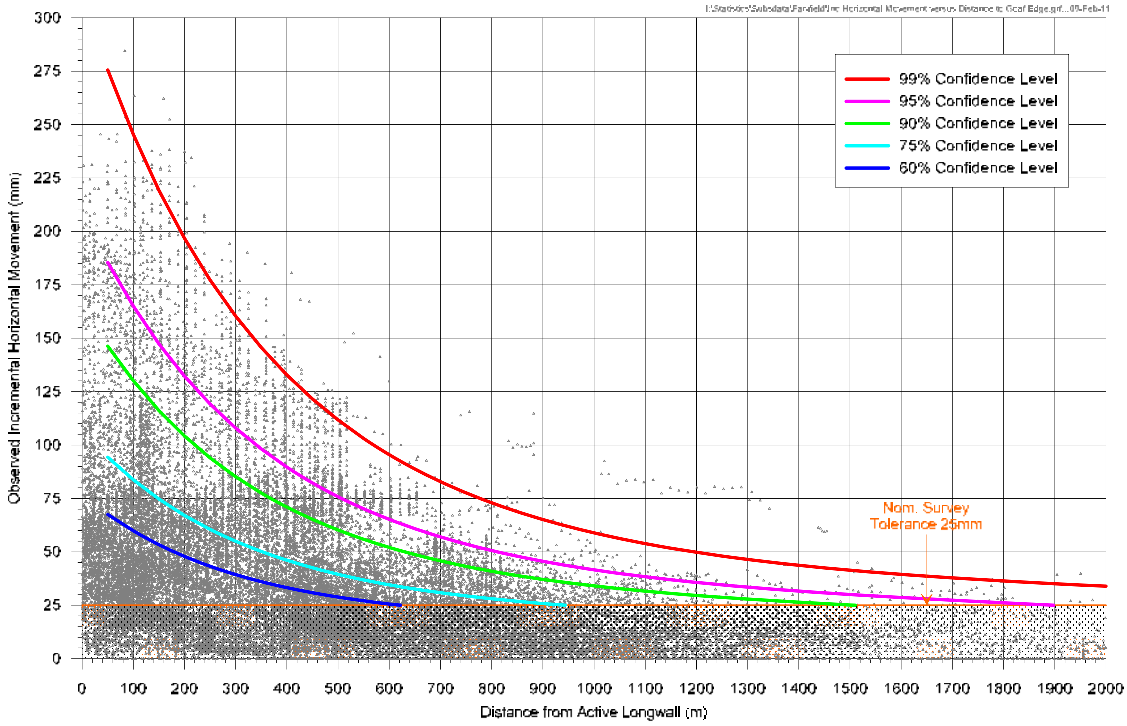

Fig. 4.6 Observed incremental far-field horizontal movements above goaf or solid coal

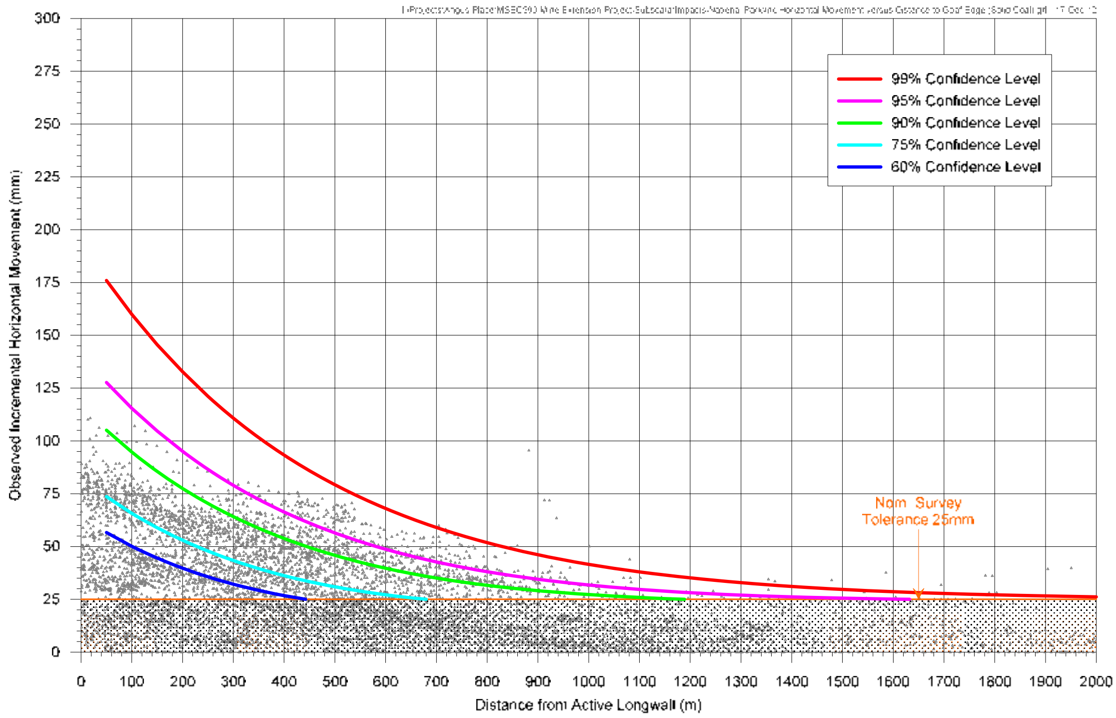

Fig. 4.7 Observed incremental far-field horizontal movements above solid coal only

4.7. Non-conventional ground movements

It is likely non-conventional ground movements will occur within and around the *Subsidence Study Area*, due to near surface geological conditions, steep topography and valley related movements, which were discussed in Section 3.4. These non-conventional movements are often accompanied by elevated tilts, curvatures and strains, which are likely to exceed the conventional predictions.

Specific predictions of upsidence, closure and compressive strain due to the valley related movements are provided for the streams in Section 5.3. The impact assessments for the streams are based on both the conventional and valley related movements. The potential for non-conventional movements associated with steep topography is discussed in the impact assessments for the steep slopes provided in Section 5.5.

In most cases, it is not possible to accurately predict the exact locations or magnitudes of the non-conventional anomalous movements due to near surface geological conditions. For this reason, the strain predictions provided in this report are based on a statistical analysis of measured strains in the Southern Coalfield, including both conventional and non-conventional anomalous strains, which is discussed in Section 4.3. In addition to this, the impact assessments for the natural features and surface infrastructure, which are provided in Chapters 5 through to 11, include historical impacts resulting from previous longwall mining which have occurred as the result of both conventional and non-conventional subsidence movements.

Mining beneath urban and semi-rural areas at Tahmoor and Thirlmere by Tahmoor Mine Longwalls 22 to 32 provides valuable "whole of panel" information. A plot of locations of potential non-conventional movement is shown in Fig. 4.9. The locations were selected based on ground monitoring results or observed impacts that appear to have been caused by non-conventional movement. A total of approximately 59 locations (not including valleys) have been identified over the extracted Longwalls 22 to 32. The surface area directly above the longwalls is approximately 9.1 km^2. This equates to a frequency of 6 sites per square kilometre or one site for every 16 hectares. The non-conventional movements were mainly characterised by elevated compressive ground strains that varied up to a maximum of approximately 5 mm/m.

The largest known case of non-conventional movement in the Southern Coalfield occurred above Appin Colliery Longwall 408 (Swarbrick, *et al.*, 2007). In this case, a low angle thrust fault was re-activated in response to mine subsidence movements, resulting in differential vertical and horizontal movements across the fault. Observations at the site showed that the non-conventional movements developed gradually over a period of time. Regular ground monitoring across the fault indicated that the rate of differential movement was less than 0.5 mm/day at the time non-conventional movements could first be detected. Subsequently as mining progressed, the rate of differential movement increased to a maximum of 28 mm/week.

A recent example occurred at a low angle fault that intersected the Main Southern Railway in the Deviation Cutting at Tahmoor, which was located directly above Longwall 29. The site was monitored extensively during the mining of Longwalls 28 to 31. This included three monitoring lines along the railway cutting, and survey prisms along the railway track.

The results of observed changes in vertical alignment of the pegs along the railway cutting are shown in Fig. 4.8. It can be seen that the most significant changes occurred during the mining of Longwall 29. The changes, however, developed gradually over time, allowing the railway track to be adjusted such that trains could continue to travel through the site.

The observations of the gradual development of differential movements have been consistently observed during the mining of previous longwalls at Tahmoor Mine. While some sites have experienced severe impacts, the subsidence movements developed gradually, allowing time for repair before they became unsafe.

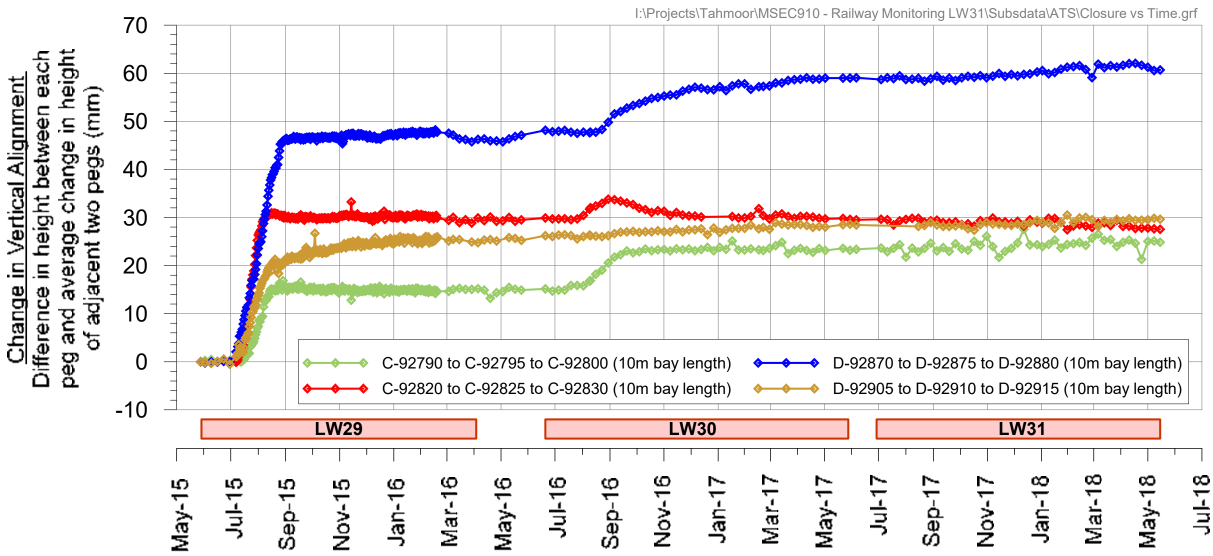

Fig. 4.8 Changes in vertical alignment across a geological fault within a railway cutting during the mining of Longwalls 29 to 31 at Tahmoor Coal

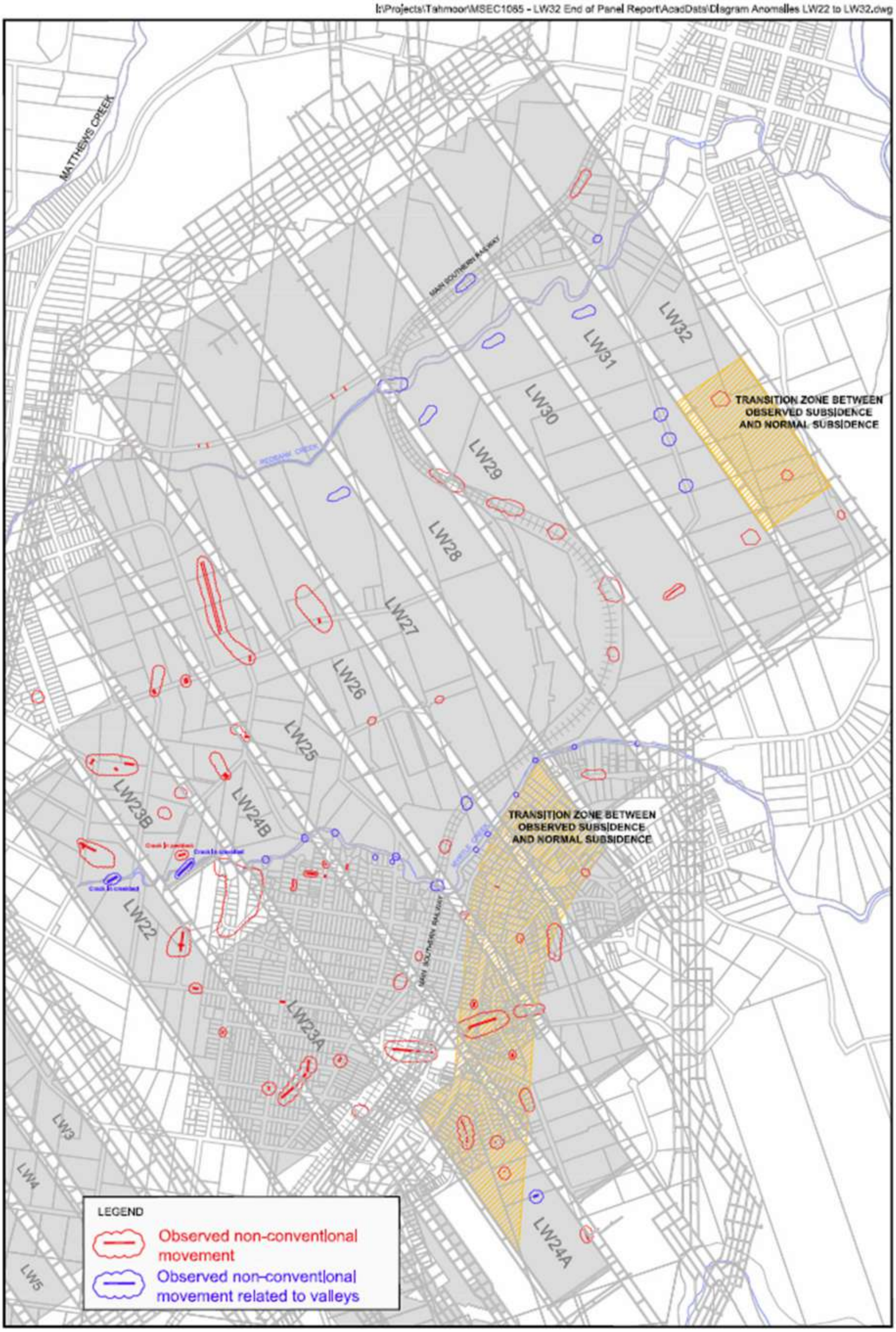

Fig. 4.9 Map showing locations of observed non-conventional movement above Tahmoor Mine Longwalls 22 to 32

4.8. General discussion on mining induced ground deformations

Longwall mining can result in surface cracking, heaving, buckling, humping and stepping at the surface. The extent and severity of these mining induced ground deformations are dependent on a number of factors, including the mine geometry, depth of cover, overburden geology, locations of natural jointing in the bedrock and the presence of near surface geological structures.

Faults and joints in bedrock develop during the formation of the strata and from subsequent distressing associated with movement of the strata. Longwall mining can result in additional fracturing in the bedrock, which tends to occur in the tensile zones, but fractures can also occur due to buckling of the surface beds in the compressive zones. The incidence of visible cracking at the surface is dependent on the pre-existing jointing patterns in the bedrock as well as the thickness and inherent plasticity of the soils that overlie the bedrock.

Surface cracking in soils as the result of conventional subsidence movements, i.e. away from valleys and steep slopes, is not commonly observed where the depths of cover are, for example, around 400 metres, such as the case within the *Subsidence Study Area*. Surface cracking that has been observed as the result of conventional subsidence movements has generally been relatively isolated and of a minor nature.

Cracking is found more often in the bases of valleys due to the compressive strains associated with upsidence and closure movements, which is discussed in Section 5.3. Cracking can also occur at the tops of steep slopes as the result of downslope movements, which is discussed in Section 5.5.

Surface cracks are more readily observed in built infrastructure such as compacted road pavements. In many cases, no visible ground deformations can be seen in the natural ground adjacent to the cracks in the road pavements. In rare instances, more noticeable ground deformations, such as humping or stepping of the ground can be observed at thrust faults. Examples of ground deformations previously observed in the Southern Coalfield, where the depths of cover are 400 metres, or greater, are provided in the photographs in Fig. 4.10 to Fig. 4.13 below.

Localised ground buckling and shearing can occur wherever faults, dykes and abrupt changes in geology occur near the ground surface. The identified geological structures within the *Subsidence Study Area* are discussed in Section 3.8 and it is possible that ground deformations could develop where the Nepean Fault daylights on the surface. Discussions on irregular ground movements were provided in Section 4.7.

Fig. 4.10 Surface compression buckling observed in a pavement

Fig. 4.11 Surface tension cracking along the top of a steep slope

Fig. 4.12 Surface tension cracking along the top of a steep slope

Fig. 4.13 Fracturing and bedding plane slippage in sandstone bedrock in the base of a stream

5.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR NATURAL FEATURES WITHIN THE SUBSIDENCE STUDY AREA

The following sections provide descriptions, predictions and impact assessments for natural features that have been identified within the *Subsidence Study Area*. The natural features located outside the *Subsidence Study Area*, which may be subjected to far-field movements or valley related movements and may be sensitive to these movements, have also been included as part of these assessments.

5.1. Catchment Areas or Declared Special Areas

There are no catchment areas or declared special areas within the Study Area. The nearest catchment area is the Metropolitan Special Area, which is located approximately 4.5 km southeast of the proposed longwalls.

5.2. The Bargo River

The location of the Bargo River is shown in Drawing No. MSEC1192-07. Descriptions, predictions and impact assessments for the river are provided in the following sections.

5.2.1. Description of the Bargo River

The Bargo River commences north of Colo Vale and near the townships of Hill Top and Yerrinbool and flows generally towards the north and to the west of the Bargo township. The Bargo River then flows to the west and north of the proposed Tahmoor South longwalls. The Bargo River then drains into the Nepean River approximately 4.9 kilometres north-east of the proposed Longwall S1A.

The Bargo River is not located within the 600m Subsidence Study Area for Natural Features. The closest distance between the Bargo River and the proposed longwalls is 690 metres, i.e. to the nearest corner of LW S2A. This section of the river was directly mined beneath by Longwalls 14B to 19.

A summary of the minimum distances between the river and the proposed longwalls is provided below in Table 5.1.

Table 5.1 Minimum distances of the proposed longwalls from the Bargo River

Longwall	Minimum distance from the centreline of Bargo River (m)
LW S1A	720
LW S2A	690
LW S3A	730
LW S4A	780
LW S5A	830
LW S6A	850

The length of the river that is nearest to the *Subsidence Study Area* is a 5th order perennial stream as defined by the Strahler Stream Order Method. This section of the river was directly mined beneath by Longwalls 14B to 19.

The surface water flows in this section of the river are controlled by the Picton Weir (also called the Bargo Weir) with discharge regulated by a fixed discharge valve. The reservoir is emptied following extended dry periods, but it is quickly filled with the spillway overtopping following large storm events. The following article from the Picton Post, dated 1945, provides some background;

> *"The existing dam was built to T.W.L.912 in 1899, the lowest foundation being at R.L.887, which was a few feet below river bed level. In 1910 the wall was raised to T.W.L.920, giving a storage of 37 m.g."*
>
> *"During the recent drought the water level dropped considerably, and it was ascertained that the dam had silted up. It is understood that the silt level is approximately at R.L.904, which would leave an available storage, if this level were uniform, of 33 m.g. It is quite probable that the silt level in the upper reaches of storage is higher."*

The water stored by the Picton Weir was initially used to supply the nearby communities. After pipes were laid from the much larger Nepean Dam, however, Bargo, Thirlmere, Picton and The Oaks were supplied water from the Nepean Dam (now through the Nepean Water Filtration Plant), and the water from the Picton Weir is no longer used for town water supply.

The reports by Fluvial Systems (2013) and the Water Management Plan (Tahmoor Coal, 2022a) provide a detailed description of the river.

As shown in Drawings No. MSEC1192-01 and MSEC1192-07, Tahmoor Mine extracted longwalls LW14B to LW19 under parts of this section of the Bargo River valley. The overall depth of the Bargo River valley varies from 90 metres down to 50 metres with the steeper sections of the valley comprising cliffs, rock outcrops and talus slopes in a number of locations.

There has been a long history of mining directly beneath or near the Bargo River at Tahmoor Mine. While impacts have occurred when various previously extracted longwalls were mined directly beneath the river (refer Section 5.3.4), impacts have been not observed when mining has been undertaken more than 500 metres away from the river.

Previously extracted Longwall 24A was approximately 340 metres from the river at its closest point and Longwall 25 was approximately 510 metres from the river. Ground surveys measured very little vertical subsidence (less than 20 mm) and closure (less than 10 mm) occurred even though at this section of the river the gorge was 80 metres deep. Impacts to the river were not observed during the extraction of these longwalls.

Based on the previous experience at Tahmoor Mine, it is unlikely that the extraction of the proposed longwalls would result in any adverse impacts on the river. Even if the predictions and impact assessments were exceeded, the likelihood of pool drainage is considered extremely low given the water flows in the river.

Further detailed discussions on the impacts and consequences of changes in the surface water flows are provided in the Water Management Plan (Tahmoor Coal, 2022a).

5.2.2. Management of potential impacts on the Bargo River

Tahmoor Coal has previously developed Environmental Management Plans to manage potential impacts on streams during the mining of longwalls, including the Bargo River. The management plans include monitoring and triggered response plans. They include monitoring of the required pre-mining conditions and data collection during mining. Monitoring typically continues for a period following mining.

While the proposed longwalls do not mine directly beneath the Bargo River, it is recommended that Tahmoor Coal monitor changes in the Bargo River during the extraction of proposed Tahmoor South longwalls. Tahmoor Coal is required to development and implement a Water Management Plan as part of the Extraction Plan.

5.3. Streams

5.3.1. Descriptions of the streams

The locations of the streams within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-07. A summary of the major streams within the *Subsidence Study Area* is provided below in Table 5.2.

The reports by Fluvial Systems (2013) and the Water Management Plan (Tahmoor Coal, 2022a) provide a description of the streams.

Table 5.2 Streams within the Subsidence Study Area

Location	Strahler Stream Order	Description
Teatree Hollow	3rd Order	Located directly above the proposed LW S1A to LW S6A, with a total length of 2.1 kilometres directly mined beneath. LW1 and LW2 have been previously mined beneath a 0.5 kilometre section downstream of LW S1A
Tributary to Teatree Hollow (Wirrimbirra Creek)	3rd Order	Located directly above the proposed LW S1A to LW S4A, with a total length of 1.3 kilometres directly mined beneath

The streams have flow controlling features along their alignments that include; rockbars, riffles, knick points and debris accumulations. The locations of pools along the streams were determined by the specialist geomorphology consultant, (Fluvial Systems, 2013), and the locations of the pools are shown in Drawing No. MSEC1192-09. Descriptions of the streams are provided in the Water Management Plan (Tahmoor Coal, 2022a).

Example photographs of the streams within the *Subsidence Study Area* are shown in Fig. 5.1 to Fig. 5.4.

Fig. 5.1 Pool TT9 in Teatree Hollow directly above proposed LW S2A

Fig. 5.2 Pool TT12 in Teatree Hollow directly above proposed LW S1A

Fig. 5.3 Pool TT11 and TT3 (Ockenden Pools) in Tributary to Teatree Hollow directly above proposed LW S2A

The Tributary of Teatree Hollow is named Wirrimbirra Creek and Pools TT3 and TT11 are named Ockenden Pools at the Australian Wildlife Sanctuary (formerly called Wirrimbirra Sanctuary). Water levels at Ockenden Pools are partly controlled by a small weir, which was damaged during the 2019 bush fire. The pools were dry at this time. A surface water level sensor is located at this site.

Fig. 5.4 Pool TT2 (Big Pool) in Tributary to Teatree Hollow directly above proposed LW S3A

Pool TT2 is named the Big Pool at Wirrimbirra Sanctuary. The pool was observed to contain water after the 2019 bush fire. A surface water level sensor is located at this site.

Hidden creeks are defined as natural watercourses that appear to have been covered during development of a property or road. Hidden creeks have been identified from surface contours and historical aerial photographs. Two hidden creeks have been identified within the *Subsidence Study Area*. The creeks were infilled as part of the development of Tahmoor Mine and their locations are shown in Drawing No. MSEC1192-09.

5.3.2. Predictions for the streams

The predicted profiles of subsidence, upsidence and closure, using the IPM subsidence model and the 2002 ACARP valley closure prediction model, along the streams within the *Subsidence Study Area* are shown in Figs. E.02 to E.03, in Appendix E. The predictions are based on the extraction of the proposed longwalls, as shown in Drawing No. MSEC1192-07. The predicted total profiles along the alignments of the streams, after the completion of each of the proposed amended longwalls, are shown as solid blue lines.

A summary of the maximum predicted values of total subsidence, upsidence and closure for the streams is provided in Table 5.3.

Table 5.3 Maximum predicted total subsidence, upsidence and closure for the streams

Location	Figure no. (Appendix E)	Maximum predicted subsidence (mm)	Maximum predicted upsidence (mm)	Maximum predicted closure (mm)
Teatree Hollow	E.02	1,350*	400*	275*
Tributary to Teatree Hollow	E.03	1,300	450	375

** Note: downstream sections of Teatree Hollow have been previously mined beneath by LW1 and LW2 at Tahmoor Mine. The maximum predicted parameters provided in the above table include those resulting from the extraction of these earlier longwalls.*

The streams, which are located directly above the proposed longwalls, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

5.3.3. Predicted changes in stream gradients

The natural and the predicted post mining surface levels and grades along Teatree Hollow are illustrated in Fig. 5.5 and indicated in Fig. E.02. The natural grades along the stream vary between 20 mm/m and 50 mm/m above the proposed longwalls. The predicted maximum tilts, therefore, are substantially less than the natural grades along the stream.

The predicted maximum decreasing tilts are 8 mm/m (i.e. 0.8 %, or 1 in 125) along Teatree Hollow, directly above LW S1A.

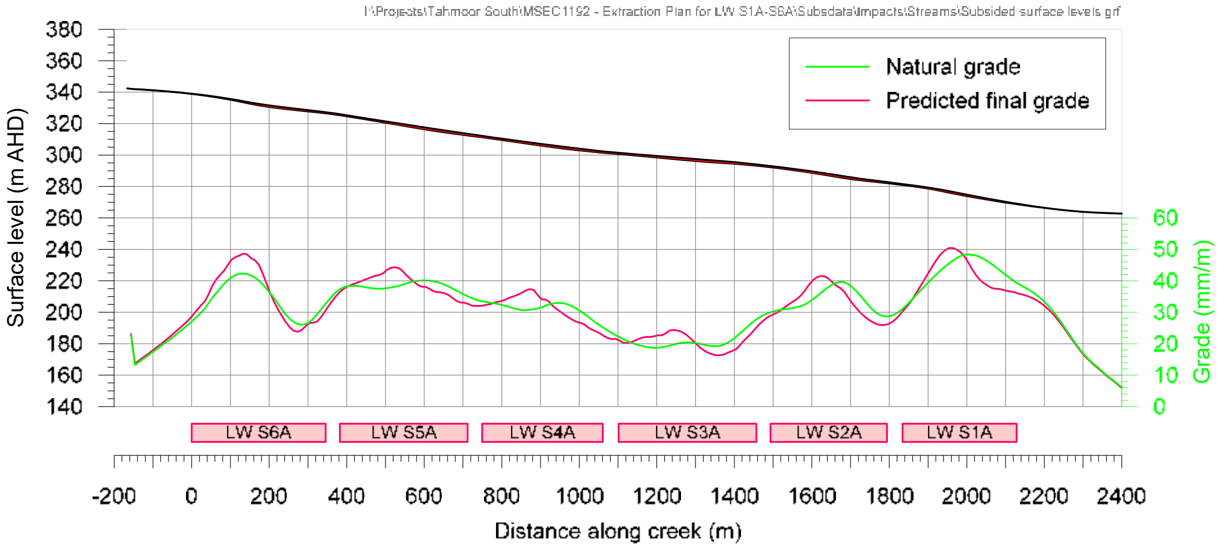

Fig. 5.5 Natural and predicted post mining surface levels along Teatree Hollow

The natural and the predicted post mining surface levels and grades along the Tributary of Teatree Hollow are illustrated in Fig. 5.6 and indicated in Fig. E.03. The natural grades along the stream vary between 9 mm/m and 40 mm/m above the proposed longwalls. The predicted maximum tilts, therefore, are substantially less than the natural grades along the stream.

The predicted maximum decreasing tilts are 6 mm/m (i.e. 0.6 %, or 1 in 167) along the Tributary of Teatree Hollow, directly above LW S1A.

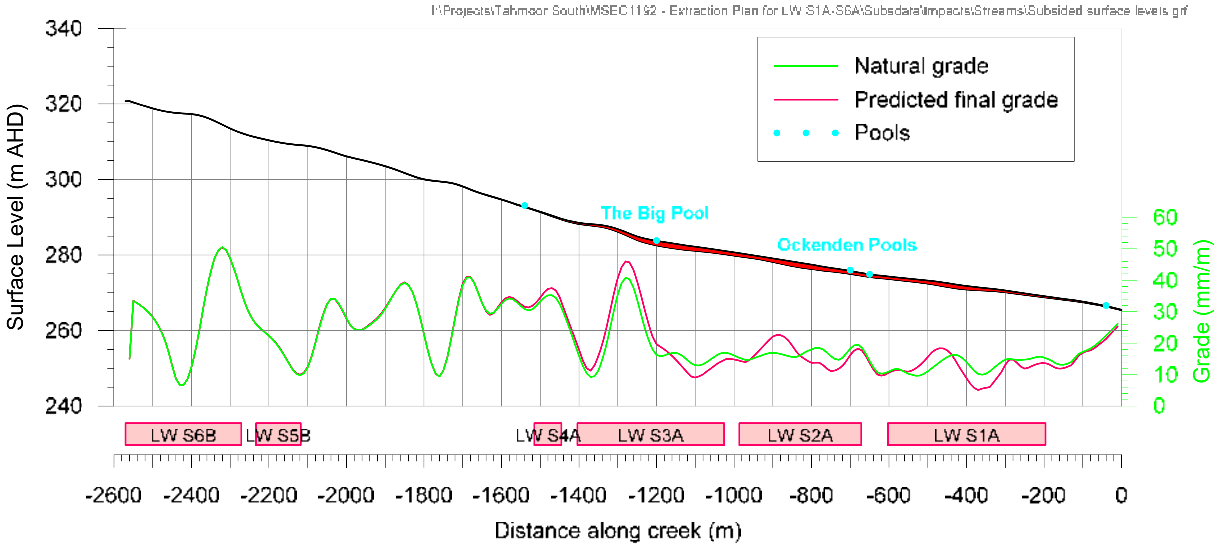

Fig. 5.6 Natural and predicted post mining surface levels along Tributary of Teatree Hollow

A summary of the maximum predicted changes in grade and the predicted curvatures, due to the conventional subsidence resulting from the extraction of the proposed longwalls, is provided in Table 5.4. The maximum predicted increases in grades occur downstream of the longwall goaf edges, whilst the maximum predicted decreases in grade occur upstream of the longwall goaf edges.

The predicted changes in grade provided in Table 5.4 are the maxima along the alignments of the streams after the extraction of any or all of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of the proposed longwalls.

The streams will also experience strains resulting from far field movements and valley related movements and discussions are provided in Section 5.3.4 on the impact assessments from these movements.

The locations of the pools along the streams are shown in Drawing No. MSEC1123-09. A summary of the maximum predicted subsidence, upsidence and closure at the pools along Teatree Hollow and the Tributary to Teatree Hollow is provided in Table D.01, in Appendix D.

Table 5.4 Maximum predicted changes in grade along the streams

Location	Maximum change in grade (mm/m)		Maximum conventional curvature (km^{-1})	
	Increase in grade	Decrease in grade	Hogging curvature	Sagging curvature
Teatree Hollow	7.0	8.0	0.11	0.22
Tributary to Teatree Hollow	6.0	6.0	0.10	0.21

5.3.4. Impact assessments for the streams

The impact assessments for the streams within the *Subsidence Study Area* are provided in the following sections. The assessments provided in this report should be read in conjunction with the Water Management Plan (Tahmoor Coal, 2022a) and the Biodiversity Management Plan (Tahmoor Coal, 2022c), which assess the consequences of the impacts on surface water flows and ecology.

Potential for increased levels of ponding, scouring or desiccation due to mining tilt

Mining can potentially result in increased levels of ponding in locations where the mining induced tilts oppose and are greater than the natural stream gradients that exist before mining. Mining can also potentially result in an increased likelihood of scouring of the stream beds in the locations where the mining induced tilts considerably increase the natural stream gradients that exist before mining.

There are no other predicted reversals of grade due to the proposed extraction of LWs S1A to S6A.

It is possible that there could be localised areas along the streams which could experience small increases in the levels of ponding, where the predicted maximum tilts occur in the locations where the natural gradients are low. As the predicted changes in grade are typically less than 1 %, however, any localised changes in ponding are expected to be minor and not result in adverse impacts on these streams.

It can also be seen from the above figures that the stream gradients increase where they flow into the predicted subsidence trough near the edges of the proposed longwalls. The streams flow predominantly over Hawkesbury Sandstone, which has a high resilience to scouring. As discussed in the report by Fluvial Systems (2013), mud was commonly found in the channel bed with soft knickpoints in small streams on the plateau. The predicted maximum increases in grade are up to 1.0 %, which are relatively small compared to the natural gradients and, therefore, the potential for increased scouring is not expected to be substantial.

Further discussions on the potential changes in ponding and flooding along the streams and the impacts, consequences and implications of the changes are provided by the specialist surface water consultant in the Water Management Plan (Tahmoor Coal, 2022a).

Potential for fracturing and surface water flow diversion in the streams

Where the longwalls mine directly beneath the streams it is considered likely that fracturing could result in surface water flow diversions. Upsidence and compressive strains due to valley closure are expected to be of sufficient magnitude to cause the underlying strata to buckle and induce cracking at the surface at some locations. This can lead to the diversion of water from the stream beds into the dilated strata beneath it.

It is unlikely, however, that there would be any net loss of water from the catchment since any redirected flow would not intercept any flow path that would allow the water to be diverted into deeper strata or the mine.

Geotechnical and groundwater reports by Strata Control Technology (2013) and SLR (2022a) present further discussions on the impacts, consequences and implications of the changes and potential for hydraulic connectivity from surface to seam.

The maximum predicted conventional curvatures for the streams located directly above the proposed longwalls are 0.11 km^{-1} hogging and 0.22 km^{-1} sagging, which equate to minimum radii of curvature of 9.1 kilometres and 4.5 kilometres, respectively.

The range of non-valley related movement strains above the proposed longwalls is expected to be similar to the range of strains measured during the previously extracted longwalls in the Southern Coalfield, which is described in Section 4.3 and the results illustrated in Fig. 4.4. It is also likely that the streams would experience elevated compressive strains as a result of valley closure movements.

The compressive strains resulting from valley related movements are more difficult to predict than conventional strains. It has been observed in the past, however, that compressive strains due to valley related movements between 10 mm/m and 20 mm/m (over a standard 20 metre bay length) have occurred above previously extracted longwalls at similar depths of cover, where the magnitudes of closure were similar to those predicted for the streams in the *Subsidence Study Area*.

It has been observed in the past that the depth of buckling and dilation of the uppermost bedrock, resulting from longwall mining, is generally less than 10 metres to 15 metres (Mills 2003, Mills 2007, and Mills and Huuskes 2004).

If substantial fracturing were to occur, partial or complete diversion of surface water and drainage of pools could occur at locations and times where the rate of flow diversion is greater than the rate of incoming surface water. The majority of the streams are ephemeral and so water typically flows during and for a period of time after each rain event. In times of heavy rainfall, most of the runoff would flow over the beds of the streams and would not be diverted into the dilated strata below the stream beds. In times of low flow, however, some or all of the water could be diverted into the strata below the stream beds for those sections of the streams that are located over the mined panels.

While much of the channel beds are exposed bedrock, Fluvial Systems (2013) report that sand, gravel, cobble and mud were also commonly found in the channel beds throughout the Project Area. Where such loose materials occur, it is possible that fracturing in the bedrock would not be seen at the surface. In the event that fracturing of the bedrock occurs in these locations within the alignments of the streams, the fractures may be filled with soil during subsequent flow events reducing the flow through the fractures.

Tahmoor Mine has previously extracted longwalls beneath streams and their ability to naturally fill mining-induced fractures has varied, mainly depending on the availability of sediment.

- Longwalls 1 and 2 were mined in 1987 directly beneath a 500 metre section of Teatree Hollow immediately downstream of the proposed longwalls. Bord and pillar workings with secondary extraction also took place prior to longwall mining directly beneath this stream.

  Substantial fracturing was observed by Fluvial Systems (2013) at one location in a small tributary to Teatree Hollow (Site TT1-18) directly above the bord and pillar workings with secondary extraction. It is likely that this fracturing was mining-induced.

  No flow diversions were reported at this location, nor in other sections of Teatree Hollow located directly above Longwalls 1 and 2. Water flows in the section of Teatree Hollow, which is located above the previously extracted longwalls and secondary extraction workings, were greatly controlled by Tahmoor Mine's licensed discharge LDP4 and this has likely aided in filling the mining-induced fractures.

- Longwalls 8, 10 to 13 were mined between 1991 and 1994 directly beneath a 2.0 kilometre section of the Bargo River and directly beneath a 1.0 kilometre section of Dog Trap Creek.

  These were the first series of longwalls to be mined directly beneath the Bargo River at Tahmoor Mine. Very little monitoring of the river occurred during this time, although extensive protective works were undertaken at the Rockford Road Bridge that was located over Longwall 12.

Surface fracturing of exposed bedrock was observed near to the supporting piers of the Bridge following the extraction of Longwalls 12 and 13. Fractures were also observed in flute holes downstream of the bridge over the goaf edge of Longwall 13, which were first observed during the extraction of Longwall 12 (Holla and Barclay, 2000). The fractures were localised and did not consistently run along the length of the river valley. They appeared to be the result of localised shearing and compressive buckling and some fractures were located where there was noticeable cross bedding within the river bed. There were no reports of impact to water flows along this section of river.

While surface fracturing is still visible in the flute holes that are located on a large, exposed rockbar, surface water diversion is not evident and large pools exist directly above the previously extracted longwalls, as Tahmoor Mine's licensed discharge has contributed a base flow to this section of the Bargo River.

Fig. 5.7 Large pool in the Bargo River, located upstream of Rockford Road Bridge, directly above previously extracted Longwall 12

Very little monitoring of the Dog Trap Creek occurred when Longwalls 12 and 13 mined directly beneath it, although extensive monitoring and works were undertaken at the small Road Bridge over Dog Trap Creek on Arina Road. No surface fractures are visible in the stream at the location, however, and pools are observed to exist. It is noted that this section of Dog Trap Creek contains plenty of sediment that could assist in the filling of fractures.

Fig. 5.8 Ponded water in Dog Trap Creek near bridge over Arina Road above previously extracted Longwall 13

- Longwalls 14 to 19 were mined between 1995 and 2002 directly beneath a 1.7 kilometre section of the Bargo River. As shown in Table 5.1, this section of river is located between 720 metres and 850 metres north-west of the proposed LWs S1A to S6A.

  Limited monitoring indicated little impact on the River during the extraction of Longwalls 14 to 17. Fracturing was not observed on the surface, although many sections were concealed by alluvial and talus deposits.

  The first adverse impacts on the river were reported in January 2002, after the extraction of Longwall 18, when residents alerted Tahmoor Mine to reduced pool levels downstream of the mining area. At that time there was very little water in the Picton Weir due to low rainfalls and surface flows from the weir had reduced to a mere trickle. Inspections along the river indicated minor fracturing of rock shelves in the river bed and drainage of some shallow pools.

Fig. 5.9 Immediately upstream of Picton Weir – January 2002

Detailed subsidence monitoring of survey pegs within the Bargo River over the centre of LW18 after LW18 was extracted, i.e. in October 2001 had indicated that total upsidence in the base of LW18 was 250 mm, the total valley closure was approximately 400 mm and the maximum measured valley closure strain was 15 mm/m.

The inspections in January 2002 found that the river had been drained directly above Longwall 18 and the length of drainage extended downstream for some distance beyond Longwall 14.

Shortly after this time a large rainfall event occurred, which filled the Weir and restored surface water flows along the River. A dry period followed and by July 2002 the Picton Weir was empty again and the extraction of Longwall 19 was completed. Inspections showed that surface flows ceased again, with the furthest drained pool from the longwalls being located 125 metres upstream of LW19. This coincided with the completion of this longwall.

Detailed subsidence monitoring of survey pegs within the Bargo River over the centre of LW18 after LW19 was extracted indicated that total upsidence in the base of LW18 was 450 mm, the total valley closure was approximately 700 mm and the maximum measured valley closure strain was 18 mm/m.

A further period of heavy rainfall occurred in February 2003 which then refilled the upstream sections of Picton Weir which then overtopped (see Fig. 5.10 and Fig. 5.11).

Fig. 5.10 Picton Weir 1st February 2003

Fig. 5.11 Picton Weir 24th February 2003

After this large storm, it was then observed that the water flows along the surface above the longwalls were progressively restored even during the following drier periods. It is believed that the high sediment load in the river, that was retained by the Picton Weir except when it is overtopped, had been washed down the river and filled in the mining induced fractures in the bedrock reducing the loss of surface water flows.

The extraction of Longwalls 14 to 19 also mined directly beneath small tributaries to the Bargo River. Fluvial Systems (2013) reports fracturing and surface flow diversions in two unnamed tributaries, which are located above previously extracted Longwalls 15 and 19. The stream channel bed in this was exposed bedrock.

- Longwalls 22 to 28 were mined between 2004 and 2014 beneath a 3 kilometre section of Myrtle Creek.

  The impacts observed along this creek were localised bed cracking in exposed sandstone areas, surface flow diversions in four locations over Longwalls 22, 23B and 25 as well as cracking in soil within the upper banks and flanks over Longwall 23B. Three areas of isolated cracking of exposed sandstone were also observed in the base or sides of generally dry pools above Longwall 25.

  The extraction of Longwalls 26 to 28 has resulted in further mining-induced fractures on exposed bedrock. At times of low flow, pools have been observed to drain.

- Longwalls 25 to 32 have mined, since 2008, beneath a 2.8 kilometre section of Redbank Creek.

  The impacts observed along the creek were cracks along most pools located directly above Longwalls 25 to 32. At times of low flow, pools have been observed to drain. Stream flow re-emerges in a section of the creek downstream from Longwall 32.

Based on the previous experience of mining beneath streams at Tahmoor Mine, it is likely that fracturing and surface flow diversions will occur in the sandstone bedrock along the streams over Tahmoor South, particularly for streams that are located directly above the proposed longwalls. In some of these locations, the fracturing could impact the holding capacity of the standing pools, particularly those located directly above the proposed longwalls. It is unlikely, however, that there would be any net loss of water from the catchment.

Where there are substantial sediment accumulations upstream of these areas, it is expected that some of the fractures would be naturally filled over time with sediment during subsequent flow events, as was observed in the Bargo River. Where little sediment is present, the impacts are likely to remain for longer periods of time and remediation may be required after the completion of mining, which could include sealing these fractures and voids with grout.

With respect to streams or sections of streams located away from the proposed longwalls, the likelihood of fracturing and surface flow diversions reduces substantially compared to stream sections located directly above the proposed longwalls. The furthest known rockbar impact site where fracturing resulted in the diversion of surface water was at Pool F in the Waratah Rivulet that was being affected by a previously extracted longwall on one side and by the end of another longwall, i.e. the rockbar was located over solid unmined coal, but it was located in the corner between two longwalls. This site was located 160 metres to the side of one longwall and 230 metres from the approaching face of the active longwall. Surface water diversions have also been observed at three sites from the sides of longwalls at distances between 125 metres and 100 metres at the Bargo River, Waratah Rivulet and Native Dog Creek. Surface water diversion has only been observed at one site at Pool G1 in the Waratah Rivulet beyond the ends of the longwalls and in this case the closest distance was approximately 75 metres.

Minor and isolated fracturing could also occur outside the extents of the proposed longwalls. The furthest distance of an observed fracture from longwall mining was at the base of Broughtons Pass Weir, which was located approximately 415 metres from Appin Colliery Longwall 401. Another minor fracture was also recorded in the upper Cataract River, approximately 375 metres from Appin Colliery Longwall 301. This fracture occurred in a large rockbar, which was formed in thinly bedded sandstone, which had experienced movements from nearby previously extracted longwalls. These are the furthest most recorded fractures from longwall mining in the NSW Coalfields.

Further discussions on the potential impacts of surface cracking and on changes in surface water flows are provided in the Water Management Plan (Tahmoor Coal, 2022a) and the Biodiversity Management Plan (Tahmoor Coal, 2022c).

Potential for Gas Emissions and Changes to Water Quality

Gas emissions from the sandstone strata have been previously observed above and adjacent to mining areas in the Southern Coalfield, and some gas emissions have also been observed in water bores. Analyses of gas compositions indicate that the Bulli seam is not the direct and major source of the gas and that the most likely source is the Hawkesbury Sandstone (APCRC, 1997).

It is likely that gas emissions will occur as a result of the mining of the longwalls. Gas is often released into rivers and streams as these areas form topographical low points in the landscape. Where these gas releases occur into the water column there is insufficient time for any substantial amount of gas to dissolve into the water. The majority of the gas is released into the atmosphere and is unlikely to have an adverse impact on water quality.

It is possible for substantial gas emissions at the surface to cause localised vegetation die-back. This is a rare event and has only been observed to occur previously on one occasion at Tower Colliery, over small areas in the base of the Cataract Gorge that had been directly mined beneath by Longwalls 10 and 14. These impacts were limited to small areas of vegetation, local to the points of emission, and when the gas emissions declined, the affected areas were successfully restored.

A description of potential water quality impacts, including iron stains, and environmental consequences is presented in the Water Management Plan (Tahmoor Coal, 2022a) and the Biodiversity Management Plan (Tahmoor Coal, 2022c).

5.3.5. Impact assessments for the streams based on increased predictions

If the actual conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilts along the streams would be 16 mm/m (i.e. 1.6 %, or 1 in 63) along Teatree Hollow. The existing stream grades are greater than the predicted tilts multiplied by a factor of 2 times and no reversals of grade due to the proposed extraction of LWs S1A to S6A.

If the actual conventional subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilts along the streams would be 12 mm/m (i.e. 1.2 %, or 1 in 83) along the Tributary of Teatree Hollow. This would result in a short section of stream of approximately 10 to 20 metres experiencing grades that are close to level or slightly reverse.

If the actual strains or valley related movements exceeded those predicted by a factor of 2 times, the extent of fracturing in the uppermost bedrock would increase along the streams which are located directly above the proposed longwalls.

While the predicted ground movements are important parameters when assessing the potential impacts on the streams, it is noted that the impact assessments for fracturing and loss of surface water were primarily based on historical observations from previous longwall mining at Tahmoor Mine and other mines operating at similar depths of cover in the Southern Coalfield. The overall levels of impact on the streams, resulting from the extraction of the proposed longwalls, are expected to be similar to those observed where longwalls have previously mined directly beneath streams at the mine.

Further discussions on the potential impacts, consequences and implications of changes along these streams are provided in the surface water and ecology reports by Water Management Plan (Tahmoor Coal, 2022a) and the Biodiversity Management Plan (Tahmoor Coal, 2022c).

5.3.6. Comparison of predictions and assessments provided based on the proposed LWs S1A to S6A and the EIS Layout

A summary comparison between maximum predicted subsidence, upsidence and closure along the streams between the approved EIS Layout and the proposed LWs S1A to S6A is shown in Table 5.5.

Table 5.5 Predicted Total Subsidence, Upsidence and Closure along Streams resulting from the extraction of the Extraction Plan Layout and the approved EIS Layout

Layout	Location	Maximum predicted total subsidence (mm)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Proposed Extraction Plan LWs S1A to S6A	Teatree Hollow	1,350*	400*	275*
	Tributary to Teatree Hollow	1,300	450	375
EIS Layout (MSEC1123)	Teatree Hollow	1,350*	375*	275*
	Tributary to Teatree Hollow	1,250	400	350

It can be seen that the predicted maximum total conventional subsidence, upsidence and closure movements due to the extraction of proposed LWs S1A to S6A are slightly greater than the predicted maxima from the EIS Layout. The differences for Teatree Hollow are very slight and reflect the very minor changes in panel and chain pillar widths. The differences for the Tributary to Teatree Hollow are also very slight and in addition to the panel and chain pillar widths, the increase in predictions is also due to the extensions of the commencing ends of LWs S3A and S4A.

It should be noted though that, whilst the overall predicted total subsidence, upsidence and closure along the streams have been increased slightly, predictions at points on the surface directly above the longwalls will be greater or less than predictions previously provided for the EIS Layout due to the lateral shift in the mine layout.

Specific subsidence predictions have been provided for streams in this report. Detailed comparisons can be made for each stream by comparing this report with detailed predictions that were provided in our previous Report No. MSEC1123.

The potential for physical impacts (i.e. surface cracking and rock fracturing) is not, however, dependent on absolute vertical subsidence. Physical impacts develop due to differential movements, which are described by curvature and strain.

Whilst the predicted strains and valley closure and, hence, the potential for physical impacts increase with wider longwall panel widths and narrower pillar widths, the strains and valley closure due to the extraction of the proposed Extraction Plan and the EIS layout are both predicted to be of sufficient magnitude to result in the fracturing of bedrock.

Based on the above, the potential for impacts on the sections of streams that are proposed to be directly mined beneath due to the extraction of proposed Extraction Plan do not materially change as a result of the changes in mine layout, even though the overall mining-induced movements and associated frequency and severity of impacts are expected to slightly increase.

This assessment is supported by the observations of adverse impacts along streams that have been directly mined beneath at nearby collieries at similar depths of cover in the Southern Coalfield, including where longwall void widths are less than those that are proposed in the Extraction Plan.

In the case of streams that are not directly mined beneath, the offset distances between the proposed longwalls in the proposed LWs S1A to S6A and the streams remain sufficiently large such that the impact assessments do not change significantly compared to the assessments that were provided for the approved EIS Layout. This includes the fourth and fifth order sections of Hornes Creek and the Bargo River, which are located more than 670 metres and 690 metres, respectively, from the proposed longwalls.

5.3.7. Management of potential impacts on the streams

Tahmoor Coal has previously developed Environmental Management Plans to manage the potential impacts on streams during the mining of longwalls. The management plans include ground monitoring, water quality and pool level monitoring and visual inspections. The plans also commit to remediation of waterways if impacts occur.

Tahmoor Coal is required to develop and implement a Water Management Plan as part of the Extraction Plan for LWs S1A to S6A.

5.4. Cliffs

5.4.1. Descriptions of the cliffs

A total of 2 cliffs are located within the *600 metre Study Area for Natural Features* but outside the general *Subsidence Study Area*. The locations of the cliffs are shown in Drawing No. MSEC1192-08, and in greater detail in Drawing No. MSEC1192-09.

One cliff is located within a tributary to the Bargo River and is more than 500 metres from the proposed LW S4A. A small portion of another cliff is located along Hornes Creek and is located approximately 600 metres from the proposed LW S6A.

For the purposes of this report, a cliff has been defined as a continuous rockface having a maximum height greater than 10 metres, a minimum length of 20 metres and a minimum slope of 2 in 1, i.e. having a minimum angle to the horizontal of 63°. The definition is consistent with the definition provided in the Project Approval of the EIS layout. The locations and heights of cliffs within the *Subsidence Study Area* were determined by Fluvial Systems based on the results of an airborne laser scan, refer to Fluvial Systems (2013).

5.4.2. Predictions for the cliffs

The cliffs are located outside the predicted limit of subsidence due to the extraction of LWs S1A to S6A. They are not expected to experience any substantial conventional tilts, curvatures and strains.

5.4.3. Impact assessments for cliffs located above solid coal

The two cliffs are located more than 500 metres from the proposed longwalls and will not be directly mined beneath.

It is extremely difficult to assess the likelihood of cliff instabilities based upon predicted ground movements. The likelihood of a cliff becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rock mass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors influence the stability of a cliff naturally or when it is exposed to mine subsidence movements. It is possible, therefore, that cliff instabilities may occur during mining that may be attributable to either natural causes, mine subsidence, or both.

The likelihood of cliff instabilities can be assessed using case studies where previous longwall mining has occurred close to but not directly beneath cliffs. Although very minor rock falls have been observed over solid coal outside the extracted goaf areas of longwall mining in the Southern Coalfield, there have been no recorded large cliff instabilities outside the extracted goaf areas of longwall mining in the Southern Coalfield. This statement is based on the following observations:-

- ***Tahmoor Longwalls 24A to 26***

  Tahmoor Longwalls 24A to 26 were mined near and adjacent to the cliff lines along the Bargo River valley between November 2007 and July 2011. The cliff lines are continuous on both sides of the valley along this section of the river. The cliffs are located at a minimum distance of 300 metres east of Longwall 24A, at their closest point to these longwalls. The whilst the overall valley depths, within one depth of cover of this gorge was over 100 metres, the heights of the cliffs are around 60 metres and are formed within the Hawkesbury Sandstone.

  Tahmoor Longwalls 24A to 26 have void widths of 285 metres, solid chain pillar widths of 35 metres to 40 metres and were extracted from the Bulli seam at a depth of cover of 350 metres at the base of the gorge and 450 metres around the plateau areas. There were no impacts observed on the cliffs along the Bargo River Valley as a result of the extraction of Tahmoor Longwalls 24A to 26.

- ***Appin Longwalls 301 and 302 near the Cataract River***

  Appin Longwalls 301 and 302 were mined adjacent to a number of cliff lines located along the Cataract River valley between October 2006 and September 2007. A total of 68 cliffs were identified within a 35 degree angle of draw from these longwalls. These cliffs had continuous lengths ranging between 5 metres and 230 metres, overall cliff heights ranging between 10 metres and 37 metres, overall valley depths, within one depth of cover of the river, ranging from 50 to 75 metres, and had been formed within the Hawkesbury Sandstone.

  Appin Longwalls 301 and 302 have void widths of 260 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 420 metres at the base of the gorge and 490 metres around the plateau areas. These longwalls mined to within 50 metres of the identified locations of the cliffs along the Cataract River valley.

  There were no large cliff instabilities observed as a result of the extraction of Appin Longwalls 301 and 302. There were, however, five minor rock falls or disturbances which occurred during the mining period, of which, three were considered likely to have occurred due to a substantial rainfall event and one was probably a natural instability of the cliff overhang. Nevertheless, the length of cliff line disturbed as a result of the extraction of Appin Longwalls 301 and 302 was, therefore, estimated to be less than 0.5 % of the total face area of the cliff lines within the mining domain.

- ***Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704 near the Nepean River***

  Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704 mined adjacent to a number of cliff lines located along the Nepean River valley. A total of approximately 50 cliffs were identified within a 35 degree angle of draw from these longwalls. The cliffs had continuous lengths ranging between 5 metres and 225 metres, overall heights ranging between 10 metres and 40 metres, overall valley depths, within one depth of cover of the river, ranging from 60 to 80 metres and had been formed within the Hawkesbury Sandstone.

  Tower Longwalls 18 to 20 have void widths of 235 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 460 metres at the base of the gorge and 510 metres around the plateau areas. Appin Longwalls 701 to 704 have void widths of 320 metres, solid chain pillar widths of 40 metres and were extracted from the Bulli seam at a depth of cover of 460 metres at the base of the gorge and 510 metres around the plateau areas.

Tower Longwall 20 was mined directly beneath some cliffs located at the confluence of Elladale Creek and the Nepean River. Appin Longwalls 701 to 704 mined to within 75 metres of the identified locations of the cliffs along the Nepean River valley.

There were no cliff instabilities observed as a result of the extraction of Tower Longwalls 18 to 20 and Appin Longwalls 701 to 704.

Based on this previous experience of mining at Tahmoor, Appin and Tower Collieries, it is unlikely that cliffs beyond the extent of the longwall panels will experience large instabilities. It is possible that isolated rock falls could occur during the mining period due to natural weathering processes. Any impacts are expected to represent less than 0.5 % of the total face area of the cliffs.

5.4.4. Impact assessments for the cliffs based on increased predictions

If the actual mine subsidence exceeded those predicted values by a factor of 2 times, the likelihood of impacts for the cliffs that are located well outside the proposed longwalls would still be expected to be very low.

While the predicted ground movements are important parameters when assessing the potential impacts on the cliffs, it is noted that the impact assessments for cliff instabilities have primarily been based on historical observations from previous longwall mining in the Southern Coalfield.

5.5. Steep slopes

The purpose of identifying steep slopes for this assessment is to highlight areas in which existing ground slopes may be marginally stable. As a conservative first pass, a steep slope has been defined as an area of land having a gradient greater than 1 in 3 (33 % or 18.3°). The definition is consistent with the definition provided in the Project Approval of the EIS layout. The minimum slope of 1 to 3 represents a slope that would generally be considered stable for slopes consisting of rocky soils or loose rock fragments. Clearly the stability of natural slopes varies depending on their soil or rock types, and in many cases, natural slopes are stable at much higher gradients than 1 to 3 (for example, talus slopes in Hawkesbury Sandstone).

The locations of the steep slopes within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-08, with greater detail in Drawing No. MSEC1192-09. The steep slopes were identified by Fluvial Systems from an airborne laser scan supplied by Tahmoor Coal. The steep slopes shown on the drawings can be broadly categorised as:

a) Steep slopes on the sides of valleys;
b) Batters of road and railway embankments and cuttings;
c) Slopes on Farm dams; and
d) Slopes around Tahmoor Mine infrastructure, including spoil heaps, coal piles and dams.

Types (b) to (d) are addressed in Chapter 6 of this report.

The steep slopes on the sides of valleys are predominantly found in Hawkesbury Sandstone and consist of a mixture of cliffs and rock outcrops, which are stable at vertical to overhanging, and screed slopes with rocky soils and loose rock fragments. The majority of slopes are stabilised, to some extent, by natural vegetation.

The ranges of predicted subsidence parameters for the steep slopes are similar to those predicted along the streams, which are provided in Section 5.3.2.

There has been extensive experience of mining beneath steep slopes in the Southern Coalfield. These include steep slopes along the Cataract, Nepean, Bargo and Georges Rivers and streams such as Myrtle Creek and Redbank Creek above Tahmoor Mine Longwalls 22 to 32, slopes on Redback Range above Tahmoor Mine Longwalls 26 and 27 and slopes along ridges and valleys above Tahmoor LWs W1-W3. No large-scale slope failures have been observed along these slopes, even where longwalls have been mined directly beneath them. Surface cracking and minor rock falls along clifflines or rock outcrops have been observed, for example, during the mining of Appin Longwalls 301 and 302 adjacent to the Cataract River, however, no large-scale slope failures have been observed.

Potential impacts on steep slopes would generally result from the movement of soils, causing tension cracks to appear at the tops of the slopes and compression ridges to form at the bottoms of the slopes. These movements are consistent with observations of upsidence and closure of creek valleys where compression is developed at the bottoms of the valleys and tension is developed at the tops of the valleys. If tension cracks were left untreated it is possible that soil erosion could occur.

It is possible, therefore, that some remediation might be required to ensure that mining-induced surface cracking does not result in the formation of soil erosion channels. In some cases, erosion protection measures may be needed, such as the planting of additional vegetation in order to stabilise the slopes in the longer term.

While in most cases impacts to slopes are likely to consist of surface cracking, there remains a low probability of large-scale slope slippage. The probability is assessed to be very low for slopes that will not be directly mined beneath by the longwalls. Experience indicates that the probability of mining induced large-scale slippages is extremely low due to the substantial depths of cover within the *Subsidence Study Area*. While the risk is extremely low, some risk remains and attention must therefore be paid to any structures or roads that may be located in the vicinity of steep slopes.

There are no structures or roads located along natural steep slopes within the *Subsidence Study Area*.

5.5.1. Management of potential impacts on steep slopes

Tahmoor Coal has developed subsidence management plans for managing potential impacts on steep slopes during the mining of Longwalls 22 to 32 and LWs W1-W4. These management plans include:

- Identification of all structures, dams and roads that are in close proximity to steep slopes;
- Site investigation and landslide risk assessment of structures near slopes by a qualified geotechnical engineer;
- Site investigation and structural assessment of structures where recommended by the geotechnical engineer. This may include recommendations to mitigate against potential impacts;
- Monitoring, including ground survey and visual inspections; and
- Remediation if cracking or slippage occurs.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on slopes during the mining of the proposed longwalls. Tahmoor Coal is required to develop and implement a Land Management Plan as part of the Extraction Plan for LWs S1A to S6A.

5.6. Escarpments

There are no major escarpments within the *Subsidence Study Area*. Discussions on the cliffs are provided in Section 5.4.

5.7. Land prone to flooding and inundation

There are areas prone to flooding or inundation within the *Subsidence Study Area*. The subsidence ground movement predictions determined for the Tahmoor South project have been provided to hydrologist ATC Williams, who have undertaken a detailed flood study for the project and provided detailed discussions of the impacts and consequences of the subsidence ground movements on future floods within the *Subsidence Study Area* in the Water Management Plan (Tahmoor Coal, 2022a).

5.8. Swamps, wetlands and water related ecosystems

As discussed in detail in the Biodiversity Management Plan (Tahmoor Coal, 2022c), there are some water related ecosystems and wet areas in the headwaters of some streams but there are no upland swamps or wetlands within the *Subsidence Study Area*.

Please refer to the Biodiversity Management Plan (Tahmoor Coal, 2022c).

5.9. Threatened, protected species or critical habitats

Please refer to the Biodiversity Management Plan (Tahmoor Coal, 2022c).

5.10. National Parks or Wilderness Areas

There are no National Parks, nor any land identified as wilderness under the Wilderness Act 1987 within the *Subsidence Study Area*.

5.11. State Recreational or Conservation Areas

There are no State Recreational or Conservation Areas within the *Subsidence Study Area*.

5.12. Natural vegetation

Please refer to the terrestrial and aquatic ecology assessments in the Biodiversity Management Plan (Tahmoor Coal, 2022c).

5.13. Areas of significant geological interest

There are no areas of significant geological interest within the *Subsidence Study Area*.

5.14. Any other natural feature considered significant

The Australian Wildlife Sanctuary is located on Remembrance Driveway. The site is also known as Wirrimbirra Sanctuary, which is the name that is listed as an item of heritage on the State Heritage Register (01508). The Australian Wildlife Sanctuary covers an area of approximately 95 ha.

Wirrimbirra preserves a part of the original 'Bargo Brush' which was of considerable historical importance in the problems which faced the settlement of the Argyle or Southern Tablelands during the early half of the 1800s. The Sanctuary contains rich and diverse plantings of native plants in formalised gardens, which were developed to provide areas of representative native plants for education and research purposes. Within the 43 established gardens, there are over 1800 native plants representing a resource base for the study of native flora.

The Australian Wildlife Sanctuary is located above LWs S1A to S4A near Teatree Hollow and the Main Southern Railway Line and will be directly mined beneath by the proposed longwalls.

The Australian Wildlife Sanctuary has named the creeks that flow through its property. Wirrimbirra Creek has been identified as Tributary of Teatree Hollow in this report. The Big Pool (Ref. TT2) and Ockenden Pools (TT3 and TT11) are located on Tributary of Teatree Hollow (Wirrimbirra Creek) and their locations are shown in Drawing No. MSEC1123-09. Predictions for these pools are provided in Table D.01. The descriptions and impact assessments for streams are provided in Section 5.3 of this report.

Predictions and impact assessments for the structures within the Australian Wildlife Sanctuary are provided separately in Section 10.2.3 of this report. A site of archaeological significance has been identified on the property and predictions and impact assessments for the site are provided separately in Section 10.1 of this report.

The following sections provide the descriptions, predictions and impact assessments for the Public Utilities within the *Subsidence Study Area*. The public utilities located outside the *Subsidence Study Area*, which may be subjected to far-field movements or valley-related movements and may be sensitive to these movements, have also been included as part of these assessments.

6.1. The Main Southern Railway

The location of the Main Southern Railway is shown in Drawing No. MSEC1192-11. Descriptions, predictions and impact assessments for the railway are provided in the following sections.

6.1.1. Description of the Main Southern Railway

The Main Southern Railway is a key national transport route that carries substantial freight and passenger services between Sydney and Melbourne. The Main Southern Railway is leased by Australian Rail Track Corporation (ARTC), who is responsible for maintaining the track.

Approximately 3 km of track is located within the *Subsidence Study Area* between kilometrages 98 km and 101 km. Approximately 2.1 km of track is located directly above proposed Longwalls S1A to S5A, between 98.6 km and 100.7 km.

The railway line is a dual track consisting of 60 kg rail on concrete sleepers with a mix of straight and curved track sections within the *Subsidence Study Area*. The maximum speed limits on both tracks are 95 km/h for normal services and 105 km/h for XPT services. A photograph of a section of the railway at 99.400 km directly above proposed LW S4A is provided in Fig. 6.1.

Photograph courtesy Newcastle Geotech

Fig. 6.1 Main Southern Railway at 99.400 km

The railway consists of a number of items of infrastructure within the *Subsidence Study Area* and these are listed below in Table 6.1. Further details on each feature are provided later in this report.

Table 6.1 Major railway structures within the Subsidence Study Area

Approximate Kilometrage	Major structure	Closest distance to extent of amended longwall layout
96.300	Railway Viaduct over Bargo River	1.75 kilometres north of LW S1A
96.400	Remembrance Drive Bridge over Bargo River and Main Southern Railway	1.69 kilometres north of LW S1A
98.160	Tahmoor Mine overhead coal conveyor	450 metres to the north western side of LW S1A
101.162	Wellers Road Overbridge	370 metres south of LW S6A

In addition to the major structures listed in Table 6.1, there are a number of smaller railway structures within the *Subsidence Study Area*. These include:-

- Culverts;
- Cuttings;
- Embankments; and
- Signalling, electrical and telecommunications equipment.

6.1.2. Predictions for the Main Southern Railway

The predicted profiles of conventional subsidence and tilt along the alignment of Main Southern Railway, resulting from the extraction of the proposed longwalls, are shown in Fig. E.04, in Appendix E. The initial and the predicted post mining grade of the track are also shown in this figure.

A summary of the maximum predicted total conventional subsidence parameters along the alignment of the railway, after the extraction of each of the proposed longwalls, is provided in Table 6.2. The predicted subsidence effects are predominately due to Longwalls S1A to S5A, which directly mine beneath the railway.

Table 6.2 Maximum predicted total conventional subsidence parameters along the alignment of the Main Southern Railway after the extraction of the proposed LWs S1A to S6A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted change in Grade (%)	Maximum predicted total hogging curvature along alignment (km^{-1})	Maximum predicted total sagging curvature along alignment (km^{-1})
After LW S1A	775	0.55	0.06	0.12
After LW S2A	1000	0.75	0.08	0.20
After LW S3A	1150	0.65	0.09	0.20
After LW S4A	1250	0.70	0.10	0.20
After LW S5A	1300	0.70	0.10	0.20
After LW S6A	1350	0.85	0.10	0.20

The maximum predicted conventional strains for the railway, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.5 mm/m tensile and 3.0 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The railway is a linear feature and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. An analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.2 and the results are provided in Fig. 4.4.

6.1.3. Impact assessments for the Main Southern Railway

Tahmoor Coal and the Australian Rail Track Corporation (ARTC) have developed detailed risk management plans for managing potential mine subsidence impacts on the Main Southern Railway due to the extraction of LWs 25 to 32 and LWs W1-W4 at Tahmoor Mine. South32 Illawarra Coal has also developed similar strategies to manage potential impacts on the railway due to the extraction of Longwalls 702 to 708, and Longwalls 901 to 904 at Appin Colliery.

The management measures described in this plan are similar to those that have been developed in consultation with ARTC and successfully implemented at Tahmoor Mine and Appin Colliery, as described in a paper by Pidgeon, et al. (2011).

A Rail Management Group have been coordinated to develop the risk management strategies. The Rail Management Group includes representatives from ARTC, Tahmoor Coal and specialist consultants in the fields of railway track engineering, geotechnical engineering, structural engineering, track signalling, mine subsidence, risk assessment and project management. The Technical Committee consults with the Resources Regulator and the Office of the National Rail Safety Regulator.

Works by the Rail Management Group include:-

- Identification of potential impacts on the railway;
- Undertaking a risk management approach, where identified risks are assessed and risk control measures are implemented; and
- Development of management measures that include mitigation and preventive works, monitoring plans, triggered response plans and communication plans; and
- Supervision and oversight of railway track and infrastructure mitigation, monitoring and maintenance of affected rail track and infrastructure.

Tahmoor Coal and ARTC continue to develop plans to manage potential impacts during the mining of the proposed LWs S1A to S6A. The following sub-sections provide details of the potential impacts to the Main Southern Railway and management measures that have been developed by the Rail Management Group to ensure that the railway remains safe and serviceable during mining.

The following sections provide the impact assessments and discuss the proposed strategies to manage the potential impacts on the Main Southern Railway for the proposed Tahmoor South longwalls.

6.1.4. Changes in track geometry

The extraction of the proposed LWs S1A to S6A will result in changes to track geometry along the Main Southern Railway. Changes to track geometry are described using a number of parameters:-

- Vertical misalignment (top) – vertical deviation of the track from design;
- Horizontal misalignment (line) – horizontal deviation of the track from design;
- Changes in Track Cant – changes in superelevation across the rails of each track from design; and
- Track Twist – changes in superelevation over a length of track from design.

The Australian Rail Track Corporation's National Code of Practice for Track Geometry provides allowable deviations in track geometry. Predictions of conventional subsidence, tilt and horizontal movement have been made at 5 metre intervals along the railway to calculate each track geometry parameters at any stage of mining. The predicted changes in cant and long twist for the railway are shown in Fig. E.05.

A summary of the maximum allowable and maximum predicted changes in geometry are provided in Table 6.3.

Table 6.3 Allowable and predicted maximum changes in track geometry due to conventional subsidence movements

Track Geometry parameter	Description	Value at which speed limit is first applied*	Value at which trains are stopped*	Predicted maximum due to conventional subsidence
Top	Mid-ordinate vertical deviation Design Offset	14 mm over 4m chord 56 mm over 20m chord	16 mm over 4m chord 66 mm over 20m chord	< 5
Line	Mid-ordinate horizontal deviation over a 10 m chord	34 mm	44 mm	< 5
Change in Cant	Deviation from design superelevation across rails spaced 1.435 m apart	20 to 50 mm (depends on whether track is on a straight or curve)	40 to 75 mm (depends on whether track is on a straight or curve)	8
Long Twist	Changes in Cant over a 14 m chord	46 mm	52 mm	< 3

Note: Values have been taken from the trigger levels in the Tahmoor Mine LW32 Railway Management Plan, which were based on the ARTC National Code of Practice.

Table 6.4 shows that the predicted changes in track geometry are an order of magnitude less than the maximum allowable deviations specified in the National Code of Practice, if conventional subsidence occurs. For example, the maximum allowable change in cant is 75 mm over a length of 1.435 metres before the trains are stopped. In mining terminology, this represents a tilt of approximately 50 mm/m, which is substantially greater than the maximum predicted tilt anywhere above the proposed longwalls of 8.3 mm/m.

It is recognised that subsidence predictions in the Southern Coalfield are generally based on the results of surveys marks that are spaced nominally 20 metres apart. The bay lengths used to measure the track geometry parameters, described in Table 6.3, are less than these mark spacings, particularly for changes in track cant and twist. However, confidence in the predictions is gained from the following observations:-

- Monitoring of track geometry at 125 mm intervals along both tracks during the mining of Longwalls 25 to 32 at Tahmoor Mine and Longwalls 703 to 708, and Longwalls 901 to 904 at Appin Colliery have shown that the observed changes compared reasonably well with predictions. The observed changes were very small and an order of magnitude less than the National Code of Practice;
- Monitoring of track geometry during the mining of other longwalls beneath railways has shown that the observed changes to track geometry have been well below ARTC standards; and
- Literature studies of mining beneath railways in NSW (Lea, 1991) and the UK (Grainger, 1993) indicate that mine subsidence results in minimal impacts to track geometry.

It is, however, possible that mine subsidence could result in changes in track geometry that exceed ARTC Standards in the following ways:-

- Track becomes unstable as the result of rail stress, which is discussed in the following section; or
- Track loses support as the result of failure or collapse of culverts or embankment slopes; or
- Development of substantial non-conventional ground movements.

Non-conventional movements can occur and have occurred in the Southern Coalfield as a result of, among other things, valley upsidence and closure movements and anomalous movements. The impact assessments for the valley related movements at the stream crossings are provided in Section 6.1.11. Discussion on the likelihood and nature of anomalous movements is provided in Sections 3.4 and 4.7.

One example occurred at a low angle fault that intersected the Main Southern Railway in a railway cutting, which was located directly above Tahmoor Longwall 29. The site was monitored extensively during the mining of Longwalls 28 to 31. This included three monitoring lines along the railway cutting, and survey prisms along the railway track. The results of observed changes in vertical alignment of the pegs along the railway cutting are shown in Fig. 4.8. It can be seen that the most significant changes occurred during the mining of Longwall 29. The changes, however, developed gradually over time, allowing sufficient time for the railway track to be adjusted such that trains could continue to travel through the site.

It is therefore considered that while non-conventional movements may potentially result in changes to track geometry that exceed National Code of Practice, the potential risk to track safety can be managed through early detection via monitoring and early response through the implementation of triggered response plans. It is likely that the following management measures will be used to manage changes in track geometry:-

- Assess pre-mining track condition and adjust track (if necessary) so that pre-mining track geometry is at or close to design prior to the development of subsidence;
- Identify potential sites of non-conventional movement, such as creeks and geological structures;
- Install a monitoring system, which includes, among other things, the monitoring of ground movements, rail stress, rail temperature, switch displacement and track geometry;
- Regularly review and assess the monitoring data;
- Conduct regular visual inspections of the track; and
- Adjust the track in response to monitoring results during mining if required to keep the track well within safety limits.

With an appropriate management plan in place, it is considered that potential impacts on track geometry can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.1.5. Changes in track grades

The Main Southern Railway climbs steadily in a southbound direction through the *Subsidence Study Area* from Tahmoor to Bargo and Yanderra.

Existing track gradients have been estimated from Curve and Gradient Diagrams provided by ARTC. The maximum gradient along the Main Southern Railway within the *Subsidence Study Area* is 1.4 % (1 in 73), which is located between 101 km and 102 km, above the proposed longwalls. Steeper grades exist regionally along the track, such as 1 in 63 (1.59 % or 15.9 mm/m) between Moss Vale and Exeter.

The predicted changes in track gradient along the Main Southern Railway and the predicted gradients along the track after the completion of mining are shown in Fig. E.04.

It can be seen that the predicted maximum grade after mining is 1.9 % or 1 in 52, which is higher than the regional maximum grades.

It should be noted, however, that the locations of high grades exist over short lengths (a couple of hundred metres), which is of less concern as freight trains are many hundreds of metres long. It is expected, however, that track resurfacing will be required to reduce the magnitude of the mining-induced undulations in the track. This work can be undertaken during planned ARTC maintenance weekends.

6.1.6. Changes in rail stress

Mine subsidence will result in changes to rail stress unless preventive measures are implemented. If no action is taken, it is likely that the rails will become unstable as a result of the mining of the proposed longwalls. The maximum predicted change in stress free temperature is approximately 140 degrees if 100 % of predicted ground strains are transferred into the rails. By comparison a change in stress free temperature of approximately 14 degrees is sufficient to warrant immediate preventative action on a track with concrete sleepers.

Management of rail stress during active mine subsidence has been a primary focus of the Rail Management Group. Traditionally, rail stress has been managed in Australia and overseas by rail strain or stress monitoring. Once measured changes in rail stress reach defined triggers, the stress is dissipated by unclipping the rails from the sleepers, cutting the rails and adding steel to, or removing steel from the rails as required, followed by re-stressing the rails to their desired stress. This process is effective, but it is labour intensive and very difficult to undertake on busy tracks such as the Main Southern Railway, particularly if the frequency of required rail re-stressing is likely to be more often than weekly, as would be expected during the mining of the proposed longwalls at Tahmoor Mine.

For this reason, the Rail Management Group has introduced a combination of rail expansion switches and zero toe load clips to dissipate mining and temperature related rail stress during mining. Rail expansion switches consist of a tapered joint in the track, which allow the rails on each side of the joints to slide independently. Maximum allowable displacements of expansion switches vary between different types of switches and those that have been employed above Tahmoor Mine Longwalls 25 to 32 have a capacity of approximately 310 mm. Expansion switches are standard rail equipment and operate in non-subsidence applications in Australia and overseas to accommodate, for example, differential thermal movements between bridges and natural ground. A rail expansion switch is shown in Fig. 6.2.

Fig. 6.2 Rail expansion switch

Zero toe load clips allow the rails to slide longitudinally along the track while maintaining lateral stability. In combination, the rails are able to expand or contract in response to mine subsidence and thermal loads into and out of the expansion switches. It is estimated that the switches will be spaced between 200 metres and 400 metres apart along the track within the subsidence area.

The combination of expansion switches and zero toe load clips has been successfully employed during the mining of Longwalls 25 to 32 at Tahmoor Mine and Longwalls 703 to 708, and Longwalls 901 and 902 at Appin Colliery.

A substantial advantage of using rail expansion switches and zero toe load clips is that the system is flexible and can be adjusted during mining should the tolerance of the switches reach their design limits. The rails can be cut and steel can be either added or removed as necessary to restore capacity in the switches. The process is substantially faster than conventional re-stressing work as the clips do not have to be removed and reinstated and no stressing work is required. The process can be safely achieved in between the passage of trains without delaying the operation of trains.

It is likely that the following management measures will be used to manage changes in rail stress:

- Assess pre-mining track condition and adjust track if required so that pre-mining track geometry and sleeper arrangements are at or close to design prior to the development of subsidence. This will include non-destructive measurement of rail stresses in the track;
- Identify potential sites of non-conventional movement, such as creeks and geological structures;
- Assess the required spacing of expansion switches based on the predicted ground movements;
- Install the expansion switches and zero toe load clips;
- Install a monitoring system, which includes, among other things, the monitoring of ground movements, rail stress, rail temperature, switch displacement and track geometry;
- Regularly review and assess the monitoring data;
- Conduct regular visual inspections of the track, switches and clips; and
- Adjust the track in response to monitoring results during mining if required.

With an appropriate management plan in place, it is considered that potential impacts on rail stress can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.1.7. Potential impacts on Railway Viaduct over Bargo River and Remembrance Drive Bridge over Bargo River and Main Southern Railway

The Railway Viaduct and Remembrance Drive Road Bridge are located approximately 1.7 km to the north of LW S1A. While the Viaduct and Bridges may experience small far field horizontal movements during the extraction of the proposed longwalls, they are not expected to experience impacts.

The Viaduct consists of a series of masonry arches and is an item of Heritage Significance. The Remembrance Drive Bridge is a reinforced concrete deck supported by a series of reinforced concrete piers.

Previous mining at Tahmoor Mine has virtually surrounded the Viaduct and Bridge. The closest distance between the Viaduct and Bridge and the previously extracted Longwalls 4 and 5 is 640 metres. No impacts have been reported at the Viaduct or Bridge during mining at Tahmoor Mine.

It is planned to monitor horizontal movements on both side of the Viaduct as part of Tahmoor Coal's monitoring program.

6.1.8. Potential impacts on Tahmoor Mine overhead coal conveyor 3R

Tahmoor Mine's overhead coal conveyor 3R crosses over the Main Southern Railway near 98.160 km. It is located approximately 450 metres to the side of LW S1A.

The conveyor is supported by a series of steel supports, and is shown in Fig. 6.3.

Fig. 6.3 Tahmoor Mine overhead coal conveyor 3R over the Main Southern Railway near 98.160 km

The conveyor is predicted to experience approximately 50 mm of vertical subsidence at the railway crossing, with negligible tilts, curvature and strain.

The supports to the conveyor can be adjusted in the unlikely event that increased differential horizontal movements are observed.

Tahmoor Coal, in consultation with ARTC, will study the potential for impacts to the coal conveyor and develop management measures to ensure that the conveyor and the Main Southern Railway remains safe and serviceable throughout the mining period. The study would require input from structural engineers and subsidence engineers. The management measures will include a combination of:-

- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements and structure movements and visual inspections;
- Implementation of a response plan, where actions are triggered by monitoring results. This will include an adjustment of the conveyor supports if triggered by monitoring results; and
- Implementation of a reporting and communication plan.

With an appropriate management plan in place, it is considered that potential impacts on the conveyor crossing can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.1.9. Potential impacts on Wellers Road Overbridge

The Wellers Road Overbridge is located at Bargo at 101.162 km. A photograph of the Overbridge is shown in Fig. 6.4. Wellers Road Overbridge is located just outside the *Subsidence Study Area*, 370 metres from the commencing end of LW S6A.

Fig. 6.4 Wellers Road Overbridge at 101.162 km

The bridge structure consists of a single span supported by a concrete arch on masonry abutments with masonry vehicle barrier walls. The concrete arch appears to have been reinforced with old steel rails. The bridge was constructed between 1917 and 1920 and is listed as an item of heritage significance.

The bridge is predicted to experience less than 20 mm of conventional subsidence, with negligible tilt, curvature and strain due to the extraction of LWs S1A to S6A.

Mining-induced ground movements will develop gradually at the bridge. With the implementation of an effective subsidence management plan, the development of ground movements and impacts can be detected early with time to implement intervention measures before the bridge becomes unserviceable.

Tahmoor Coal, in consultation with ARTC, will study the potential for impacts to the bridge and develop management measures to ensure that the Wellers Road Overbridge remains safe and serviceable throughout the mining period. The study would require input from structural and geotechnical engineers and subsidence engineers. The management measures may include a combination of:

- Re-assessment of the pre-mining condition of the bridge prior to mining;
- Consideration of mitigation measures prior to mining and implementation if required;
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements and bridge movements. It is planned to monitor horizontal movements at the Bridge as part of Tahmoor Coal's monitoring program;
- Regular review and assess the monitoring data,
- Regular visual inspections of the bridge; and
- Implementation of planned responses if triggered by monitoring and inspections.

With an appropriate management plan in place, it is considered that potential impacts on the Wellers Road Overbridge can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.1.10. Railway Culverts

There are 7 railway culverts located within the *Subsidence Study Area* and their locations are shown in Drawing No. MSEC1192-10. A summary is provided in Table 6.4.

Table 6.4 Railway Culverts within Study Area

Kilometrage (km)	Diameter (mm)	Description	Location relative to Proposed Longwalls
98.445 km	900 dia	Brick arch culvert with concrete extension on both sides	Approx. 170 m to the side of LW S1A
98.739 km	900 dia	Brick arch culvert with concrete extension on both sides	Above LW S1A
99.035 km	1200 dia	Brick arch culvert with concrete extension on both sides	Above LW S2A
99.388 km	1200 dia	Brick arch culvert with concrete extension on UP side	Above LW S3A
100.121 km	1500 dia	Brick arch culvert	Above LW S4A
100.425 km	2000 dia	Brick arch culvert	Above LW S5A
101.000 km	1200 dia	Brick arch culvert	Approx. 230 m beyond the end of LW S6A

Photographs of culverts are shown in Fig. 6.5 to Fig. 6.9.

Photograph courtesy Robinson Rail

Fig. 6.5 Culvert with concrete extension on Up side at 98.739 km

Photographs courtesy Robinson Rail / MSEC

Fig. 6.6 Culvert at 99.388 km on Up and Down sides

Photograph courtesy Newcastle Geotech

Fig. 6.7 Internal view of Culvert at 99.035 km

Photograph courtesy Robinson Rail

Fig. 6.8 Culvert with concrete extension on Up side at 100.121 km

Photograph courtesy Robinson Rail

Fig. 6.9 Culvert with concrete extension on Up side at 100.425 km

The railway crosses a number of streams within the *Subsidence Study Area* and valley-related movements could be experienced in these locations. A summary of the maximum predicted conventional subsidence and valley related movements for the railway culverts is provided in Table 6.5.

Table 6.5 Predicted Conventional Subsidence and Valley Related Movements for the Main Southern Railway Culverts within the Study Area

Location	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
98.445 km	125	< 0.5	< 0.01	< 0.01	20	20
98.739 km	1050	8.0	0.05	0.17	100	50
99.035 km	1000	5.0	0.05	0.04	100	75
99.388 km	1225	5.0	0.06	0.04	200	150
100.121 km	1225	7.0	0.08	0.09	200	100
100.425 km	1275	3.5	0.05	0.12	150	75
101.000 km	20	< 0.5	< 0.01	< 0.01	50	20

The values provided in Table 6.5 are the maximum predicted parameters within a 20 metre radius of each culvert.

6.1.11. Potential impacts on railway culverts at creek crossings

There are a number of railway culverts within the *Subsidence Study Area*. The majority of the culverts are relatively small in size, being 2 metres in diameter or less.

The culverts above proposed LWs S1A to S6A are situated in defined drainage lines that form part of the Teatree Hollow catchment. The culverts are buried beneath small railway embankments. These culverts are expected to experience non-conventional valley related subsidence movements in addition to conventional subsidence movements.

Given that the maximum predicted tilt is 8.0 mm/m, which equates to a 0.8% change in grade, it is expected that mining-induced conventional tilts will not substantially impact the drainage flows in the culverts. It is, however, recommended that the culverts be cleared of ballast which has accumulated in the culvert prior to mining.

The main impact identified with the brick arch culverts is the potential for physical impacts to occur. It is possible that these culverts will experience some cracking and spalling of the masonry as a result of mining the longwalls. Cracking may occur in the masonry arch or in the wingwalls and headwalls. The predicted movements are not considered likely to result in collapse of the culvert.

However, given the potentially severe consequences of culvert collapse, the Rail Management Group will consider mitigation measures prior to each culvert experiencing subsidence movements. Mitigation works could include, for example, sleeving the masonry arch with new pipes. Alternatively, in the case of small shallow buried culverts, steel baulk structures could be placed above the culvert to prevent impacts on the track in the event of culvert collapse.

More substantial mitigation measures may be required for the larger culverts, which may include substantial strengthening of the culvert, wingwalls and headwalls. Substantial strengthening work has successfully been undertaken at culverts above Longwalls 25 and 29 at Tahmoor Mine (Leventhal, *et al.*, 2011; Leventhal, *et al.*, 2017).

A structural steel liner was successfully installed by Tahmoor Mine in a small culvert above Longwall 26. In this case a small air gap was left between the structural steel liner and the original masonry culvert. It was found that while the masonry culvert has experienced cracking during mining, it has remained safe and serviceable during mining. While providing effective insurance against failure, the structural steel liner was not required to support the track and maintain the waterway.

It is likely that the following management measures will be used to manage potential impacts on culverts:-

- Assess pre-mining condition of culverts;
- Consider and implement mitigation measures to reduce or avoid the potential for culvert collapse;
- Install a monitoring system, which includes, among other things, the monitoring of ground movements around the culverts and changes in track geometry and rail stress;

- Regularly review and assess the monitoring data;
- Conduct regular visual inspections of the culverts, and
- Provide additional track and/or culvert support in response to actual measurements and observations during mining.

With an appropriate management plan in place, it is considered that potential impacts on the culverts can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

The predicted valley upsidence and closure movements are also expected to result in changes in track geometry and rail stress. Methods for managing of changes in track geometry and rail stress are provided in Section 6.1.4 and Section 6.1.6.

6.1.12. Potential impacts on railway cuttings

The Main Southern Railway follows a ridgeline within the *Subsidence Study Area* and only small cuttings less than 4 metres in depth are present.

The cutting batters consist of competent sandstone rock, as shown in Fig. 6.10.

Photograph courtesy Newcastle Geotech

Fig. 6.10 Railway cutting at 98.900 km

In the unlikely event that the faces of these cuttings are impacted by mine subsidence, the failure is likely to be very minor, in the form of small fragments of rock, and likely to fall into the clear area at the base of the cutting (the *cess*).

Tahmoor Mine has successfully mined directly beneath railway cuttings during the extraction of Longwalls 25 to 32, with only minor impacts observed on cuttings.

The Rail Management Plan will consider mitigation measures before the cuttings experience subsidence movements. Mitigation works could include, for example, scaling the cutting faces and removing debris from *the cess*. *The cess* will then be maintained during the mining period.

With an appropriate management plan in place, it is considered that potential impacts on the cuttings can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.1.13. Potential impacts on embankments

The Main Southern Railway crosses relatively small valleys in the *Subsidence Study Area* and the railway embankments are less than 5 metres in height. The embankments are typically constructed with local fill material and contain relatively steep batters.

Photographs of embankments are shown previously in Fig. 6.1 and below in Fig. 6.11.

Photograph courtesy Newcastle Geotech

Fig. 6.11 Railway embankment at 100.200 km

The likelihood of impacts on the embankments is considered to be relatively low provided that the culverts remain serviceable and do not become blocked.

The embankments may experience tensile surface cracking during mining, however, these can be readily treated before they develop into a safety hazard. Compressive impacts are less likely as the voids within the embankment can accommodate some compressive movement.

The Rail Management Group will consider mitigation measures before each embankment experiences subsidence movements. Mitigation works could include, for example, cleaning out of the culverts and drainage lines beneath the embankments, or the stabilisation of the batters.

With an appropriate management plan in place, it is considered that potential impacts on the embankments can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occurred.

6.1.14. Potential impacts on signalling and communications systems

There are a number of signalling, communications and electrical services along the Main Southern Railway. These include signal boxes and an optical fibre cable.

The potential for impacts on cabling and wiring along the track is considered to be very low. Mine subsidence impacts on electrical and telecommunications cabling is historically very low in the Southern Coalfield, as discussed in Section 6.10. It is noted that there are failsafe signalling procedures designed within the track management system that substantially reduce the potential for train collisions.

With an appropriate management plan in place, it is considered that the potential impacts on signalling, communications and electrical services can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occurred.

6.2. Tahmoor Mine Rail Loop

The location of Tahmoor Mine's Rail Loop is shown in Drawing No. MSEC1192-10. Descriptions, predictions and impact assessments for the railway are provided in the following sections.

6.2.1. Description of the Rail Loop

Trains enter Tahmoor Mine's Rail Loop at 95.000 km on the Main Southern Railway and travel through the mine site in a clockwise direction. The Rail Loop passes beneath four overhead coal conveyors, the rail loader bin and a road crossing.

The Rail Loop consists of 53 kg rail on concrete sleepers. The track speed limit in the Rail Loop 15 km/hour and 5 km/hour when coal loading. Rail operations vary depending on volumes of coal available at the stockpile and the arrival of ships at port. The maximum rail activity at the mine is 4 train movements per day.

Fig. 6.12 Rail Loop under road bridge

Fig. 6.13 Aerial view of Rail Loop

The Rail Loop is located within the *Subsidence Study Area.* The closest distance between the Rail Loop and LW S1A is approximately 160 metres.

6.2.2. Predictions for the Rail Loop

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Rail Loop, resulting from the extraction of the proposed longwalls, are shown in Fig. E.09, in Appendix E.

A summary of the maximum predicted total conventional subsidence parameters along the alignment of the Rail Loop, after the extraction of each of the proposed longwalls, is provided in Table 6.6.

Table 6.6 Maximum predicted total conventional subsidence parameters along the alignment of the Rail Loop after the extraction of the proposed LWs S1A to S6A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted change in Grade (%)	Maximum predicted total hogging curvature along alignment (km^{-1})	Maximum predicted total sagging curvature along alignment (km^{-1})
After LW S6A	90	< 0.05	< 0.01	< 0.01

The majority of the subsidence movements are predicted to occur during the extraction of proposed LW S1A.

The maximum predicted conventional strains for the railway, based on applying a factor of 15 to the maximum predicted conventional curvatures, are less than 0.5 mm/m. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

6.2.3. Impact assessments for the Rail Loop

The Rail Loop is predicted to experience minor subsidence movements due to the extraction of proposed LWs S1A to S6A.

The changes in track geometry and rail stress are expected to be very minor and unlikely to adversely impact on rail operations. Non-conventional movements can, however, occur and impact the track. In the unlikely event that impacts occur, they can be readily repaired in between rail operations.

A Rail Management Group has been coordinated to develop the risk management strategies. The Rail Management Group includes representatives from ARTC, Tahmoor Coal and specialist consultants in the fields of railway track engineering, geotechnical engineering, structural engineering, track signalling, mine subsidence, risk assessment and project management. The Technical Committee consults with the Resources Regulator and the Office of the National Rail Safety Regulator.

Works by the Rail Management Group include:-

- Identification of potential impacts on the railway;
- Undertaking a risk management approach, where identified risks are assessed and risk control measures are implemented;
- Development of management measures that include mitigation and preventive works, monitoring plans, triggered response plans and communication plans; and
- Supervision and oversight of railway track and infrastructure mitigation, monitoring and maintenance of affected rail track and infrastructure.

With an appropriate management plan in place, it is considered that potential impacts on the Rail Loop can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.2.4. Potential impacts on Tahmoor Mine overhead coal conveyors 3R, 4S, 4C and 7C

Tahmoor Mine's overhead coal conveyors 3R, 4S, 4C and 7C cross over the Rail Loop. The conveyors are supported by a series of steel supports. Conveyors 4S and 4C and the Rail Loader Bin are shown in Fig. 6.14

Fig. 6.14 Conveyors 4S and 4C over Rail Loop and Rail Loader Bin

The conveyor is predicted to experience approximately 90 mm of vertical subsidence at the railway crossing, with negligible tilts, curvature and strain.

The supports to the conveyor can be adjusted in the unlikely event that increased differential horizontal movements are observed.

Tahmoor Coal will study the potential for impacts to the coal conveyor and develop management measures to ensure that the conveyor and the Rail Loop remains safe and serviceable throughout the mining period. The study would require input from structural engineers and subsidence engineers. The management measures will include a combination of:-

- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements and structure movements and visual inspections;
- Implementation of a response plan, where actions are triggered by monitoring results. This will include an adjustment of the conveyor supports if triggered by monitoring results; and
- Implementation of a reporting and communication plan.

With an appropriate management plan in place, it is considered that potential impacts on the conveyor crossings over the Rail Loop can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.2.5. Potential impacts on Tahmoor Mine road bridge over Rail Loop

The road bridge over the Rail Loop is supported by an Armco Culvert with a compacted earth embankment fill. A close up view is shown in Fig. 6.15.

Photograph courtesy JMA Solutions

Fig. 6.15 Tahmoor Mine road bridge over Rail Loop

The road bridge is predicted to experience approximately 40 mm of vertical subsidence with negligible tilts, curvatures and strains. Non-conventional movements can, however, occur and impact the road bridge.

The Armco structure is generally ductile in nature and can tolerate differential movement.

Tahmoor Coal will study the potential for impacts to the road bridge over the Rail Loop and develop management measures to ensure that the track and road remains safe and serviceable throughout the mining period. The study would require input from structural engineers and subsidence engineers. The management measures will include a combination of:-

- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements and structure movements and visual inspections;
- Implementation of a response plan, where actions are triggered by monitoring results. This will include an adjustment of the Armco culvert if triggered by monitoring results; and
- Implementation of a reporting and communication plan.

With an appropriate management plan in place, it is considered that potential impacts on the road bridge and the Rail Loop can be managed during the mining of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.3. Local roads

6.3.1. Descriptions of local roads

The locations of local roads within the Study Area are shown in Drawing No. MSEC1192-11.

The main local road within the *Subsidence Study Area* is Remembrance Drive which runs along the western side of the Main Southern Railway and crosses directly above the proposed Longwalls S1A to S5A. The road provides a connection between the M31 Hume Motorway and the township of Bargo with the township of Tahmoor to the north of the Study Area.

Caloola Road and Yarran Road are one-way sealed roads that connect to Remembrance Drive from the west. The two road are located within the *Subsidence Study Area.*

Great Southern Road runs alongside the eastern side of the Main Southern Railway and becomes Avon Dam Road, which connects to the M31 Hume Motorway. Only the northern end of Great Southern Road is located within the *Subsidence Study Area.* Charlies Point Road is a sealed local road that connects Great Southern Road and Arina Road.

The local roads are maintained by Wollondilly Shire Council. A photograph of Remembrance Drive near the intersection with Caloola Road is provided in Fig. 6.16.

Photograph courtesy Building Inspection Services

Fig. 6.16 Remembrance Drive near Caloola Road

There are no bridges along local roads within the *Subsidence Study Area.* A number of culverts are located within the *Subsidence Study Area*, as shown in Drawing No. MSEC1192-11. Almost every culvert is a reinforced concrete pipe (RCP), with the exception of one earthenware pipe on Charlies Point Road. The pipe diameters vary between 500 mm and 1.8 metres.

A photograph of twin, 1.35 metre diameter reinforced concrete culverts beneath bus stop at the end of Caloola Road is shown in Fig. 6.17. The culvert carries the pavement over Teatree Hollow and continues beneath Remembrance Drive. A photograph of the road embankment to Remembrance Drive at Teatree Hollow is shown in Fig. 6.18.

Two culverts are located in close proximity at the intersection between Remembrance Drive, Yarran Road and the Main Southern Railway. The 1800 mm RCP culvert beneath Remembrance Drive drains into a small parcel of privately owned land and a 2000 mm diameter brick arch culvert beneath the Main Southern Railway.

Photograph courtesy Building Inspection Services

Fig. 6.17 Culvert beneath approach to Caloola Road and continuing under Remembrance Drive along Teatree Hollow

Photograph courtesy Building Inspection Services

Fig. 6.18 Remembrance Drive embankment at intersection with Caloola Road

Photographs courtesy Building Inspection Services

Fig. 6.19 RCP culvert beneath Remembrance Drive and brick arch culvert beneath Main Southern Railway at 100.425 km with private land in between them

6.3.2. Predictions for local roads

The predicted profiles of conventional subsidence and tilt along the alignment of Remembrance Drive, resulting from the extraction of the proposed longwalls, are shown in Fig. E.07, in Appendix E.

A summary of the maximum predicted total conventional subsidence parameters for Remembrance Drive, after the extraction of each of the proposed longwalls, is provided in Table 6.7.

The predicted tilts are the maxima along the alignment of the road after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 6.7 Maximum predicted total conventional subsidence parameters for Remembrance Drive due to the extraction of LWs S1A to S6A

Longwall	Maximum predicted subsidence (mm)	Maximum predicted tilt along alignment (mm/m)	Maximum predicted tilt across alignment (mm/m)	Maximum predicted hogging curvature in any direction (km^{-1})	Maximum predicted sagging curvature in any direction (km^{-1})
LW S1A	325	2.5	5.0	0.06	0.06
LW S2A	1000	5.0	5.5	0.08	0.20
LW S3A	1200	6.5	5.5	0.10	0.21
LW S4A	1250	6.0	6.0	0.12	0.21
LW S5A	1300	6.5	5.5	0.12	0.21
LW S6A	1350	7.5	5.5	0.12	0.21

The maximum predicted conventional strains for Remembrance Drive, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.8 mm/m tensile and 3.2 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The road is a linear feature and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. The analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.2 and the results are provided in Fig. 4.4.

Caloola Road and Yarran Road are located directly above the proposed longwalls and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the Study Area is provided in Chapter 4.

Remembrance Drive crosses Teatree Hollow and a number of its tributaries within the *Subsidence Study Area* and valley-related movements could be experienced in these locations. A summary of the maximum predicted conventional subsidence and valley related movements for the crossing at Teatree Hollow is provided in Table 6.8.

Table 6.8 Predicted Conventional Subsidence and Valley Related Movements for the Culverts along Remembrance Drive within the Study Area

Location	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt along Culvert (mm/m)	Maximum Predicted Total Hogging Curvature (1/km)	Maximum Predicted Total Sagging Curvature (1/km)	Maximum Predicted Total Upsidence (mm)	Maximum Predicted Total Closure (mm)
Teatree Hollow (Caloola Road)	1300	6.9	0.06	-0.18	250	150
Tributary to Teatree Hollow	1100	3.6	0.05	-0.04	125	100
Tributary to Teatree Hollow (Yarran Road)	1300	6.7	0.05	-0.22	150	75
Tributary to Teatree Hollow (Wellers Road)	25	< 0.5	< 0.01	< 0.01	40	25

6.3.3. Impact assessments for local roads

There is extensive experience of mining directly beneath local roads in the Southern Coalfield which demonstrates that impacts can be managed with the implementation of suitable management strategies. In all cases the local roads have remained in safe and serviceable condition and have been remediated using normal road maintenance techniques.

Longwalls 22 to 32 and LW W1-W3 at Tahmoor Mine have mined directly beneath 28 kilometres of local roads and a total of 54 impact sites have been observed. The observed rate of impact on the local roads equates to an average of one impact for every 520 metres of pavement. In most cases, the impacts were relatively minor and were remediated by locally resurfacing the pavements.

The most severe impacts were located where substantial non-conventional movements had developed. These impact sites were identified using visual and ground monitoring and remediation was undertaken during active subsidence to maintain these roads in safe and serviceable conditions.

Photographs of typical impacts observed on local roads at Tahmoor are provided in Fig. 6.20.

Fig. 6.20 Previously observed impacts on local roads above Tahmoor Mine

As the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North, it is expected that the rates of impact on the local roads within the *Subsidence Study Area* will be greater than experienced at Tahmoor. The impacts, however, can be managed with the implementation of suitable management strategies. Impacts on local roads have been successfully managed elsewhere in the NSW Coalfields, where the predicted subsidence parameters were similar to or greater than those predicted for the proposed longwalls.

6.3.4. Impact assessments for local road culverts

The maximum predicted tilt across Remembrance Drive within the *Subsidence Study Area* is 6.9 mm/m (i.e. 0.69 %), which represents a change in grade of 1 in 145.

The predicted changes in grade are small, in the order of 1 % and, therefore, are unlikely to result in any adverse impacts on the serviceability of the drainage culverts. If the flow of water through any drainage culverts were to be adversely affected, as a result of the proposed mining, this could be remediated by re-levelling the affected culverts.

The predicted curvatures and strains could be of sufficient magnitudes to result in cracking in the culverts or the headwalls. It is unlikely, however, that these movements would adversely impact on the stabilities or structural integrities of the culverts. The potential impacts on the drainage culverts could be managed by visual inspection and, where required, any affected culverts can be repaired or replaced.

The drainage culverts are located along drainage lines and could, therefore, experience valley related upsidence and closure movements. The drainage culverts are orientated along the alignments of the drainage lines and, therefore, the upsidence and closure movements are orientated perpendicular the main axes of the culverts and unlikely to result in adverse impacts to the culvert pipes.

Previous experience of mining beneath culverts in the NSW Coalfields, at similar depths of cover, indicates that the incidence of impacts is low. Impacts have generally been limited to cracking in the concrete headwalls which can be readily remediated. In some cases, however, cracking in the culvert pipes occurred which required the culverts to be replaced.

6.3.5. Management of potential impacts on local roads

Tahmoor Coal has developed a Subsidence Management Plan in consultation with Wollondilly Shire Council for the extraction of existing longwalls at Tahmoor Mine to manage the impacts on the public roads, bridges and culverts.

It is recommended that a similar Subsidence Management Plan be developed in consultation with Wollondilly Shire Council to manage potential impacts on the local roads, bridges and culverts within the *Subsidence Study Area*. With the implementation of these management strategies, it would be expected that the local roads could be maintained in safe and serviceable conditions during and after the extraction of the proposed longwalls.

With an appropriate management plan in place, it is considered that potential impacts on the roads, bridges and culverts can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.4. Road bridges

Descriptions, predictions and impact assessments for Wellers Road Bridge over the Main Southern Railway is provided in Section 6.1.9. There are no other bridges within the *Subsidence Study Area.*

6.5. Tunnels

There are no tunnels within the *Subsidence Study Area*.

6.6. Potable water infrastructure

6.6.1. Descriptions of potable water infrastructure

The locations of the potable water infrastructure within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-12. The water pipelines are owned and operated by Sydney Water.

The potable water infrastructure includes a Cast Iron Cement Lined (CICL) 450 mm diameter watermain which follows the alignment of Remembrance Drive, before crossing beneath the Main Southern Railway and following Great Southern Road. 200 mm and 250 mm diameter Ductile Iron Cement Lined (DICL) water pipelines are located along Caloola Road, Yarran Road and along a short section Remembrance Drive to the south the railway crossing.

A summary of the potable water pipelines within the Study Area is provided in Table 6.9.

Table 6.9 Potable water pipelines within the Study Area

Type	Size (diameter) (mm)	Total length of pipeline within Study Area (km)	Total length of pipeline located directly above proposed LWs S1A to S6A (km)
450 mm dia. watermain along Remembrance Drive	450	3.0	2.4
Distribution Network	100 to 200	3.4	2.1

The distribution of water mains by pipe diameter within the Study Area is shown in Table 6.10.

Table 6.10 Distribution of water mains by pipe diameter

Pipe diameter (mm)	Total length within Study Area (km)	%
100	2.9	44.5
150	< 0.1	0.1
200	0.6	8.7
375	< 0.1	< 0.1
450	3.0	46.7
Total	**6.4**	**100.0**

The types of pipeline within the *Subsidence Study Area* are mainly DICL and CICL, with short sections of Steel Cement Lined (SCL) beneath road crossings. The distribution of water mains by type of pipe is shown in Table 6.11.

Table 6.11 Distribution of water mains by pipe type

Pipe diameter (mm)	Total length within Study Area (km)	%
CICL	4.6	71.9
DICL	1.8	27.6
SCL IBL	< 0.1	0.4
Unknown	< 0.1	< 0.1
Total	**6.4**	**100.0**

6.6.2. Predictions for potable water infrastructure

The 450 mm diameter CICL watermain generally follows the alignment of Remembrance Drive. Predictions of subsidence effects along the pipeline, including predictions of valley closure at creek crossing are provided in Section 6.3.2.

6.6.3. Impact assessments for potable water pipelines

Longwalls 22 to 32 at Tahmoor Mine have directly mined beneath approximately 5.5 kilometres of DICL pipe and 19.5 kilometres of CICL pipe, with only minor impacts recorded to the older CICL pipes. Water leaks were repaired by Sydney Water using normal response procedures.

The predicted systematic curvatures and strains for the water pipelines within the *Subsidence Study Area* are of a similar order of magnitude to those observed and predicted along the pipelines that have been mined directly beneath by previously extracted longwalls in the Southern Coalfield. The overall levels of impacts on the water pipelines in the *Subsidence Study Area*, therefore, are expected to be similar to those observed during the previously extracted longwalls in the Southern Coalfield. Longwalls in the Southern Coalfield have been mined directly beneath water pipelines in the past, and some of these cases are provided in Table 6.12.

Table 6.12 Examples of previous experience of mining beneath water pipelines in the Southern Coalfield

Colliery and Longwalls	Pipelines	Observed movements	Observed impacts
Appin LW301 and LW302	0.6 km of 150 dia. DICL 0.6 km of 300 dia. CICL 0.6 km of 1200 dia. SCL	650 mm Subsidence 4.5 mm/m Tilt 1 mm/m Tensile Strain 3 mm/m Comp. Strain (Measured M & N-Lines)	Leakage of the 150 mm and 300 mm CICL pipelines at a creek crossing, elsewhere no other reported impacts
Tahmoor Mine LW22 to LW32	5.5 km DICL pipes 19.5 km CICL pipes	1200 mm Subsidence 6 to 10 mm/m Tilt 1.5 mm Tensile Strain 2 mm (typ.) and up to 5 mm/m Comp. Strain (Extensive street monitoring)	Impacts occurred to the distribution network at 8 locations and a very small number of minor leaks in the consumer connection pipes
West Cliff LW5A3, LW5A4 & LW29 to LW34	2.8 km of 100 dia. CICL pipe directly mined beneath	1100 mm Subsidence 10 mm/m Tilt 1 mm/m Tensile Strain 5.5 mm/m Comp. Strain (Measured B-Line)	No reported impacts

Based on this experience, it is expected that some minor leakages of the water pipelines could occur at isolated locations, as the result of the extraction of the longwalls, however, the incidence of impacts is expected to be low. Impacts are more likely to occur in the locations of non-systematic movements, and at creek crossings, due to valley related movements.

Any impacts are expected to be of a minor nature which could be easily remediated. It is recommended that Tahmoor Coal develop management strategies, in consultation with Sydney Water, to manage these potential impacts.

6.6.4. Management of potential impacts on water infrastructure

Tahmoor Coal has developed a Subsidence Management Plan in consultation with Sydney Water for the extraction of existing longwalls at Tahmoor Mine to manage potential impacts on potable water infrastructure.

With an appropriate management plan in place, it is considered that the potential impacts on the Sydney Water potable water pipelines can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions.

6.7. Sewerage pipelines

6.7.1. Descriptions of sewerage pipelines

A *Priority Sewer Program* has been constructed in the township of Bargo by Sydney Water. The sewer infrastructure includes a pressure main along Remembrance Drive and a consumer reticulation network along the local roads. The locations of the sewerage infrastructure are shown in Drawing No. MSEC1192-13.

The sewerage system was designed to accommodate mine subsidence movements and consists of polyethylene (PE) pipelines with diameters up to 630 mm.

A summary of the sewerage pipelines within the *Subsidence Study Area* is provided in Table 6.13.

Table 6.13 Sewerage pipelines within the Subsidence Study Area

Type	Size (diameter) (mm)	Total length of pipeline within Subsidence Study Area (km)	Total length of pipeline located directly above proposed LWs S1A to S6A (km)
PE Pressure Main along Remembrance Drive	180	3.0	2.3

6.7.2. Predictions for sewer infrastructure

The 180 mm diameter PE pressure main generally follows the alignment of Remembrance Drive. Predictions of subsidence effects along the pipeline, including predictions of valley closure at creek crossing are provided in Section 6.3.2.

6.7.3. Impact assessments for sewer infrastructure

The sewer reticulation network within the *Subsidence Study Area* consists of a 180 mm diameter welded PE pipe.

Tahmoor Coal, in consultation with Sydney Water, has successfully mined beneath a sewerage system at Tahmoor and Thirlmere during the mining of Longwalls 22 to 32. The sewerage infrastructure at Tahmoor and Thirlmere are gravity sewers and consist mainly of PVC pipes. While impacts on the sewerage system at Tahmoor have been successfully managed, the pressurised sewerage system at Bargo will be able to accommodate substantially greater differential subsidence movements.

The sewer main transports sewage by hydraulic pressure and does not rely on gravity. While the sewer main will experience changes in grade due to subsidence, the changes will not adversely affect it.

The PE pipes can accommodate substantial deformations without losing their integrity. Only extreme deformations, such as the development of a step in the ground may adversely impact on the pipes.

If the PE pipe experiences severe deformation, the pipe may become blocked. The sewerage system has been designed to store sewage for approximately 8 hours after which time sewage may leak or overflow from the sewerage system. This can be readily repaired by local excavation and repair.

There do not appear to be any house connections to the pressure main within the *Subsidence Study Area.* Houses can connect to the system via a Sydney Water designed pot that is approximately 2 metres deep and 1 metre in diameter. The pot stores sewage, which is pumped into the reticulation network. The connection between each house and the pot consists of a gravity flow PVC pipe. It is possible that the pot and the house will act as anchors to the ground during subsidence, and that differential horizontal movements between the two structures may result in leakage at the connections. This is similar to the current connections between houses and septic tanks. Experience from mining beneath septic tanks has been that while impacts have previously occurred during, the rate of impact is low. Impacts to the connections can be readily repaired.

A number of valves and chambers are located above the proposed longwalls. These chambers, valves and pipe fittings are small in size and are connected via flange adapters. It is expected that the chambers, valves and fittings will act as anchors to the ground during subsidence, allowing the PE pipe to stretch or compress in response to mining-induced differential horizontal movements. While there is potential for impacts to occur at these locations, many similar structures are located within the Tahmoor sewerage system and no impacts have occurred to chambers, valves and other pipe fittings during mining. There is, however, a remote chance that anomalous ground deformation could occur during extraction of the proposed longwalls.

Any impacts are expected to be of a minor nature which could be easily remediated. It is recommended that Tahmoor Coal develop management strategies, in consultation with Sydney Water, to manage these potential impacts.

6.7.4. Management of potential impacts on proposed sewerage infrastructure

Tahmoor Coal has developed a Subsidence Management Plan in consultation with Sydney Water for the extraction of existing longwalls at Tahmoor Mine to manage potential impacts on sewerage infrastructure.

With an appropriate management plan in place, it is considered that the potential impacts on the Sydney Water sewerage pipelines can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions.

6.8. Gas infrastructure

6.8.1. Moomba-Sydney Gas Pipeline and Gorodok Ethane Pipeline

The *Moomba-Sydney Gas Pipeline and Gorodok Ethane Pipeline* is located south of Bargo township and is outside the *Subsidence Study Area* for LWs S1A to S6A.

6.8.2. Local Jemena infrastructure

The locations of local gas infrastructure within and adjacent to the *Subsidence Study Area* are shown in Drawing No. MSEC1192-14. There is a 150 mm diameter steel main, which runs along Remembrance Drive and distributes gas to the townships north of Bargo, including Tahmoor, Thirlmere and Picton.

The take-off point for the 150 mm steel main from the Moomba-Sydney Gas Pipeline is located on Hawthorne Road outside the *Subsidence Study Area*. The local Jemena gas infrastructure servicing the Bargo township has a take-off point at the same location. The take-off point consists of a number of buried pits, a pillar box and guard rail.

A summary of the local gas infrastructure within the *Subsidence Study Area* is provided in Table 6.14.

Table 6.14 Summary of the local gas infrastructure within the Subsidence Study Area

Type	Total length of local gas infrastructure within Subsidence Study Area (km)	Total length of local gas infrastructure directly above proposed LWs S1A to S6A (km)
32 mm nylon	0.2	0
50 mm nylon	< 0.05	0
150 mm steel	3.0	2.4

6.8.3. Predictions for gas infrastructure

The 150 mm diameter PE pressure main generally follows the alignment of Remembrance Drive. Predictions of subsidence effects along the pipeline, including predictions of valley closure at creek crossing are provided in Section 6.3.2.

6.8.4. Impact assessments for gas infrastructure

Longwalls 22 to 32 have directly mined beneath approximately 19 kilometres of gas pipes and no impacts have been recorded so far. The local nylon and 160 mm polyethylene main along Remembrance Drive are very flexible and have demonstrated that they are able to withstand the full range of subsidence experienced during longwall extraction at Tahmoor Mine to date. While no impacts have been experienced to date, it is acknowledged that the most vulnerable element of the system is the rigid copper pipe connections between the gas mains and houses, which can be readily repaired.

A difference between the gas infrastructure at Bargo compared to the gas infrastructure at Tahmoor is the existence of the 150 mm steel gas main at Bargo. This pipe passes through the Bargo township, mainly along Remembrance Drive. As the steel pipe was constructed in 1994, it was designed and constructed in accordance with the requirements of SA NSW. Steel gas pipelines of similar and larger diameter have been successfully mined directly beneath in the past in the Southern Coalfield (McGill, 2007) and Newcastle Coalfield (Robinson, 2007). Being of relatively small diameter, the pipe is expected to withstand considerable deformation.

Tahmoor Coal has consulted with Jemena and has engaged specialist pipeline engineers who are experienced in mine subsidence to conduct analyses to assess the potential for impacts on the pipeline. The analyses includes an assessment of changes in pipe stresses due to the predicted subsidence, tilt, curvature and strain movements and a sensitivity analysis to assess the magnitudes at which differential movements may exceed acceptable limits. The results indicate that the pipeline can tolerate the predicted conventional subsidence movements due to the extraction of LWs S1A and S2A.

Investigations are currently underway to assess the risks and select feasible risk controls that can be implemented either prior to mining and/or during mining, taking into account the specific site conditions along Remembrance Drive. This may include, for example, exposing sections of pipeline at creek crossings prior to the influence of subsidence.

If observed ground strains or severe ground deformations are observed to develop during mining, the pipe can be exposed and adjusted to decouple the pipe from the differential ground movements. Pre-planned traffic control and security measures would be required to be implemented if these works are required. In the event of a minor gas leak, the pipeline can also be repaired without interruption to services.

6.8.5. Management of potential impacts on gas infrastructure

Tahmoor Coal has developed Subsidence Management Plans in consultation with Jemena for the existing longwalls at Tahmoor Mine to manage potential impacts on local gas infrastructure at Tahmoor.

It is recommended that a similar Subsidence Management Plan be developed in consultation with Jemena to manage potential impacts on the local gas infrastructure within the *Subsidence Study Area*. With the implementation of these management strategies, it would be expected that the local gas infrastructure could be maintained in safe and serviceable conditions during and after the extraction of the proposed longwalls.

With an appropriate management plan in place, it is considered that potential impacts on the local gas infrastructure can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.9. Electrical Infrastructure

6.9.1. Descriptions of electrical infrastructure

The locations of the electrical infrastructure within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-15.

The electrical infrastructure comprises 66 kV, 11 kV and low voltage powerlines which are located across the *Subsidence Study Area*. There are no transmission lines located within the *Subsidence Study Area*.

A summary of the power lines within the *Subsidence Study Area* is provided in Table 6.15.

Table 6.15 Summary of the electrical infrastructure within the Subsidence Study Area

Type	Total length of powerline within Subsidence Study Area (km)	Total length of powerline directly above proposed LWs S1A to S6A (km)
66 kV Powerlines	1.5	Nil
11 kV Powerlines	11.4	5.4
Low Voltage Powerlines	11.1	6.9

The power lines generally comprise aerial copper cables supported on timber poles, but there are also some sections of direct buried cables. The power lines are owned and operated by Endeavour Energy.

6.9.2. Predictions for electrical infrastructure

The power lines are located across the *Subsidence Study Area* and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

6.9.3. Impact assessments for electrical infrastructure

The aerial power lines will not be directly affected by the ground strains, as the cables are supported by poles above ground level. The cables may, however, be affected by changes in the bay lengths, i.e. the distances between the poles at the levels of the cables, resulting from differential subsidence, horizontal movements, and tilt at the pole locations. The stabilities of the poles may also be affected by conventional tilt, and by changes in the catenary profiles of the cables.

There is extensive experience of mining directly beneath power lines in the Southern Coalfield which indicates that the incidence of impacts is very low and that any impacts are readily repairable. A summary of previous experiences is provided in Table 6.16.

Table 6.16 Previous experience of mining beneath powerlines in the Southern Coalfield

Colliery and LWs	Length of powerlines directly mined beneath (km)	Observed maximum movements at powerlines	Observed impacts
Appin LW1 to LW12	5.2 km of 11 kV 104 power poles	850 mm Subsidence 6 mm/m Tilt (Measured WX-Line)	No significant impacts
Appin LW14 to LW29	1.0 km of 66 kV 4.6 km of 11 kV 76 power poles	1200 mm Subsidence 7 mm/m Tilt (Measured A-Line)	No significant impacts
Appin LW301 and LW302	0.6 km of 66 kV 0.2 km of 11 kV 14 power poles	650 mm Subsidence 4.5 mm/m Tilt (Measured M & N-Lines)	No significant impacts
Appin LW401 to LW408	3.4 km of 66 kV 0.6 km of 33 kV 2.9 km of 11 kV 96 power poles	700 mm Subsidence 5 mm/m Tilt (Measured A-Line)	No significant impacts
Appin LW702	1.5 km of 11 kV 19 power poles	550 mm Subsidence 3.5 mm/m Tilt (Measured MPR-Line)	No significant impacts
Dendrobium LW3 and LW4	0.8 km of 33 kV	1100 mm Subsidence 40 mm/m Tilt (Measured 2000-Line)	No significant impacts
Tahmoor LW22 to LW32	Approx. 44 km of electrical cables and 1100 power poles	1200 mm Subsidence 12 mm/m Tilt (Extensive street monitoring, surveys of critical power poles)	Some minor adjustments to cable catenaries, pole tilts and consumer cables required.
Tower LW1 to LW10	6.0 km of 66 kV 4.3 km of 11 kV 112 power poles	400 mm Subsidence 3 mm/m Tilt (Measured T & TE-Lines)	No significant impacts
West Cliff LW5A3 to LW5A4 & LW29 to LW33	0.8 km of a 66 kV 3.7 km of 11 kV 113 power poles	950 mm Subsidence 5 mm/m Tilt (Measured B-Line)	No significant impacts

Some remedial measures have been required, in the past, which included adjustments to cable catenaries, pole tilts and to consumer cables which connect between the power lines and building structures. It is expected that the mining during the proposed development will result in similar experiences.

6.9.4. Impact assessments for electrical infrastructure based on increased predictions

If the actual subsidence movements exceeded those predicted by a factor of 2 times, the maximum tilt at the power lines would be 16.6 mm/m (i.e. 1.6 %), or a change in grade of 1 in 60. In this case, the tilts would still be less than the tolerable tilt, which is in the order of 33 mm/m. The incidence of impacts would increase in the locations of greatest tilt, such as adjacent to the active longwall maingate and adjacent to the ends of the proposed longwalls. It would still be expected that any impacts could remediated, including some adjustments of the cable catenaries, pole tilts and the consumer cables, as has been undertaken in the past.

While the predicted ground movements are important parameters when assessing the potential impacts on the power lines, it is noted that the impact assessments were primarily based on historical observations from previous longwall mining in the Southern Coalfield. The overall levels of impact on the power lines, resulting from the extraction of the proposed longwalls, are expected to be similar to those observed where longwalls have previously mined directly beneath power lines in the Southern Coalfield.

6.9.5. Management of potential impacts on electrical infrastructure

Tahmoor Coal has developed Subsidence Management Plans in consultation with Endeavour Energy for the existing longwalls at Tahmoor Mine to manage potential impacts on electrical infrastructure.

It is recommended that a similar Subsidence Management Plan be developed in consultation with Endeavour Energy to manage potential impacts on the electrical infrastructure within the *Subsidence Study Area*.

With an appropriate management plan in place, it is considered that potential impacts on the electrical infrastructure can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.10. Telecommunications Infrastructure

6.10.1. Description of telecommunications infrastructure

The locations of the telecommunications infrastructure are shown in Drawing No. MSEC1192-16.

The telecommunications infrastructure within the *Subsidence Study Area* comprises optical fibre cables and copper cables. A summary of the telecommunications cables within the *Subsidence Study Area* is provided in Table 6.17.

Table 6.17 Summary of telecommunications infrastructure within the Subsidence Study Area

Type	Total length of cable within Subsidence Study Area (km)	Total length of cable located directly above proposed LWs S1A to S6A (km)
Copper Cables		
Telstra	15.9	10.5
National Broadband Network (NBN)	16.7	11.1
Optical Fibre Cables		
Telstra	3.6	2.6
TPG	2.8	2.3

Telstra telecommunications infrastructure

A Telstra optical fibre cable follows the alignment of Remembrance Drive and the Main Southern Railway and crosses directly above the proposed LWs S1A to S5A.

The copper telecommunications cables are generally direct buried and follow the alignments of local roads across the *Subsidence Study Area*.

National Broadband Network (NBN) infrastructure

The National Broadband Network (NBN) cables comprise both Optical fibre and copper service cables. NBN optical fibre cable follows the alignment of Remembrance Drive. Copper service cables follow the alignments of local roads across the *Subsidence Study Area*.

An NBN telecommunications tower is located at No. 3166 Remembrance Drive, with access from Yarran Road. The tower is located directly above LW S6A, as shown in Drawing No. MSEC1192-16. An aerial photograph is shown in Fig. 6.21.

TPG infrastructure

TPG have installed an optical fibre cable along Remembrance Drive from the Wollondilly Anglican College to the Bargo Exchange, following the same route as the NBN optical fibre cable, as shown in Drawing No. MSEC1192-16.

Fig. 6.21 NBN telecommunications tower with access from Yarran Road

6.10.2. Predictions for telecommunications infrastructure

Predictions of subsidence effects along Remembrance Drive, including predictions of valley closure at creek crossings are provided in Section 6.3.2.

The predicted profiles of conventional subsidence, tilt and curvature along the Telstra optical fibre cable along Remembrance Drive and the Main Southern Railway are shown in Fig. E.08, in Appendix E. The predicted profiles of conventional subsidence, tilt and curvature along the NBN and TPG optical fibre cables along Remembrance Drive are shown in Fig. E.07, in Appendix E. The predicted incremental profiles along the alignments of the cables, due to the extraction of each of the proposed longwalls, are shown as dashed black lines. The predicted total profiles along the alignments of the cables, after the completion of each of the proposed longwalls, are shown as solid blue lines. The range of predicted curvatures in any direction to the cables, at any time during or after the extraction of the proposed longwalls, is shown by the grey shading.

A summary of the maximum predicted total conventional subsidence parameters for the optical fibre cable, after the completion of each of the proposed longwalls, is provided in Table 6.18. The predicted tilts are the maxima along the alignments of the cables after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Table 6.18 Maximum predicted total conventional subsidence parameters for the Telstra optical fibre cable along Remembrance Drive and Main Southern Railway

Longwall	Maximum predicted subsidence (mm)	Maximum predicted tilt along alignment (mm/m)	Maximum predicted hogging curvature in any direction (km^{-1})	Maximum predicted sagging curvature in any direction (km^{-1})
LW S1A	325	2.5	0.06	0.06
LW S2A	1000	7.5	0.08	0.20
LW S3A	1200	6.5	0.10	0.20
LW S4A	1250	7.0	0.14	0.20
LW S5A	1300	7.0	0.14	0.20
LW S6A	1350	8.5	0.14	0.20

The optical fibre cables along the Main Southern Railway and Remembrance Drive cross a number of streams within the *Subsidence Study Area* and could experience valley related movements in these locations. A summary of the maximum predicted upsidence and closure movements at the stream crossings is provided in Table 6.19.

Table 6.19 Maximum predicted upsidence and closure movements for optical fibre cables along Remembrance Drive and Main Southern Railway at the stream crossings

Location	Maximum predicted total subsidence (mm)	Maximum predicted total tilt (mm/m)	Maximum predicted total hogging curvature (1/km)	Maximum predicted total sagging curvature (1/km)	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Main Southern Railway						
99.388 km	1225	5.0	0.06	0.04	200	150
100.121 km	1225	7.0	0.08	0.09	200	100
100.425 km	1275	3.5	0.05	0.12	150	75
101.000 km	20	< 0.5	< 0.01	< 0.01	50	20
Remembrance Drive						
Teatree Hollow (Caloola Road)	1300	6.9	0.06	-0.18	250	150
Tributary to Teatree Hollow	1100	3.6	0.05	-0.04	125	100
Tributary to Teatree Hollow (Yarran Road)	1300	6.7	0.05	-0.22	150	75
Tributary to Teatree Hollow (Wellers Road)	25	< 0.5	< 0.01	< 0.01	40	25

The predicted total closure at each stream crossing is the sum of the valley related movement calculated using the 2002 ACARP prediction method (Waddington and Kay, 2002) plus the conventional movement within the valley. It is noted that this provides some additional conservatism, as the 2002 ACARP prediction method also includes some component of the conventional movement.

The maximum predicted conventional strains for the optical fibre cables, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 2.1 mm/m tensile and 3.0 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The optical fibre cables are linear features and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. An analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.2 and the results are provided in Fig. 4.4.

The Telstra, NBN and TPG copper telecommunications cables are located across the *Subsidence Study Area* and, therefore, could experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

The NBN telecommunications tower is located off at No. 3166 Remembrance Drive, with access from Yarran Road. Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of the tower and the shed, as well as at points located at a distance of 20 metres from the perimeter of each structure. A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each structure is provided in Table 6.20.

Table 6.20 Maximum predicted total conventional subsidence parameters for the NBN telecommunications tower at No. 3166 Remembrance Drive

Structure	Maximum predicted subsidence (mm)	Maximum predicted tilt along alignment (mm/m)	Maximum predicted hogging curvature in any direction (km^{-1})	Maximum predicted sagging curvature in any direction (km^{-1})
Shed	900	3.0	0.05	0.04
Tower	850	2.5	0.04	0.04

6.10.3. Impact assessments for optical fibre cables

The optical fibre cables are direct buried or buried in conduit and could, therefore, potentially be impacted by ground strains. The greatest potential for impacts will occur as the result of localised ground strains due to non-conventional movements or valley related movements.

Tensile strains in the optical fibre cables could be higher than predicted, where the cables connect to the support structures, which may act as anchor points, preventing any differential movements that may have been allowed to occur with the ground. Tree roots have also been known to anchor cables to the ground. The extent to which the anchor points affect the ability of the cables to tolerate the mine subsidence movements depends on the cable size, type, age, installation method and ground conditions.

In addition to this, optical fibre cables contain additional fibre lengths over the sheath lengths, where the individual fibres are loosely contained within tubes. Compression of the sheaths can transfer to the loose tubes and fibres and result in “micro-bending” of the fibres constrained within the tubes, leading to higher attenuation of the transmitted signal. If the maximum predicted compressive strains were to be fully transferred into the optical fibre cables, the strains could be of sufficient magnitude to result in the reduction in capacities of the cables or transmission loss.

Strains transferred into the optical fibre cables can be monitored using Optical Time Domain Reflectometry (OTDR), which can be used to notify the infrastructure owners of strain concentrations due to non-conventional ground movements or valley related movements.

Longwalls in the Southern Coalfield have been successfully mined directly beneath optical fibre cables in the past, with little to no adverse impacts on these cables. A summary of some of these cases is provided in Table 6.21.

Table 6.21 Examples of mining beneath optical fibre cables

Colliery and Longwalls	Length of optical fibre cables directly mined beneath (km)	Observed maximum movements at optical fibre cables	Pre-mining mitigation, monitoring and observed impacts
Appin LW301 and LW302	0.8	650 mm Subsidence 1 mm/m Tensile Strain 3 mm/m Comp. Strain (Measured M & N-Lines)	600 metre aerial cable on standby. Ground survey, visual, OTDR. No reported impacts.
Appin LW703 to LW705	10.0 total for five cables	1200 mm Subsidence 2.1 mm/m Tensile Strain 4.5 mm/m Comp. Strain (Measured HW2, ARTC and MPR Lines)	New cable redirection to avoid potential impacts to old optical fibre cable. Ground survey, visual, OTDR. Strain concentrations detected in three cables, attenuation losses were relieved by locally exposing the cables or by building a bypass cable.
Tahmoor LW22 to LW32	4.5	775 mm Subsidence 0.8 mm/m Tensile Strain 1.9 mm/m Comp. Strain	Ground survey, visual, OTDR, SBS. No reported impacts.
Tower LW1 to LW10	1.7	400 mm Subsidence 3 mm/m Tilt 0.5 mm/m Tensile Strain 1 mm/m Comp. Strain	No reported impacts
West Cliff LW5A3, LW5A4 and LW29 to LW36	3.4	1300 mm Subsidence 1.3 mm/m Tensile Strain 5.5 mm/m Comp. Strain (Measured B-Line)	Survey, visual, OTDR, SBS. No reported impacts.

Note: SBS is a method of monitoring optical fibres and means Stimulated Brillouin Scattering

6.10.4. Impact assessments for copper telecommunications cables

The copper telecommunications cables are direct buried and could, therefore, potentially be impacted by ground strains. The greatest potential for impacts will occur as the result of localised ground strains due to non-conventional movements or valley related movements.

The copper cables are more likely to be impacted by tensile strains rather than compressive strains. It is possible, that the direct buried cables could experience higher tensile strains where they are anchored to the ground by associated infrastructure, or by tree roots. The cables could also experience higher compressive strains at the creek crossings as the result of valley related movements.

Aerial copper telecommunications cables are generally not affected by ground strains, as they are supported by the poles above ground level. The aerial cables, however, could be affected by the changes in bay lengths, i.e. the distances between the poles at the levels of the cables, which result from mining induced differential subsidence, horizontal ground movements and lateral movements at the tops of the poles due to tilting of the poles. The stabilities of the poles can also be affected by mining induced tilts and by changes in the catenary profiles of the cables.

Longwalls in the Southern Coalfield have been successfully mined directly beneath copper telecommunications cables, where the magnitudes of the predicted mine subsidence movements were similar to those predicted within the *Subsidence Study Area*. Some of these cases have been summarised in Table 6.22.

Table 6.22 Examples of mining beneath copper telecommunications cables

Colliery and Longwalls	Length of copper cables directly mined beneath (km)	Observed maximum movements at the copper cables	Observed impacts
Appin LW301 and LW302	0.8	650 mm Subsidence 1 mm/m Tensile Strain 3 mm/m Comp. Strain (Measured M & N-Lines)	No adverse impacts
Appin LW401 to LW409	4 km of underground cables and 0.8 km of aerial cables	700 mm Subsidence 5 mm/m Tilt 1 mm/m Tensile Strain 2 mm/m Comp. Strain (Measured A6000-Line)	No adverse impacts
Appin LW702 to LW705	8.3	1200 mm Subsidence 2.1 mm/m Tensile Strain 4.5 mm/m Comp. Strain (Measured HW2, ARTC and MPR Lines)	No adverse impacts
Tahmoor Mine LW22 to LW30	43.1 km of underground cables and 4.9 km of aerial cables	1300 mm Subsidence 12 mm/m Tilt 3.2 mm Tensile Strain 2 mm (typ.) and up to 7 mm/m Comp. Strain (Extensive street monitoring)	No adverse impacts to underground cables. Some pole tilts and cable catenaries adjusted. Some consumer cables were re-tensioned as a precautionary measure
West Cliff LW29 to LW36	13.9 km of underground cables	1300 mm Subsidence 1.3 mm/m Tensile Strain 5.5 mm/m Comp. Strain (Measured B-Line)	No adverse impacts

It can be seen from the above table, that there were no reported impacts on the direct buried copper telecommunications cables in the above examples. It is expected that the mining during the proposed development will result in similar experiences.

6.10.5. Impact assessments for NBN telecommunications tower

The NBN telecommunications tower is expected to experience subsidence during the extraction of proposed LWs S4A and S6A. The tower is a single pole structure and its structural integrity is unlikely to be adversely affected by the extraction of the proposed longwalls. The predicted tilts of 2.5 mm/m, while small, may affect the operation of the antennae on the structure.

The tilts can be readily adjusted by either relevelling the pole or the individual antennae, if required.

It is recommended that Tahmoor Coal consult with NBN regarding the tower to manage potential impacts on the tower and its operations.

6.10.6. Management of potential impacts on telecommunications infrastructure

Tahmoor Coal has developed Subsidence Management Plans in consultation with Telstra for the existing longwalls at Tahmoor Mine to manage potential impacts on telecommunications infrastructure.

It is recommended that similar Subsidence Management Plans be developed in consultation with Telstra, NBN and TPG to manage potential impacts on the telecommunications infrastructure within the *Subsidence Study Area*.

With appropriate management plans in place, it is considered that potential impacts on the telecommunications infrastructure can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

6.11. Dams, reservoirs or associated works

The Picton Weir is located on the Bargo River just downstream of the confluence with Hornes Creek. The weir was constructed in the late 19th century and it provided water to the surrounding townships. It is now heavily silted and is no longer used for water supply. Water retained by the weir is released at its base through a seized open valve and outlet pipe. No impacts were reported on the Picton Weir during the mining of previously extracted Longwalls 14 to 19, the closest of which was approximately 1.5 kilometres from the Weir (Longwall 19).

The Picton Weir is located approximately 940 metres from LW S6A. At this distance the Weir could experience very small far-field horizontal movements. While the Weir may experience very small differential horizontal movements as a result of the extraction of the proposed longwalls, it is extremely unlikely that the Picton Weir would be adversely impacted by the proposed mining.

It is recommended that Tahmoor Coal, in consultation with relevant government agencies, study the potential for impacts to the Picton Weir and develop management measures to ensure that it remains safe throughout the mining period and that impacts on the Picton Weir do not result in environmental consequences on the Bargo River. The study would require input from structural, geotechnical and subsidence engineers. The management measures may include a combination of:

- Mitigation or strengthening measures prior to mining;
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements;
- Conduct regular visual inspections of the Picton Weir; and
- Implement planned responses if triggered by monitoring and inspections.

As Tahmoor Mine will progressively approach the Picton Weir, it will be possible to review observations during the mining of each longwall and adjust the mine plan, if necessary to reduce the potential for impacts on Picton Weir. Picton Weir is also located beyond the finishing ends of the longwalls and it will be possible to stop the longwall during mining, if necessary based on actual observations during mining.

With an appropriate management plan in place, it is considered that the Picton Weir will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

6.12. Survey control marks

The locations of the survey control marks in the vicinity of the proposed longwalls are shown in Drawing No. MSEC1192-21. The locations and details of the survey control marks were obtained from Spatial Services using the *SCIMS Online* website (SCIMS, 2013).

The survey control marks are located across the *Subsidence Study Area* and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

The survey control marks located outside and in the vicinity of the *Subsidence Study Area* are also expected to experience small amounts of subsidence and small far-field horizontal movements. It is possible that other survey control marks outside the immediate area could also be affected by far-field horizontal movements, up to 3 kilometres outside the *Subsidence Study Area*. Far-field horizontal movements and the methods used to predict such movements are described further in Sections 3.5 and 4.6.

6.12.1. Recommendations for the survey control marks

In accordance with the Surveying and Spatial Information Act (2002) and the Surveyor-General's Direction No. 11 (2017), Tahmoor Coal is required to make a POSI application to disturb the survey control marks.

It will be necessary on the completion of the longwalls, when the ground has stabilised, to re-establish any state survey control marks that are required for future use. Consultation between Tahmoor Coal and Spatial Services NSW will be required throughout the mining period to ensure that these survey marks are reinstated at an appropriate time, as required.

7.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR THE PUBLIC AMENITIES

A number of public amenities have been identified within the Study Area and their locations are shown in Drawing No. MSEC1192-19.

7.1. Predictions and impact assessments for each public amenity

The public amenities within the *Subsidence Study Area* are spread over the proposed longwall mining area. The structures will collectively experience a range of subsidence movements varying from very small movements, where longwalls do not extract directly beneath them, to the maximum movements directly above the proposed longwalls. In a small proportion of cases, non-conventional subsidence movements will develop on the surface and these may coincide with the structures.

The maximum predicted values of conventional subsidence, tilt and curvature, based on the proposed LWs S1A to S6A, are provided in Table D.08, in Appendix D.

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each structure, as well as at points located at a distance of 20 metres from the perimeter of each public amenity.

The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

7.2. Methods of impact assessment

Some public amenities are of similar size and construction to houses and the method of assessment adopted for houses has been applied to these public amenities, the results of which are summarised in Appendix C.

Other public amenities are substantial in size and the method of assessment for houses is not applicable. The potential for impacts to these structures has been assessed on a case by case basis.

7.3. Hospitals

There are no hospitals within the *Subsidence Study Area*.

7.4. Places of worship

There are no places of worship within the *Subsidence Study Area*.

7.5. Schools

The Wollondilly Anglican College is located within the *Subsidence Study Area* and its location is shown in Drawing No. MSEC1192-19.

The Wollondilly Anglican College is located on Remembrance Drive opposite Tahmoor Mine, directly above and beyond the finishing end of proposed LW S1A. The structures have been constructed in stages from 2003 to 2020. Photographs of some of the buildings are provided in Fig. 7.1 to Fig. 7.11.

Fig. 7.1 Wollondilly Anglican College – Clifford Warne Auditorium

Fig. 7.2 Wollondilly Anglican College – Clifford Warne Auditorium with articulation joints in brick wall

Fig. 7.3 Wollondilly Anglican College – Banks Cottage and Sturt Cottage (single storey)

Fig. 7.4 Wollondilly Anglican College – Elizabeth Cottage (two-storey)

Fig. 7.5 Wollondilly Anglican College – Example of brickwork details

Fig. 7.6 Wollondilly Anglican College – Example of equipment inside Bradfield Cottage

Fig. 7.7 Wollondilly Anglican College – Hospitality training facilities inside TTC

Fig. 7.8 Wollondilly Anglican College – Lift in Cuthbert Cottage

Fig. 7.9 Wollondilly Anglican College – Shoulder to Shoulder Shelter

Fig. 7.10 Wollondilly Anglican College – Footbridge

Fig. 7.11 Wollondilly Anglican College – Sewage treatment tanks

The buildings are a mixture of single and double storey structures. The majority of the structures are steel framed with brick veneer walls. Newer double storey structures have been constructed as reinforced concrete frames with brick veneer walls. The oldest building, Sturt Cottage, is a single storey, double brick structure.

As demonstrated by the photographs, the building structures are in good condition and have been designed to accommodate future subsidence movements. The brickwork is consistent across the buildings, with recessed yellow coloured brickwork beneath the window sills. Most of the windows have light-weight panelling above the window and door openings, which will reduce the potential for impacts (Fig. 7.5).

While the majority of the building consist of standard classrooms, there are some specialised rooms that contain manufacturing and hospitality training equipment. A passenger lift is located within Cuthbert Cottage, as shown in Fig. 7.8. The open air Shoulder to Shoulder Shelter has been constructed with structural steel portal frames, as shown in Fig. 7.9.

Small creeks drainage surface water at the rear of the campus. A steel footbridge crosses a creek to provide access to the Rev. John Flynn Collegiate. A photograph of the footbridge is shown in Fig. 7.10. The steel deck connects to the concrete pavements at each end of the bridge, where a small air gap is present to accommodate expansion and contraction of the deck in response to changes in temperature.

Wollondilly Anglican College has provided details of services infrastructure within the property. Reinforced concrete sewage treatment tanks are located at the rear of the campus, as shown in Fig. 7.11.

7.5.1. Predictions for school infrastructure

The maximum predicted values of conventional subsidence, tilt and curvature, based on the proposed LWs S1A to S6A, are provided in Table D.08, in Appendix D. A summary image overlaying the predicted subsidence contours over Wollondilly Anglican College is shown in Fig. 7.12.

Fig. 7.12 Predicted subsidence contours overlaid on aerial photograph of Wollondilly Anglican College

It can be seen from Fig. 7.12 that the majority of the school structures are predicted to experience less than 100 mm of vertical subsidence, with very small tilts and curvatures. One structure, the Auditorium, is partly located directly above the finishing end of proposed LW S1A. The Auditorium is predicted to experience 300 mm of vertical subsidence, with maximum tilt of 4 mm/m and hogging curvature of 0.05 km^{-1}.

As the Wollondilly Anglican College is adjacent to previously extracted Longwalls 14B to 19, the property may also experience additional subsidence as has been previously observed above similar unmined coal barriers, as discussed in Section 4.4.

Where longwalls have previously been extracted on either side of main headings, the amount of increased subsidence in these areas has been generally been between 50 and 150 mm of subsidence above what was predicted using the prediction model. Subsidence monitoring from previous situations has shown that the additional subsidence is usually accompanied by relatively low conventional tilts, curvatures and strains (less than 0.5 mm/m and usually within survey tolerance).

7.5.2. Impact assessments for school infrastructure

Whilst many of the school buildings are larger in size, the form of construction of the structures within the Wollondilly Anglican School are similar to other rural and residential structures in the area. There is extensive experience of mining directly beneath similar structures in the Southern Coalfield which indicates that the incidence of impacts on these structures is very low and the structures have remained in safe and serviceable conditions. This is not surprising as these structures are generally small in size and of light-weight construction, such that they are relatively flexible and ductile compared to masonry buildings.

Tahmoor Mine has mined directly beneath more than 2000 structures of similar construction during the mining of LWs 22 to 32 and LW W1-W3. It has managed the mining induced impacts with the implementation of suitable management strategies. The structures have remained safe and serviceable during mining.

The primary risk associated with mining beneath the school structures is public safety. Occupants of building structures have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mining at the depths of cover similar to those found within the *Subsidence Study Area*. This includes the recent experience at Tahmoor Mine, where longwall mining has occurred beneath more than 2000 houses and civil structures. Tahmoor Mine has successfully mined directly beneath public amenity structures during the extraction of Longwalls 22 to 32.

Emphasis is placed on the words “immediate and sudden” as in rare cases, some structures have experienced severe impacts, but the impacts did not present an immediate risk to public safety as they developed gradually with ample time (over a period of months or weeks rather than hours) to relocate occupants.

Given that the proposed longwalls do not mine directly beneath the majority of the school campus, the potential for impacts is considered to be relatively low. The building structures have been designed to accommodate mine subsidence parameters. The structures consist of steel or reinforced concrete frames and the external walls are generally well articulated, with flexible panelling above window and door openings.

While the potential for impacts on the health and safety of students and staff at the school is considered to be very low, there is a chance that some cracking may develop at the school in isolated locations. The most likely areas to experience cracking are long brick walls, including the rendered feature walls that are located on the campus. Trip hazards may also develop along footpaths.

Tahmoor Coal has commenced consultation with Wollondilly Anglican School and has engaged an experienced structural engineer to conduct a pre-mining hazard identification inspection to assess the potential for impacts on school infrastructure, taking into account the predicted subsidence movements. The inspection has been completed and the findings from the structural assessments will inform a risk assessment.

In the event that impacts occur, repairs can be undertaken outside school hours, on weekends or during school holidays, to minimise inconvenience to students and staff. Any impacts would be expected to be minor and develop gradually, allowing them to be repaired at a suitable time. In the extremely unlikely event that severe impacts develop, it would be possible to pause longwall extraction as it approaches the school to ensure that the school remains safe, serviceable and operational during and after the proposed mining.

Based on the above information, it is assessed that with the implementation of a robust subsidence management plan, the proposed longwalls can be extracted without impacting on the safety of students and staff, or affect the use of the buildings at any time for educational or other purposes.

7.5.3. Management of potential impacts on Wollondilly Anglican School

Tahmoor Coal has extensive experience in successfully managing potential impacts on critical public amenities, including Picton High School during the extraction of LW 32.

Tahmoor Coal will develop a Property Subsidence Management Plan in consultation with Wollondilly Anglican School to manage potential impacts on during the extraction of the proposed longwalls. The management measures will include a combination of:

- Pre-mining hazard identification inspection of each structure by structural engineer (complete);
- Consider the implementation of possible mitigation measures prior to mining to reduce the likelihood of severe impacts;
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements around the school buildings, footbridge and sewage treatment tanks, and baseline measurements of sensitive classroom equipment;
- Conduct regular visual inspections of the building structures, and
- Implement planned responses if triggered by monitoring and inspections. Repairs would be completed outside school hours.

With an appropriate management plan in place, it is considered that potential impacts on the Wollondilly Anglican School can be managed during the extraction of the proposed longwalls, even if actual subsidence movements are greater than the predictions or substantial non-conventional movements occur.

7.6. Shopping centres

There are no shopping centres within the *Subsidence Study Area*. There are, however, a number of shops are located along Remembrance Drive within the *Subsidence Study Area* and the predictions and impact assessments for these establishments are provided in Section 9.1.

7.7. Community centres

With there are no community centres within the *Subsidence Study Area*.

7.8. Office buildings

There are no large commercial office buildings within the *Subsidence Study Area*. Small office buildings are located within the *Subsidence Study Area* and the predictions and impact assessments for these establishments are provided in Section 9.1.

7.9. Swimming Pools

There are no public swimming pools within the *Subsidence Study Area*.

7.10. Bowling greens

There are no bowling greens within the *Subsidence Study Area*.

7.11. Ovals or cricket grounds

A sportsground is located at the Wollondilly Anglican College. The oval, which is called the WACA, is located 260 metres from the end of proposed LW S2A. Given the offset distance from the proposed longwalls, it is not expected to experience impacts as a result of the proposed extraction.

Part of the oval is located above previously extracted LW 16 but was constructed well after mining had occurred. As the oval is located between previously extracted Longwalls 14B to 19 and the proposed LW S1A to S6A, the oval may also experience additional subsidence as has been previously observed above similar unmined coal barriers, as discussed in Section 4.4.

Where longwalls have previously been extracted on either side of main headings, the amount of increased subsidence in these areas has generally been between 50 and 150 mm of subsidence above what was predicted using the prediction model. Subsidence monitoring from previous situations has shown that the additional subsidence is usually accompanied by relatively low systematic tilts, curvature and strains (less than 0.5 mm/m and usually within survey tolerance).

With an appropriate management plan in place, it is considered that the oval will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

7.12. Racecourses

There are no racecourses within the *Subsidence Study Area*.

7.13. Golf courses

There are no golf courses within the *Subsidence Study Area*.

7.14. Tennis courts

There are two tennis courts within the *Subsidence Study Area* at the Wollondilly Anglican College. The courts are located 150 and 180 metres from the end of proposed LW S1A. Given the offset distance from the proposed longwalls, it is not expected to experience impacts as a result of the proposed extraction.

With an appropriate management plan in place, it is considered that the tennis courts will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

7.15. Any other public amenities

Australian Wildlife Sanctuary

The Australian Wildlife Sanctuary (formerly the Wirrimbirra Sanctuary) is located on Remembrance Drive and covers an area of approximately 95 ha. The Sanctuary contains rich and diverse plantings of native plants in formalised gardens, which were developed to provide areas of representative native plants for education and research purposes.

Australian Wildlife Sanctuary includes a visitor centre, a glass house and other shade structures, along with established gardens and walks. A dingo sanctuary is located on the property. Two cottages are located next to the visitor centre. Some structures were destroyed by bushfires in late 2019 but the main structures within the sanctuary, and the dingo sanctuary were successfully protected. It is planned to replace the lost buildings in the future.

The Australian Wildlife Sanctuary structures are located above LWs S3A and S4A near Teatree Hollow and the Main Southern Railway Line and will be directly mined beneath by the proposed longwalls. Predictions of subsidence, tilt and curvature have been provided for the identified structures within the Australian Wildlife Sanctuary in Table D.08, in Appendix D.

The visitor centre and surrounding structures are located directly above a chain pillar between LWs S3A and S4A. These structures will, therefore, experience slightly reduced subsidence, tilt and curvature compared to locations that are closer to the centre of LW S4A where greater subsidence movements typically occur.

The structures were inspected by John Matheson of JMA Solutions in January 2020. The structures generally comprise timber-framed structures with metal-clad timber-framed rooves on reinforced concrete ground slabs. The structures were found to be in serviceable condition. A photograph of the visitor centre is shown in Fig. 7.13.

Fig. 7.13 Australian Wildlife Sanctuary visitor centre

The nature and footprint size of structures within the Australian Wildlife Sanctuary are similar to other rural and residential structures in the area. There is extensive experience of mining directly beneath similar structures in the Southern Coalfield which indicates that the incidence of impacts on these structures is very low and the structures have remained in safe and serviceable conditions. This is not surprising as these structures are generally small in size and of light-weight construction, such that they are relatively flexible and ductile compared to masonry buildings.

Tahmoor Mine has mined directly beneath more than 2000 structures of similar construction during the mining of Longwalls 22 to 32. It has managed the mining induced impacts with the implementation of suitable management strategies. The structures have remained safe and serviceable during mining.

If impacts occur, they will most likely consist of non-structural cracking of walls, concrete floors or ceilings. There remains a small probability (less than 2 %), however, that a structure may experience severe impacts as result of substantial non-conventional movements. If impacts occur to heritage listed properties, the damage can be repaired in consultation with a heritage consultant to ensure that the heritage value of the structure is restored.

The primary risk associated with mining beneath the public amenity structures is public safety. Occupants of building structures have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mining at the depths of cover similar to those found within the *Subsidence Study Area*. This includes the recent experience at Tahmoor Mine, where longwall mining has occurred beneath more than 2000 houses and civil structures. Tahmoor Mine has successfully mined directly beneath public amenity structures during the extraction of Longwalls 22 to 32.

Emphasis is placed on the words “immediate and sudden” as in rare cases, some structures have experienced severe impacts, but the impacts did not present an immediate risk to public safety as they developed gradually with ample time (over a period of months or weeks rather than hours) to relocate occupants.

The Dingo Sanctuary Bargo is located on the same property as the Australian Wildlife Sanctuary but is managed separately. The dingos reside in a fenced enclosure with small structures. It is unlikely that dingo enclosure and associated structures will experience adverse impacts due to the extraction of the proposed longwalls. It is important, however, that integrity of the fences be monitored during periods of active subsidence, so that potential impacts can be readily repaired.

Tahmoor Coal has developed a draft Property Subsidence Management Plan to manage potential impacts on the Australian Wildlife Sanctuary. The management plan is currently being considered by Australian Wildlife Sanctuary as part of the consultation process. The management measures include a combination of:-

- Pre-mining hazard identification inspection of each structure by structural engineer (complete);
- Consider the implementation of possible mitigation measures prior to mining to reduce the likelihood of severe impacts (complete);
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements around the visitor centre;
- Conduct regular visual inspections of the building structures and the adjacent Dingo Sanctuary; and
- Implement planned responses if triggered by monitoring and inspections. Repairs to heritage structures would be planned in consultation with a heritage consultant.

With an appropriate management plan in place, it is considered that the Australian Wildlife Sanctuary will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

Bargo Cemetery

The Bargo Cemetery is managed by Wollondilly Shire Council. It is located at the northern end of Great Southern Road directly above the south-eastern end of the proposed LW 5SA, as shown in Drawing No. MSEC1192-19. The Cemetery is expected to experience less than the maximum predicted movements as provided in Table 4.1. Non-conventional subsidence movements may also develop at the cemetery.

The small cemetery is surrounded by a plantation of mature trees (Tahmoor Coal, 2022d). The grave sites and tombstones are in various condition and some graves do not have tombstones. The tombstones are generally of low height. The grounds are grassed and well kept. The cemetery is listed as an item of Heritage Significance.

The grave sites consist of isolated concrete and stone structures that are typically placed on the natural ground surface with minimal foundations. Due to their small sizes, the sites are expected to accommodate normal conventional subsidence movements. Impacts may occur, however, if substantial non-conventional movements developed at the cemetery. This may result in cracking of the surrounds or displacement of tombstones relative to the graves. Non-conventional movements are localised in nature and should substantial non- conventional movements develop at the cemetery, it is extremely unlikely that they will affect every grave site.

It is recommended that Tahmoor Coal consult with Wollondilly Shire Council to develop a subsidence management plan.

With an appropriate management plan in place, it is considered that the grave sites can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

The following sections provide the descriptions, predictions and impact assessments for the farm land and farm facilities within the *Subsidence Study Area*.

8.1. Agricultural utilisation

The agricultural land classification types within the *Subsidence Study Area* are illustrated in Fig. 8.1.

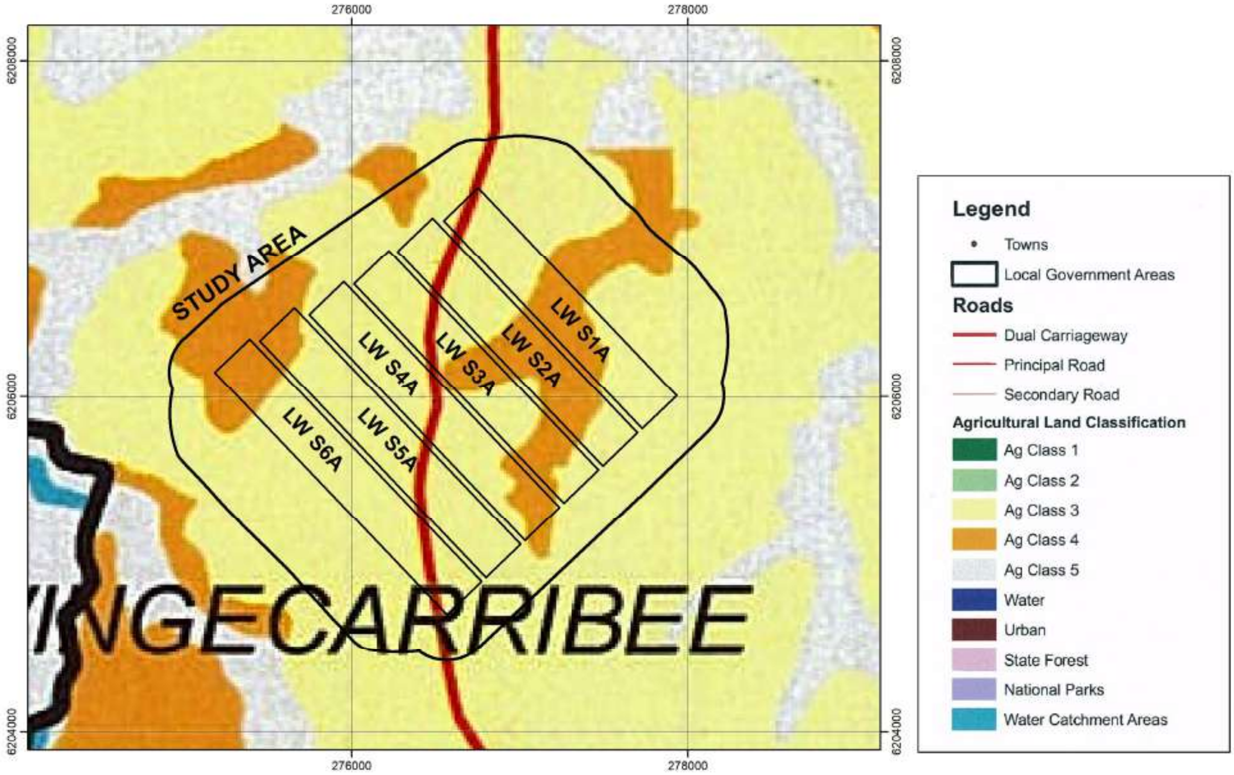

Fig. 8.1 Agricultural Land Classification within the Subsidence Study Area (Source DTIRIS, November 2008)

The above figure shows that there are two main agricultural land classification types within the *Subsidence Study Area*, which are:-

- Class 3 – Grazing land or land well suited to pasture improvement; and
- Class 4 – Land suitable for grazing but not for cultivation.

The flatter areas of land within the *Subsidence Study Area* have been predominately cleared and are used for light agricultural and residential purposes. The deeper valleys within the *Subsidence Study Area* have generally not been cleared of the natural vegetation.

Further information is included in the Land Management Plan (Tahmoor Coal, 2022b).

8.2. Rural structures

8.2.1. Descriptions of the rural structures

The locations of the rural structures (Structure Type R) within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-18.

There are 441 rural structures which have been identified within the *Subsidence Study Area*, of which 62 % will be mined directly beneath by the proposed longwalls. The rural structures include sheds, garages, carports, gazebos, pergolas, greenhouses, shade structures and other non-residential structures. The locations and sizes of the rural structures were determined from aerial photographs of the area.

8.2.2. Predictions for rural structures

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each rural structure, as well as at eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each rural structure within the *Subsidence Study Area* is provided in Table D.04, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Distributions of the maximum predicted conventional subsidence, tilt and curvature for the rural structures within the *Subsidence Study Area* are illustrated in Fig. 8.2 and Fig. 8.3.

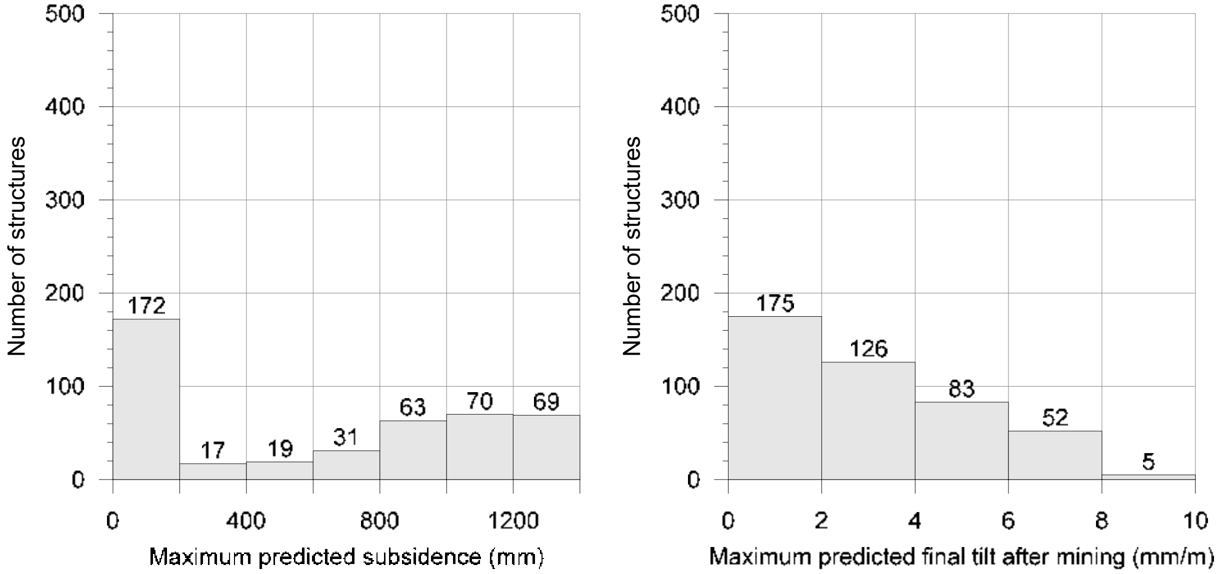

Fig. 8.2 Maximum predicted conventional subsidence and tilt for rural structures within the Subsidence Study Area

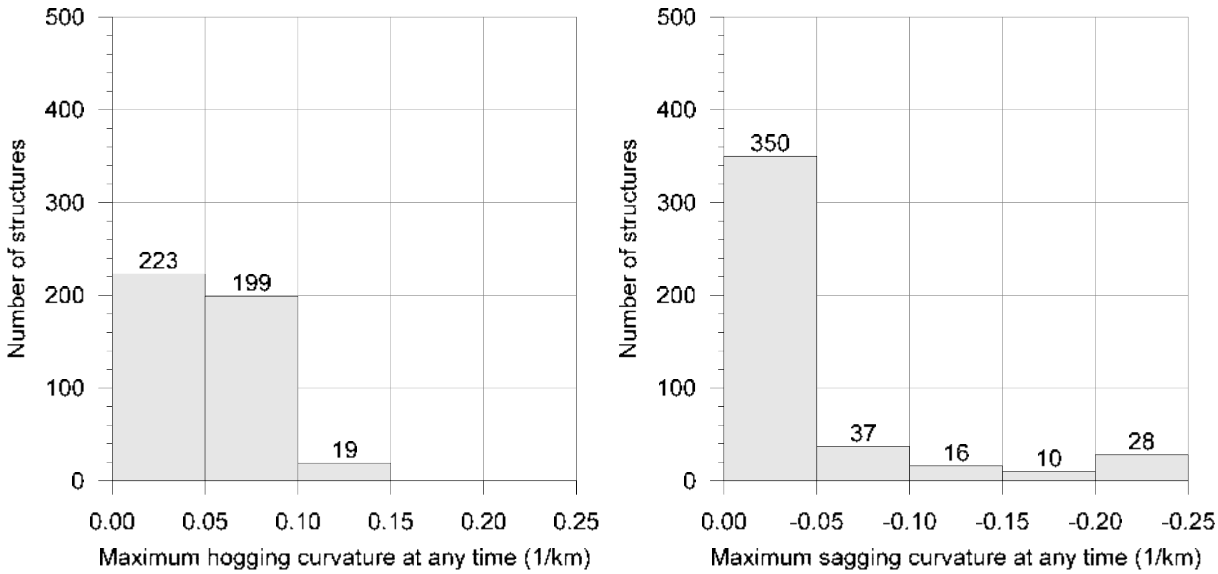

Fig. 8.3 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for rural structures within the Subsidence Study Area

The maximum predicted conventional curvatures for the rural structures are 0.11 km^{-1} hogging and 0.23 km^{-1} sagging, which equate to minimum radii of curvature of 9.1 kilometres and 4.3 kilometres, respectively. The maximum predicted conventional strains for the rural structures, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.7 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The rural structures are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

8.2.3. Impact assessments for rural structures

The maximum predicted tilt for the rural structures is 9 mm/m (i.e. 0.9 %), which represents a change in grade of 1 in 111. The majority of the rural structures within the *Subsidence Study Area* are of lightweight construction and able to tolerate mining-induced tilt. It has been found from past longwall mining experience that tilts of the magnitudes predicted within the *Subsidence Study Area* generally do not result in adverse impacts on rural structures. Some minor serviceability impacts could occur at the higher levels of predicted tilt, including door swings and issues with roof and pavement drainage, all of which can be remediated using normal building maintenance techniques.

There is extensive experience of mining directly beneath rural structures in the Southern Coalfield which indicates that the incidence of impacts on these structures is very low and the structures have remained in safe and serviceable conditions. This is not surprising as rural structures are generally small in size and of light-weight construction, which makes them less susceptible to impact than houses which are typically more rigid.

Tahmoor Mine has mined directly beneath more than 2000 rural structures of similar construction during the mining of LWs 22 to 32 and LW W1-W3. It has managed the mining induced impacts with the implementation of suitable management strategies. The structures have remained safe and serviceable during mining.

Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North, it would still be expected that the rates of impact would be low and could be managed with the implementation of suitable management strategies. Impacts on rural structures have been successfully managed elsewhere in the NSW Coalfields, where the predicted subsidence parameters were similar to or greater than those predicted for the proposed longwalls.

Based on previous experiences, it is expected that the rural structures within the *Subsidence Study Area* would remain safe and serviceable during the mining period, provided that they are in sound existing condition. The risk of impact is clearly greater if the structures are in poor existing condition, though the chances of there being a public safety risk remains very low. A number of rural structures which were in poor existing condition have been directly mined beneath and these structures have not experienced impacts during mining.

Impacts on the rural structures that occur as the result of the extraction of the proposed longwalls are expected to be remediated using well established building techniques. With these remediation measures available, it is unlikely that there would be long term impacts on rural structures resulting from the extraction of the proposed longwalls.

8.2.4. Impact assessments for rural structures based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the rural structures would be 18 mm/m (i.e. 1.8 %), or a change in grade of 1 in 56. In this case, the incidence of serviceability impacts, such as door swings and issues with gutter and pavement drainage, would increase in the locations of greatest tilt, such as adjacent to the active longwall maingate and adjacent to the ends of the proposed longwalls. It would still be unlikely that stabilities of these rural structures would be affected by tilts of these magnitudes.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts would increase for the rural structures located directly above the proposed longwalls. Since rural structures are generally small in size and of light-weight construction, they would still be expected to remain safe, serviceable and repairable using normal building maintenance techniques. With the implementation of any necessary remediation measures, it is unlikely that there would be any substantial long-term impacts on the rural structures.

While the predicted ground movements are important parameters when assessing the potential impacts on the rural structures, it is noted that the impact assessments were primarily based on historical observations from previous longwall mining in the Southern Coalfield. The overall levels of impact on the rural structures, resulting from the extraction of the proposed longwalls, are expected to be similar to those observed where longwalls have previously mined directly beneath rural structures in the Southern Coalfield.

8.2.5. Management of potential impacts on rural structures

Tahmoor Coal has developed and acted in accordance with a risk management plan to manage potential impacts to farm buildings during the mining of LWs 22 to 32 and LWs W1-W3. The management plan provides for identification of buildings in poor pre-mining condition that are hazardous or may become hazardous due to mining, and monitoring of structures during active subsidence. If impacts occur, the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on rural structures during the mining of the proposed longwalls.

With an appropriate management plan in place, it is considered that rural structures can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

8.3. Tanks

8.3.1. Descriptions of the tanks

The locations of the tanks (Structure Type T) within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-18.

There are 74 tanks which have been identified within the *Subsidence Study Area*, just less than half of which will not be mined directly beneath by the proposed longwalls. The locations and sizes of the tanks were determined from aerial photographs of the area and kerb side inspections. There are also a number of smaller rainwater tanks associated with the houses which are not shown in these drawings.

8.3.2. Predictions for the tanks

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each tank, as well as at points located at a distance of 20 metres from the perimeter of each tank.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each tank within the *Subsidence Study Area* is provided in Table D.05, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Distributions of the maximum predicted conventional subsidence, tilt and curvature for the tanks within the *Subsidence Study Area* are illustrated in Fig. 8.4 and Fig. 8.5.

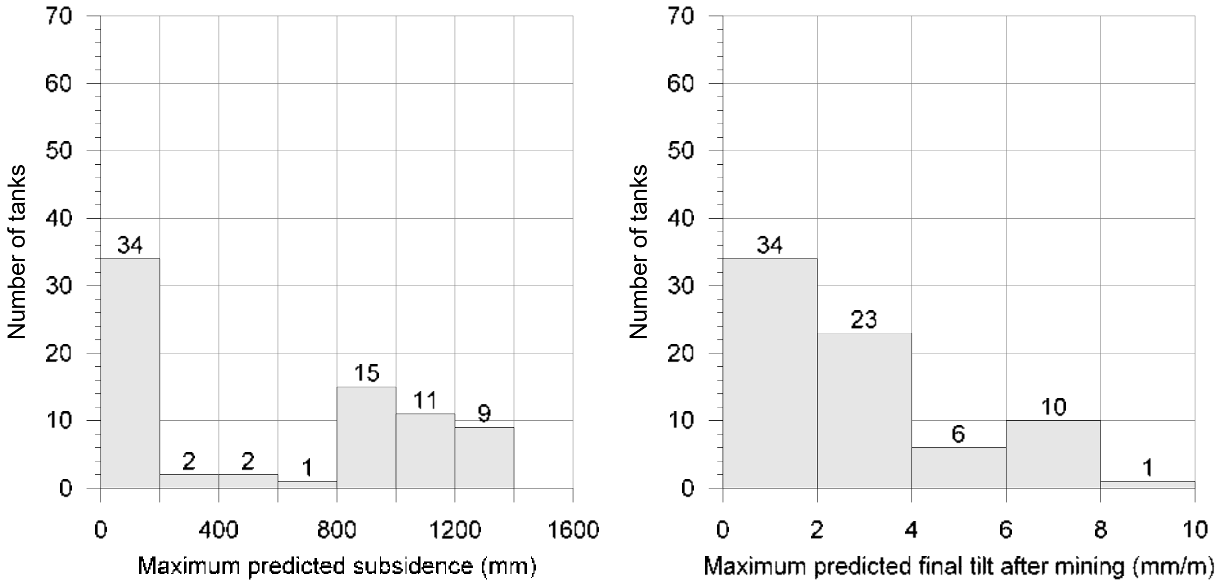

Fig. 8.4 Maximum predicted conventional subsidence and tilt for tanks within the Subsidence Study Area

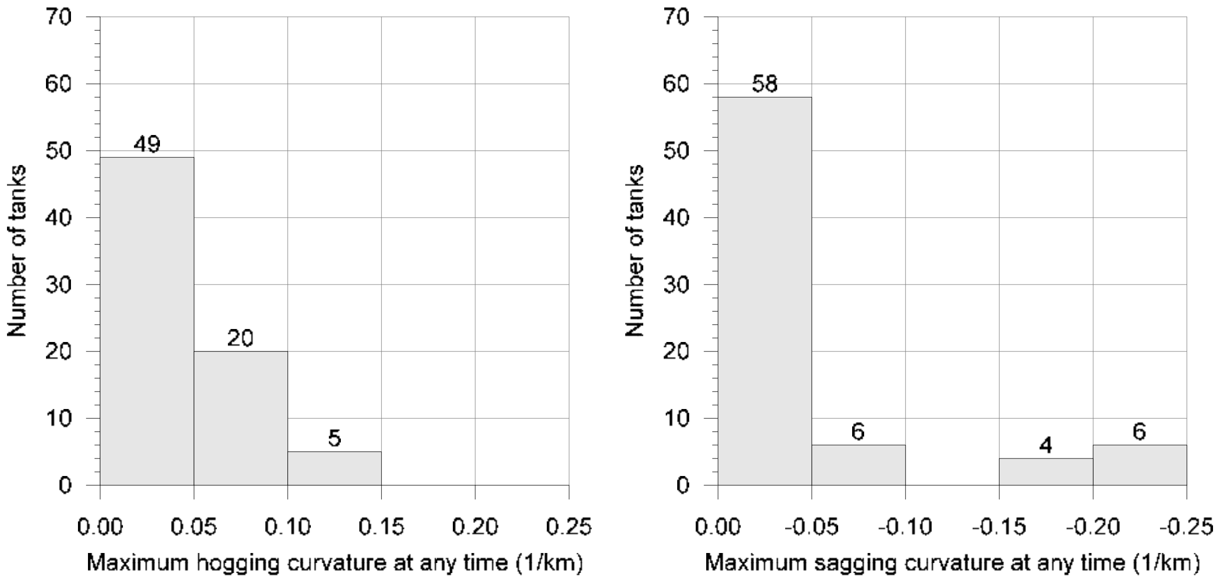

Fig. 8.5 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for tanks within the Subsidence Study Area

The maximum predicted conventional strains for the tanks, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.7 mm/m tensile and 3.3 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The tanks are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

8.3.3. Impact assessments for the tanks

Tilt can potentially affect the serviceability of tanks by altering the water levels in the tanks, which can in turn affect the minimum level of water which can be released from the outlets. The maximum predicted conventional tilt for the tanks within the *Subsidence Study Area* is 9 mm/m (i.e. 0.9 %), which represents a change in grade of 1 in 111. The predicted changes in grade are small and unlikely, therefore, to result in any adverse impacts on the serviceability of the tanks.

The tanks are typically constructed above ground level and, therefore, are unlikely to experience the curvatures and ground strains resulting from the extraction of the proposed longwalls. It is possible that any buried water pipelines associated with the tanks within the *Subsidence Study Area* could be impacted by the ground strains, if they are anchored by the tanks, or by other structures in the ground.

Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be easily repaired. With these remedial measures in place, it would be unlikely that there would be any adverse impacts on the pipelines associated with the tanks.

8.3.4. Impact assessments for the tanks based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the tanks would be 18 mm/m (i.e. 1.8 %), or a change in grade of 1 in 56. In this case, the incidence of serviceability impacts, such as changes in the minimum water levels which can be released from the outlets, could increase in the locations of greatest tilt, such as adjacent to the active longwall maingate and adjacent to the ends of the proposed longwalls. Impacts would be expected to be remediated by relevelling the tanks.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts on the tank structures would not be expected to change substantially, as they are not expected to experience these ground movements. The incidence of impacts on the buried pipelines would, however, be expected to increase in the locations directly above the proposed longwalls. Impacts would still be expected to be of a minor nature which could be easily repaired. With these remediation measures in place, it would be unlikely that there would be long term impacts on the pipelines associated with the tanks.

8.3.5. Management of potential impacts on the tanks

Tahmoor Coal has developed and acted in accordance with a risk management plan to manage potential impacts to tanks during the mining of LWs 22 to 32 and LWs W1-W3. The management plan provides for identification of tanks in poor pre-mining condition that are hazardous or may become hazardous due to mining, and monitoring of structures during active subsidence. If impacts occur, the structure will be repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on tanks during the mining of the proposed longwalls.

With an appropriate management plan in place, it is considered that tanks can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

8.4. Gas and fuel storages

A number of the residences within the *Subsidence Study Area* have gas or fuel storages.

The domestic gas and fuel storages are located across the *Subsidence Study Area* and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

The storage tanks are generally elevated above ground level and, therefore, are not susceptible to mine subsidence movements. It is possible, however, that any buried gas pipelines associated with the storage tanks within the *Subsidence Study Area* could be impacted by the curvatures and ground strains, if they are anchored by the storage tanks, or by other structures in the ground.

Impacts are expected to be of a minor nature, including minor gas leaks, which could be easily repaired. It is unlikely that there would be any adverse impacts on the pipelines associated with the gas and fuel storage tanks, even if the actual movements exceeded the predictions by a factor of 2 times.

8.5. Poultry sheds

There are 21 poultry sheds within the *Subsidence Study Area*. The poultry sheds are lightweight structures up to 113 metres in length.

The Inghams Bargo Chicken Breeder Complex Production Complex is located on Remembrance Drive, beyond the finishing ends of LWs S2A and S3A (MSEC Ref. BRE_030). The Inghams Turkey Farm (MSEC Ref. BYR_065) and Bargo Valley Produce poultry sheds, which are leased to Inghams (MSEC Ref. BYR_055) are located on Yarran Road, to the side of LW S6A. Part of one shed at Bargo Valley Produce is located directly above LW S6A.

8.5.1. Predictions for the poultry sheds

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each poultry shed, as well as at points located at a distance of 20 metres from the perimeter of each poultry shed.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each poultry shed within the *Subsidence Study Area* is provided in Table D.10, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures provided in this table are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

The poultry sheds are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

8.5.2. Impact assessments for the poultry sheds

The poultry sheds are predicted to experience relatively mild conventional subsidence, tilt, curvatures and strains as the proposed LWs S1A to S6A do not mine directly beneath all but one of them. The maximum predicted conventional subsidence for the poultry sheds within the *Subsidence Study Area* is 325 mm.

Tilt can potentially affect the serviceability of poultry sheds by altering the watering and drainage systems in the sheds. The maximum predicted conventional tilt for the poultry sheds within the *Subsidence Study Area* is 3.5 mm/m (i.e. 0.35 %), which represents a change in grade of 1 in 285. The predicted changes in grade are small and unlikely, therefore, to result in any adverse impacts on the serviceability of the poultry sheds.

Mining-induced curvature and ground strain can result in the opening of gaps or cracks in the wall linings of the poultry sheds. This may adversely affect their hygiene integrity, depending on the birds that are housed in them. The potential for impacts are, however, considered low as the proposed LWs S1A to S6A do not mine directly beneath all but one of the sheds.

A number of large poultry sheds have been previously mined beneath in the Southern Coalfield. West Cliff Longwalls 30 to 33, for example, mined directly beneath 40 poultry sheds and in all cases the structures remained in safe and serviceable condition. This included four sheds which experienced large non-conventional ground movements, due to near surface geological structures, which resulted in impacts to the walls and roofs of the sheds but did not result in the structures becoming unsafe.

It is expected that the predicted mine subsidence movements on the sheds and ancillary building structures can be managed by the implementation of suitable management strategies, which may include visual monitoring during active subsidence. The level of monitoring and management may vary depending on the type and age of bird in the sheds and the level of isolation that is required from the external environment.

8.5.3. Management of potential impacts on the poultry sheds

Tahmoor Coal has developed and acted in accordance with a risk management plan to manage potential impacts to commercial operations during the mining of LWs 22 to 32 and LWs W1-W3.

It is recommended that Tahmoor Coal continues its current practice of ensuring that the structures remain safe and serviceable at all times during mining and that impacts on business operations are minimised. It is recommended that Tahmoor Coal, in consultation with the owners of the poultry farms, study the potential for impacts on the poultry sheds and other infrastructure and develop management measures. The management measures may include a combination of:-

- Pre-mining hazard identification inspection of each structure by structural engineer;
- Consider the implementation of possible mitigation measures prior to mining to reduce the likelihood of severe impacts;

- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements;
- Conduct regular visual inspections of the poultry farms; and
- Implement planned responses if triggered by monitoring and inspections.

With an appropriate management plan in place, it is considered that poultry farms will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occur.

8.6. Glass houses

No glass houses have been identified within the *Subsidence Study Area*, though there are a number of greenhouses and hothouses. These structures are expected to experience the full range of predicted subsidence movements. As these structures are relatively lightweight in construction, they are usually able to tolerate differential subsidence movements. Impacts can occur, for example, if the roof materials are designed to be slid open or closed to ventilation the greenhouse or hothouse, as substantial differential horizontal movements can cause the frames to rack and prevent sliding of the materials.

It is expected that the predicted mine subsidence movements on the greenhouses and hothouses can be managed in consultation with the landowner by the implementation of suitable management strategies, which may include visual monitoring during active subsidence.

8.7. Hydroponic systems

There are no known hydroponic systems within the *Subsidence Study Area*. However, there are a number of greenhouses and hothouses. These buildings may have hydroponic systems. While the water pipes are usually flexible and able to tolerate differential subsidence movements, the drainage of the systems may require monitoring and adjustment, if necessary.

It is expected that the predicted mine subsidence movements on the hydroponic systems can be managed in consultation with the landowner by the implementation of suitable management strategies, which may include visual monitoring during active subsidence.

8.8. Irrigation systems

Irrigation systems are used on commercial and private properties with agricultural utilisation. Elevated troughs are located on Bargo Valley Produce on Yarran Road, to the side of LW S6A. Irrigation systems are usually constructed from polyethylene pipes which can tolerate ground movements much larger than the predicted mine subsidence movements within the *Subsidence Study Area*.

Elevated strains can occur in the pipelines where they are anchored to the ground, or where they are subjected to non-systematic ground movements. Impacts are expected to be minor, including leaking joints, which could be readily remediated.

8.9. Farm fences

Fences are located across the *Subsidence Study Area* and, therefore, are expected to experience the full range of predicted subsidence movements. A summary of the maximum predicted conventional subsidence movements within the *Subsidence Study Area* is provided in Chapter 4.

The fences are linear features and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. The analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.2 and the results are provided in Fig. 4.4.

Non-conventional movements can also occur and have occurred in the NSW Coalfields as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The fences within the *Subsidence Study Area* are constructed in a variety of ways, generally using either timber, brick or metal materials.

Wire fences can be affected by tilting of the fence posts and by changes of tension in the fence wires due to strain as mining occurs. These types of fences are generally flexible in construction and can usually tolerate tilts of up to 10 mm/m and strains of up to 5 mm/m without adverse impacts. It is possible, that some of the wire fences within the *Subsidence Study Area* could be impacted as the result of the extraction of the proposed longwalls. Any impacts on the wire fences are likely to be of a minor nature and relatively easy to remediate by re-tensioning the fencing wire, straightening the fence posts, and if necessary, replacing some sections of fencing.

Colorbond, brick and timber paling fences are more rigid than wire fences and, therefore, are more susceptible to impacts resulting from mine subsidence movements. It is possible that these types of fences could be impacted as the result of the extraction of the proposed longwalls. Any impacts on Colorbond, brick or timber paling fences can be remediated or, where necessary, affected sections of the fences replaced.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on fences during the mining of the proposed longwalls.

8.10. Farm dams

8.10.1. Descriptions of the farm dams

The locations of the farm dams within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-18. The maximum plan dimensions and plan areas for these dams are provided in Table D.07, in Appendix D.

There are 45 farm dams (Structure Type D) which have been identified within the *Subsidence Study Area*. The locations and sizes of the farm dams were determined from aerial photographs of the area. The distributions of the longest lengths and surface areas of the farm dams within the *Subsidence Study Area* are shown in Fig. 8.6.

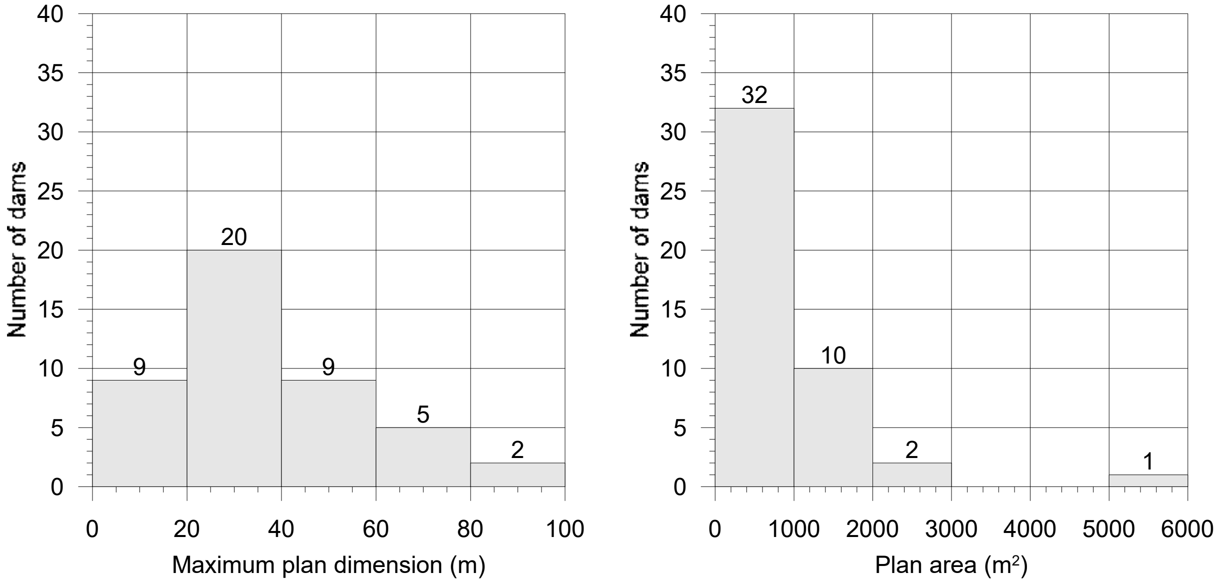

Fig. 8.6 Distributions of longest lengths and surface areas of the farm dams

The longest lengths of the farm dams within the *Subsidence Study Area* vary between 8 metres and 99 metres and the plan areas vary between 26 m^2 and 5,047 m^2.

The dams are typically of earthen construction and have been established by localised cut and fill operations within the natural streams. The farm dams are generally shallow, with the dam wall heights generally being less than 3 metres.

8.10.2. Predictions for the farm dams

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and around the perimeters of each farm dam, as well as at points located at a distance of 20 metres from the perimeter of each dam.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each farm dam within the *Subsidence Study Area* is provided in Table D.07, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Distributions of the maximum predicted conventional subsidence, tilt and curvature for the farm dams within the *Subsidence Study Area* are illustrated in Fig. 8.7 and Fig. 8.8.

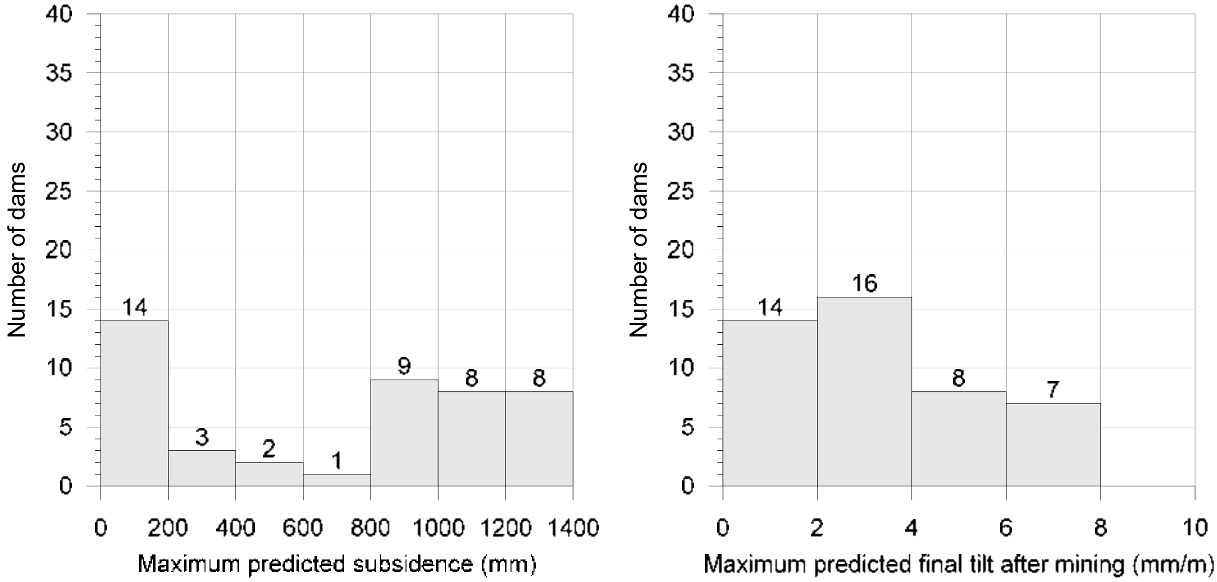

Fig. 8.7 Maximum predicted conventional subsidence and tilt for the farm dams within the Subsidence Study Area

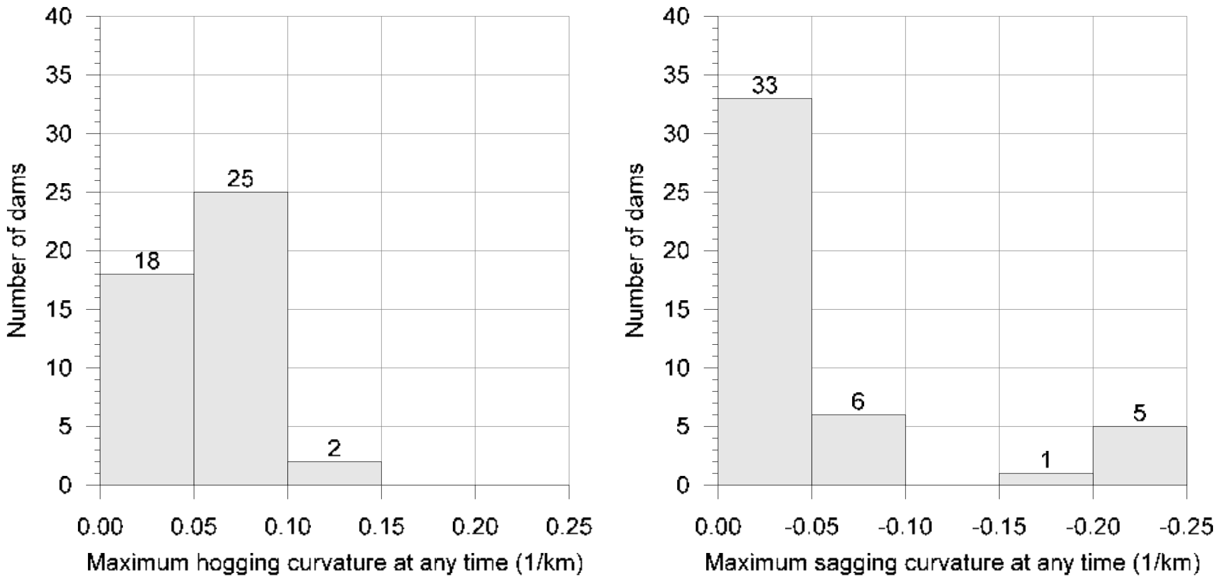

Fig. 8.8 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for the farm dams within the Subsidence Study Area

The maximum predicted conventional strains for the farm dams, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 2.0 mm/m tensile and 3.3 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The farm dams are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

The farm dams have typically been constructed within the streams and, therefore, may be subjected to valley related movements resulting from the extraction of the proposed longwalls. The equivalent valley heights at the dams are very small and it is expected, therefore, that the predicted valley related upsidence and closure movements at the dam walls would be much less than the predicted conventional subsidence movements and would not be substantial.

8.10.3. Impact Assessments for the farm dams

The maximum predicted final tilt for the farm dams is 7.5 mm/m (i.e. 0.75 %), which represents a change in grade of 1 in 133. Mining induced tilts can affect the water levels around the perimeters of farm dams, with the freeboard increasing on one side, and decreasing on the other. Tilt can potentially reduce the storage capacity of farm dams, by causing them to overflow, or can affect the stability of the dam walls.

The predicted changes in freeboard at the farm dams within the *Subsidence Study Area* were determined by taking the difference between the maximum predicted subsidence and the minimum predicted subsidence anywhere around the perimeter of each farm dam. The predicted maximum changes in freeboard at the farm dams within the *Subsidence Study Area*, after the completion of the proposed longwalls, are provided in Table D.07, in Appendix D, and are illustrated in Fig. 8.9.

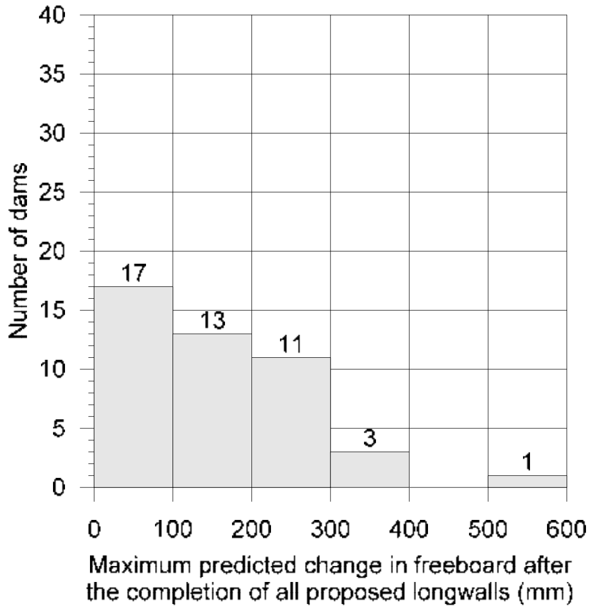

Fig. 8.9 Predicted changes in freeboards for the farm dams within the Subsidence Study Area

It can be seen from the above figure, that the predicted changes in freeboard are less than 300 mm at 41 dams within the *Subsidence Study Area* (i.e. 91 % of the total) and less than 400 mm at 44 dams (i.e. 98 % of the total). It is unlikely that the majority of the farm dams within the *Subsidence Study Area* would experience adverse impacts on the storage capacities due to these small changes in freeboard.

The predicted changes in freeboard are greater than 500 mm at 1 dam within the *Subsidence Study Area* (i.e. < 2 % of the total), with the maximum predicted change in freeboard being 500 mm. It is possible that this dam could experience a reduced storage level, however, this could be remediated by increasing the height of the affected dam wall.

The maximum predicted conventional curvatures for farm dams are 0.14 km^{-1} hogging and 0.22 km^{-1} sagging, which represent minimum radii of curvature of 7.1 kilometres and 4.5 kilometres, respectively. The predicted curvatures and strains could be sufficient to result in cracking in the bases and walls of some farm dams within the *Subsidence Study Area*.

There is extensive experience of mining directly beneath farm dams in the Southern Coalfield, which indicates that the incidence of impacts on these features is very low. Farm dams are commonly constructed with cohesive materials in the bases and walls which can absorb the conventional subsidence movements typically experienced in the Southern Coalfield without the development of substantial cracking. Non-conventional movements can result in localised cracking and deformations at the surface and, where coincident with farm dams, could result in adverse impacts.

Tahmoor Coal has mined LW22 to LW32 and LW W1-W3 beneath approximately 110 dams. While a small number of landowners have advised of impacts, there has been one claim to SA NSW for impacts on farm dams at the time of the report.

Similarly, South32 Illawarra Coal has mined directly beneath more than 200 farm dams in Appin Area 3, Appin Area 4, Appin Area 7, Appin Area 9 and West Cliff Area 5. Loss of water was reported for one dam in Appin Area 7, however, it was noted that this dam was of poor, shallow construction and seepage was observed at the base of the dam wall prior to mining.

Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North and at Appin and West Cliff Collieries, it would still be expected that the rates of impact on the farm dams would be very low and could be managed with the implementation of suitable management strategies.

Any substantial cracking in the dam bases or walls could be repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

8.10.4. Impact assessments for the farm dams based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilt at the farm dams, at the completion of mining, would be 15 mm/m (i.e. 1.5 %), or a change in grade of 1 in 67. In this case, there would be 7 dams within the *Subsidence Study Area* (i.e. 16 % of the total) where the predicted change in freeboard was greater than 500 mm. In some cases, the tilts could be sufficient to reduce the capacities of the farm dams below acceptable levels, however, these could be remediated by increasing the heights of the affected dam walls.

If the actual curvatures or strains exceeded those predicted by a factor of 2 times, the likelihood and extent of cracking would increase for the farm dams located directly above the proposed longwalls. Any surface cracking would still be expected to be of a minor nature and could be readily repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

8.10.5. Management of potential impacts on the farm dams

Tahmoor Coal has developed and acted in accordance with a risk management plan to manage potential impacts to dams during the mining of LWs 22 to 32 and LWs W1-W3. This includes an assessment of potential environmental or safety consequences as a result of dam breach. The management plan provides for visual monitoring of dams immediately prior to and after active subsidence at each dam.

If impacts occur to the dams, Tahmoor Coal will supply water to the landowner on a temporary basis until the dam is repaired in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts on dams during the mining of the proposed longwalls, as part of the Land Management Plan.

With an appropriate management plan in place, it is considered that dams can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

8.11. Groundwater bores

The Groundwater Impact Assessment (SLR, 2022a) provides an assessment on groundwater bores.

9.1. Industrial, commercial and business establishments in general

A total of 143 structures are located within the *Subsidence Study Area* that are used for industrial, commercial or business purposes. The establishments include the Bargo Petroleum and Hill Top Pit Stop (petrol station, automotive repair workshop), Wreck1 (an auto wreckers yard), MKD Machinery (a concrete plant), Inghams poultry farms, Bargo Valley Produce facilities, the Canine Country Club and Cattery, Pamak Hobbies and garden railway and the Tahmoor Garden Centre. They also include mine infrastructure owned and operated by Tahmoor Mine.

The Bargo Waste Management Centre is located more than 1 kilometre from the proposed LWs S1A to S6A and will not experience mine subsidence as a result of the extraction of the proposed longwalls.

As shown in Drawing No. MSEC1192-19, most of the structures are located along either Remembrance Drive or Yarran Road.

Photograph courtesy JMA Solutions

Fig. 9.1 Tahmoor Garden Centre

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and around the perimeters of each structure, as well as at points located at a distance of 20 metres from the perimeter of each structure.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature and impact assessments for each structure within the *Subsidence Study Area* is provided in Table D.10, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Tahmoor Coal has previously developed and acted in accordance with risk management plans to successfully manage potential impacts to industrial, commercial and business establishments during the mining of LWs 22 to 32, including a turkey processing plant, a large shopping centre and a variety of shops.

Each business is unique in terms of the structures on the property and the activities that are conducted on each property.

Due to the unique nature of each business, it is recommended that individual subsidence management plans be developed in consultation with the owners of each business that are predicted to experience more than 20 mm of subsidence due to the extraction of the proposed longwalls. The management strategy for each business would include:

- Consultation with the owner of each business
- Pre-mining hazard identification inspection of each structure by structural engineer
- Identification and assessment of potential impacts to the operation of each business and safety of workers and the general public
- Consideration of mitigation measures to reduce risk prior to the commencement of subsidence movements
- Consideration of appropriate monitoring measures
- Consideration of appropriate triggered responses during mining
- Development of an agreed detailed subsidence management plan between Tahmoor Coal and the owners of each business

Each management plan would be reviewed periodically by Tahmoor Coal and the owners of each business.

9.2. Gas or fuel storages and associated plant

The Bargo Petroleum service station (MSEC Structure Ref. BRE_040) is located on Remembrance Drive near the Wollondilly Anglican College. It is located directly above LW S2A. A vehicle mechanic workshop and a wreckers yard is located adjacent to the service station.

Photographs of the site were taken during the pre-mining hazard identification inspection by structural engineer JMA Solutions and a selection is provided in Fig. 9.2.

Photographs courtesy JMA Solutions

Fig. 9.2 Bargo Petroleum and Mechanic's Workshop

There is limited history of longwall mining beneath petrol stations in the Southern Coalfield. Appin Longwall 1 mined directly beneath a petrol station in the 1970's and no information on impacts on this operation is known.

West Cliff Longwall 5A3 mined directly beneath a petrol station at Appin. A flexible coupling was installed prior to mining to ensure that ground movement between pumps, tanks and the connecting pipes could be accommodated. A monitoring line (B-Line) was installed directly outside the petrol station. Substantial non-conventional movements were observed in the vicinity of the petrol station, including a bulge in the road directly outside it. The monitoring line indicated that total subsidence of 140 mm to 290 mm developed during the mining of Longwalls 5A1 to 5A4, with observed compressive ground strain of 3.7 mm/m, which is substantial.

The MSB (now SA NSW) reported that no impacts were observed to the petrol tank, though some impacts were observed to the anti-flood valve and some lines connecting the petrol tank to the bowsers and fill points. There were also some impacts to the shop and concrete pavement. The impacts did not present an immediate public safety hazard.

Tahmoor Mine Longwall 25 mined adjacent to but not directly beneath a petrol station located at Thirlmere Way at Tahmoor. The petrol station experienced approximately 250 mm of subsidence during the mining of Longwalls 22 to 25. While no impacts were observed to the petrol tanks, some impacts were observed to the concrete slabs and kerbs. The structural steel columns to the awning were also observed to bend as a result of differential subsidence movements.

Predictions for the petrol station structures are provided in Table D.10, in Appendix D, where it can be seen that the Bargo Petroleum service station is predicted to experience subsidence of approximately 1000 mm at the workshop.

It is possible the Bargo Petroleum station could experience impacts to the petrol tanks and fuel lines, the hardstand areas or the building and awning structures as a result of the extraction of the proposed longwalls.

Tahmoor Coal has commenced consultation with the owner of the petrol station, for the purposes of developing management measures to ensure that the petrol station remains safe and serviceable throughout the mining period. The management measures may include a combination of:

- Engineering inspections of existing condition of the petrol stations, including the buried tanks;
- Pre-mining hazard identification inspection of each structure by structural engineer;
- Mitigation or strengthening measures prior to mining, particularly to the petrol tanks and fuel lines;
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements and integrity of the petrol tanks and fuel lines;
- Conduct regular visual inspections of the petrol station; and
- Implement planned responses if triggered by monitoring and inspections.

With appropriate management plans in place, it is considered that the petrol station will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

9.3. Mine infrastructure including tailings dams or emplacement areas

Surface facilities at Tahmoor Mine, including a total of 142 building structures, tanks and dams are located within the *Subsidence Study Area*, as shown in Drawing No. MSEC1192-20. The majority of the facilities will not be directly mined beneath but a number of structures and other infrastructure will experience mine subsidence movements due to the extraction of the proposed LWs S1A to S6A. These include:

- Rail loop line;
- The coal stockpile area;
- Overhead coal conveyors;
- Underground coal conveyors and associated tunnels;
- Plant associated with the coal conveyors,
- The drift portal;
- The winder;
- Building structures, including the coal bins, mine office, bath houses, the washery, workshops and the administration building;
- Overhead gantry crane and monorail within the washery;
- The road bridge over the Rail Loop;

- Associated services infrastructure;
- Dams; and
- Unsealed access roads.

There are also surface facilities just outside the *Subsidence Study Area*, including the No. 3 Shaft that is the second entry and egress from the mine, the gas plant and the power generation plant.

The stockpile area will be directly mined beneath by LW S1A and this consists of an Overhead Conveyor 5C with the reclaim tunnel and Conveyor 6C underneath. Photographs are provided in Fig. 9.3 to Fig. 9.5.

Fig. 9.3 Aerial view of Tahmoor Mine site

Fig. 9.4 Aerial view of Stockpile area and Overhead Conveyor 5C

Fig. 9.5 Reclaim tunnel with Underground Conveyor 6C

9.3.1. Predictions for the mine infrastructure

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and around the perimeters of each structure, tank and dam, as well as at points located at a distance of 20 metres from the perimeter of each feature.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature and impact assessments for each mine structure, tank and dam within the *Subsidence Study Area* is provided in Table D.10, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

The predictions in Table D.10 do not include linear infrastructure features, including the rail loop and the conveyors. A map of the surface facilities at Tahmoor Mine has been overlaid with the predicted subsidence contours, which is shown in Fig. 9.6

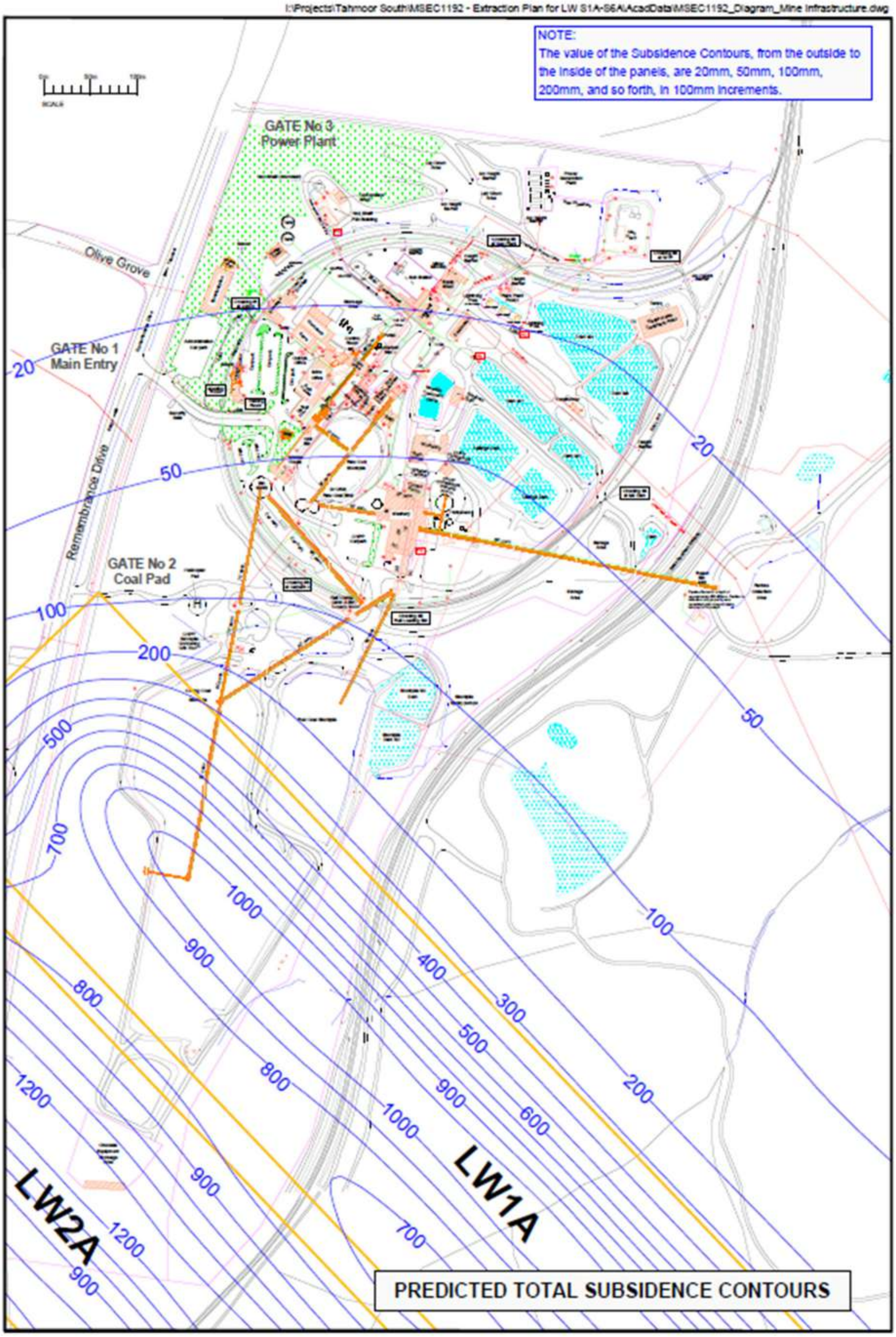

Fig. 9.6 Tahmoor Mine Site overlaid with predicted total subsidence contours due to LWs S1A to S6A

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Rail Loop, resulting from the extraction of the proposed longwalls, are shown in Fig. E.09, in Appendix E.

The predicted profiles of conventional subsidence, tilt and curvature along the alignment of Conveyors 5C, 6C and 7C, resulting from the extraction of the proposed longwalls, are shown in Fig. E.10, in Appendix E.

A summary of the maximum predicted total conventional subsidence parameters along the alignment of the Conveyors 5C, 6C and 7C, after the extraction of each of the proposed longwalls, is provided in Table 9.1. The predicted subsidence effects are predominately due to Longwalls S1A to S3A.

Table 9.1 Maximum predicted total conventional subsidence parameters along the alignment of Conveyors 5C, 6C and 7C after the extraction of the proposed LWs S1A to S6A

Longwall	Maximum predicted total subsidence (mm)	Maximum predicted tilt along conveyors (mm/m)	Maximum predicted tilt across conveyors (mm/m)	Maximum predicted total hogging curvature along alignment (km^{-1})	Maximum predicted total sagging curvature along alignment (km^{-1})
After LW S1A	750	5.0	4.0	0.06	0.17
After LW S2A	975	6.0	3.5	0.07	0.17
After LW S3A	1000	6.0	3.5	0.07	0.17
After LW S4A	1050	6.0	3.5	0.07	0.17
After LW S5A	1050	6.0	3.5	0.07	0.17
After LW S6A	1050	6.0	3.5	0.07	0.17

The majority of the subsidence movements are predicted to occur during the extraction of proposed LW S1A.

The maximum predicted conventional strains for the conveyors and associated structures, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.1 mm/m tensile and 2.6 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The reclaim tunnel is a linear feature and, therefore, the most relevant distribution of strain is the maximum strains measured along whole monitoring lines above previous longwall mining. An analysis of strains along whole monitoring lines during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.2 and the results are provided in Fig. 4.4.

A minor creek was infilled during the construction of the surface facilities. Using historical aerial photographs, the “hidden creek” passed through conveyor 7C. Minor valley closure and upsidence movements of less than 20 mm may develop across the conveyors, potentially resulting in closure between the bases of the conveyor trestles.

9.3.2. Impact assessments for Mine Infrastructure

Rail Loop

Predictions and impact assessments for the Rail Loop are provided in Section 6.2.

Conveyors

Conveyor 5C and 6C and the associated supporting structures in the Stockpile area are located directly above proposed LW S1A. The infrastructure is predicted to experience up to 1,050 mm of vertical subsidence.

The conveyors are predicted to experience a reversal in grade of up to 6 mm/m. The conveyors were constructed with a grade of 20 mm/m (2%) and the predicted changes in grade will not affect the operation of the conveyors and the tripper that runs along the conveyor.

Tahmoor Coal conduct regular structural engineering inspections of the conditions of its building structures and the support structure for Conveyor 5C is currently in reasonable condition. Inspections and structural assessments are currently being conducted by JMA Solutions to assess the ability of the structure to accommodate the predicted conventional subsidence movements and potential non-conventional subsidence movements.

The support structure consists of reinforced concrete piers with 6 structural steel trestles in between them. The legs of the steel trestles are mounted on and cast into the reinforced concrete reclaim tunnel structure underneath. Whilst each pair of trestle legs are effectively held together by reinforced concrete, it is possible that mining-induced ground strains could result in differential movements between each trestle.

The primary concern is the potential for impacts resulting in workplace safety hazards. Tahmoor Coal is currently considering options to control the risks. This may include managing the gap in the structural frame superstructure to accommodate potential differential movements. Monitoring measures are currently being developed, which include the monitoring the gap in the superstructure and surveying the tops of the trestles and along the reclaim tunnel underneath. It is also possible, for example, to restrict stockpiling operations in areas of concern.

The other conveyors on site will not be directly mined beneath. The support trestles for the overhead conveyors are founded on concrete footings at the surface. While the potential for adverse impacts on these conveyors is low, the primary concern remains the potential for impacts resulting in workplace safety hazards. Tahmoor Coal is currently considering options to control the risks associated with mining adjacent to these overhead conveyors, including where they cross railways, access roads, carparking spaces and pedestrian walkways.

Tahmoor Coal is currently considering options to control the risks associated with mining adjacent to the conveyors themselves. The conveyors can be readily managed for potential changes due to subsidence. The conveyor linestands can be adjusted, if required, to maintain vertical and lateral alignment to with operating tolerances. The alignment can be monitored by a combination of surveys and visual inspections.

Building structures

The building structures generally consist of structural steel frames with metal sheet cladding on concrete slabs. These structures can accommodate substantial differential movements. They will be inspected and assessed prior to mining by a structural engineer to identify potential hazards and consider risk controls.

The Washery building includes an overhead gantry crane and a monorail, which are regularly serviced. Tahmoor Coal has extensive experience in managing potential impacts on overhead gantry cranes. An inspection and assessment will be conducted by a mechanical engineer that is experienced with overhead gantry cranes and mine subsidence. The advice will be used to develop monitoring and management measures.

Three circular reinforced concrete bin structures are located on site. The bins temporarily hold either raw or washed coal material. The structures are found on reinforced concrete slabs. The structures will not be mined directly beneath and will likely withstand the predicted mining-induced tilts, even if they are greater than predicted. They will be inspected and assessed prior to mining by a structural engineer to identify potential hazards and consider controls.

While the potential for adverse impacts to occur on the building structures is considered to be low, Tahmoor Coal will implement measures to ensure that the buildings remain safe and serviceable during the mining of the proposed longwalls. The measures will include monitoring for changes in addition to visual inspections.

Fig. 9.7 Aerial photograph showing Bins, Raw Stockpile, Drift Portal and Winder

Drift Portal

The Drift is the primary entry and exit to the underground mine. The drift conveyor is mounted on the roof of the drift and trolley cars transport workers, materials and equipment on rails via a rope and pulley system that is powered by a winder at the surface. The drift portal is located approximately 380 metres from proposed LW S1A. The drift then proceeds underground away from the proposed longwalls. A photograph of the drift portal is shown in Fig. 9.8.

Fig. 9.8 Drift Portal

The portal structure is predicted to experience approximately 20 mm of vertical subsidence with negligible tilt, curvature and strain. While the potential for adverse impacts to occur on the drift portal is considered to be very low, Tahmoor Coal will implement measures to ensure that the drift remains safe and serviceable during the mining of the proposed longwalls. The measures will include monitoring for changes across the drift, in addition to visual inspections that are routinely conducted as part of the mine's safety management system.

Reject Emplacement Area (REA)

The section of the REA within the *Subsidence Study Area* is predominantly bush with unsealed access roads. The western portion of emplacement activities is located within the *Subsidence Study Area*. The REA will experience low level subsidence movements (less than 50 mm) as a result of the proposed longwall extraction. Tahmoor Coal will implement measures to ensure that the emplacement area remains safe and serviceable during the mining of the proposed longwalls. The measures will include visual inspections that are routinely conducted as part of the mine's safety management system.

Dams

A number of dams are located within the *Subsidence Study Area* a, as shown in Drawing No. MSEC1192-20. As discussed in Section 8.10, the likelihood of impacts on dams is very low. Despite the low likelihood, it is recognised that the dams are located in close proximity to a tributary to Teatree Hollow. The consequences of leakage from the pond can be minimised by dewatering the pond prior to active subsidence and the likelihood of impacts could be reduced by installing a flexible waterproof liner in the pond.

The dams will be inspected by geotechnical engineer Douglas Partners prior to the influence of mining to identify potential hazards and consider risk controls. While the potential for adverse impacts to occur on the dams is considered to be very low, Tahmoor Coal will implement measures to ensure that the dams remain safe and serviceable during the mining of the proposed longwalls. The measures will include monitoring for changes across dam walls, in addition to visual inspections that are routinely conducted as part of the mine's safety management system.

Services infrastructure

Tahmoor Coal has an extensive network of services infrastructure, including water pipework, sewer pipework, gas pipework, electrical and telecommunications cabling. Tahmoor Coal has extensive experience in managing services infrastructure. While the potential for impacts is considered to be low, Tahmoor Coal will implement measures to ensure that the infrastructure remains safe and serviceable during the mining of the proposed longwalls. The measures will include monitoring of subsidence and visual inspections.

Summary

Tahmoor Coal is currently developing management measures to ensure that the mine remains safe and serviceable throughout the mining period and that impacts on the facilities do not result in environmental consequences on the adjacent Teatree Hollow catchment. The study would require input from structural, geotechnical and subsidence engineers. The management measures may include a combination of:

- Mitigation or strengthening measures prior to mining, particularly in relation to the coal conveyor support structures and dams,
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements,
- Conduct regular visual inspections of the surface facilities, and
- Implement planned responses if triggered by monitoring and inspections.

With appropriate management plans in place, it is considered that the surface facilities at Tahmoor Mine will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non-conventional movements occurred.

10.0 DESCRIPTIONS, PREDICTIONS AND IMPACT ASSESSMENTS FOR AREAS OF ARCHAEOLOGICAL AND HERITAGE SIGNIFICANCE

Descriptions, predictions and impact assessments for the archaeological and heritage sites within the *Subsidence Study Area* are provided in the following sections. The sites located outside the *Subsidence Study Area*, which may be subjected to far-field movements or valley related movements and may be sensitive to these movements, have also been included as part of these assessments.

10.1. Archaeological sites

There are no lands within the *Subsidence Study Area* declared as an Aboriginal Place under the *National Parks and Wildlife Act 1974*.

There are 3 archaeological sites which have been identified within the *Subsidence Study Area* and their locations are shown in Drawing No. MSEC1192-17. There is one rock shelter site on the Tributary to Teatree Hollow, one open camp site and one isolated find. Detailed descriptions of the archaeological sites within the *Subsidence Study Area* are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

10.1.1. Predictions for the archaeological sites

The predicted conventional subsidence, tilts and curvatures for the archaeological sites within the *Subsidence Study Area* are provided in Table D.11, in Appendix D. A summary of the maximum predicted conventional subsidence parameters for the archaeological sites is provided in Table 10.1. The predicted tilts are the maxima after the completion of any or all of the proposed longwalls. The predicted curvatures are the maxima at any time during or after the extraction of the proposed longwalls.

Table 10.1 Maximum Predicted Total Conventional Subsidence Parameters for the Archaeological Sites

Site Type	Maximum predicted total conventional subsidence (mm)	Maximum predicted total conventional tilt (mm/m)	Maximum predicted total conventional hogging curvature (km^{-1})	Maximum predicted total conventional sagging curvature (km^{-1})
Open Camp Site (52-2-3968)	550	5.0	0.05	0.02
Rock Shelter Site (52-2-4471)	900	4.5	0.06	0.03
Isolated Find (48-2-0275)	70	< 0.5	< 0.01	< 0.01

The maximum predicted conventional strains for the archaeological sites, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.9 mm/m tensile and 0.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The archaeological sites are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays above goaf are provided in Fig. 4.2. The results for survey bays above solid coal are provided in Fig. 4.3.

The rock shelter is located along the side of a valley and, therefore, could experience valley-related movements. A summary of the maximum predicted upsidence and closure movements for the stream in the location of this sites is provided in Table 10.2.

Table 10.2 Maximum predicted total upsidence and closure for the archaeological sites

Site Type	Stream	Maximum predicted total upsidence (mm)	Maximum predicted total closure (mm)
Rock Shelter Site (52-2-4471)	Tributary of Teatree Hollow (Wirrimbirra Creek)	300	350

10.1.2. Impact assessments for the Open Camp Site

There is one open camp site located within the *Subsidence Study Area*. The site is located directly above the chain pillars between proposed LWs S3A and S4A.

The maximum predicted final tilt for the open camp site is 5.0 mm/m (i.e. 0.5 %), which represents a change in grade of 1 in 200. It is unlikely that the sites would experience any adverse impacts resulting from the mining induced tilts.

The maximum predicted curvatures for the open camp site are 0.05 km^{-1} hogging and 0.02 km^{-1} sagging, which represent minimum radii of curvature of 20 kilometres and 50 kilometres, respectively. The maximum predicted conventional strains for this site, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.8 mm/m tensile and 0.3 mm/m compressive.

The open camp site can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that artefacts within the camp site would be impacted by surface cracking.

Further assessments of the potential impacts on the open camp site are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

10.1.3. Impact assessments for the rock shelter

There is one rock shelter identified within the *Subsidence Study Area*, directly above LW S2A on the Tributary to Teatree Hollow.

The maximum predicted tilt for the rock shelters is 4.5 mm/m (i.e. 0.45 %), which represents a change in grade of 1 in 222. It is unlikely that the site would experience any adverse impacts resulting from the mining induced tilt.

The maximum predicted curvatures for the rock shelters are 0.06 km^{-1} hogging and 0.03 km^{-1} sagging, which represent minimum radii of curvature of 17 kilometres and 33 kilometres, respectively. The maximum predicted conventional strains for these sites, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.9 mm/m tensile and 0.5 mm/m compressive. The predicted closure across the valley at the rock shelter site is 350 mm.

It is extremely difficult to assess the likelihood of instabilities for the rock shelters based upon predicted ground movements. The likelihood of the shelters becoming unstable is dependent on a number of factors which are difficult to fully quantify. These factors include jointing, inclusions, weaknesses within the rockmass, groundwater pressure and seepage flow behind the rockface. Even if these factors could be determined, it would still be difficult to quantify the extent to which these factors may influence the stability of the shelter naturally or when it is exposed to mine subsidence movements.

The predicted conventional and valley related movements at the rock shelters are similar to the typical movements in the Southern Coalfield, where there is extensive experience of mining beneath rock shelters. It has been reported that, where longwall mining has previously been carried out in the Southern Coalfield, beneath 52 shelters, that approximately 10 % of the shelters have been affected by fracturing of the strata or shear movements along bedding planes and that none of the shelters have collapsed (Sefton, 2000). Regal Heritage (2022) advises that 221 rock shelter sites have been monitored since 1990, of which 22 sites have observed changes due to mine subsidence, which is consistent with Sefton's advice in 2000. Two of the affected sites have experienced adverse consequences to the physical fabric that supports the heritage value of the site.

The experience from the Southern Coalfield indicates that the likelihood of substantial physical impacts on rock shelters within the *Subsidence Study Area* is relatively low.

10.1.4. Impact assessments for the Isolated Find site

There is one isolated find site located within the *Subsidence Study Area*. The site is located to the north of LW S1A directly above the previously extracted Tahmoor LW 2.

The maximum predicted final tilt for the isolated find site is less than 0.5 mm/m (i.e. 0.05 %), which represents a change in grade of 1 in 2000. It is unlikely that the site would experience any adverse impacts resulting from the mining induced tilts.

The maximum predicted curvatures for the isolated find site are less than 0.01 km^{-1} hogging and sagging, which represent minimum radii of curvature of 100 kilometres. The maximum predicted conventional strains for these sites, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.2 mm/m tensile and compressive.

The isolated find site can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that the isolated finds themselves would be impacted by surface cracking.

Further assessments of the potential impacts on the isolated find site are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

10.1.5. Impact assessments for the archaeological sites based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the maximum tilts would be 10 mm/m (i.e. 1.0 %, or 1 in 100) for the open camp site, 9 mm/m (i.e. 0.9 %, or 1 in 111) for the rock shelter and less than 1 mm/m (i.e. 0.1 %, or 1 in 1000) for the isolated find. These types of archaeological sites are not adversely affected by tilt and, therefore, the likelihoods of impact would not be expected to increase.

If the actual curvatures or strains at the open camp site exceeded those predicted by a factor of 2 times, the likelihoods and extents of cracking in the surface soils would also increase. It would still be unlikely that the artefacts themselves would be impacted by the surface cracking and the methods of subsidence management would not be expected to change.

If the actual curvatures or strains at the rock shelter site exceeded those predicted by a factor of 2 times, the likelihoods and extents of fracturing in the bedrock would also increase. Whilst the observed curvatures could exceed those predicted, the experience from the Southern Coalfield indicates that the likelihood of substantial impacts on shelters is relatively low, particularly when they are not directly mined beneath.

10.1.6. Management of potential impacts on the archaeological sites

Tahmoor Coal has developed a Heritage Management Plan to manage potential impacts to Aboriginal heritage sites for previously extracted longwalls at the mine. The management plan included consultation with the community, monitoring and reporting. Tahmoor Coal is required to develop a Heritage Management Plan as part of the Extraction Plan for LWs S1A to S6A, in consultation with the community, to manage the Aboriginal heritage sites during the extraction of the proposed longwalls.

10.2. Heritage sites

10.2.1. Descriptions of the heritage sites

There are 5 heritage sites which have been identified within the *Subsidence Study Area* and their locations are shown in Drawing Nos. MSEC1192-17. Brief descriptions of the heritage sites are provided below in Table 10.3, and more detailed descriptions are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

Table 10.3 Heritage sites within the Subsidence Study Area

Name	Description	Closest distance to extent of longwall mining area
Bargo Cemetery	Grave sites	Directly above longwall mining area
Wirrimbirra Sanctuary (now called Australian Wildlife Sanctuary)	Native gardens	Directly above longwall mining area
Great Southern Road	Local road	Directly above LW S5A
Tahmoor Mine	Coal mine and coal handling preparation plant	Centre of surface facilities ~500 m from extent of LW mining area
Picton Weir	Concrete arch dam	850 m west of LW S6A

Wellers Road Railway Overbridge over the Main Southern Railway is located just outside the *Subsidence Study Area*. Descriptions and impact assessments for this site are provided in Section 6.1.9.

10.2.2. Predictions and impact assessments for heritage sites previously discussed

Predictions and impact assessments have been provided previously in this report for some of the heritage sites:

- Bargo cemetery (Section 7.15);
- Tahmoor Mine (Section 9.3); and
- Picton Weir (Section 6.11).

The predictions and impact assessments for heritage aspects of Wirrimbirra Sanctuary and Great Southern Road are provided below.

10.2.3. Wirrimbirra Sanctuary

The Wirrimbirra Sanctuary is located on Remembrance Driveway and is listed as an item of heritage on the State Heritage Register (01508). Wirrimbirra Sanctuary is now called the Australian Wildlife Sanctuary and covers an area of approximately 95 ha.

Wirrimbirra preserves a part of the original 'Bargo Brush' which was of considerable historical importance in the problems which faced the settlement of the Argyle or Southern Tablelands during the early half of the 1800s. The Sanctuary contains rich and diverse plantings of native plants in formalised gardens, which were developed to provide areas of representative native plants for education and research purposes. Within the 43 established gardens, there are over 1800 native plants representing a resource base for the study of native flora.

The Australian Wildlife Sanctuary includes a visitor centre, a glass house and other shade structures, along with established gardens and walks. Two cottages are located next to the visitor centre. Dingo Sanctuary Bargo is also located on the property. Some structures were destroyed by bushfires in late 2019 but the main structures within the sanctuary, and the dingo sanctuary were successfully protected. It is planned to replace the lost buildings in the future.

The Australian Wildlife Sanctuary structures are located directly above proposed LWs S3A and S4A. The Australian Wildlife Sanctuary was inspected by heritage consultant EMM in January 2020. The Heritage Management Plan (Tahmoor Coal, 2022d) has identified the following items of heritage significance.

- Complex of building structures at and around the visitor centre;
- Animal pens (dingo sanctuary)
- Allen Strom pond
- Landscaping
- Shale and sandstone relics at multiple locations
- Artefact deposits
- Wells

Structures including within the Dingo Sanctuary

Predictions of subsidence, tilt and curvature have been provided for the identified heritage structures within the Australian Wildlife Sanctuary in Table D.10, in Appendix D.

The Australian Wildlife Sanctuary property will experience the full range of subsidence movements due to the extraction of the proposed longwalls. The visitor centre and surrounding structures are located near the chain pillar between LWs S3A and S4A. These structures will, therefore, experience slightly reduced subsidence, tilt and curvature compared to locations that are closer to the centre of the longwall panels where greater subsidence movements typically occur.

The structures were inspected by John Matheson of JMA Solutions in January 2020. The structures generally comprise timber-framed structures with metal-clad timber-framed rooves on reinforced concrete ground slabs. The structures were found to be in serviceable condition. Impact assessments for the building structures and the dingo sanctuary are provided in Section 7.15.

A farm dam is located to the north of the complex. The dam has been constructed with compacted earth. The inlet to the dam appears to have been cut through surface rock.

There is extensive experience of mining directly beneath farm dams in the Southern Coalfield, which indicates that the incidence of impacts on these features is very low. Farm dams are commonly constructed with cohesive materials in the bases and walls which can absorb the conventional subsidence movements typically experienced in the Southern Coalfield without the development of substantial cracking. Non-conventional movements can result in localised cracking and deformations at the surface and, where coincident with farm dams, could result in adverse impacts.

Tahmoor Coal has mined LW22 to LW32 and LW W1-W3 beneath approximately 110 dams. While a small number of landowners have advised of impacts, there has been one claim to SA NSW for impacts on farm dams at the time of the report.

Any substantial cracking in the dam bases or walls could be repaired by reinstating with cohesive materials. If any farm dams were to lose water as a result of mining, the mine would provide an alternative water source until the completion of repairs in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

Further assessments of the potential impacts on the structures are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

Allen Strom Pond

The Allen Strom Pond is a shallow pond, which is located within the formalised garden area of the Australian Wildlife Sanctuary. The pond was damaged during the bushfires of late 2019. EMM inspected the pond after the bushfires. A random-split sandstone edging surrounds the pond and does not appear to have been mortared together. The floor of the pond has been lined with cement or concrete.

The pond may experience adverse impacts from ground strains and curvature due to the extraction of the proposed longwalls. The cement or concrete floor may experience cracking, resulting in leakage. The damage can be readily repaired.

Further assessments of the potential impacts on the Pond are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

Landscape

The Australian Wildlife Sanctuary preserves a part of the original 'Bargo Brush' landscape, which was of considerable historical importance in the problems which faced the settlement of the Argyle or Southern Tablelands during the early half of the 1800s.

While the landform will experience mine subsidence movements, the mining-induced changes in slope will be orders of magnitude less than natural gradients and not visually perceptible. It is very unlikely, therefore, that the vertical subsidence would reduce the visual aesthetics or the heritage value of the landscape.

Historical relics and artefact deposits

A number of historical relic sites were identified by EMM during the site inspection in January 2020. Some of the sites were discovered following the loss of vegetation by the bushfires.

The relics include remnant sandstone structures including an old fireplace, old fireplaces consisting of mixtures of clay and small stones, and collections of rocks and pebbles.

The relic sites can potentially be affected by cracking of the surface soils as a result of mine subsidence movements. It is unlikely, however, that the sandstone features or isolated artefact deposits would be impacted by surface cracking. The cracks would fill in over time and not be visible.

Further assessments of the potential impacts on the relic sites are provided in the Heritage Management Plan (Tahmoor Coal, 2022d).

Wells

Two small, shallow excavations were identified on the property. The excavations have previously been identified as wells but have been reinterpreted as non-specific waterholes/soaks. The wells are relatively shallow, being less than 2 metres deep. The sides and base of these features are unlined.

The wells are very unlikely to experience adverse impacts due to the extraction of the proposed longwalls.

Heritage Management Plan

Tahmoor Coal has previously developed historical heritage management plans to manage potential impacts on items of heritage significance above previously extracted LWs 22 to 32 and LWs W1-W3.

Tahmoor Coal has developed a draft Property Subsidence Management Plan to manage potential impacts on the Australian Wildlife Sanctuary. The management plan is currently being considered by Australian Wildlife Sanctuary as part of the consultation process. The management measures include a combination of:-

- Pre-mining hazard identification inspection of each structure by structural engineer (complete);
- Consider the implementation of possible mitigation measures prior to mining to reduce the likelihood of severe impacts (complete);
- Installation of a monitoring system, which includes, among other things, the monitoring of ground movements around the visitor centre;
- Conduct regular visual inspections of the building structures and dingo sanctuary; and
- Implement planned responses if triggered by monitoring and inspections. Repairs to heritage structures would be planned in consultation with a heritage consultant.

With an appropriate management plan in place, it is considered that the Australian Wildlife Sanctuary will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

10.2.4. Great Southern Road

The northern section of Great Southern Road is located directly above the southern end of proposed LW S5A. There are sealed and unsealed sections of pavement within the *Subsidence Study Area*.

The sealed and unsealed sections of pavement are predicted to experience minor subsidence movements and impacts as a results of the extraction of the proposed longwalls. Further information is provided in Section 6.3.3.

As the road has been upgraded many times, there is little evidence of the original heritage fabric. While impacts may occur to the road, repairs will not impact on the heritage value of the road, which is generally related to its alignment and this will not be affected by the proposed mining.

10.2.5. Management of potential impacts on heritage sites

Tahmoor Coal has previously developed a Heritage Management Plan to manage the potential impacts on heritage sites. The management plans include pre-mining assessments by structural engineers and heritage consultants, monitoring and triggered response plans. Monitoring typically continues for a period following mining.

Tahmoor Coal has developed a Heritage Management Plan as part of the Extraction Plan for LWs S1A to S6A to manage potential impacts on heritage sites in consultation with each landowner during the mining of the proposed longwalls.

10.3. Items of architectural significance

There are no items of architectural significance within the *Subsidence Study Area*.

11.1. Houses

11.1.1. Descriptions of the houses

There are 105 houses that have been identified within the *Subsidence Study Area.* A total of 65 houses are located directly above the proposed longwalls. The locations of the houses are shown in Drawing No. MSEC1192-18 and details are provided in Table D.02, in Appendix D.

The locations, sizes, and construction details of the houses were determined from orthophotographs of the area in 2017 and 2021, kerbside inspections in 2013 and *Google Street View®* in February 2021. In some cases, the houses were inspected at the request or consent of the landowners.

Given the medium-term nature of the proposed mining activity, it is likely that there will be a growth and renewal of houses over time. It is likely the total number of houses affected by the extraction of the proposed longwalls will be greater than currently identified.

The following provides further discussions on the details of the houses within the *Subsidence Study Area*.

Locations

There are 65 houses located directly above the proposed longwalls (i.e. 62 % of the total number of houses within the *Subsidence Study Area*). A summary of the number of houses located directly above each of the proposed longwalls is provided in Table 11.1.

Table 11.1 Number of houses located directly above each of the proposed longwalls

Layout	Longwall	Number of houses directly above each proposed longwall
Extraction Plan LWs S1A to S6A	LW S1A	0
	LW S2A	1
	LW S3A	13
	LW S4A	20
	LW S5A	20
	LW S6A	11
	Total	**65**
EIS Layout (MSEC1123) LWs S1A to S6A	LW101A	0
	LW102A	1
	LW103A	8
	LW104A	22
	LW105A	16
	LW106A	8
	Total	**55**

When compared to the count provided in Report No. MSEC1123 for the EIS, the numbers of houses directly above the proposed LWs S1A to S6A have increased for the following reasons:

- The commencing ends of LWs S1A to S6A have been aligned compared to the previous staggered layout. The outcome of the change is that LWs S2A to S6A have been extended in length. The gap between the A and B series longwalls will be maintained, such that the future B series will be shortened when compared to the mine layout that was submitted for development consent. This means that fewer houses will experience mine subsidence movements due to future extraction in the B Series than were previously counted under the previous EIS layout.
- Six new houses have been constructed and identified from recent aerial images that were not present since the area was previously mapped for the EIS report from a 2017 aerial photograph.
- Two structures that were previously mapped as sheds have been identified to be houses or granny flats.

Maximum plan dimension, plan area and height

Distributions of the maximum plan dimensions and plan areas of the houses within the *Subsidence Study Area* are provided in Fig. 11.1. The majority of the houses are between 10 metres and 30 metres in length, with an average of 20 metres. The majority of the houses have plan areas between 100 m^2 and 300 m^2, with an average of 220 m^2.

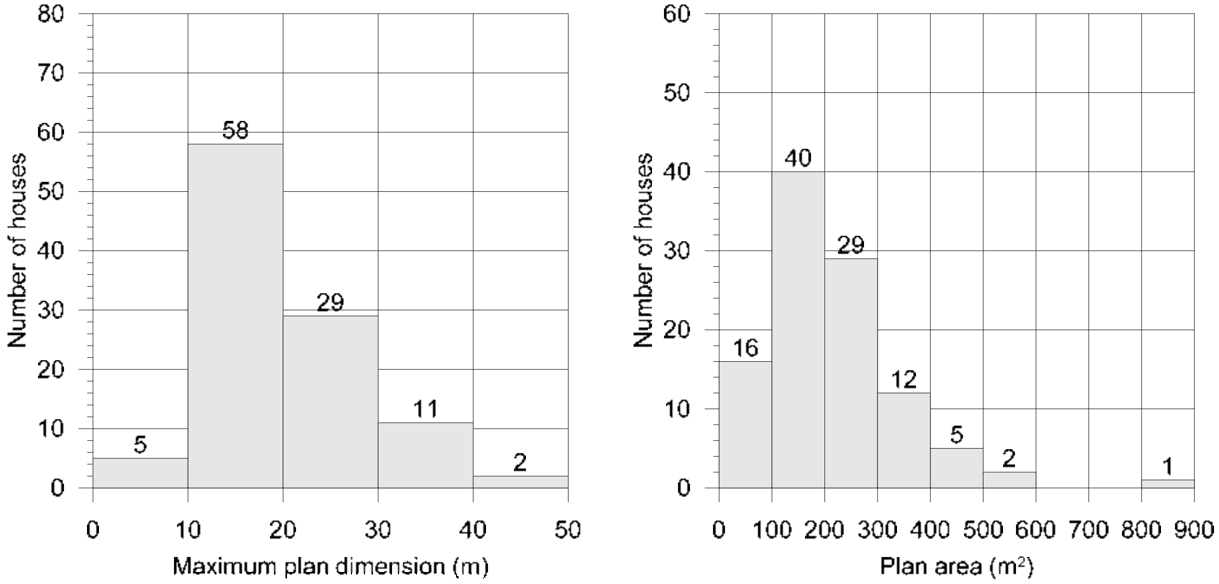

Fig. 11.1 Distribution of houses by maximum plan dimension and plan area

The houses have been categorised into four groups, on the basis of their maximum plan dimension and the number of stories. A summary of these house type categories is provided in Table 11.2 below. It is noted that two-storey houses include split-level houses.

Table 11.2 House type categories

House type	Description	Number	Percentage
H1	Single-storey with maximum plan dimension less than 30 metres	86	81 %
H2	Single-storey with maximum plan dimension of 30 metres or greater	13	12 %
H3	Two-storey with maximum plan dimension less than 30 metres	6	6 %
H4	Two-storey with maximum plan dimension of 30 metres or greater	0	0 %

It can be seen from the above table that the majority of houses within the *Subsidence Study Area* are single-storey with a maximum plan dimension less than 30 metres (i.e. Type H1), and there are no two-storey houses with a maximum plan dimension greater than 30 metres (i.e. Type H4) identified within the *Subsidence Study Area*.

The distribution of house heights within the *Subsidence Study Area* at this point in time has been compared to the distribution of house types in the township of Tahmoor, which have previously experienced mine subsidence movements. Of the 105 houses within the *Subsidence Study Area*, 86 houses (81 %) are single-storey houses with maximum plan dimension less than 30 metres.

Type of construction

Distributions of the wall and footing construction of the houses within the *Subsidence Study Area* are provided in Fig. 11.2. The majority of the houses within the *Subsidence Study Area* are of brick or brick-veneer construction. There are similar numbers of houses with slab on ground and piered footings, with a small number of houses on strip footings.

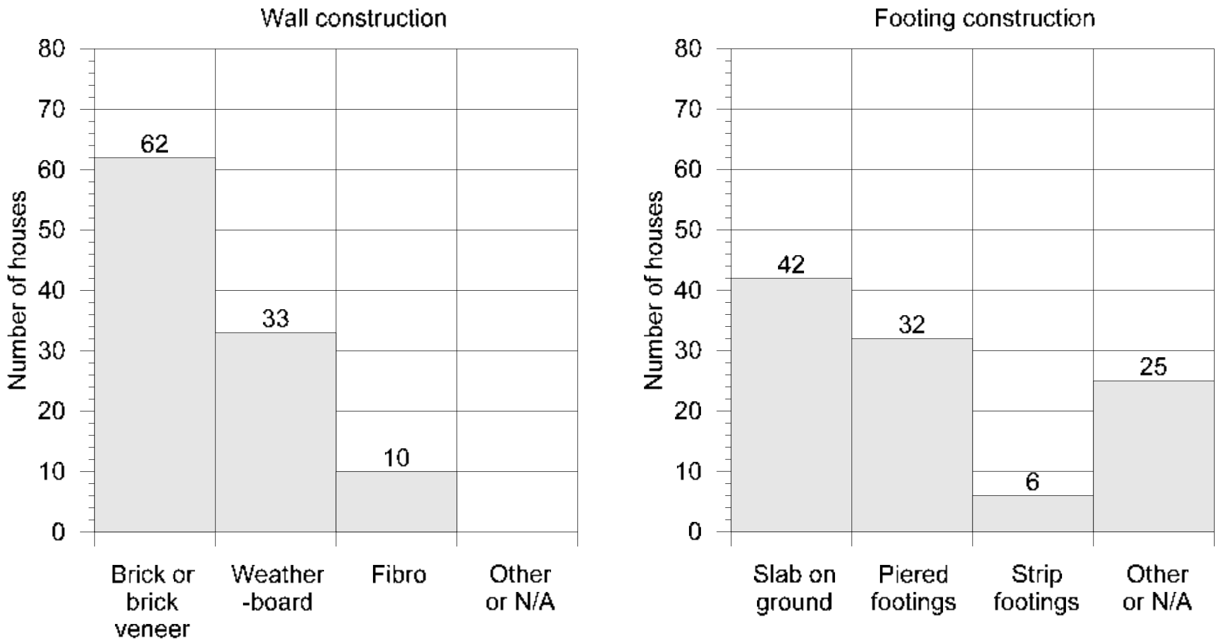

Fig. 11.2 Distributions of wall and footing construction for houses within the Subsidence Study Area

Following a review of impacts to houses during the mining of Tahmoor Mine Longwalls 22 to 25, it was found that there was a noticeable difference in structural performance in response to mine subsidence movements between the following construction types:-

- Brick or brick-veneer houses constructed on a ground slab;
- Brick or brick-veneer houses constructed on strip footings; and
- Weatherboard or fibro houses constructed on either ground slabs or strip footings.

The distribution of houses by construction type is provided in Table 11.3.

Table 11.3 Distribution of houses by construction type

Description	Number of houses	Percentage of houses
Brick or brick-veneer houses constructed on a ground slab	37	35 %
Brick or brick-veneer houses constructed on strip footings	25	24 %
Weatherboard or fibro houses constructed on either ground slabs or strip footings or other	43	41 %

Of the 105 houses within the *Subsidence Study Area*, 62 houses (58 %) are brick or brick-veneer houses.

A map showing the spatial distribution of structures by construction type is provided in Fig. 11.3.

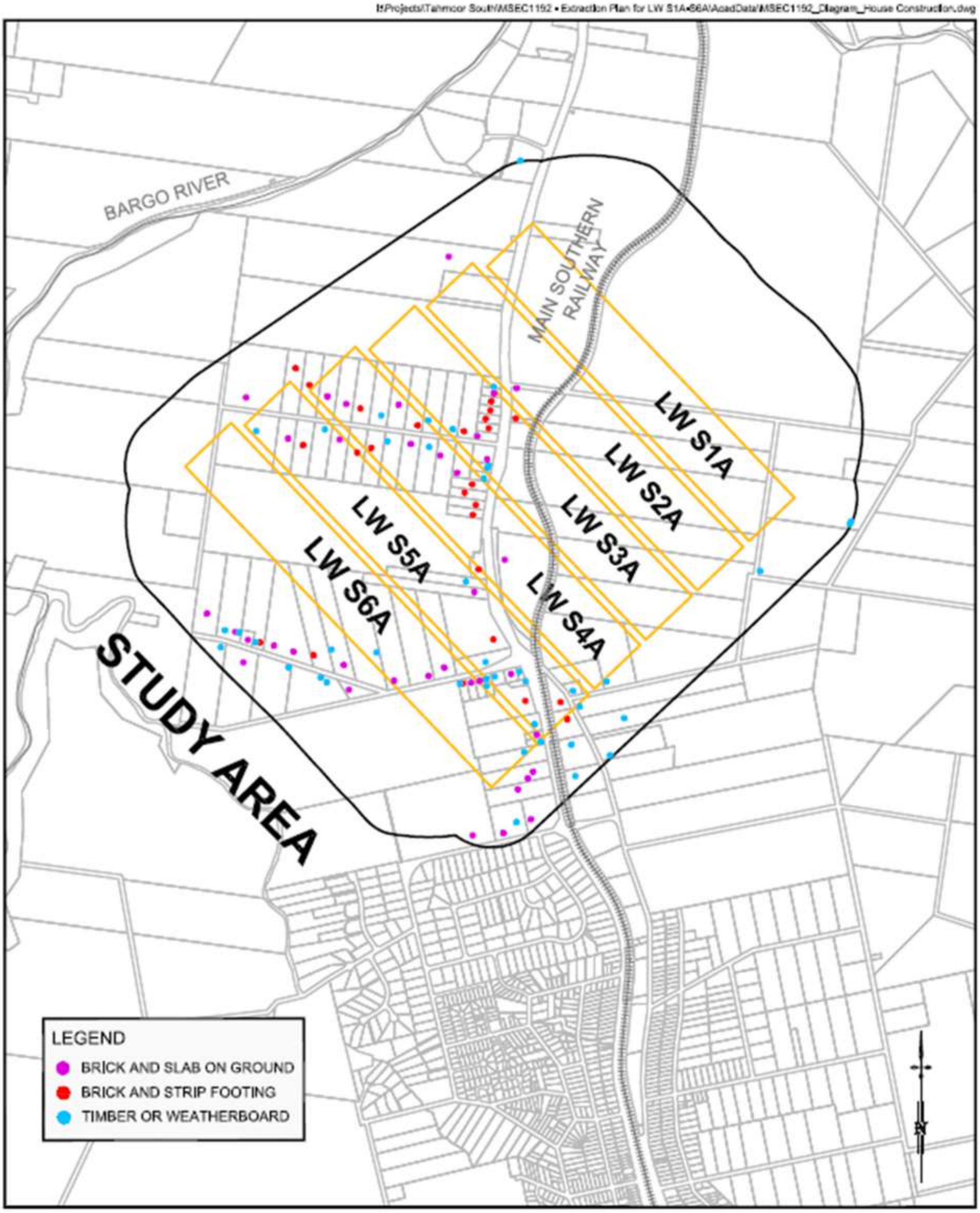

Fig. 11.3 Location of houses by construction type

The information on construction types has been undertaken using *Google Street View®* images and front of house inspections. It is possible that some houses will be renovated or rebuilt before the proposed longwalls are extracted.

As discussed in Section 11.1.3 and in Appendix C, construction type is an input parameter to the probabilistic method of assessment of impacts.

Age of houses

The Bargo area has expanded from a rural township to an urban village, as demonstrated by the following two images. An aerial photograph taken in 1975 is shown in Fig. 11.4. The most recent available aerial photograph in 2021 is shown in Fig. 11.5 for comparison. 51% of houses in the *Subsidence Study Area* have been built since the Bargo Mine Subsidence District was declared in 1975.

House age has been determined by examination of a series of historical aerial photographs provided by Land and Property Information. The photographs that were available over the Subsidence Study Area were taken in 1963, 1975, 1984, 1994, 2002 and Tahmoor Mine commissioned orthophotographs over the *Subsidence Study Area* in 2013. A Nearmap image taken in 2017 was used to identify houses with the *Subsidence Study Area* at the time MSEC's report in support of the original EIS was submitted. A Nearmap image taken in 2021 was used to identify new houses with the *Subsidence Study Area* at the time of preparing the Extraction Plan.

Photograph courtesy Department of Lands (now Spatial Services NSW)

Fig. 11.4 Aerial photograph of Study Area in 1975 when Mine Subsidence District was declared

Photograph courtesy Nearmap

Fig. 11.5 Aerial photograph of Study Area in 2021

A map showing the spatial distribution of structures by house age is provided in Fig. 11.7. The older houses are located throughout the *Subsidence Study Area*. A histogram showing the distribution of houses by age is shown in Fig. 11.6.

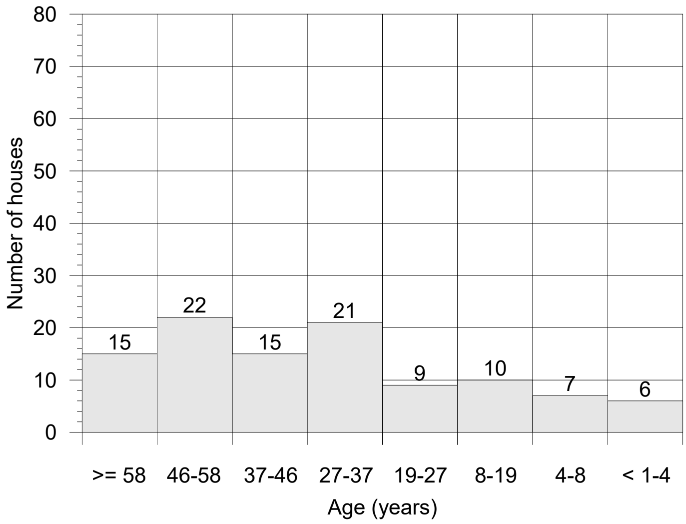

Fig. 11.6 Distribution of Houses by Age as at 2021

It can be seen from Fig. 11.6 that, as at 2021, the greatest proportion of houses were constructed 27 to 58 years prior between 1975 and 1994.

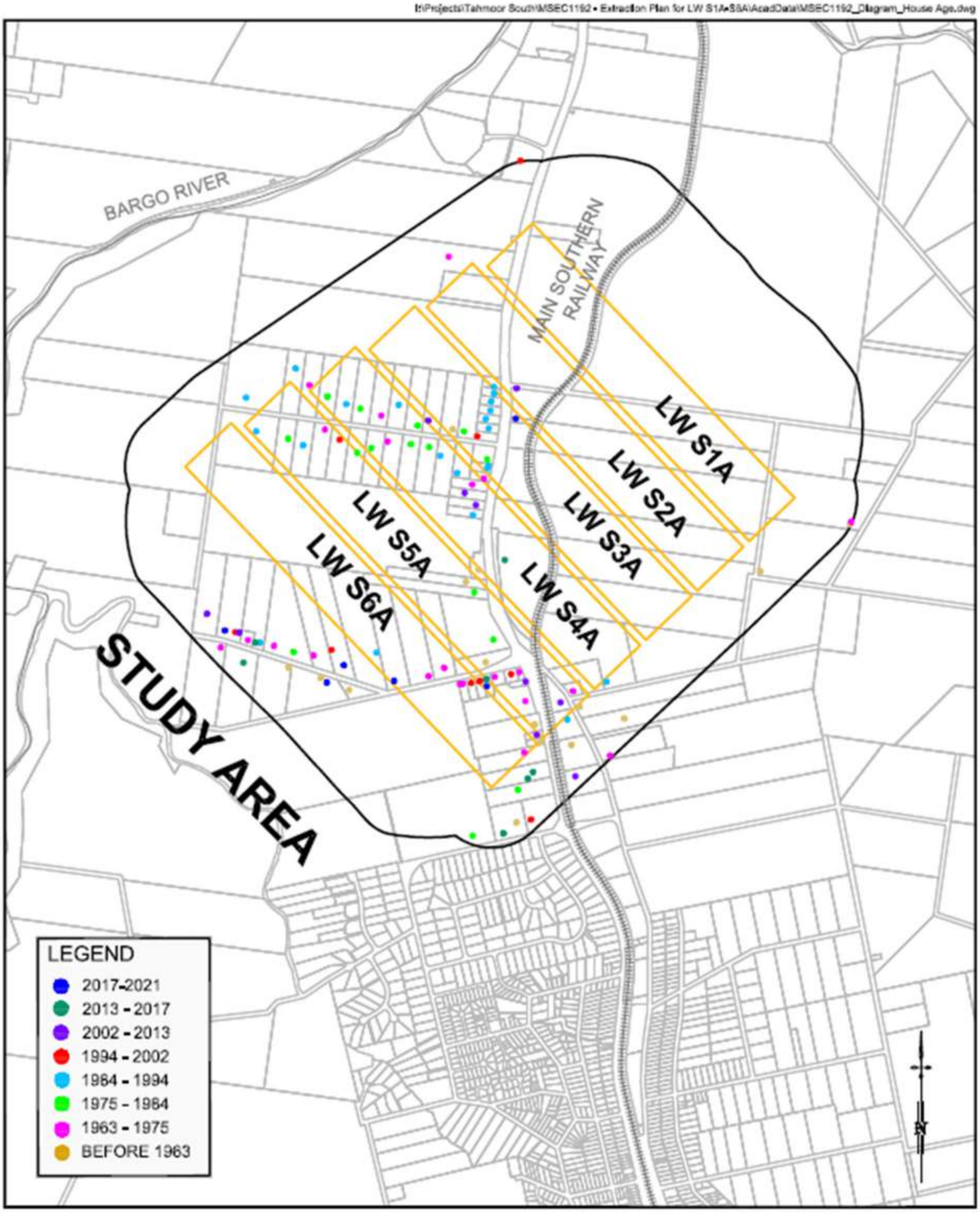

Fig. 11.7 Location of houses by age

11.1.2. Predictions for the houses

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at the vertices of each house, as well as eight equally spaced points placed radially around the centroid and vertices at a distance of 20 metres. In the case of a rectangular shaped structure, predictions have been made at a minimum of 45 points within and around the structure.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each house within the *Subsidence Study Area*, resulting from the extraction of the proposed longwalls, is provided in Table D.03, in Appendix D. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Distributions of the predicted conventional subsidence parameters for the houses within the *Subsidence Study Area* are illustrated in Fig. 11.8, Fig. 11.9 and Fig. 11.10 below.

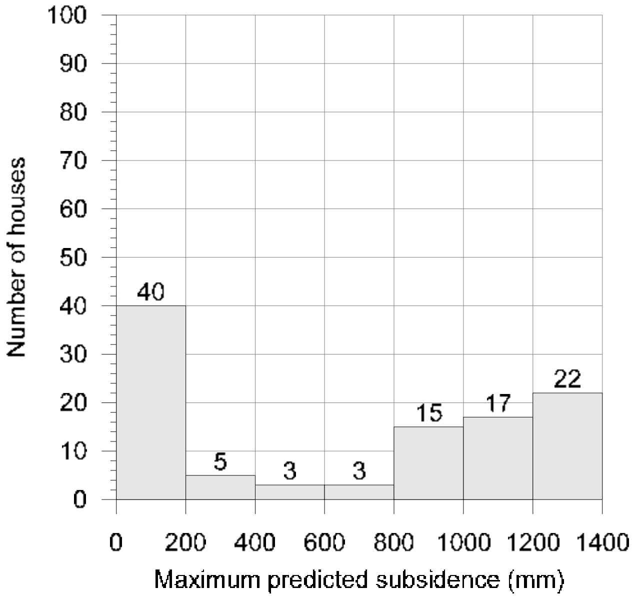

Fig. 11.8 Maximum predicted conventional subsidence for the houses within the Subsidence Study Area

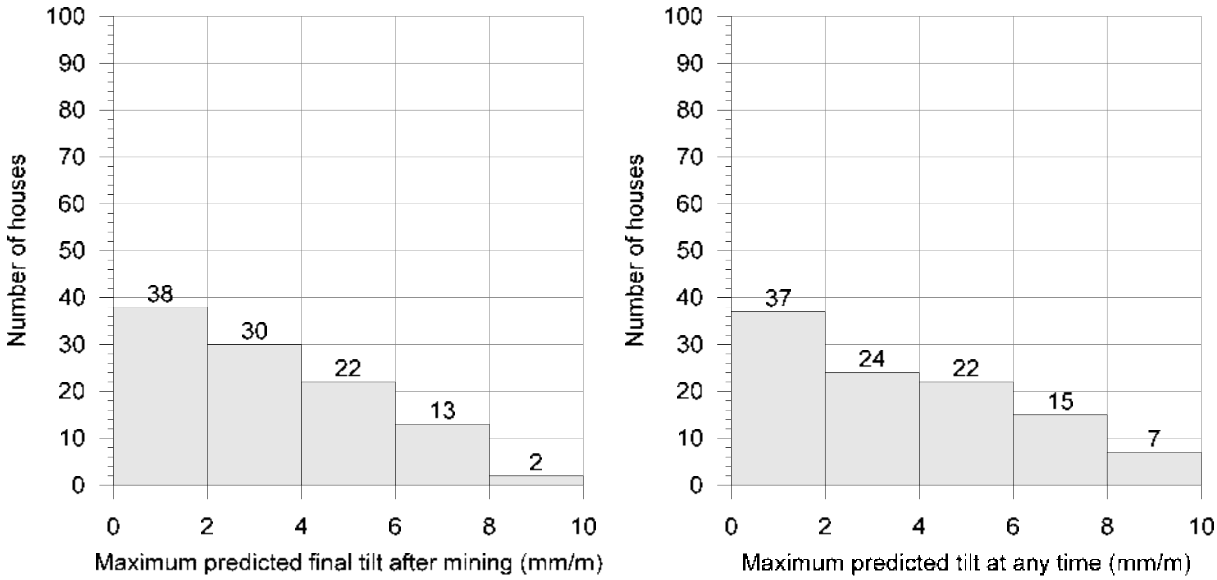

Fig. 11.9 Maximum predicted conventional tilts after the extraction of all longwalls (left) and maximum predicted conventional tilts after the extraction of any longwall (right)

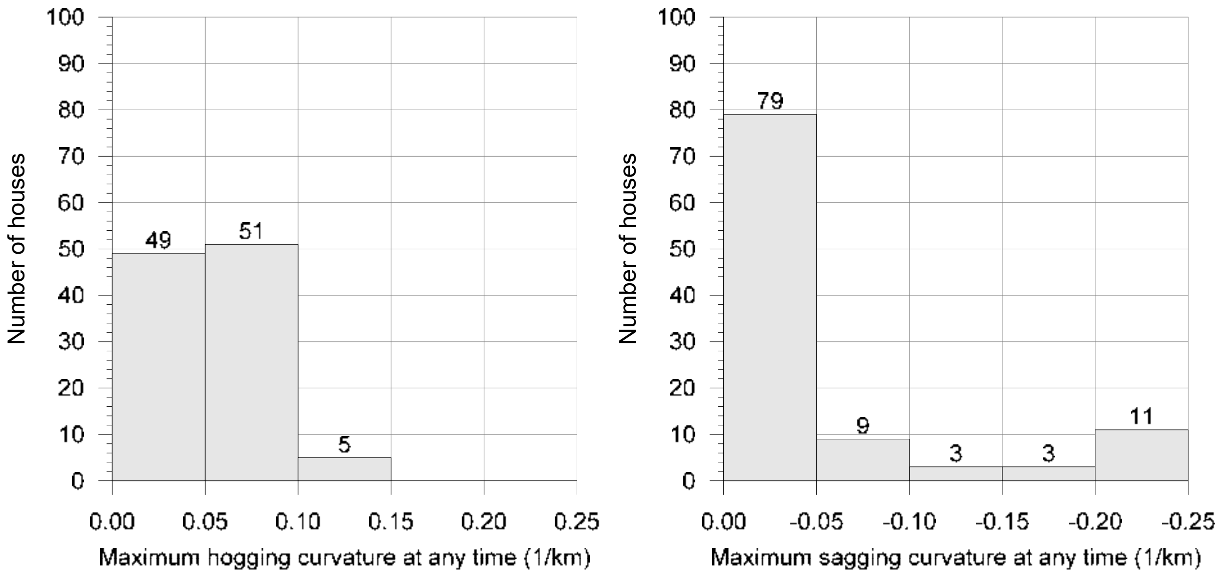

Fig. 11.10 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for the houses within the Subsidence Study Area

The maximum predicted conventional strains for the houses, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.7 mm/m tensile and 3.5 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The houses are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. An analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

11.1.3. Impact assessments for the houses

The following sections provide the impact assessments for the houses within the *Subsidence Study Area*.

Potential impacts resulting from vertical subsidence

Vertical subsidence does not directly affect the stability or serviceability of houses. The potential for impacts on houses is affected by differential subsidence, which includes tilt, curvature and strain, and the impact assessments based on these parameters are described in the following sections.

Vertical subsidence may affect the heights of some the houses above the flood level. The potential impacts on the houses resulting from the changes in flood level from the proposed mining has been assessed as part of the flood model, which is described in the Water Management Plan (Tahmoor Coal, 2022a).

Potential impacts resulting from tilt

It has been found from past longwall mining experience that tilts of less than 7 mm/m generally do not result in any substantial impacts on houses. Some minor serviceability impacts can occur at these levels of tilt, including door swings and issues with roof gutter and wet area drainage, all of which can be remediated using normal building maintenance techniques. Tilts greater than 7 mm/m can result in greater serviceability impacts which may require more substantial remediation measures, including the relevelling of wet areas or, in some cases, the relevelling of the building structure.

The predicted maximum tilts are less than 7 mm/m at 97 of the houses within the *Subsidence Study Area* (i.e. 92 % of the total) at the completion of mining. It is expected that only minor serviceability impacts would occur at these houses, as the result of tilt, which could be remediated using normal building techniques.

The maximum predicted tilt for the houses is 9 mm/m (i.e. 0.9 %, or 1 in 111). A total of 8 houses (i.e. 8 % of the total) are predicted to experience tilts greater than 7 mm/m. The potential for serviceability impacts is greater for these houses. In some cases, more substantial remediation measures may be required, such as relevelling of the building structure.

The distribution of predicted final tilts for the houses within the *Subsidence Study Area* is provided in Fig. 11.11.

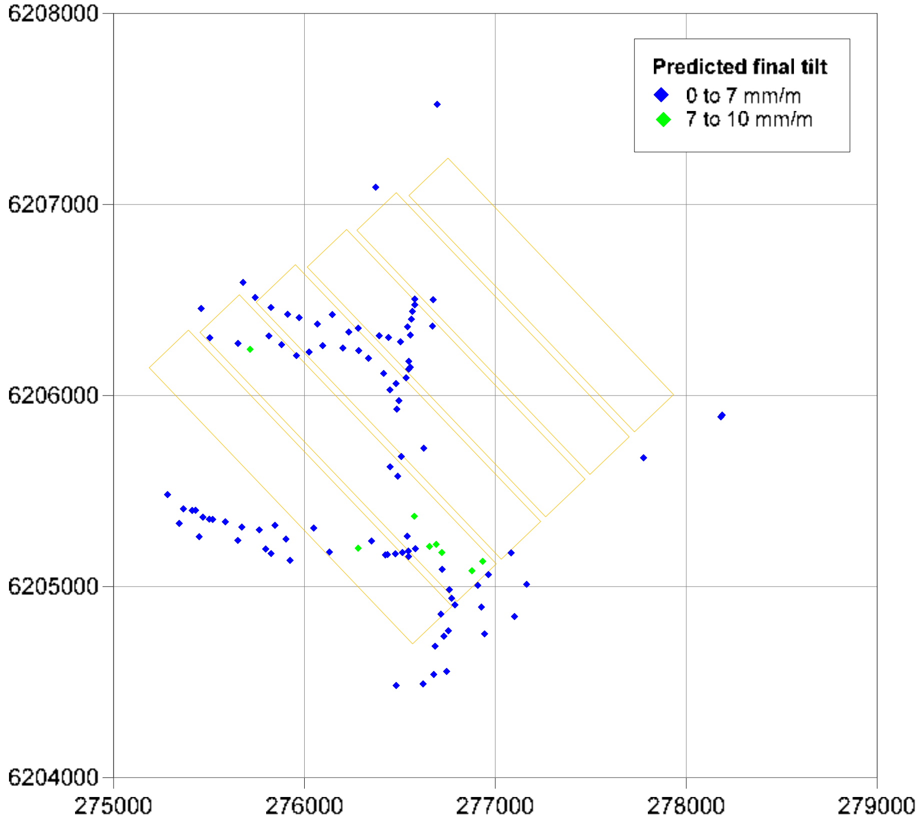

Fig. 11.11 Distribution of predicted final tilts for the houses at the completion of mining

It can be seen from the above figure, that the houses with predicted final tilts greater than 7 mm/m are located above proposed LWs S5A and S6A.

Houses located above previously extracted longwalls at Tahmoor have experienced mining-induced tilts within the predicted range for the Amended Layout. This includes tilts at magnitudes of 10 mm/m and greater, which were observed above Tahmoor Mine LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. To date, there have been very few claims to SA NSW for impacts on houses as a result of mining induced tilt. Claims in these areas have mainly been based on impacts resulting from mining induced curvatures or strains.

The distribution of measured tilts for the survey bays located in the area of increased subsidence above LWs 24B, 25 and 26, is provided in Fig. 11.12. A gamma function has also been fitted to the observed data which is shown by the blue curve.

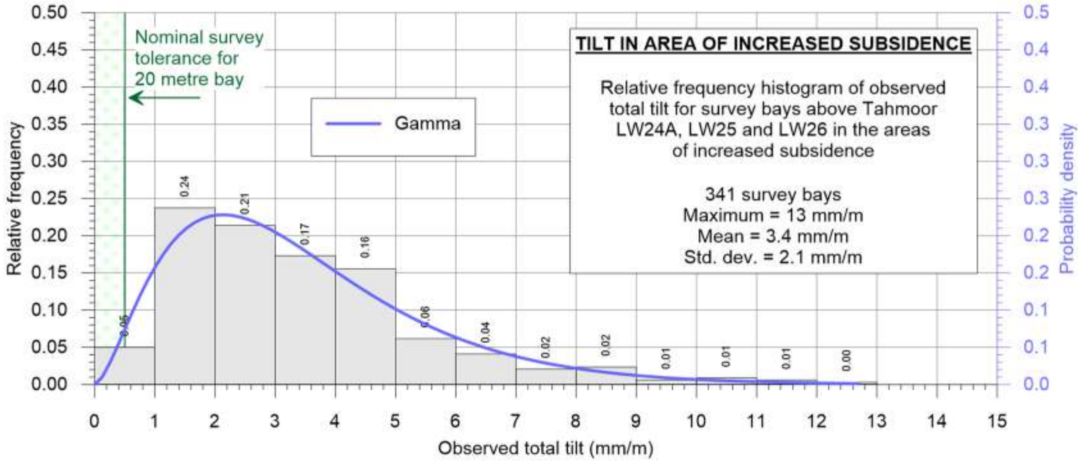

Fig. 11.12 Distribution of measured tilts for survey bays located in the areas of increased subsidence above Tahmoor Mine longwalls 24A, 25 and 26

It can be seen from the above figure, that the maximum observed total tilt for the survey bays in the areas of increased subsidence was 13 mm/m, which is greater than the maximum predicted tilt at the houses directly above the proposed longwalls, which is 9 mm/m.

The range of predicted tilts for the houses within the *Subsidence Study Area*, therefore, is less than that observed above previously extracted longwalls at Tahmoor Mine, including LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. It is expected that the incidence of claims for impacts resulting from the mining induced tilt would be low, due to the extraction of the proposed longwalls, as was previously experienced in the areas of increased subsidence.

It is expected that, in all cases, the houses within the *Subsidence Study Area* will remain in safe and serviceable conditions as the result of the mining induced tilts as tilts by themselves rarely impact on the stability of building structures at the levels that are predicted to occur.

Potential impacts resulting from curvature and strain

It has been found from past longwall mining experience that the majority of mining-induced impacts on houses are a result of curvature and strain.

There are 100 houses within the *Subsidence Study Area* (i.e. 95 % of the total) that are predicted to experience hogging curvatures less than 0.10 km^{-1} and 88 houses (i.e. 84 % of the total) that are predicted to experience sagging curvatures less than 0.10 km^{-1}, which represent minimum radii of curvature of 10 kilometres.

The maximum predicted curvatures for the houses within the *Subsidence Study Area* are 0.11 km^{-1} hogging and 0.23 km^{-1} sagging, which represent minimum radii of curvature of 9.1 kilometres and 4.3 kilometres, respectively.

The distribution of predicted curvatures for the houses within the *Subsidence Study Area* is provided in Fig. 11.13.

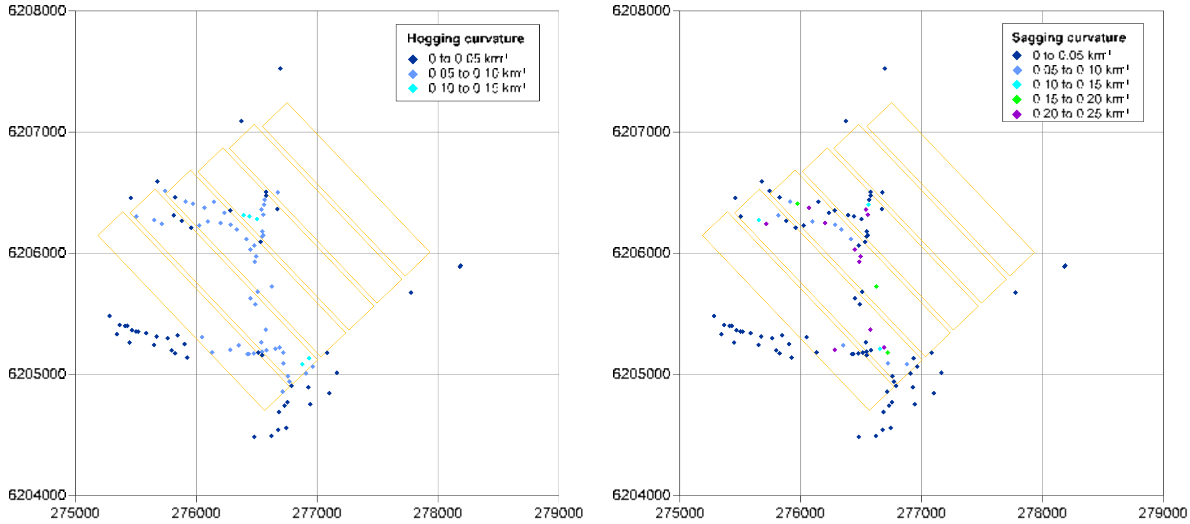

Fig. 11.13 Distribution of predicted hogging curvatures (left) and sagging curvatures (right) for houses at the completion of mining

The above figure shows that the greatest predicted curvatures occur directly above the proposed longwalls.

Houses located above previously extracted longwalls at Tahmoor have experienced mining-induced curvatures within the predicted range for the Amended Layout. This includes curvatures greater than 0.10 km^{-1}, which were observed above Tahmoor Mine LW 24A and above the south-eastern ends of LWs 25 and 26, in the areas of increased subsidence. The distributions of measured hogging and sagging curvatures for the survey bays located in the area of increased subsidence above LW 24A, LWs 25 and 26, is provided in Fig. 11.14. Generalised Pareto Distributions (GDPs) have also been fitted to the observed data which are shown by the blue curves.

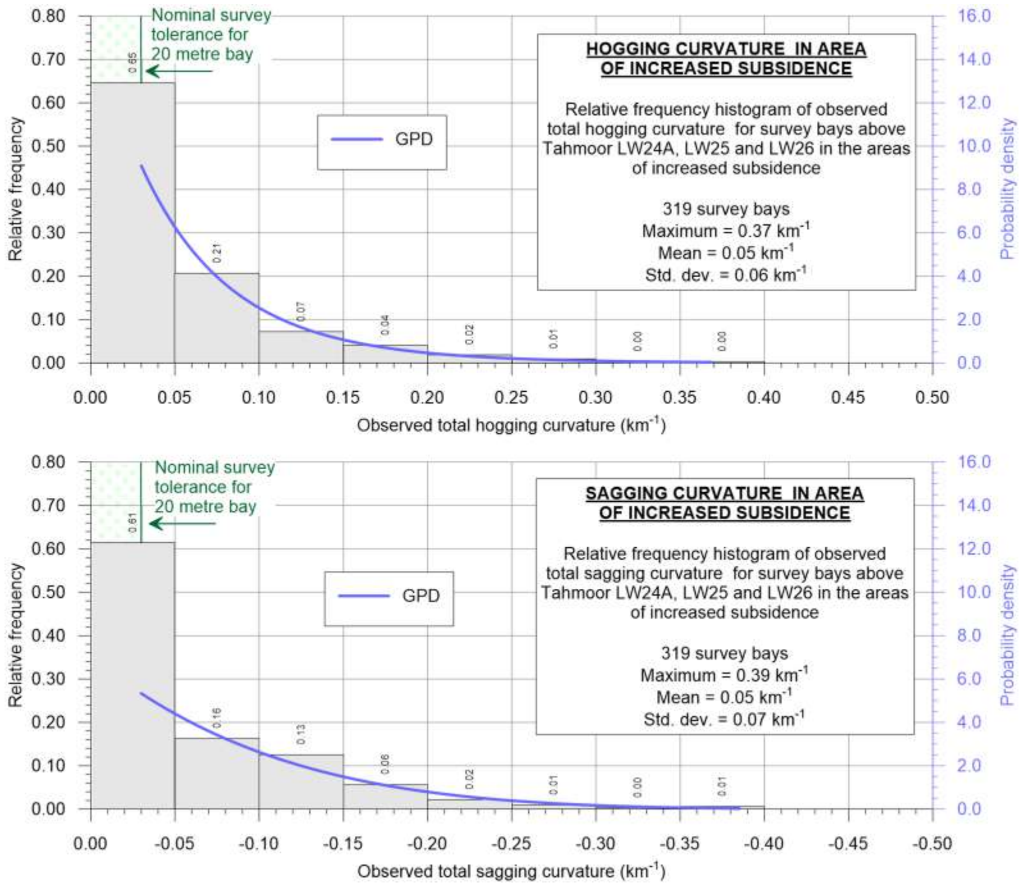

Fig. 11.14 Distributions of measured curvatures for survey bays located in the areas of increased subsidence above Tahmoor Mine LWs 24A, 25 and 26

It can be seen from the above figure, that the maximum observed total curvatures for the survey marks in the areas of increased subsidence were 0.37 km^{-1} hogging and 0.39 km^{-1} sagging, which are greater than the maximum predicted curvatures at the houses within the *Subsidence Study Area* of 0.11 km^{-1} hogging and 0.23 km^{-1} sagging.

The range of predicted curvatures for the houses within the *Subsidence Study Area*, therefore, less than those observed above previously extracted longwalls at Tahmoor Mine, including LW 24A and above the eastern ends of LWs 25 and 26 in the areas of increased subsidence. It is expected, therefore, that the incidence of claims for impacts resulting from the mining induced curvature and strain for the proposed longwalls would be similar to those previously experienced in the areas of increased subsidence. The methods for predicting and assessing impacts on building structures have developed over time as knowledge and experience has grown. MSEC has provided predictions and impact assessments for the houses within the *Subsidence Study Area* using the latest methods available at the time of writing.

Building structures have been directly mined beneath at a number of collieries throughout the NSW Coalfields. The experience gained has provided substantial information that has been used to continually develop the methods of impact assessment for houses. The assessments provided in this report are based on the latest research, which is summarised in Appendix C.

Trend analyses were conducted following the mining of Tahmoor Mine LWs 22 to 29. The analyses indicated that the chance of impact is higher for the following houses:-

- Houses predicted to experience higher strains and curvatures,
- Houses with masonry walls,
- Masonry walled houses that are constructed on strip footings,
- Larger houses, and
- Houses with variable foundations, such as those with extensions added.

The probabilities of impacts for each house within the *Subsidence Study Area* have been assessed using the method developed as part of ACARP Research Project C12015 (Waddington, 2009) and it has been updated based on observations of impacts at Tahmoor up to 2016 when the extraction of Longwall 29 was completed. This method uses the primary parameters of ground curvature and type of construction and is described in Appendix C. The parameter of strain is indirectly used in this method due to its relationship with curvature. A summary of the predicted movements and the assessed impacts for each house within the *Subsidence Study Area* is provided in Table D.03, in Appendix D.

The overall distribution of the assessed impacts for the houses within the *Subsidence Study Area* is provided in Table 11.4. The assessed impacts have been determined based on the existing construction type of each house, as described in Section 11.1.1.

Table 11.4 Assessed impacts for houses within the *Subsidence Study Area*

Group	Repair category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses (total of 105)	74 (71 %)	21 (20 %)	8 (8 %)	2 (1 %)
Directly above proposed longwalls (total of 65)	38 (59 %)	18 (28 %)	7 (11 %)	1 (2 %)
Directly above solid coal (total of 40)	36 (90 %)	3 (8 %)	1 (2 %)	< 1 (< 0.5 %)

In comparison, extensive data has come from the extraction of Tahmoor Mine Longwalls 22 to 29, where approximately 1,900 houses have experienced mine subsidence movements. A summary of the observed distribution of impacts for all houses within a 35° angle of draw of previously extracted Longwalls 22 to 29 as at 2016 is provided in Table 11.5.

Table 11.5 Observed frequency of impacts for building structures resulting from the extraction of Tahmoor Mine longwalls 22 to 29

Group	Repair category			
	No Claim or R0	R1 or R2	R3 or R4	R5
All houses within 35 degree angle of draw of LWs 22 to 29 (total of 1890)	1430 (76 %)	329 (17 %)	111 (6 %)	20 (1 %)
All houses, located directly above LWs 24A to 27 in Zone of Increased Subsidence (total of 432)	235 (54 %)	128 (30 %)	55 (13 %)	14 (3 %)

As discussed previously, the range of predicted curvatures for the houses within the *Subsidence Study Area* are less than but similar to those observed above Tahmoor Mine Longwalls 24A to 27 within the observed zone of increased subsidence.

When the assessed distribution of impacts for the houses located directly above the proposed longwalls (second row of Table 11.4) are compared with the observed distribution of impacts of houses and major civil structures located directly above Longwalls 24A to 27 within the zone of increased subsidence (bottom row of Table 11.5), it can be seen that these are reasonably similar.

As mentioned earlier, the assessed impacts have been undertaken based on the existing construction type of each house. It is recognised that houses may be rebuilt in the future before the proposed mining occurs. The proportion of houses impacted by mining would, for example, increase if a greater proportion of houses are constructed directly above the proposed longwalls, or if a greater proportion of houses are constructed with brick walls rather than timber-framed weatherboard style structures. The most vulnerable style of house affected by mine subsidence movements above Tahmoor Mine Longwalls 22 to 29 were constructed as brick or brick-veneer houses on strip footings.

Severe impacts have previously occurred as a result of substantial non-conventional movements and in plateau areas away from incised valleys, such as where the houses are located within the *Subsidence Study Area.* The precise location of non-conventional movements cannot be predicted prior to mining. The impacts, however, develop gradually such that they can be detected early and repairs can be undertaken incrementally to ensure that the houses remain safe and serviceable during mining.

As noted in Appendix C, at the time of writing ACARP Research Project C12015 (Waddington, 2009), the observed proportion of houses where the Mine Subsidence Board (MSB, now SA NSW) and affected landowners had agreed to rebuild rather than repair, i.e. Category R5 impacts was less than 0.5 %. Since the publication of the research report, the proportion of houses where a decision has been made to rebuild has increased to approximately 1.1 % overall and 3.2 % above Longwalls 24A to 27 within the observed zone of increased subsidence.

The observed proportion of houses with Category R1 to R4 impacts have also increased since the original ACARP study. This is partly due to the time lag effect between the mining impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW. The latest review includes observations up to the end of Longwall 29 in 2016, which was approximately two years after the completion of Longwall 27 and one year after the completion of Longwall 28, which was the last panel to directly mine beneath the urban areas of Tahmoor.

The primary risk associated with mining beneath houses is public safety. Residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements in the NSW Coalfields, where the depths of cover were greater than 350 metres, such as the case above the proposed longwalls. This includes the recent experience at Tahmoor Mine, which has affected more than 1,950 houses, and the experiences at Appin, Teralba, West Cliff and West Wallsend Collieries, which have affected around 500 houses.

Emphasis is placed on the words “immediate and sudden” as in rare cases, some structures have experienced severe impacts, but the impacts did not present an immediate risk to public safety as they developed gradually with ample time to temporarily relocate residents.

All houses within the *Subsidence Study Area* are expected to remain safe and repairable throughout the mining period, provided that effective management measures are adopted during mining and these are described in Section 11.1.5.

11.1.4. Future development of houses within the *Subsidence Study Area*

There are no known future developments within the *Subsidence Study Area*.

11.1.5. Management of potential impacts on the houses

Tahmoor Mine has extensive experience of mining beneath urban areas. It has developed and acted in accordance with a risk management process to manage potential impacts to residential structures during the mining of LWs 22 to 32 and LWs W1-W3.

The Subsidence Management Process has been developed in consideration of the following facts and observations:

1. Australian standards have been available for use in the design of structures since 1948. The great majority of structures at Tahmoor and Thirlmere (approximately 80 %) have been constructed after the declaration of the Bargo Mine Subsidence District in November 1975.
2. There is sufficient redundancy in structural design such that ductile deformation will develop and be noticeable to residents before structural failure occurs.
3. Subsidence movements develop gradually over time at Tahmoor Mine as they have above other previously extracted longwalls at similar depths of cover.
4. Experiences during the mining of LWs 22 to 32 and LWs W1-W3 have found that the most effective method of managing potential impacts on the safety and serviceability of structures are by way of community consultation. Residents living within the active subsidence zone have often provided early feedback to Tahmoor Mine and/or SA NSW about impacts developing at their houses or along their local roads. Contact is made well before impacts develop to a level of severity sufficient to become a safety hazard.
5. On the basis of the above, there is sufficient time for residents to notify Tahmoor Mine or SA NSW of significant displacement or deflection well before structural failure will occur.
6. The conclusions are supported by the observation that residents have not been exposed to immediate and sudden safety hazards as a result of impacts that occur due to mine subsidence movements at Tahmoor Mine and above other previously extracted longwalls at similar depths of cover. This includes the recent experience at Tahmoor Mine during the mining of LWs 22 to 32 and LWs W1-W3, which have affected more than 2000 houses and civil structures.

While severe impacts have developed during the mining of LWs 22 to 32, there is sufficient redundancy in structural design such that when structures have experienced severe impacts, they have developed gradually with ample time for residents to notify Tahmoor Mine or SA NSW to repair the structure and/or relocate residents before structural failure occurs.

While the three most important factors in managing risks to public safety are redundancy in structural design, gradual development of subsidence movements and an effective community consultation program, a number of additional management measures have been undertaken, including site specific investigations, regular surveys and inspections during mining and triggered response measures. The method of management would not change if additional houses are constructed in the future as described in Section 11.1.4.

It is recommended that Tahmoor Coal continues its current practice of ensuring that built structures remain safe and serviceable at all times during mining. It is recommended that Tahmoor Coal, in consultation with landowners, study the potential for impacts on the structures and other infrastructure and develop management measures. The study would require input from structural and subsidence engineers. The risk management process includes the following processes:-

1. Regular consultation, cooperation and coordination with the community before, during and after mining. This includes letters and door knocking to all residents of structures that will soon be affected by subsidence. The letters offer a free pre-mining inspection and hazard identification inspection by a structural engineer;
2. Site-specific investigations, where they are necessary and appropriate, into the conditions of buildings and associated structures and their surrounding environment (where access is allowed). The site-specific investigations have been and will continue to be undertaken early so that there is adequate time, if required, to arrange additional inspections and/or surveys and implement any mitigation measures before mining-induced impacts are experienced;

   For properties located directly above the first 300 metres of the commencing end of a longwall, the investigations are targeted to be undertaken prior to extraction or at the latest, they will be undertaken prior to the first 200 metres of extraction of the longwall.

   The site-specific investigations include the following:

   a) Identification of structures from aerial photographs and kerbside inspections;
   b) Front of house risk and visual screening inspections by Tahmoor Coal in company with a structural engineer for all properties that are predicted to experience more than 20 mm of incremental vertical subsidence due to the extraction of each upcoming longwall. The purpose of the inspections is to identify hazards where access has not been granted by the landowner.

In some cases, particularly in semi-rural and rural areas, it is difficult to inspect a structure that is remote from the street front. Where these cases involve properties that are located directly above a longwall, Tahmoor Coal will request access to conduct a pre-mining inspection and hazard identification inspection by a structural engineer;

c) Tahmoor Coal will request access to conduct pre-mining geotechnical inspections of structures located on or immediately adjacent to steep slopes that are predicted to experience more than 20 mm of incremental vertical subsidence due to the extraction of each longwall;

d) Tahmoor Coal will request access to conduct pre-mining hazard identification inspections by a structural engineer (where access is allowed by the landowner) to properties with structures that have been specifically targeted on the basis that may be more sensitive to mine subsidence movements. These include:

   i) Commercial and business establishments, public amenities and public utilities;
   ii) Structures of heritage significance;
   iii) Structures that are located above hidden creeks (none identified within the *Subsidence Study Area*);
   iv) Structures that are located above mapped geological structures (none identified within the *Subsidence Study Area*);
   v) Structures that are located on or adjacent to steep slopes or that have been recommended for structural inspection by the geotechnical engineer;
   vi) Structures that have been identified as being potentially unstable or unsafe by landowners (Item 1), or from the front of house inspections (Item 2b);
   vii) Houses and units located outside the declared Mine Subsidence Districts; and
   viii) Houses and units estimated to have been constructed prior to the declaration of the Bargo Mine Subsidence District (in November 1975).

3. Implementation of pre-mining mitigation measures following inspections by the geotechnical engineer and the structural engineer, in consultation and agreement with the landowner.

4. Surveys and inspections during mining within the active subsidence area:
   a) detailed visual inspections and vehicle-based inspections along the streets;
   b) ground surveys along the streets;
   c) specific ground surveys for selected properties, where recommended by the geotechnical engineer or structural engineer due to their proximity to steep slopes or pre-existing condition;
   d) visual inspections of residential structures that are either: located on or adjacent to steep slopes, are in poor existing condition (based on the hazard identification inspections), have previously reported impacts, or where recommended by the Structures Response Group;
   e) visual inspections of pool fences and gates; and
   f) visual inspections of commercial, industrial and business establishments, public amenities and public utilities.

With appropriate management plans in place, it is considered that the houses will remain safe and serviceable at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

11.2. Flats or units

There are no flats or units within the *Subsidence Study Area*.

11.3. Caravan parks

There are no caravan parks within the *Subsidence Study Area*.

11.4. Retirement or aged care villages

There is no retirement village within the *Subsidence Study Area*.

11.5. Swimming pools

11.5.1. Descriptions of the swimming pools

The locations of the private swimming pools within the *Subsidence Study Area* are shown in Drawing No. MSEC1192-18.

There are 22 privately owned swimming pools which have been identified within the *Subsidence Study Area*. The majority of these pools (68 %) will be directly mined beneath by the proposed longwalls. The locations and sizes of the pools were determined from orthophotographs of the area.

11.5.2. Predictions for the swimming pools

Predictions of conventional subsidence, tilt and curvature have been made at the centroid and at points located around the perimeter of each pool, as well as at points located at a distance of 20 metres from the perimeter of each pool.

A summary of the maximum predicted values of conventional subsidence, tilt and curvature for each pool within the *Subsidence Study Area* is provided in Table D.06, in Appendix D. The predictions are based on the proposed longwall layout, as shown in Drawing No. MSEC1192-18. The predicted tilts provided in this table are the maxima in any direction after the completion of each of the proposed longwalls. The predicted curvatures are the maxima in any direction at any time during or after the extraction of each of the proposed longwalls.

Distributions of the maximum predicted conventional subsidence, tilt and curvature for the pools within the *Subsidence Study Area* are illustrated in Fig. 11.15 and Fig. 11.16.

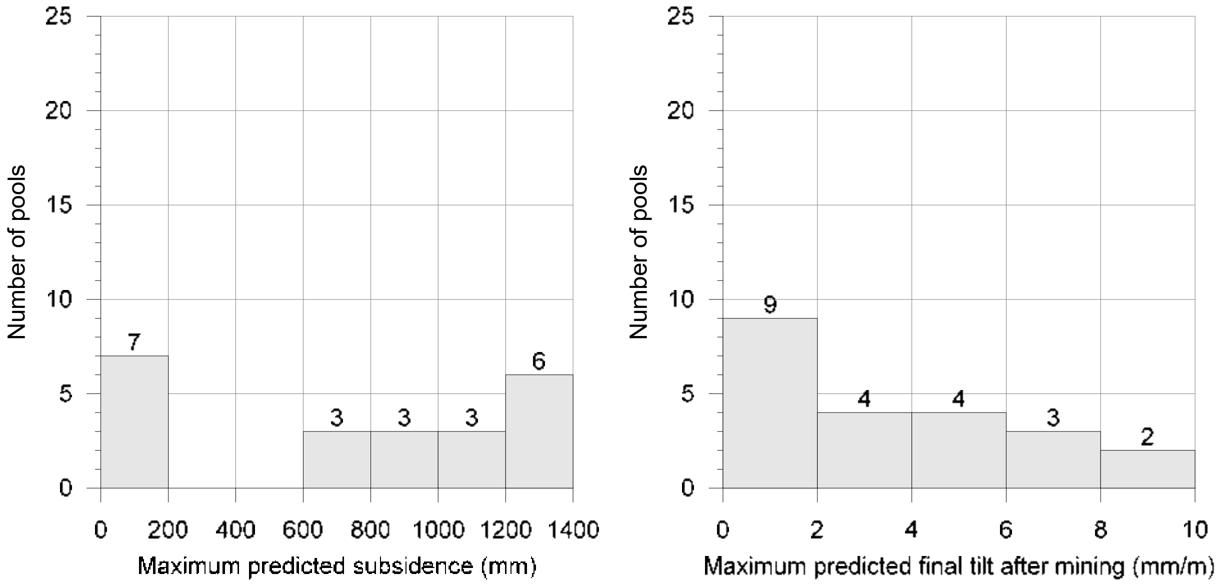

Fig. 11.15 Maximum predicted conventional subsidence and tilt for pools within the Subsidence Study Area

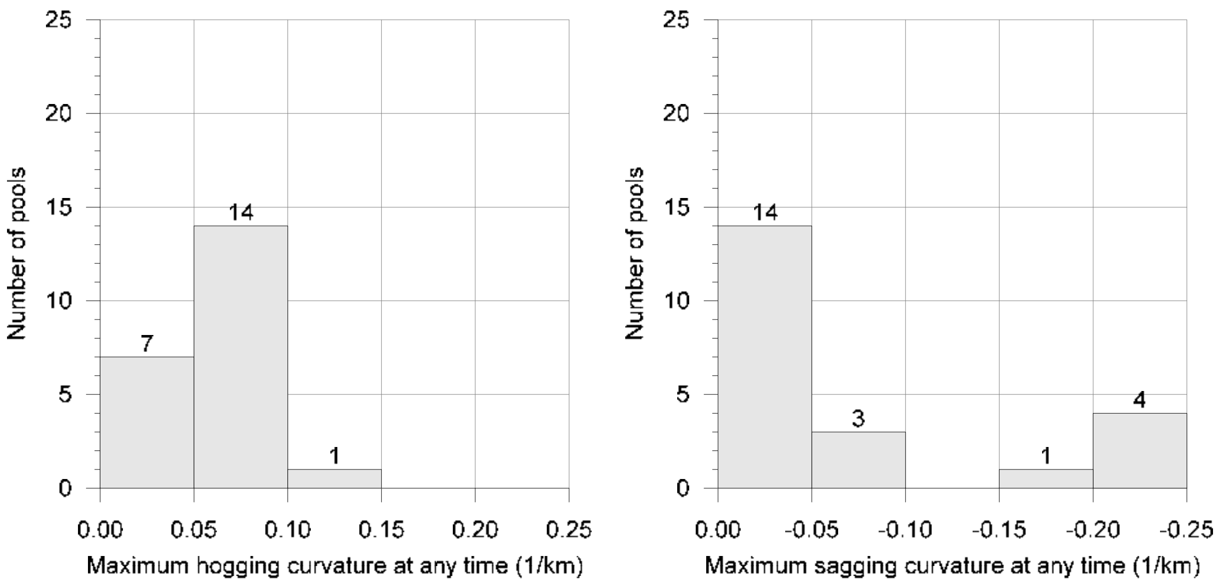

Fig. 11.16 Maximum predicted conventional hogging curvature (left) and sagging curvature (right) for the pools within the Subsidence Study Area

The maximum predicted conventional strains for the pools, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 1.7 mm/m tensile and 3.4 mm/m compressive. Non-conventional movements can also occur as a result of, among other things, anomalous movements. The analysis of strains provided in Chapter 4 includes those resulting from both conventional and non-conventional anomalous movements.

The pools are at discrete locations and, therefore, the most relevant distributions of strain are the maximum strains measured in individual survey bays from previous longwall mining. The analysis of strains in survey bays during the mining of previous longwalls in the Southern Coalfield is discussed in Section 4.3.1. The results for survey bays located above goaf are provided in Fig. 4.2 and the results for survey bays located above solid coal are provided in Fig. 4.3.

11.5.3. Impact assessments for the swimming pools

Mining-induced tilts are more noticeable in pools than other structures due to the presence of the water line and the small gap to the edge coping, particularly when the pool lining has been tiled. Skimmer boxes are also susceptible of being lifted above the water line due to mining tilt.

The Australian Standard AS2783-1992 (Use of reinforced concrete for small swimming pools) requires that pools be constructed level ± 15 mm from one end to the other. This represents a tilt of approximately 3 mm/m for pools that are 10 metres in length. Australian Standard AS/NZS 1839:1994 (Swimming pools – Pre-moulded fibre-reinforced plastics – Installation) also requires that pools be constructed with a tilt of 3 mm/m or less.

There are 11 pools within the *Subsidence Study Area* (i.e. 50 % of the total) which are predicted to experience final tilts of 3 mm/m or less, at the completion of the proposed longwalls, which is similar to or less than the Australian Standard.

There are 9 pools (i.e. 41 % of the total) predicted to experience final tilts between 3 mm/m and 7 mm/m and 2 pools (i.e. 9 % of the total) predicted to experience final tilts greater than 7 mm/m. The maximum predicted final tilt for the pools is 9 mm/m (i.e. 0.9 %), which represents a change in grade of 1 in 111. It is likely that a number of these pools would require some remediation of the pool copings.

The maximum predicted conventional curvatures for the pools are 0.11 km^{-1} hogging and 0.23 km^{-1} sagging, which equate to minimum radii of curvature of 9.1 kilometres and 4.3 kilometres, respectively. Whilst the predicted subsidence parameters for the proposed longwalls are greater than those at Tahmoor North, it would still be expected that the rates of impact on pools at Tahmoor North would provide a reasonable guide to the likely levels of impact.

Observations during the mining of Tahmoor Mine LWs 22 to 32 have shown that pools, particularly in-ground pools, are more susceptible to severe impacts than houses and other structures. Pools cannot be easily repaired and most of the impacted pools need to be replaced.

As of June 2017, a total of 157 pools have experienced mine subsidence movements during the mining of Tahmoor Mine Longwalls 22 to 30, of which 141 were located directly above the extracted longwalls. A total of 36 pools have reported impacts, all of which were located directly above the extracted longwalls. This represents an impact rate of approximately 23 %. A higher proportion of impacts have been observed for in-ground pools, particularly fibreglass pools. The majority of the impacts related to tilt or cracking, though in a small number of cases the impacts were limited to damage to skimmer boxes or the edge coping.

It is expected that the rate of impact on the pools within the *Subsidence Study Area* would be similar, but, slightly greater than those previously experienced at Tahmoor North. Impacts to the pools would be repaired or, if required the pool would be replaced in accordance with the *Coal Mine Subsidence Compensation Act 2017*.

11.5.4. Impact assessments for the swimming pools based on increased predictions

If the actual tilts exceeded those predicted by a factor of 2 times, the final tilts would still be 3 mm/m or less at 7 pools within the *Subsidence Study Area* (i.e. 32 % of the total) at the completion of mining. In this case, there would be 5 pools (i.e. 23 % of the total) predicted to experience final tilts between 3 mm/m and 7 mm/m and 10 pools (i.e. 45 % of the total) predicted to experience final tilts greater than 7 mm/m. It is possible that approximately half the pools within the *Subsidence Study Area* would require some remediation of the coping due to the mining induced tilt, if the actual tilts exceeded those predicted by a factor of 2 times.

If the actual curvatures exceeded those predicted by a factor of 2 times, the incidence of impacts would increase for the pools located directly above the proposed longwalls. While the predicted ground movements are important parameters when assessing the potential impacts on the pools, it is noted that the impact assessments were primarily based on observed rate of impact from Tahmoor North. The overall levels of impact on the pools, resulting from the extraction of the proposed longwalls, are expected to be similar to, but, slightly greater than those observed at Tahmoor North.

11.5.5. Management of potential impacts on the swimming pools

Tahmoor Coal has developed and acted in accordance with a risk management plan to manage potential impacts to pools during the mining of LWs 22 to 32 and LWs W1-W3. The management plan is reviewed periodically by Tahmoor Coal. It is recommended that Tahmoor Coal continue to develop management plans to manage potential impacts during the mining of the proposed longwalls.

While not strictly related to the pool structure, a number of pool gates have been impacted as the result of the previous extraction of longwalls beneath pools. While the gates can be easily repaired, the worst-case consequence of breaching pool fence integrity could be severe. As a result, Tahmoor Coal inspects the integrity of pool fences once a week for pools that are experiencing active subsidence during mining.

With an appropriate management plan in place, it is considered that pools and pool fences can be maintained at all times during the extraction of the proposed longwalls, even if actual subsidence movements were greater than the predictions or substantial non- conventional movements occurred.

11.5.6. Tennis courts

There are no privately owned tennis courts within the *Subsidence Study Area*.

11.5.7. On-site waste water systems

The majority of the residences within the *Subsidence Study Area* operate on-site waste water systems.

The on-site waste water system tanks are generally small, typically less than 3 metres in diameter, are constructed from reinforced concrete, and are usually bedded in sand and backfilled. It is unlikely, therefore, that the maximum predicted curvatures and strains would be fully transferred into the tank structures.

It is possible, however, that the buried pipelines associated with the on-site waste water tanks could be impacted by the strains if they are anchored by the tanks or other structures in the ground. Any impacts are expected to be of a minor nature, including leaking pipe joints, and could be readily repaired. With the implementation of these remedial measures, it would be unlikely that there would be any adverse impacts on the pipelines associated with the on-site wastewater systems.

11.5.8. Rigid external pavements

Adverse impacts on rigid external pavements are often reported to SA NSW in the NSW Coalfields. This is because pavements are typically thin relative to their length and width. The design of external pavements is also not regulated by Council or SA NSW.

A study by MSEC of 120 properties at Tahmoor and Thirlmere indicated that 98 % of the properties with external concrete pavements demonstrated some form of cracking prior to mining. These cracks are sometimes difficult to distinguish from cracks caused by mine subsidence. It is therefore uncertain how many claims for damage can be genuinely attributed to mine subsidence impacts.

Residential concrete pavements are typically constructed with tooled joints which do not have the capacity to absorb compressive movements. It is possible that some of the smaller concrete footpaths or pavements within the *Subsidence Study Area*, in the locations of the larger compressive strains, could buckle upwards if there are insufficient movement joints in the pavements. It is expected, however, that the buckling of footpaths and pavements would not be common, given the magnitudes of the predicted ground strains, and could be easily repaired.

11.6. Fences

Predictions and impact assessments for fences are provided in Section 8.9.

11.7. Any other residential feature

There are no other substantial residential features within the *Subsidence Study Area*.

12.0 ANY KNOWN FUTURE DEVELOPMENTS

There are currently no known future developments *Subsidence Study Area*.

13.0 CONCLUSIONS

Mine Subsidence Engineering Consultants (MSEC) has studied the Extraction Plan Layout and identified the natural features and items of surface infrastructure that are in the *Subsidence Study Area*.

Predictions of subsidence movements have been provided for each of these natural features and items of surface infrastructure. The predictions have been produced using a model that has been calibrated from observations of previous movements during the extraction of previous longwalls at Tahmoor Mine and more broadly from observations of previous movements during the extraction of previous longwalls at similar depths of cover at nearby mines in the Southern Coalfield.

The maximum predicted total subsidence, after the completion of the proposed longwalls, is 1,350 mm which represents around 61 % of the extraction height.

The potential for impacts has been assessed based on the predicted subsidence movements, consultation with infrastructure owners and experiences gained during the extraction of previous longwalls at Tahmoor Mine and more broadly from experiences during the extraction of previous longwalls at similar depths of cover at nearby mines in the Southern Coalfield.

The overall findings of the assessments undertaken by MSEC are that the levels of impact and damage to all identified natural features and built infrastructure are manageable and can be controlled by the preparation and implementation of Subsidence Management Plans (or Extraction Plans), many of which have been successfully implemented during previous mining at Tahmoor Mine. These management plans are developed in consultation with the owners of infrastructure and are approved by relevant government agencies. The findings in this report should be read in conjunction with all other associated consultant reports.

Recommended management measures generally include monitoring of ground movements and the condition of surface features. Some mitigation measures are recommended to mitigate or avoid the risk of serious consequences should impacts occur to some critical surface features.

It is recommended that Tahmoor Coal continues to develop management plans to manage the potential impacts for the surface features due to the extraction of the proposed longwalls.

APPENDIX A. GLOSSARY OF TERMS AND DEFINITIONS

Glossary of Terms and Definitions

Some of the more common mining terms used in the report are defined below:-

Angle of draw	The angle of inclination from the vertical of the line connecting the goaf edge of the workings and the limit of subsidence (which is usually taken as 20 mm of subsidence).
Chain pillar	A block of coal left unmined between the longwall extraction panels.
Cover depth (H)	The depth from the surface to the top of the seam. Cover depth is normally provided as an average over the area of the panel.
Closure	**T**he reduction in the horizontal distance between the valley sides. The magnitude of closure, which is typically expressed in the units of *millimetres (mm)*, is the greatest reduction in distance between any two points on the opposing valley sides. It should be noted that the observed closure movement across a valley is the total movement resulting from various mechanisms, including conventional mining induced movements, valley closure movements, far-field effects, downhill movements and other possible strata mechanisms.
Critical area	The area of extraction at which the maximum possible subsidence of one point on the surface occurs.
Curvature	The change in tilt between two adjacent sections of the tilt profile divided by the average horizontal length of those sections, i.e. curvature is the second derivative of subsidence. Curvature is usually expressed as the inverse of the **Radius of Curvature** with the units of *1/kilometres (km-1)*, but the value of curvature can be inverted, if required, to obtain the radius of curvature, which is usually expressed in *kilometres (km)*. Curvature can be either **hogging** (i.e. convex) or **sagging** (i.e. concave).
Extracted seam	The thickness of coal that is extracted. The extracted seam thickness is thickness normally given as an average over the area of the panel.
Effective extracted seam thickness (T)	The extracted seam thickness modified to account for the percentage of coal left as pillars within the panel.
Face length	The width of the coalface measured across the longwall panel.
Far-field movements	The measured horizontal movements at pegs that are located beyond the longwall panel edges and over solid unmined coal areas. Far-field horizontal movements tend to be bodily movements towards the extracted goaf area and are accompanied by very low levels of strain.
Goaf	The void created by the extraction of the coal into which the immediate roof layers collapse.
Goaf end factor	A factor applied to reduce the predicted incremental subsidence at points lying close to the commencing or finishing ribs of a panel.
Horizontal displacement	The horizontal movement of a point on the surface of the ground as it settles above an extracted panel.
Inflection point	The point on the subsidence profile where the profile changes from a convex curvature to a concave curvature. At this point the strain changes sign and subsidence is approximately one half of S max.
Incremental subsidence	The difference between the subsidence at a point before and after a panel is mined. It is therefore the additional subsidence at a point resulting from the excavation of a panel.
Panel	The plan area of coal extraction.
Panel length (L)	The longitudinal distance along a panel measured in the direction of mining from the commencing rib to the finishing rib.
Panel width (Wv)	The transverse distance across a panel, usually equal to the face length plus the widths of the roadways on each side.
Panel centre line	An imaginary line drawn down the middle of the panel.
Pillar	A block of coal left unmined.
Pillar width (Wpi)	The shortest dimension of a pillar measured from the vertical edges of the coal pillar, i.e. from rib to rib.

Shear deformations The horizontal displacements that are measured across monitoring lines and these can be described by various parameters including; horizontal tilt, horizontal curvature, mid-ordinate deviation, angular distortion and shear index.

Strain The change in the horizontal distance between two points divided by the original horizontal distance between the points, i.e. strain is the relative differential displacement of the ground along or across a subsidence monitoring line. Strain is dimensionless and can be expressed as a decimal, a percentage or in parts per notation.

Tensile Strains are measured where the distance between two points or survey pegs increases and **Compressive Strains** where the distance between two points decreases. Whilst mining induced **strains** are measured **along** monitoring lines, ground **shearing** can occur both vertically, and horizontally **across** the directions of the monitoring lines.

Sub-critical area An area of panel smaller than the critical area.

Subsidence The vertical movement of a point on the surface of the ground as it settles above an extracted panel, but, 'subsidence of the ground' in some references can include both a vertical and horizontal movement component. The vertical component of subsidence is measured by determining the change in surface level of a peg that is fixed in the ground before mining commenced and this vertical subsidence is usually expressed in units of *millimetres (mm)*. Sometimes the horizontal component of a peg's movement is not measured, but in these cases, the horizontal distances between a particular peg and the adjacent pegs are measured.

Super-critical area An area of panel greater than the critical area.

Tilt The change in the slope of the ground as a result of differential subsidence, and is calculated as the change in subsidence between two points divided by the horizontal distance between those points. Tilt is, therefore, the first derivative of the subsidence profile. Tilt is usually expressed in units of *millimetres per metre (mm/m)*. A tilt of 1 mm/m is equivalent to a change in grade of 0.1 %, or 1 in 1000.

Uplift An increase in the level of a point relative to its original position.

Upsidence Upsidence results from the dilation or buckling of near surface strata at or near the base of the valley. The magnitude of upsidence, which is typically expressed in the units of *millimetres (mm)*, is the difference between the observed subsidence profile within the valley and the conventional subsidence profile which would have otherwise been expected in flat terrain.

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APPENDIX C. METHOD OF IMPACT ASSESSMENTS FOR HOUSES

APPENDIX C METHOD OF IMPACT ASSESSMENT FOR HOUSES

C.1. Introduction

The methods for predicting and assessing impacts on building structures have developed over time as knowledge and experience has grown. MSEC has provided predictions and impact assessments for the building structures within the *Subsidence Study Area* using the latest methods available at this time.

Longwall mining has occurred directly beneath building structures at a number of collieries in the Southern Coalfield, including Appin, West Cliff, Tower and Tahmoor Mines. The most extensive data has come from extraction of Tahmoor Mine Longwalls 22 to 29, where approximately 2000 houses have experienced subsidence movements. The experiences gained during the mining of these longwalls, as well as longwalls at other collieries in the Southern and Newcastle Coalfields, have provided substantial additional information that has been used to further develop the methods.

The information was initially collected during the mining of Tahmoor Mine Longwalls 22 to 24A and reviewed in two parallel studies, one as part of a funded ACARP Research Project C12015 (Waddington, 2009), and the other at the request of Industry and Investment NSW (now the Department of Planning, Industry and Environment – Resources Regulator).

The outcomes of these studies include:-

- Review of the performance of the previous method,
- Recommendations for improving the method of Impact Classification, and
- Recommendations for improving the method of Impact Assessment.

Additional information was collected in 2016 after the completion of Longwall 29 and impact assessments for the houses in this report have been based on the updated information provided. A summary is provided in the following sections.

C.2. Review of the Performance of the Previous Method

The previous method of impact assessment applied predictions of curvature on the overall length of each house to predict a crack width in the external walls that was classified based primarily in accordance with Table C1 of Australian Standard 2870-1996. This method did not include impacts to other elements, finishes or services.

Extensive data on house impacts has come from extraction of Tahmoor Mine Longwalls 22 to 25 and a comparison between predicted and observed impacts is provided in Table C.1. The comparison is based on pre-mining predictions that were provided in SMP Applications for these longwalls and the observations of impacts using the previous method of impact classification. The comparison is based on information up to 30 November 2008. At that point in time, the length of extraction of Longwall 25 was 611 metres.

A total of 1037 houses and civil structures were affected by subsidence due to the mining of Tahmoor Mine Longwalls 22 to 25 at that time. A total of 175 claims had been received by the MSB, now SA NSW (not including claims that were refused) of which 14 claims did not relate to the main residence or civil structure.

Table C.1 Summary of Comparison between Observed and Predicted Impacts for each Structure

Strain Impact Category	Total No. of Observed Impacts for Structures predicted to be Strain Impact Category 0	Total No. of Observed Impacts for Structures predicted to be Strain Impact Category 1	Total No. of Observed Impacts for Structures predicted to be Strain Impact Category 2	Total
No impact	483	373	20	876
Cat 0	31	70	6	107
Cat 1	8	9	1	18
Cat 2	7	11	2	20
Cat 3	2	2	0	4
Cat 4	3	5	0	8
Cat 5	3	1	0	4
Total	537	471	29	1037
% claim	**10 %**	**21 %**	**31 %**	16 %
% Obs > Pred	**4 %**	**4 %**	**0 %**	-
% Obs <= Pred	**96 %**	**96 %**	**100 %**	-

Note: Predicted impacts due to conventional subsidence only, as described in the SMP Application.

Given that observed impacts are less than or equal to predicted impacts in 96 % of cases, it is considered that the previous methods are generally conservative even though non-conventional movements were not taken into account in the predictions and assessments. However, when compared on a house by house basis, the predictions have been substantially exceeded in a small proportion of cases.

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

The inability to specify the number or probability of impacts due to the potential for non-conventional movements is a shortcoming of the previous method. It was considered that there was substantial room for improvement in this area and recommendations are provided to improve the previous method.

The comparison shows a favourable observation that the overall proportion of claims increased for increasing observed ground movements. This suggests that the main parameters currently used to make impact assessments (namely predicted conventional curvature and maximum plan dimension of each structure) are credible. Please note that we have stated predicted conventional curvature rather than strain, as predictions of strain were directly based on predictions of conventional curvature.

A substantial over-prediction is observed at the low end of the spectrum of impacts (Category 0 and 1). A number of causes and/or possible causes for the deviations have been identified:

- Construction methods and standards may mitigate against small differential ground movements.
- The impacts may have occurred but the residents have not made a claim for the following reasons:-
  - All structures contain some existing, pre-mining defects. A pre-mining field investigation of 119 structures showed that it is very rare for all elements of a building to be free of cracks. Cracks up to 3 mm in width are commonly found in buildings. Cracks up to 1 mm in width are very common. There is a higher incidence of cracking in brittle forms of construction such as masonry walls and tiled surfaces.
  - In light of the above, additional very slight Category 0 and 1 impacts may not have been noticed by residents. A forensic investigation of all structures before or after mining may reveal that the number of actual impacts is greater than currently known.
  - Similarly, impacts have been noticed but some residents may consider them to be too trivial to make a claim. While difficult to prove statistically, it is considered that the frequency of claims from tenanted properties is less than the frequency of claims from owner-occupied properties.
- The impacts have been noticed but some residents are yet to make a claim at this stage. It has been observed that there is a noticeable time lag between the moment of impact and the moment of making a claim. At the time of the original study in 2008, more claims were therefore expected to be received in the future within areas that have already been directly mined beneath. This has been confirmed by the findings of the most recent study based on information received in 2016. It has also been found that as assessments and repairs were progressively determined at each house, the level of impacts at each house has generally been greater than was originally reported.
- The predictive method is deliberately conservative in a number of ways.
  - Predicted subsidence movements for each structure are based on the maximum predicted subsidence movements within 20 metres of the structure.
  - An additional 0.2 mm/m of strain was added
  - Maximum strains were applied to the maximum plan dimension, regardless of the maximum predicted strain orientation.
  - The method of impact assessment does not provide for “nil impacts”. The minimum assessed level of impact is Category 0.
  - The impact data was based on double-storey full masonry structures in the UK.

Finally, it is considered that the previous method impact classification has masked the true nature and extent of impacts. It is recommended that an improved method of classification be adopted before embarking on any further analysis. This is discussed in the next chapter of this report.

C.3. Method of Impact Classification

C.3.1. Previous Method

The impacts to structures were previously classified in accordance with Table C1 of Australian Standard 2870-1996, but the table has been extended by the addition of Category 5 and is reproduced below.

Table C.2 Classification of Damage with Reference to Strain

Impact Category	Description of typical damage to walls and required repair	Approximate crack width limit
0	Hairline cracks.	< 0.1 mm
1	Fine cracks which do not need repair.	0.1 mm to 1.0 mm
2	Cracks noticeable but easily filled. Doors and windows stick slightly	1 mm to 5 mm
3	Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weather-tightness often impaired	5 mm to 15 mm, or a number of cracks 3 mm to 5 mm in one group
4	Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window or door frames distort. Walls lean or bulge noticeably. Some loss of bearing in beams. Service pipes disrupted.	15 mm to 25 mm but also depends on number of cracks
5	As above but worse, and requiring partial or complete rebuilding. Roof and floor beams lose bearing and need shoring up. Windows broken with distortion. If compressive damage, severe buckling and bulging of the roof and walls.	> 25 mm

Note 1 of Table C1 states that *"Crack width is the main factor by which damage to walls is categorized. The width may be supplemented by other factors, including serviceability, in assessing category of damage.*

Impacts relating to tilt were classified according to matching impacts with the description in Table C.3, not the observed actual tilt. This is because many houses that had experience tilts greater than 5 mm had not made a claim to the MSB (now SA NSW).

Table C.3 Classification of Damage with Reference to Tilt

Impact Category	Tilt (mm/m)	Description
A	< 5	Unlikely that remedial work will be required.
B	5 to 7	Adjustment to roof drainage and wet area floors might be required.
C	7 to 10	Minor structural work might be required to rectify tilt. Adjustments to roof drainage and wet area floors will probably be required and remedial work to surface water drainage and sewerage systems might be necessary.
D	> 10	Considerable structural work might be required to rectify tilt. Jacking to level or rebuilding could be necessary in the worst cases. Remedial work to surface water drainage and sewerage systems might be necessary.

C.3.2. Need for Improvement to the Previous Method of Impact Classification

It is very difficult to design a method of impact classification that covers all possible scenarios and permutations. The application of any method is likely to find some instances that do not quite fit within the classification criteria.

Exposure to a large number of affected structures has allowed the mining industry to appreciate where improvements can be made to all aspects including the identification of areas for improvement in the previous method of impact classification.

A number of difficulties have been experienced with the previous method during the mining period. The difficulty centres on the use of crack width as the main classifying factor, as specified in Table C1 of Australian Standard 2870-1996.

A benefit of using crack width as the main factor is that it provides a clear objective measure by which to classify impact. However, experience has shown that crack width is a poor measure of the overall impact and extent of repair to a structure. The previous method of impact classification may be useful for assessing impact to newly built structures in a non-subsidence environment but further improvement and clarification is recommended before it can be effectively applied to houses impacted by mine subsidence.

The following aspects highlight areas where the previous classification system could be improved.-

- *Slippage on Damp Proof Course*

  Many houses have experienced slippage along the damp proof course in Tahmoor. Slippage on some houses is relatively small (less than 10 mm) though substantial slippage has been observed in a number of cases, such as shown in Fig. C.1 below.

Fig. C.1 Example of slippage on damp proof course

Under the previous classification method, the "crack" width of the slippage may be very small (Category 1) but the distortion in the brickwork is substantial. Moreover, the extent of work required to repair the impact is substantial as it usually involves re-lining the whole external skin of the structure. Such impacts would be considered Category 4 based on extent of repair but only Category 1 or 2 based on maximum crack width.

There is no reference to slippage of damp proof course in the previous method of impact classification. However, if the extent of repair was used instead of using crack width as the main factor, the impact category would be properly classified as either Category 4 or Category 5.

It was recommended that slippage of damp proof courses be added to the previous impact classification table.

- *Cracks to brickwork*

  In some cases, cracks are observed in mortar only. For example, movement joints in some structures have been improperly filled with mortar instead of a flexible sealant, as shown in Fig. C.2. In these situations, the measured crack width may be substantial but the impact is relatively simple to repair regardless of the crack width.

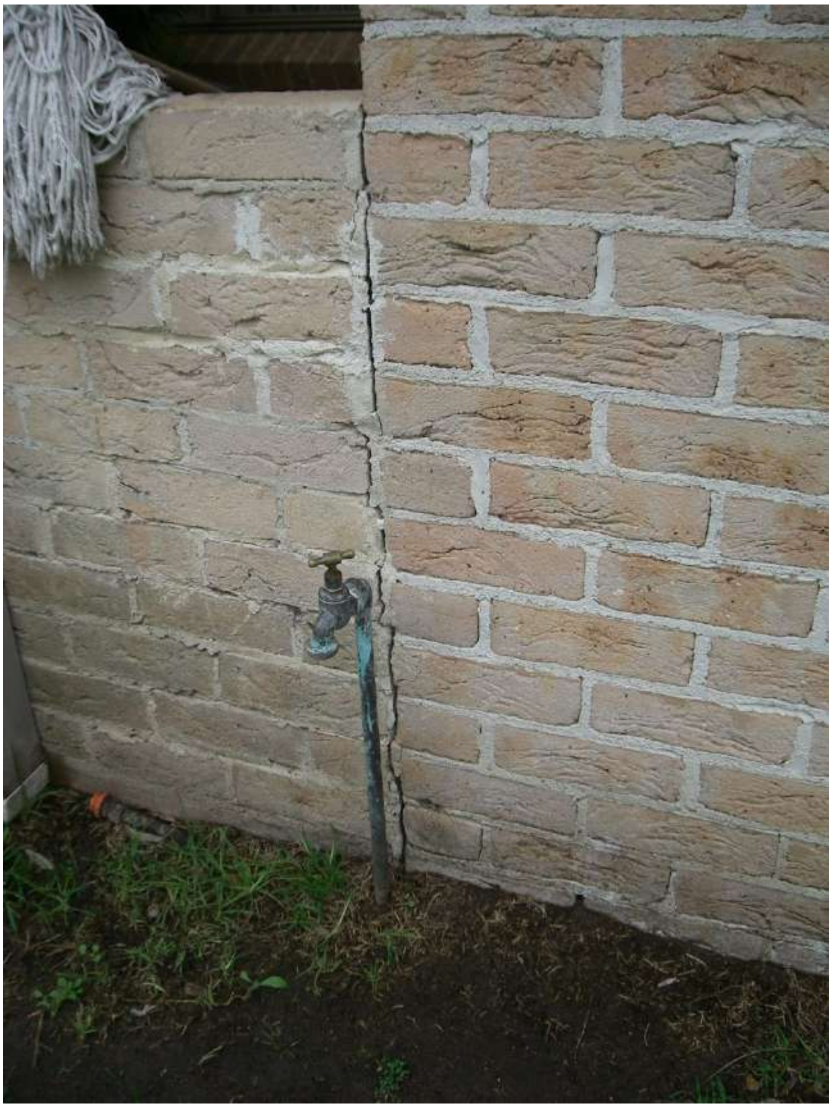


Fig. C.2 Example of crack in mortar only

In other cases, a small number of isolated bricks have been observed to crack or become loose. This is usually straightforward to repair. Under the previous impact classification method, a completely loose brick could be strictly classified as Category 5 as the crack width is infinitely large. This is clearly not the intention of the previous method but clarification is recommended to avoid confusion.

If a panel of brickwork is cracked, the method of repair is the same regardless of the width. While it is considered reasonable to classify large and severe cracks by its width, it is recommended that cracks less than 5 mm in width be treated the same rather than spread across Categories 0, 1 and 2.

If a brick lined structure contains many cracks of width less than 3 mm, the impact would be classified as no more than Category 2 under the previous method of impact classification. The extent of repair may be substantially more than a house that has experienced only one single 5 mm crack. However, it is recognised that it is very difficult to develop a simple method of classifying impacts based on multiple cracks in wall panels. How many cracks are needed to justify an increase in impact category?

- *Structures without masonry walls*

  Timber framed structures with lightweight external linings such weatherboard panels and fibro sheeting are not referenced in the previous classification table. If crack widths were strictly adopted to classify impacts, it may be possible to classify movement in external wall linings beyond Category 3 when in reality the repairs are usually minor.

  It was recommended that the impact classification table be extended to include structures with other types of external linings.

- *Minor impacts such as door swings*

  Experience has shown that one of the earliest signs of impact is the report of a sticking door. In some instances, the only observed impact is one or two sticking doors. It takes less than half an hour to repair a sticking door and impact is considered negligible.

  Such an impact would be rightly classified as Category 0 based on the previous method of impact classification as there is no observed crack. However, the previous classification table suggests that sticking doors and windows occur when Category 2 crack widths develop. It was recommended that the impact classification table be amended in this respect.

C.3.3. Broad Recommendations for Improvement of Previous Method of Impact Classification

It was recommended that crack width no longer be used as the main factor for classifying impacts. This does not mean that the use of crack width should be abandoned altogether. Crack width remains a good indicator of the severity of impacts and should be used to assist classification, particularly for impacts that are moderate or greater.

By focussing on crack width, the previous impact classification table appears to be classifying impacts from a structural stability perspective. It was recommended that a revised impact classification table be more closely aligned with all aspects of a building, including its finishes and services. Residents who are affected by impacts are concerned as much about impacts to internal linings, finishes and services as they are about cracks to their external walls and a revised impact classification method should reflect this.

With crack width no longer used as the main factor, it was recommended that the wording of the descriptions of impact in the classification table be extended to cover impacts to more elements of buildings. In keeping with the previous method of assessment, the level of impact should distinguish between cosmetic, serviceability and stability related impacts:-

- Low impact levels should relate to cosmetic impacts that do affect the structural integrity of the building and are relatively straight-forward to repair,
- Mid-level impact categories should relate to impacts to serviceability and minor structural issues, and
- High level impacts should be reserved for structural stability issues and impacts requiring extensive repairs.

C.3.4. Revised Method of Impact Classification

The following revised method of impact classification has been developed.

Table C.4 Revised Classification based on the Extent of Repairs

Repair Category	Extent of Repairs
Nil	No repairs required
R0 **Adjustment**	One or more of the following, where the damage does not require the removal or replacement of any external or internal claddings or linings:- - **Door** or **window** jams or swings, or - Movement of **cornices**, or - Movement at external or internal **expansion joints**.
R1 **Very Minor Repair**	One or more of the following, where the damage can be repaired by filling, patching or painting without the removal or replacement of any external or internal brickwork, claddings or linings:- - Cracks in **brick mortar** only, or isolated cracked, broken, or loose **bricks** in the external façade, or - Cracks or movement < 5 mm in width in any external or internal wall **claddings**, **linings**, or **finish**, or - Isolated cracked, loose, or drummy floor or wall **tiles**, or - Minor repairs to any **services** or **gutters**.
R2 **Minor Repair**	One or more of the following, where the damage affects a small proportion of external or internal claddings or linings, but does not affect the integrity of external brickwork or structural elements:- - Continuous cracking in **bricks** < 5 mm in width in one or more locations in the total external façade, or - Slippage along the **damp proof course** of 2 to 5 mm anywhere in the total external façade, or - Cracks or movement ≥ 5 mm in width in any external or internal wall **claddings**, **linings**, **finish**, or - Several cracked, loose or drummy floor or wall **tiles**, or - Replacement of any **services**.
R3 **Substantial Repair**	One or more of the following, where the damage requires the removal or replacement of a large proportion of external brickwork, or affects the stability of isolated structural elements:- - Continuous cracking in **bricks** of 5 to 15 mm in width in one or more locations in the total external façade, or - Slippage along the **damp proof course** of 5 to 15 mm anywhere in the total external façade, or - Loss of bearing to isolated walls, piers, columns, or other load-bearing elements, or - Loss of stability of isolated structural elements.
R4 **Extensive Repair**	One or more of the following, where the damage requires the removal or replacement of a large proportion of external brickwork, or the replacement or repair of several structural elements:- - Continuous cracking in **bricks** > 15 mm in width in one or more locations in the total external façade, or - Slippage along the damp proof course of 15 mm or greater anywhere in the total external façade, or - Relevelling of building, or - Loss of stability of several structural elements.
R5 **Re-build**	Extensive damage to house where the MSB (now SA NSW) and the owner have agreed to rebuild as the cost of repair is greater than the cost of replacement.

As discussed at the start of this chapter, it is very difficult to design a method of impact classification that covers all possible scenarios and permutations. While the method has been floated among some members of the mining industry, it is recommended that this table be reviewed broadly.

The recommended method has attempted to follow the current Australian Standard in terms of the number of impact categories and crack widths for Categories 3 and 4. The method is based on the extent of repairs required to repair the physical damage that has occurred, and does not include additional work that is occasionally required because replacement finishes cannot match existing damaged ones. It is therefore likely that the actual cost of repairs will vary greatly between houses depending on the nature of the existing level and type of finishes used.

The impacts experienced at Tahmoor have been classified in accordance with the revised method of classification with good results. The method allowed clearer trends to be found when undertaking statistical analyses.

A comparison between the previous and revised methods is shown in Fig. C.3.

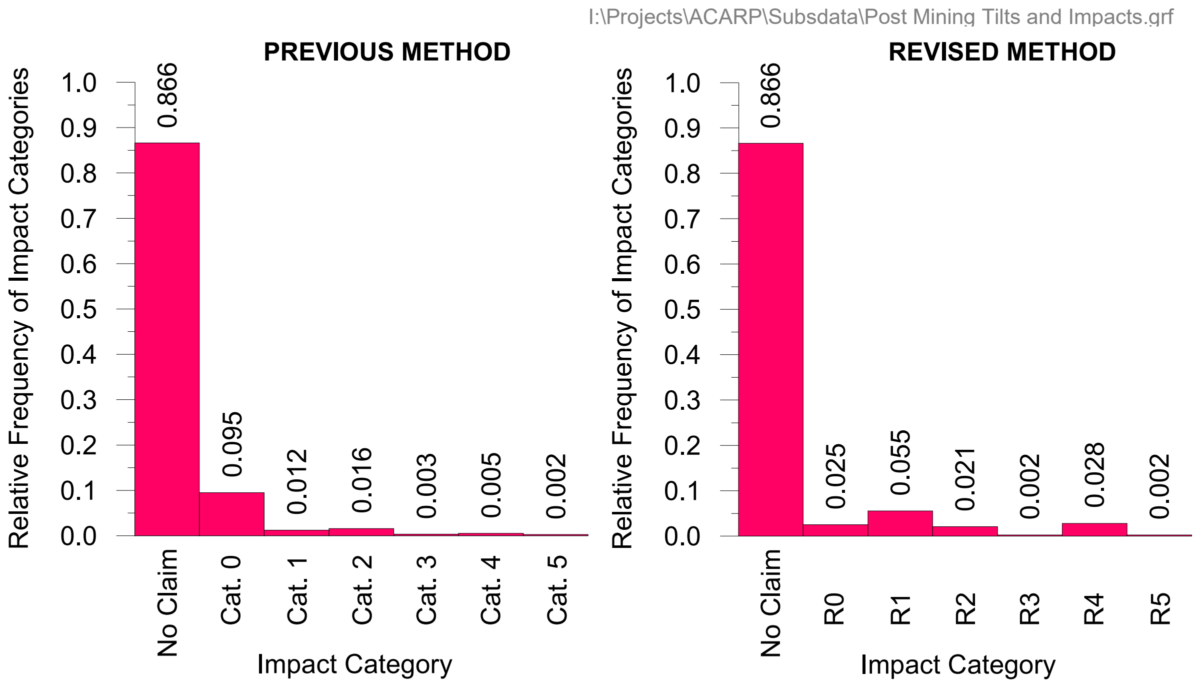


Fig. C.3 Comparison between Previous and Revised Methods of Impact Classification

It can be seen that there was an increased proportion in the higher impact categories using the revised method. This is brought about mainly by the recorded slippage on damp proof courses, which are classified as either Category 3 or Category 4 when they were previously classified as Category 1 or 2.

There was also a noticeable reduction in proportion of Category 0 impacts and noticeable increase in proportion of Category 1 impacts using the revised method. This is because the revised method reserves Category 0 impacts for impacts that did not result in cracking any linings, while the previous method allows hairline cracking to occur.

The consistent low proportion of Category 3 impacts under both the previous and current methods raises questions as to whether this category should be merged with Category 4.

C.4. Method of Impact Assessment

C.4.1. Need for Improvement of the Previous Method

The previous method of impact assessment provided specific quantitative predictions based on predicted conventional subsidence movements and general qualitative statements concerning the potential for impacts due to non-conventional movements. These non-conventional movements are additional to the predicted conventional movements.

This message was quite complex and created the potential for confusion and misunderstanding among members of the community who may easily focus on numbers and letters in a table that deal specifically with their house and misunderstand the message contained in the accompanying words of caution about the low level of reliability concerning predictions of conventional strain and potential for non-conventional movements.

This was unfortunately a necessary shortcoming of the previous method at the time as there was very little statistical information available to quantify the potential for impacts due to non-conventional movement. However, a great deal of statistical information was available following the mining of Tahmoor Mine Longwalls 22 to 24A at the time of the 2009 ACARP study and the method and message to the community could be improved. Additional statistical information was collected in 2016, which was approximately two years after the completion of Longwall 27 and one year after the completion of Longwall 28, which was the last panel to directly mine beneath the urban areas of Tahmoor. The timing of the data is such that it accounts for much of the time lag effect that occurs between the time of impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW.

While additional statistical information is now available, there remains limited knowledge at this point in time to accurately predict the locations of non-conventional movement. Substantial gains are still to be made in this area.

In the meantime, therefore, a probabilistic method of impact assessment has been developed. The method combines the potential for impacts from both conventional and non-conventional subsidence movement.

C.4.2. Factors that Could be Used to Develop a Probabilistic Method of Prediction

Trend analyses have highlighted a number of factors that could be used to develop a probabilistic method. The trends examined were:-

- *Ground tilt*

  This was found to be an ineffective parameter at Tahmoor Mine as ground tilts have been relatively benign and a low number of claims have been made solely in relation to tilt.

- *Ground strain*

  There appears to be a clear link between ground strain and impacts, particularly compressive strain. The difficulty with adopting ground strain as a predictive factor lies in the ability to accurately predict ground strain at a point.

  Another challenge with using strain to develop a probabilistic method is that there is limited information that links maximum observed strains with observed impacts at a structure. Horizontal strain is a two-dimensional parameter and it has been measured along survey lines that are oriented in one direction only.

  The above issues are less problematic for curvature and the statistical analysis on the relationship between strain and curvature shows that the observed frequency of high strains increased with increasing observed curvature.

- *Ground curvature*

  Curvature appears to be the most effective subsidence parameter to develop a probabilistic method. The trend analysis showed that the frequency of impacts increased with increasing observed curvature.

  It should be noted that we are referring to conventional curvature and not curvatures that have developed as a result of non-conventional subsidence behaviour. This is because conventional curvature can be readily predicted with reasonable correlation with observations. It is also a relatively straight-forward exercise to estimate the observed smoothed or "conventional" mining-induced curvature that has previously been experienced at houses provided some ground monitoring is undertaken across and along extracted longwalls.

  Non-conventional curvature cannot be predicted prior to mining and is accounted for by using a probabilistic method of impact assessment.

  It has also been shown that the observed frequency of high strains increased with increasing observed curvature.

- *Position of structure relative to longwall*

  A clear trend was understandably found that structures located directly above goaf were substantially more likely to experience impact. The calculated probabilities may be applicable for mining conditions that are similar to those experienced at Tahmoor Mine but will be less applicable for other mining conditions. An effective probabilistic method should create a link between the magnitude of differential subsidence movements and impact.

- *Construction type*

  Two trends have been observed. Not surprisingly, structures constructed with lightweight flexible external linings are able to accommodate a far greater range of subsidence movements than brittle inflexible linings such as masonry. The analyses merely quantified what was already well known. The second observation was that houses constructed with strip footings were noticeably more likely to experience impacts than houses constructed with a ground slab, particularly in relation to higher levels of impact. This is because houses with strip footings are more susceptible to slippage along the damp proof course.

- *Structure size*

  Trend analysis showed that larger structures attract a higher likelihood of impact. This is understandable as the chance of impacts increases with increasing footprint area. However, it is noted that the probability of severe impacts was not substantially greater for larger structures even though this would be expected if considering probabilities theoretically rather than empirically. It may be worthwhile including structure size as a factor in the development of a probabilistic method, though it is considered that it is a third order effect behind subsidence movements and construction type.

- *Structure age*

  The trend analysis for structure age did not reveal any noticeable trends.

- *Extensions, variable foundations and building joints*

  There is a clear trend of a higher frequency of impacts for structures that include extensions, variable foundations and building joints. The increased frequency appears to be related mainly to lower impact categories.

- *Urban or rural setting*

  While trends were observed, it is considered that they can be explained by other factors. However, consideration can be made to provide a more conservative estimate of probabilities in rural areas if structure size has not been taken into account.

C.4.3. Revised Method of Impact Assessment

A revised method of impact assessment has been developed, based on information received in 2016 at a time when the extraction of Longwall 29 had been completed. The method is probabilistic and currently includes conventional ground curvature and construction type as input factors.

At the time of the original 2009 ACARP study, the trends in the data were difficult to determine within small ranges of curvature because of the relatively low number of buildings that reported damage at this time. A decision was therefore taken to analyse the data in a limited number of curvature ranges, so that where possible a reasonable sample size would be available in each range. The ranges of curvature originally chosen were 5 to 15 kilometres, 15 to 50 kilometres and greater than 50 kilometres.

Additional information provided in 2016 has demonstrated that the proportion of houses reporting impacts has increased. This has allowed statistical analyses to be conducted using narrower bands of observed curvatures though some inconsistencies remain in some bands due to the sample sizes. The ranges of curvature provided in this report are 2.5 to 15 kilometres, 15 to 50 kilometres and greater than 50 kilometres.

Because the incidence of damage for different construction types showed strong trends and because the sample size was reasonable for each type of structure, the data were analysed to determine the effect of radius of curvature on the incidence of damage for each of the three structure types and for each of the three curvature ranges.

The following probabilities are proposed in Table C.5.

Table C.5 Probabilities of Impact based on Curvature and Construction Type based on the Revised Method of Impact Classification

R (km)	Repair Category			
	No Repair or R0	R1 or R2	R3 or R4	R5
Brick or brick-veneer houses with Slab on Ground				
> 50	90 ~ 95 %	3 ~ 10 %	1 %	< 0.5 %
15 to 50	70 ~ 75 %	20 ~ 25 %	5 ~ 10 %	< 0.5 %
2.5 to 15	45 ~ 65 %	25 ~ 35 %	10 ~ 15 %	1 ~ 3 %
Brick or brick-veneer houses with Strip Footing				
> 50	85 ~ 90 %	5 ~ 15 %	1 ~ 3 %	< 2 %
15 to 50	60 ~ 75 %	20 ~ 30 %	5 ~ 15 %	1 ~ 3 %
2.5 to 15	45 ~ 65 %	25 ~ 30 %	5 ~ 15 %	5 ~ 10 %
Timber-framed houses with flexible external linings of any foundation type				
> 50	90 ~ 95 %	3 ~ 10 %	1 %	< 0.5 %
15 to 50	75 ~ 85 %	10 ~ 20 %	5 ~ 10 %	< 0.5 %
2.5 to 15	70 ~ 80 %	20 ~ 25 %	7 ~ 12 %	< 0.5 %

The results have been expressed as a range of values rather than a single number, recognising that the data had considerable scatter within each curvature range. While structure size and building extensions have not been included in the predictive tables, it is recommended to adopt percentages at the higher end of the range for larger structures or those with building extensions.

The percentages stated in each table are the percentages of building structures of that type that would be likely to be damaged to the level indicated within each curvature range. The levels of damage in the tables are indicated with reference to the repair categories described in the damage classification given in Table C.4.

To place these values in context, Table C.6 shows the actual percentages recorded at Tahmoor Mine for all buildings within the sample.

Table C.6 Observed Frequency of Impacts observed for all buildings at Tahmoor Mine

R (km)	Repair Category			
	No Claim or R0	R1 or R2	R3 or R4	R5
> 50	91 %	7 %	2 %	0 %
15 to 50	72 %	20 %	7 %	1 %
5 to 15	59 %	27 %	14 %	3 %

It can be seen that the proposed probabilities for the higher impact categories have been increased compared to those observed to date. These have been deliberately increased, because it has been noticed that some of the claims for damage have been submitted well after the event and it is possible that the numbers damaged in this category could be increased as further claims are received and investigated. These numbers are sensitive to change. In light of the above, it is recommended that the probabilities be revisited in the future as mining progresses.

The ranges provided in Table C.5 have been converted into a set of probability curves to remove artificial discontinuities that are formed by dividing curvatures into three categories. These are shown in Fig. C.4. The probability curves are applicable for all houses and civil structures.

At the time of writing ACARP Research Project C12015 (Waddington, 2009), the observed proportion of houses where the MSB (now SA NSW) and affected landowners had agreed to rebuild rather than repair (Category R5) impacts was less than 0.5 %. Since the publication of the research report, the proportion of houses where a decision has been made to rebuild has increased to approximately 1.1 % overall and 3.2 % above Longwalls 24A to 27 within the observed zone of increased subsidence. The decision to rebuild rather than repair a house is based on a variety of factors.

Whilst acknowledging the significance of a decision to rebuild compared to repair a house, all houses previously impacted at Tahmoor could have been repaired rather than replaced, including those where a decision has been made to rebuild them. This does not diminish the significance of this category from a social and economic impact point of view and it is important to continue recording the number of instances where a decision has been made to rebuild a house.

C.4.4. Review of Observed Probabilities as mining continues

Reviews of observed probabilities are continually undertaken as Tahmoor Mine and other mines continue to extract beneath houses. The provision of additional information on impact on houses in 2016 has improved the level of understanding on the nature and frequency of impacts during the mining of Longwalls 22 to 29 compared to the information that was collected for the previous 2009 ACARP study, which was conducted after the mining of Longwalls 22 to 24A.

Additional statistical information was collected in 2016, which was approximately two years after the completion of Longwall 27 and one year after the completion of Longwall 28, which was the last panel to directly mine beneath the urban areas of Tahmoor.

A finding from the additional information is that the proportion of houses that have experienced impacts has increased over time. The reasons for the increase are due to the time lag effect that occurs between the mining impact, when damage is claimed by residents and when the nature and level of the damage requiring repairs is assessed in detail by SA NSW.

In light of the above, it is recommended that the probabilities be revisited in the future.

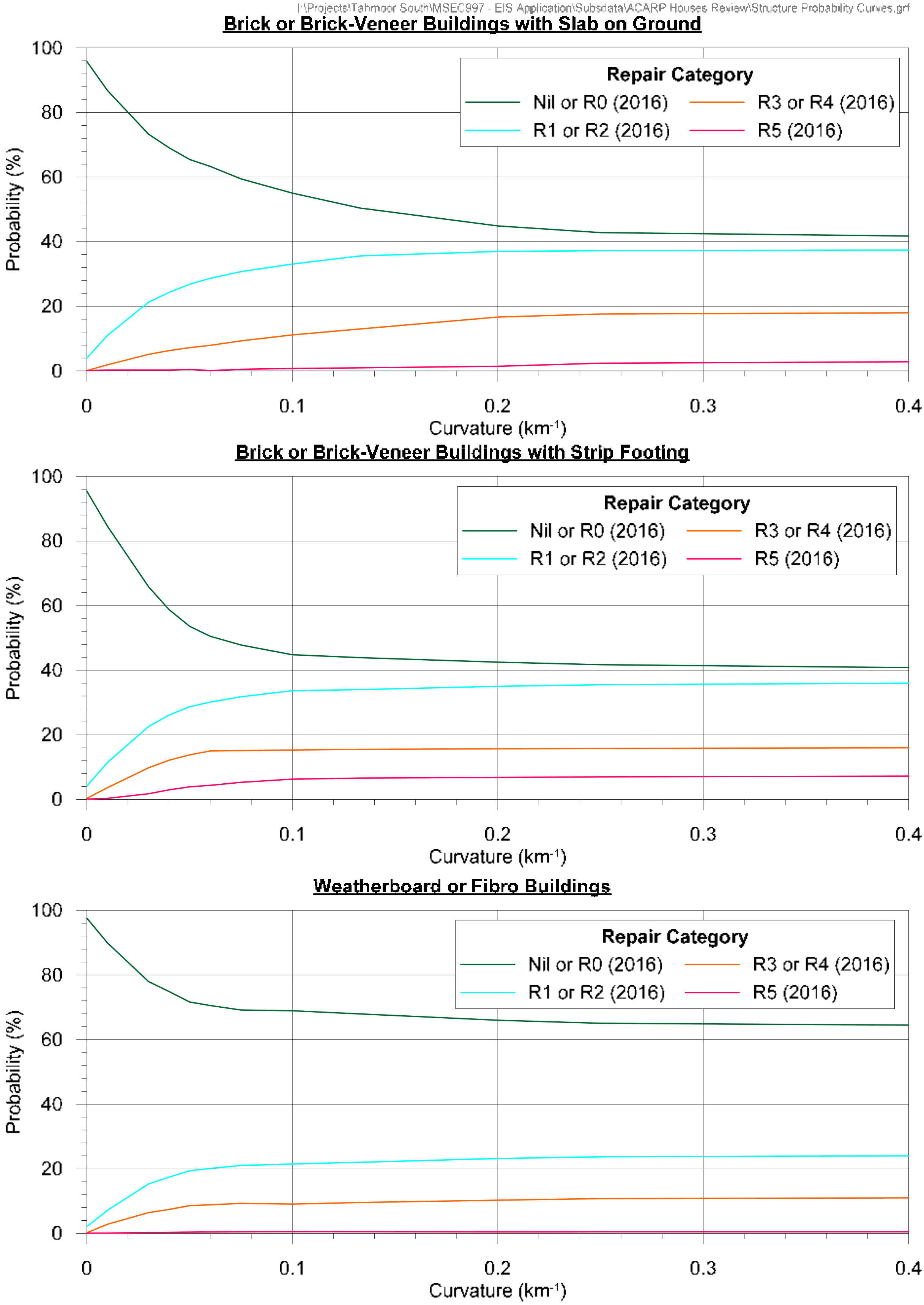


Fig. C.4 Probability Curves for Impacts to Buildings (based on observations up to Longwall 29)

APPENDIX D. TABLES

Table D.01 - Tahmoor South - Predictions for Stream Pools

Stream	Pool	Predicted Total Subsidence after all Longwalls (mm)	Predicted Total Upsidence after all Longwalls (mm)	Predicted Total Closure after all Longwalls (mm)
Teatree Hollow	TT9	1250	275	225
	TT12	1050	375	250
	TT7	100	90	175
	TT14	100	80	150
	TT5	70	50	100
	TT6	< 20	< 20	< 20
	TT4	< 20	< 20	< 20
	TT8	< 20	< 20	< 20
Tributary of Teatree Hollow	TT1	125	125	70
	TT2	1300	375	225
	TT11	850	275	325
	TT3	750	300	350
	TT13	200	125	250

Table D.02 - Tahmoor South - Details of the Houses

House Ref.	Maximum Plan Dimension (m)	Plan Area (m2)	Number of Stories	Wall Construction	Footing Construction	Wall and Footing Construction	Roof Construcftion	House Located Above Goaf	House Located Above Solid Coal
BCA_001_h01	21	234	1	Fibro	Slab on Ground	Timber Framed	Metal	1	
BCA_010_h01	24	252	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_015_h01	18	227	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Metal	1	
BCA_020_h01	17	217	1	Weatherboard	N/A	Timber Framed	Metal	1	
BCA_025_h01	30	298	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_030_h01	32	291	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_035_h01	17	181	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_040_h01	14	159	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BCA_045_h01	18	138	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BCA_050_h01	10	71	2	Fibro	Suspended on Piers	Timber Framed	Metal	1	
BCA_055_h01	21	239	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BCA_060_h01	28	350	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_065_h01	23	337	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_070_h01	19	194	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BCA_075_h01	15	106	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BCA_080_h01	17	176	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_085_h01	22	241	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BCA_090_h01	13	138	1	Fibro	Suspended on Piers	Timber Framed	Tiled	1	
BCA_095_h01	22	279	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BCA_100_h01	31	370	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BCA_105_h01	22	196	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BCA_110_h01	23	189	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal		1
BCA_115_h01	34	377	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Metal		1
BCA_120_h01	19	230	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BCP_010_h01	13	124	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled		1
BCP_040_h01	14	98	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BCP_050_h01	6	32	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BCP_050_h02	11	98	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BGR_180_h01	19	207	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled		1
BGR_193_h01	16	244	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BGR_203_h01	16	185	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BGR_213_h01	18	145	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BGR_218_h01	27	245	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal	1	
BGR_221_h01	26	304	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Tiled		1
BGR_225_h01	19	180	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BGR_230_h01	32	432	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BRE_016_h01	15	106	1	Weatherboard	Slab on Ground	Timber Framed	Metal		1
BRE_030_h01	17	140	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BRE_055_h01	13	91	1	Weatherboard	Slab on Ground	Timber Framed	Metal	1	
BRE_057_h01	13	127	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_059_h01	19	189	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_061_h01	18	197	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_063_h01	28	349	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_065_h01	22	256	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_067_h01	15	172	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_070_h01	18	175	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	

Table D.02 - Tahmoor South - Details of the Houses

House Ref.	Maximum Plan Dimension (m)	Plan Area (m2)	Number of Stories	Wall Construction	Footing Construction	Wall and Footing Construction	Roof Construcftion	House Located Above Goaf	House Located Above Solid Coal
BRE_075_h01	18	172	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_075_h02	11	95	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_077_h01	16	126	1	Fibro	Suspended on Piers	Timber Framed	Metal	1	
BRE_080_h01	29	260	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_083_h01	19	236	2	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Metal	1	
BRE_086_h01	29	409	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Metal	1	
BRE_089_h01	18	285	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_140_h01	28	361	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal	1	
BRE_143_h01	17	176	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_148_h01	20	303	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_154_h01	19	174	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Tiled	1	
BRE_165_h01	9	63	1	Weatherboard	N/A	Timber Framed	Metal	1	
BRE_167_h01	19	160	2	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BRE_177_h01	14	158	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BRE_187_h01	29	396	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_189_h01	11	94	1	Fibro	Suspended on Piers	Timber Framed	Metal	1	
BRE_191_h01	15	134	1	Weatherboard	N/A	Timber Framed	Metal	1	
BRE_195_h01	30	372	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BRE_195_h02	14	146	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BRE_201_h01	22	272	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BRE_515_h02	26	401	2	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BRE_644_h01	31	317	1	Brick or Brick-Veneer	Strip Footing	Brick with Strip Footings	Metal	1	
BRE_665_h01	23	261	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BWE_031_h01	16	143	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BWE_041_h01	11	96	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BWE_041_h02	31	412	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BWE_051_h01	22	201	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_001_h01	10	95	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled	1	
BYR_005_h01	22	165	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_015_h01	17	232	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_025_h01	35	538	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal	1	
BYR_035_h01	17	119	1	Weatherboard	N/A	Timber Framed	Metal	1	
BYR_045_h01	18	152	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BYR_045_h02	50	819	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BYR_055_h01	19	275	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled		1
BYR_065_h01	18	245	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_065_h02	15	131	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BYR_075_h01	21	264	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled		1
BYR_075_h02	10	80	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BYR_084_h01	17	171	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_085_h01	19	200	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_085_h02	8	45	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BYR_085_h03	18	147	1	Weatherboard	Slab on Ground	Timber Framed	Metal		1
BYR_095_h01	37	591	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1
BYR_105_h01	11	87	1	Fibro	Suspended on Piers	Timber Framed	Metal		1
BYR_115_h02	24	281	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Metal		1

Table D.02 - Tahmoor South - Details of the Houses

House Ref.	Maximum Plan Dimension (m)	Plan Area (m2)	Number of Stories	Wall Construction	Footing Construction	Wall and Footing Construction	Roof Construcftion	House Located Above Goaf	House Located Above Solid Coal
BYR_125_h01	18	156	1	Weatherboard	Suspended on Piers	Timber Framed	Metal		1
BYR_135_h01	16	141	1	Weatherboard	Suspended on Piers	Timber Framed	Tiled		1
BYR_135_h02	41	484	1	Weatherboard	Slab on Ground	Timber Framed	Metal		1
BYR_145_h01	21	215	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled		1
BYR_150_h01	12	102	1	Brick or Brick-Veneer	N/A	Brick with Unknown Footings	Tiled	1	
BYR_150_h02	7	39	1	Weatherboard	N/A	Timber Framed	Tiled	1	
BYR_152_h01	20	257	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_154_h01	27	327	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_156_h01	22	268	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_156_h02	12	95	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_158_h01	13	89	1	Weatherboard	Suspended on Piers	Timber Framed	Metal	1	
BYR_160_h01	30	285	1	Brick or Brick-Veneer	Slab on Ground	Brick with Slab on Ground	Tiled	1	
BYR_162_h01	18	156	1	Weatherboard	N/A	Timber Framed	Metal	1	

Table D.03 - Tahmoor South - Predictions for Houses

House Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)	Predicted Probability of Nil or Category R0 Impact (%)	Predicted Probability of Category R1 or R2 Impact (%)	Predicted Probability of Category R3, R4 or R5 Impact (%)	Predicted Probability of Category R3 or R4 Impact (%)	Predicted Probability of Category R5 Impact (%)
BCA_001_h01	450	4.5	4.5	0.05	0.02	71.5	19.4	9.0	8.6	0.4
BCA_010_h01	1100	7.0	7.5	0.09	0.14	49.9	35.7	14.4	13.4	1.0
BCA_015_h01	1250	7.0	8.0	0.09	0.22	42.3	35.2	22.6	15.7	6.9
BCA_020_h01	1150	4.0	4.0	0.04	0.05	71.5	19.5	9.0	8.6	0.4
BCA_025_h01	1100	3.5	3.5	0.05	0.04	66.7	26.0	7.3	6.9	0.4
BCA_030_h01	1050	3.5	3.5	0.05	0.04	55.2	27.9	16.9	13.3	3.6
BCA_035_h01	900	2.0	4.5	0.08	0.03	46.7	32.5	20.8	15.2	5.6
BCA_040_h01	1200	6.5	8.0	0.09	0.09	69.0	21.4	9.6	9.1	0.5
BCA_045_h01	1350	5.0	6.0	0.06	0.21	44.3	37.1	18.6	16.9	1.7
BCA_050_h01	1300	4.5	4.5	0.06	0.07	70.0	20.5	9.5	9.0	0.5
BCA_055_h01	1300	4.5	4.5	0.06	0.06	62.7	29.0	8.3	8.1	0.2
BCA_060_h01	1300	4.5	4.5	0.06	0.06	63.4	28.6	8.0	7.9	0.1
BCA_065_h01	1000	5.5	7.0	0.10	0.03	44.7	33.7	21.6	15.3	6.3
BCA_070_h01	850	2.5	4.5	0.10	0.02	68.9	21.5	9.6	9.1	0.5
BCA_075_h01	1000	3.5	3.5	0.04	0.03	74.3	17.8	7.9	7.6	0.3
BCA_080_h01	1200	4.0	4.0	0.05	0.04	52.3	29.3	18.4	14.3	4.1
BCA_085_h01	1200	4.0	4.0	0.05	0.04	65.4	26.9	7.7	7.2	0.5
BCA_090_h01	1350	6.0	7.0	0.06	0.21	65.9	23.3	10.9	10.4	0.5
BCA_095_h01	1250	6.0	7.5	0.08	0.17	43.1	34.6	22.3	15.6	6.7
BCA_100_h01	1000	5.5	7.0	0.08	0.06	58.7	31.1	10.2	9.6	0.6
BCA_105_h01	650	4.0	4.0	0.05	0.03	65.9	26.5	7.6	7.1	0.5
BCA_110_h01	375	5.0	5.0	0.05	< 0.01	52.2	29.3	18.4	14.3	4.1
BCA_115_h01	100	1.5	1.5	0.03	< 0.01	64.7	23.1	12.2	10.2	2.0
BCA_120_h01	80	1.0	1.0	0.01	< 0.01	84.2	13.0	2.8	2.5	0.3
BCP_010_h01	150	2.0	2.0	0.05	< 0.01	73.2	18.4	8.4	8.0	0.4
BCP_040_h01	50	< 0.5	< 0.5	< 0.01	< 0.01	95.2	3.7	1.1	1.0	0.1
BCP_050_h01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	97.4	2.2	0.4	0.3	0.1
BCP_050_h02	< 20	< 0.5	< 0.5	< 0.01	< 0.01	97.4	2.3	0.4	0.3	0.1
BGR_180_h01	20	< 0.5	< 0.5	< 0.01	< 0.01	96.0	3.2	0.9	0.8	0.1
BGR_193_h01	30	< 0.5	< 0.5	< 0.01	< 0.01	96.1	3.1	0.8	0.7	0.1
BGR_203_h01	175	2.5	2.5	0.05	< 0.01	71.2	19.6	9.1	8.7	0.4
BGR_213_h01	475	7.5	7.5	0.11	< 0.01	68.7	21.6	9.7	9.2	0.5
BGR_218_h01	650	9.0	9.0	0.11	0.09	44.4	33.8	21.8	15.4	6.4
BGR_221_h01	175	2.5	2.5	0.06	0.02	51.2	29.8	19.0	14.7	4.3
BGR_225_h01	50	< 0.5	< 0.5	< 0.01	< 0.01	94.3	4.2	1.4	1.3	0.1
BGR_230_h01	20	< 0.5	< 0.5	< 0.01	< 0.01	96.6	2.7	0.6	0.5	0.1
BRE_016_h01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	97.1	2.4	0.5	0.4	0.1
BRE_030_h01	90	1.0	1.0	< 0.01	< 0.01	87.2	10.7	2.1	1.8	0.3
BRE_055_h01	950	3.5	3.5	0.05	0.03	72.3	19.0	8.7	8.4	0.4

Table D.03 - Tahmoor South - Predictions for Houses

House Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)	Predicted Probability of Nil or Category R0 Impact (%)	Predicted Probability of Category R1 or R2 Impact (%)	Predicted Probability of Category R3, R4 or R5 Impact (%)	Predicted Probability of Category R3 or R4 Impact (%)	Predicted Probability of Category R5 Impact (%)
BRE_057_h01	1050	4.0	4.0	0.05	0.03	66.2	26.3	7.5	7.0	0.5
BRE_059_h01	1200	4.5	4.5	0.05	0.04	52.6	29.2	18.2	14.2	4.0
BRE_061_h01	1300	4.5	4.5	0.06	0.11	44.6	33.7	21.7	15.3	6.3
BRE_063_h01	1300	5.5	7.0	0.06	0.21	42.3	35.1	22.6	15.7	6.8
BRE_065_h01	1350	6.5	8.0	0.06	0.21	42.3	35.1	22.6	15.7	6.8
BRE_067_h01	1150	6.5	8.0	0.11	0.04	54.1	33.6	12.3	11.5	0.8
BRE_070_h01	950	3.5	6.0	0.10	0.02	55.8	32.7	11.5	10.8	0.7
BRE_075_h01	900	2.5	4.5	0.09	0.02	69.0	21.4	9.6	9.1	0.5
BRE_075_h02	900	2.0	3.5	0.09	0.03	69.0	21.3	9.6	9.1	0.5
BRE_077_h01	1000	3.5	3.5	0.04	0.03	74.5	17.7	7.9	7.6	0.3
BRE_080_h01	1250	4.0	4.0	0.06	0.04	51.9	29.5	18.6	14.4	4.1
BRE_083_h01	1350	4.0	4.0	0.06	0.20	42.4	35.0	22.5	15.7	6.8
BRE_086_h01	1350	4.0	4.0	0.06	0.20	42.4	35.0	22.5	15.7	6.8
BRE_089_h01	1350	6.0	8.0	0.06	0.20	42.4	35.0	22.5	15.7	6.8
BRE_140_h01	950	3.0	3.0	0.07	0.03	49.6	30.7	19.7	15.0	4.7
BRE_143_h01	1200	3.5	3.5	0.05	0.04	71.1	19.7	9.2	8.7	0.4
BRE_148_h01	1250	3.5	3.5	0.06	0.05	63.8	28.2	7.9	7.7	0.2
BRE_154_h01	1300	7.0	8.0	0.06	0.22	42.2	35.2	22.6	15.7	6.9
BRE_165_h01	1250	7.0	8.0	0.08	0.19	66.4	22.9	10.6	10.1	0.5
BRE_167_h01	800	5.0	6.0	0.08	0.05	46.8	32.4	20.8	15.2	5.6
BRE_177_h01	400	5.5	5.5	0.07	< 0.01	69.3	20.9	9.8	9.3	0.5
BRE_187_h01	250	4.5	4.5	0.08	< 0.01	59.3	30.8	9.9	9.4	0.5
BRE_189_h01	125	2.0	2.0	0.04	< 0.01	73.7	18.1	8.2	7.8	0.3
BRE_191_h01	200	3.5	3.5	0.08	< 0.01	69.1	21.1	9.8	9.3	0.5
BRE_195_h01	80	0.5	0.5	< 0.01	< 0.01	87.2	10.7	2.1	1.8	0.3
BRE_195_h02	70	0.5	0.5	< 0.01	< 0.01	88.2	9.9	1.9	1.6	0.3
BRE_201_h01	40	0.5	0.5	< 0.01	< 0.01	92.3	6.7	1.0	0.8	0.2
BRE_515_h02	1300	6.0	8.0	0.09	0.17	47.5	36.3	16.2	14.9	1.2
BRE_644_h01	1100	4.5	4.5	0.05	0.04	54.4	28.3	17.3	13.6	3.8
BRE_665_h01	850	3.0	5.0	0.10	0.02	55.1	33.0	11.9	11.1	0.8
BWE_031_h01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	94.8	4.8	0.4	0.3	0.1
BWE_041_h01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	97.1	2.5	0.5	0.4	0.1
BWE_041_h02	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.5	4.2	0.3	0.2	0.1
BWE_051_h01	< 20	< 0.5	< 0.5	< 0.01	< 0.01	95.3	4.4	0.3	0.2	0.1
BYR_001_h01	850	4.0	5.5	0.09	0.02	69.0	21.3	9.7	9.2	0.5
BYR_005_h01	1100	3.0	3.0	0.06	0.08	59.4	30.8	9.8	9.3	0.5
BYR_015_h01	1100	8.5	8.5	0.06	0.23	43.7	37.1	19.2	17.2	2.0
BYR_025_h01	350	4.0	4.0	0.07	0.01	60.6	30.1	9.3	8.9	0.4
BYR_035_h01	450	5.5	5.5	0.09	0.02	69.0	21.3	9.7	9.2	0.5

Table D.03 - Tahmoor South - Predictions for Houses

House Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)	Predicted Probability of Nil or Category R0 Impact (%)	Predicted Probability of Category R1 or R2 Impact (%)	Predicted Probability of Category R3, R4 or R5 Impact (%)	Predicted Probability of Category R3 or R4 Impact (%)	Predicted Probability of Category R5 Impact (%)
BYR_045_h01	150	1.0	1.0	< 0.01	< 0.01	91.7	6.0	2.3	2.2	0.1
BYR_045_h02	150	1.0	1.0	< 0.01	< 0.01	88.1	10.0	1.9	1.7	0.3
BYR_055_h01	100	< 0.5	< 0.5	< 0.01	< 0.01	90.4	7.5	2.1	1.9	0.2
BYR_065_h01	80	< 0.5	< 0.5	< 0.01	< 0.01	92.5	6.6	0.9	0.8	0.2
BYR_065_h02	60	< 0.5	< 0.5	< 0.01	< 0.01	93.1	6.1	0.8	0.6	0.2
BYR_075_h01	60	< 0.5	< 0.5	< 0.01	< 0.01	92.5	6.1	1.4	1.2	0.2
BYR_075_h02	50	< 0.5	< 0.5	< 0.01	< 0.01	95.7	3.4	1.0	0.9	0.1
BYR_084_h01	50	< 0.5	< 0.5	< 0.01	< 0.01	93.7	5.6	0.7	0.5	0.1
BYR_085_h01	40	< 0.5	< 0.5	< 0.01	< 0.01	93.8	5.5	0.6	0.5	0.1
BYR_085_h02	50	< 0.5	< 0.5	< 0.01	< 0.01	95.9	3.2	0.9	0.8	0.1
BYR_085_h03	40	< 0.5	< 0.5	< 0.01	< 0.01	96.1	3.1	0.8	0.7	0.1
BYR_095_h01	40	< 0.5	< 0.5	< 0.01	< 0.01	94.0	5.4	0.6	0.5	0.1
BYR_105_h01	30	< 0.5	< 0.5	< 0.01	< 0.01	96.4	2.9	0.7	0.6	0.1
BYR_115_h02	30	< 0.5	< 0.5	< 0.01	< 0.01	94.2	5.2	0.5	0.4	0.1
BYR_125_h01	60	< 0.5	< 0.5	< 0.01	< 0.01	95.4	3.5	1.0	0.9	0.1
BYR_135_h01	80	< 0.5	< 0.5	< 0.01	< 0.01	94.7	4.0	1.3	1.2	0.1
BYR_135_h02	80	< 0.5	< 0.5	< 0.01	< 0.01	94.6	4.1	1.3	1.2	0.1
BYR_145_h01	100	< 0.5	< 0.5	< 0.01	< 0.01	91.4	7.4	1.2	1.0	0.2
BYR_150_h01	1050	3.0	3.0	0.06	0.05	50.5	30.1	19.3	15.0	4.4
BYR_150_h02	1100	3.0	3.0	0.06	0.05	70.5	20.2	9.4	8.9	0.5
BYR_152_h01	1000	3.0	3.0	0.06	0.04	64.4	27.8	7.9	7.6	0.3
BYR_154_h01	900	3.0	3.0	0.05	0.04	66.2	26.3	7.5	7.0	0.5
BYR_156_h01	850	2.5	2.5	0.06	0.03	70.6	20.1	9.3	8.8	0.5
BYR_156_h02	850	3.0	3.0	0.04	0.04	73.4	18.3	8.3	7.9	0.3
BYR_158_h01	800	2.5	4.5	0.09	0.03	69.1	21.2	9.7	9.2	0.5
BYR_160_h01	1150	7.0	8.0	0.09	0.10	54.8	33.2	12.0	11.2	0.8
BYR_162_h01	1300	7.0	8.0	0.08	0.22	65.6	23.4	11.0	10.5	0.5
Maxima:	**1350**	**9.0**	**9.0**	**0.11**	**0.23**					

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BCA_001_r01	375	4.5	4.5	0.05	< 0.01
BCA_001_r02	800	5.5	5.5	0.02	0.06
BCA_001_r03	850	4.0	4.0	0.03	0.05
BCA_001_r04	950	4.5	4.5	0.04	0.06
BCA_001_r05	800	7.0	7.0	0.03	0.12
BCA_001_r07	475	5.5	5.5	0.04	0.03
BCA_001_r09	950	4.0	4.0	0.04	0.06
BCA_001_r10	950	4.0	4.0	0.04	0.06
BCA_010_r01	1000	7.0	7.5	0.09	0.05
BCA_010_r02	800	4.5	6.0	0.08	0.04
BCA_010_r03	850	5.0	7.0	0.08	0.03
BCA_010_r04	1000	6.5	8.0	0.09	0.04
BCA_010_r05	1050	7.0	8.0	0.09	0.06
BCA_010_r06	1050	7.0	8.0	0.09	0.04
BCA_010_r07	1000	7.0	8.0	0.09	0.04
BCA_010_r08	800	2.5	2.5	0.05	0.04
BCA_010_r09	800	5.0	6.5	0.08	0.04
BCA_015_r01	1150	7.0	8.0	0.09	0.12
BCA_015_r02	1200	7.0	8.0	0.09	0.12
BCA_015_r03	1050	7.0	8.0	0.09	0.04
BCA_020_r02	1150	4.0	4.0	0.04	0.05
BCA_020_r03	1150	4.0	4.0	0.05	0.05
BCA_020_r07	1100	3.5	3.5	0.04	0.05
BCA_020_r08	1150	3.5	3.5	0.05	0.05
BCA_020_r09	1200	3.5	3.5	0.05	0.05
BCA_020_r10	1200	3.5	3.5	0.05	0.05
BCA_020_r11	1200	4.0	4.0	0.05	0.06
BCA_020_r12	1250	4.0	4.0	0.05	0.06
BCA_020_r13	1250	4.0	4.0	0.05	0.08
BCA_020_r14	1250	3.5	3.5	0.05	0.10
BCA_020_r15	1250	3.5	3.5	0.05	0.14
BCA_020_r16	1250	3.5	3.5	0.05	0.17
BCA_020_r17	1250	3.0	3.0	0.05	0.20
BCA_020_r18	1300	3.0	3.0	0.05	0.21
BCA_025_r01	1100	3.5	3.5	0.05	0.04
BCA_025_r03	1150	3.5	3.5	0.05	0.04
BCA_025_r04	1200	3.5	3.5	0.05	0.05
BCA_025_r05	1250	3.5	3.5	0.06	0.05
BCA_025_r06	1200	3.5	3.5	0.06	0.05
BCA_025_r07	1250	3.5	3.5	0.06	0.05
BCA_025_r08	1250	3.5	3.5	0.06	0.05
BCA_025_r09	1150	3.5	3.5	0.05	0.04
BCA_030_r01	1000	3.0	3.0	0.04	0.03
BCA_030_r02	1200	3.5	3.5	0.06	0.04
BCA_030_r03	1050	3.5	3.5	0.05	0.04
BCA_030_r04	1100	3.5	3.5	0.05	0.04
BCA_035_r01	900	1.5	4.0	0.08	0.03
BCA_035_r02	1050	3.5	3.5	0.05	0.04
BCA_035_r03	1100	3.5	3.5	0.05	0.04
BCA_040_r02	1100	6.0	8.0	0.09	0.03
BCA_040_r03	1050	5.5	7.5	0.09	0.03
BCA_040_r04	1000	5.0	7.5	0.09	0.03
BCA_040_r05	1000	5.0	7.0	0.09	0.03
BCA_040_r06	950	4.0	6.0	0.09	0.02
BCA_045_r01	1350	5.0	6.0	0.06	0.21
BCA_045_r07	1300	6.5	8.0	0.07	0.18
BCA_045_r08	1350	6.0	6.5	0.06	0.21

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BCA_050_r01	1350	4.0	4.0	0.06	0.22
BCA_050_r03	1350	3.5	4.5	0.06	0.22
BCA_055_r01	1300	4.5	4.5	0.06	0.05
BCA_055_r07	1200	4.5	4.5	0.06	0.04
BCA_055_r08	1200	4.5	4.5	0.06	0.04
BCA_060_r01	1150	4.0	4.0	0.05	0.04
BCA_060_r02	1150	4.0	4.0	0.05	0.04
BCA_060_r03	1200	4.0	4.0	0.05	0.04
BCA_060_r04	1200	4.0	4.0	0.05	0.04
BCA_060_r05	1200	4.0	4.0	0.05	0.04
BCA_060_r06	1250	4.0	4.0	0.06	0.04
BCA_060_r07	1300	4.5	4.5	0.06	0.06
BCA_065_r01	950	5.0	7.0	0.10	0.02
BCA_065_r02	1000	5.5	7.5	0.10	0.03
BCA_065_r03	950	4.5	7.0	0.10	0.02
BCA_065_r04	950	5.0	7.0	0.10	0.03
BCA_065_r05	1200	6.5	8.0	0.10	0.11
BCA_065_r06	1250	6.5	8.0	0.10	0.12
BCA_070_r01	900	3.0	5.5	0.10	0.02
BCA_070_r02	850	3.0	5.0	0.10	0.02
BCA_075_r01	900	3.5	5.5	0.09	0.02
BCA_075_r02	850	2.5	4.5	0.09	0.02
BCA_075_r03	850	1.5	4.0	0.09	0.02
BCA_075_r04	1300	6.5	8.0	0.10	0.20
BCA_075_r05	1000	3.0	3.0	0.04	0.03
BCA_075_r06	850	2.0	4.5	0.10	0.02
BCA_080_r01	1150	4.0	4.0	0.05	0.04
BCA_080_r02	1050	3.5	3.5	0.04	0.04
BCA_080_r03	950	3.0	3.0	0.04	0.03
BCA_080_r06	900	2.5	3.0	0.08	0.03
BCA_080_r07	900	2.0	3.5	0.09	0.03
BCA_080_r08	1150	4.0	4.0	0.05	0.04
BCA_080_r09	950	3.0	3.0	0.04	0.03
BCA_085_r03	1200	4.0	4.0	0.05	0.05
BCA_085_r04	1050	4.0	4.0	0.04	0.04
BCA_085_r05	950	3.0	3.0	0.04	0.04
BCA_090_r07	1050	4.5	4.5	0.03	0.05
BCA_095_r01	1100	7.0	7.0	0.01	0.16
BCA_095_r02	1150	6.0	7.5	0.07	0.14
BCA_095_r03	1200	6.0	7.5	0.07	0.15
BCA_100_r01	800	5.5	6.0	0.07	0.05
BCA_100_r02	800	5.5	6.5	0.06	0.05
BCA_100_r03	750	5.5	6.0	0.06	0.05
BCA_100_r04	750	4.5	5.5	0.07	0.05
BCA_100_r05	750	4.5	5.5	0.07	0.05
BCA_105_r01	800	4.5	4.5	0.03	0.04
BCA_105_r02	475	4.0	4.0	0.04	0.02
BCA_105_r03	700	4.5	4.5	0.03	0.04
BCA_110_r01	375	5.0	5.0	0.05	< 0.01
BCA_110_r02	375	4.0	4.0	0.04	0.01
BCA_110_r04	350	4.0	4.0	0.04	< 0.01
BCA_110_r05	125	2.0	2.0	0.03	< 0.01
BCA_110_r07	800	5.0	5.0	0.03	0.04
BCA_110_r08	200	3.0	3.0	0.04	< 0.01
BCA_115_r01	60	0.5	0.5	0.01	< 0.01
BCA_115_r02	60	0.5	0.5	< 0.01	< 0.01
BCA_115_r03	90	1.0	1.0	0.02	< 0.01

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BCA_115_r04	80	1.0	1.0	0.02	< 0.01
BCA_115_r05	60	0.5	0.5	< 0.01	< 0.01
BCA_120_r01	90	1.0	1.0	0.02	< 0.01
BCA_120_r02	90	1.0	1.0	0.02	< 0.01
BCA_120_r03	90	1.0	1.0	0.02	< 0.01
BCA_120_r04	50	< 0.5	< 0.5	< 0.01	< 0.01
BCA_120_r05	80	1.0	1.0	0.01	< 0.01
BCA_120_r06	70	0.5	0.5	< 0.01	< 0.01
BCA_120_r07	50	< 0.5	< 0.5	< 0.01	< 0.01
BCP_010_r01	200	3.0	3.0	0.07	0.02
BCP_010_r02	150	2.0	2.0	0.04	< 0.01
BCP_040_r01	40	< 0.5	< 0.5	< 0.01	< 0.01
BCP_040_r02	50	< 0.5	< 0.5	< 0.01	< 0.01
BCP_040_r04	40	< 0.5	< 0.5	< 0.01	< 0.01
BCP_040_r05	40	< 0.5	< 0.5	< 0.01	< 0.01
BCP_040_r06	30	< 0.5	< 0.5	< 0.01	< 0.01
BCP_040_r07	50	< 0.5	< 0.5	< 0.01	< 0.01
BCP_050_r05	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BCP_050_r06	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BCP_050_r09	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_180_r01	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_180_r02	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_180_r03	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r01	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r02	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r03	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r04	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r05	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r06	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r07	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_193_r08	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_203_r01	200	3.0	3.0	0.07	< 0.01
BGR_203_r02	175	2.5	2.5	0.06	< 0.01
BGR_203_r03	125	1.5	1.5	0.03	< 0.01
BGR_203_r04	100	1.0	1.0	0.02	< 0.01
BGR_203_r05	90	1.0	1.0	0.01	< 0.01
BGR_203_r06	80	0.5	0.5	< 0.01	< 0.01
BGR_203_r09	150	2.0	2.0	0.04	< 0.01
BGR_213_r01	500	8.0	8.0	0.10	< 0.01
BGR_213_r02	475	7.5	7.5	0.10	< 0.01
BGR_213_r03	450	7.0	7.0	0.10	< 0.01
BGR_213_r04	375	6.5	6.5	0.10	< 0.01
BGR_213_r05	500	7.5	7.5	0.10	< 0.01
BGR_218_r01	450	7.5	7.5	0.11	0.06
BGR_218_r02	600	9.0	9.0	0.11	0.09
BGR_218_r03	450	7.5	7.5	0.11	0.05
BGR_218_r04	800	9.0	9.0	0.08	0.13
BGR_221_r01	300	5.5	5.5	0.10	0.03
BGR_221_r02	175	2.5	2.5	0.06	0.01
BGR_221_r03	100	1.5	1.5	0.02	< 0.01
BGR_221_r04	175	3.0	3.0	0.06	0.02
BGR_221_r05	175	2.5	2.5	0.06	0.02
BGR_221_r06	300	5.5	5.5	0.10	0.02
BGR_221_r07	300	5.5	5.5	0.10	0.02
BGR_225_r01	60	0.5	0.5	< 0.01	< 0.01
BGR_225_r02	50	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r03	50	< 0.5	< 0.5	< 0.01	< 0.01

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BGR_225_r04	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r05	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r06	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r07	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r08	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r09	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r10	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r11	50	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r12	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r13	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r14	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r15	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r16	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_r17	30	< 0.5	< 0.5	< 0.01	< 0.01
BGR_230_r01	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_016_r02	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_016_r03	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_016_r04	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_016_r05	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_016_r06	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_r30	80	1.0	1.0	< 0.01	< 0.01
BRE_030_r31	90	1.0	1.0	< 0.01	< 0.01
BRE_055_r01	900	3.0	3.0	0.05	0.03
BRE_057_r01	950	3.5	3.5	0.05	0.03
BRE_057_r02	900	3.0	3.0	0.05	0.03
BRE_057_r03	950	3.5	3.5	0.05	0.03
BRE_057_r04	950	3.5	3.5	0.05	0.03
BRE_057_r06	1000	4.0	4.0	0.05	0.03
BRE_057_r07	1000	4.0	4.0	0.05	0.03
BRE_057_r08	1200	4.5	4.5	0.05	0.04
BRE_059_r01	1300	4.5	4.5	0.06	0.09
BRE_059_r02	1300	4.5	4.5	0.06	0.10
BRE_059_r03	1300	4.5	4.5	0.06	0.10
BRE_061_r02	1300	4.5	4.5	0.06	0.08
BRE_061_r03	1300	4.5	4.5	0.06	0.12
BRE_061_r04	1300	4.0	4.0	0.06	0.21
BRE_061_r05	1200	4.5	4.5	0.05	0.04
BRE_063_r01	1300	6.5	8.0	0.06	0.21
BRE_063_r02	1300	4.0	5.5	0.06	0.21
BRE_063_r03	1300	4.5	6.0	0.06	0.21
BRE_063_r04	1300	5.0	6.5	0.06	0.21
BRE_065_r01	1350	6.5	8.0	0.06	0.21
BRE_065_r02	1250	6.5	8.0	0.10	0.13
BRE_065_r03	1350	6.5	8.0	0.06	0.21
BRE_065_r04	1300	6.5	8.0	0.07	0.19
BRE_070_r01	950	4.0	6.5	0.10	0.02
BRE_070_r02	900	3.5	5.5	0.10	0.02
BRE_070_r03	900	2.0	3.5	0.09	0.03
BRE_070_r04	900	2.0	3.5	0.10	0.03
BRE_070_r05	850	1.5	4.0	0.10	0.02
BRE_070_r06	900	1.5	3.5	0.09	0.03
BRE_070_r07	850	2.0	4.0	0.10	0.02
BRE_070_r08	950	3.5	6.0	0.10	0.02
BRE_070_r09	900	3.5	6.0	0.10	0.02
BRE_070_r10	900	3.5	6.0	0.10	0.02
BRE_075_r01	1000	3.0	3.0	0.04	0.03
BRE_075_r02	900	2.0	3.5	0.09	0.03

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BRE_075_r03	900	2.5	2.5	0.07	0.03
BRE_075_r04	900	2.0	3.5	0.09	0.03
BRE_077_r02	1050	3.5	3.5	0.04	0.03
BRE_077_r05	1050	4.0	4.0	0.04	0.04
BRE_077_r06	1000	3.0	3.0	0.04	0.03
BRE_080_r01	1300	4.0	4.0	0.06	0.09
BRE_080_r02	1150	4.0	4.0	0.05	0.04
BRE_080_r03	1300	4.0	4.0	0.06	0.05
BRE_080_r04	1150	4.0	4.0	0.05	0.04
BRE_080_r05	1200	4.0	4.0	0.05	0.04
BRE_080_r06	1350	4.0	4.0	0.06	0.10
BRE_080_r07	1200	4.0	4.0	0.05	0.04
BRE_080_r08	1200	4.0	4.0	0.05	0.04
BRE_080_r09	1200	4.0	4.0	0.05	0.04
BRE_083_r01	1350	4.5	5.5	0.06	0.21
BRE_083_r02	1350	5.0	6.0	0.06	0.21
BRE_083_r03	1350	6.0	7.0	0.06	0.21
BRE_083_r04	1350	4.0	4.0	0.06	0.21
BRE_086_r01	1350	6.5	8.0	0.06	0.21
BRE_086_r02	1350	6.5	8.0	0.06	0.21
BRE_089_r01	1350	6.0	8.0	0.06	0.20
BRE_089_r02	1300	6.0	8.0	0.06	0.19
BRE_089_r03	1250	6.5	8.0	0.08	0.14
BRE_089_r04	1300	6.5	8.0	0.08	0.16
BRE_090_r01	1200	3.5	3.5	0.05	0.04
BRE_140_r01	950	2.5	2.5	0.05	0.03
BRE_140_r02	1000	3.0	3.0	0.04	0.03
BRE_143_r01	1200	3.5	3.5	0.06	0.04
BRE_143_r02	1250	3.5	3.5	0.06	0.05
BRE_143_r03	1250	3.5	3.5	0.06	0.04
BRE_148_r01	1250	3.5	3.5	0.06	0.05
BRE_148_r02	1250	3.5	3.5	0.06	0.08
BRE_148_r03	1300	3.0	3.0	0.06	0.21
BRE_148_r04	1250	3.5	3.5	0.06	0.06
BRE_154_r01	1300	7.0	8.0	0.07	0.22
BRE_154_r02	1250	7.0	8.0	0.08	0.20
BRE_154_r03	1300	7.0	8.0	0.08	0.22
BRE_154_r04	1200	7.0	8.0	0.08	0.15
BRE_154_r05	1100	7.0	8.0	0.09	0.05
BRE_154_r06	1100	7.0	8.0	0.09	0.04
BRE_154_r07	1100	7.0	8.0	0.09	0.06
BRE_167_r01	850	5.0	6.5	0.09	0.05
BRE_167_r02	800	3.5	5.0	0.09	0.04
BRE_167_r03	750	3.0	4.5	0.08	0.04
BRE_167_r04	750	2.5	4.0	0.08	0.04
BRE_167_r05	750	3.0	3.0	0.05	0.05
BRE_167_r06	750	2.0	3.5	0.07	0.04
BRE_167_r07	700	2.5	3.0	0.07	0.04
BRE_167_r08	750	3.0	4.0	0.08	0.05
BRE_167_r09	700	3.0	3.5	0.07	0.05
BRE_167_r10	750	3.5	4.5	0.08	0.05
BRE_167_r12	700	3.0	3.0	0.06	0.05
BRE_167_r13	700	3.0	3.0	0.06	0.05
BRE_167_r14	700	3.0	3.0	0.06	0.05
BRE_167_r15	750	4.5	4.5	0.05	0.06
BRE_167_r16	750	3.5	3.5	0.05	0.05
BRE_167_r17	850	3.5	3.5	0.04	0.05

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BRE_167_r18	750	3.0	4.0	0.08	0.04
BRE_177_r01	400	5.5	5.5	0.07	0.01
BRE_187_r01	300	5.5	5.5	0.08	< 0.01
BRE_187_r02	200	3.5	3.5	0.07	< 0.01
BRE_187_r03	225	4.0	4.0	0.08	< 0.01
BRE_189_r01	200	3.0	3.0	0.07	< 0.01
BRE_189_r02	125	2.0	2.0	0.04	< 0.01
BRE_189_r03	175	3.0	3.0	0.06	< 0.01
BRE_191_r01	200	3.5	3.5	0.08	0.01
BRE_191_r02	250	4.5	4.5	0.09	0.02
BRE_191_r03	400	7.0	7.0	0.09	0.07
BRE_195_r01	100	1.0	1.0	0.02	0.01
BRE_195_r02	100	1.0	1.0	0.02	0.01
BRE_195_r03	125	1.5	1.5	0.03	0.02
BRE_195_r04	60	0.5	0.5	< 0.01	< 0.01
BRE_195_r05	100	1.0	1.0	0.02	0.01
BRE_195_r06	125	1.5	1.5	0.03	0.02
BRE_195_r07	60	0.5	0.5	< 0.01	< 0.01
BRE_195_r08	60	0.5	0.5	< 0.01	< 0.01
BRE_195_r09	90	1.0	1.0	0.01	< 0.01
BRE_195_r10	80	0.5	0.5	< 0.01	< 0.01
BRE_195_r11	125	2.5	2.5	0.05	< 0.01
BRE_195_r12	100	1.5	1.5	0.03	0.01
BRE_195_r13	80	1.0	1.0	0.01	0.01
BRE_201_r01	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_201_r02	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_201_r03	40	0.5	0.5	< 0.01	< 0.01
BRE_201_r04	40	0.5	0.5	< 0.01	< 0.01
BRE_515_r01	1300	4.0	5.0	0.06	0.20
BRE_515_r02	1300	4.0	5.0	0.06	0.20
BRE_644_r03	900	3.5	3.5	0.05	0.03
BRE_644_r04	1000	4.0	4.0	0.05	0.03
BRE_665_r01	850	2.5	5.0	0.10	0.02
BRE_665_r02	800	1.5	4.0	0.09	0.02
BWE_031_r01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_031_r02	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_031_r03	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_031_r04	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_031_r05	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_r01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_r02	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_r03	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_r04	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r01	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r02	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r03	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r04	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r05	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_051_r07	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BYR_001_r02	850	4.0	6.0	0.09	0.03
BYR_001_r03	900	5.0	7.0	0.09	0.02
BYR_001_r05	950	5.5	7.5	0.09	0.03
BYR_005_r01	1100	3.0	3.0	0.06	0.09
BYR_005_r02	1100	3.0	3.0	0.06	0.07
BYR_005_r03	1050	3.0	3.0	0.06	0.06
BYR_005_r04	1100	3.0	3.0	0.06	0.10
BYR_005_r05	1000	3.0	3.0	0.06	0.04

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BYR_015_r01	1100	6.5	6.5	0.06	0.23
BYR_015_r02	1100	8.5	8.5	0.06	0.23
BYR_015_r06	1100	3.0	3.0	0.06	0.15
BYR_015_r07	1050	8.5	8.5	0.07	0.23
BYR_025_r05	325	3.5	3.5	0.07	0.01
BYR_025_r08	275	2.5	2.5	0.04	0.01
BYR_035_r02	400	5.0	5.0	0.08	0.02
BYR_035_r03	425	5.0	5.0	0.09	0.02
BYR_035_r04	450	6.0	6.0	0.09	0.02
BYR_035_r05	550	7.0	7.0	0.09	0.02
BYR_035_r06	600	7.5	7.5	0.09	0.03
BYR_035_r07	750	8.5	8.5	0.09	0.03
BYR_035_r08	550	7.0	7.0	0.09	0.02
BYR_035_r09	550	7.0	7.0	0.09	0.02
BYR_035_r10	550	7.0	7.0	0.09	0.02
BYR_035_r12	450	5.5	5.5	0.09	0.02
BYR_045_r10	125	0.5	0.5	< 0.01	< 0.01
BYR_045_r11	125	0.5	0.5	< 0.01	< 0.01
BYR_065_r01	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r02	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r03	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r04	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r05	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r06	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r07	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r08	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r09	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r10	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_r11	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r01	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r02	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r03	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r04	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r05	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r06	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r07	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r08	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r09	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r10	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_r11	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_084_r01	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_084_r02	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_084_r03	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r01	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r03	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r04	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r05	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r06	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r08	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r09	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r10	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r11	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r12	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r13	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r14	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_r15	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_r02	50	< 0.5	< 0.5	< 0.01	< 0.01

Table D.04 - Tahmoor South - Predictions for Rural Structures

Structure Ref.	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BYR_095_r03	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_r04	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_r05	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_r06	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r01	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r02	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r03	20	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r07	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r08	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r09	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_105_r10	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_r01	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_r02	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_r04	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_r08	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_125_r04	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_r01	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_r02	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_r03	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_r04	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_r01	100	0.5	0.5	< 0.01	< 0.01
BYR_145_r02	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_r03	125	0.5	0.5	< 0.01	< 0.01
BYR_145_r04	90	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_r05	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_r06	90	< 0.5	< 0.5	< 0.01	< 0.01
BYR_150_r01	1100	3.0	3.0	0.06	0.05
BYR_150_r02	1100	3.0	3.0	0.06	0.05
BYR_150_r03	1100	3.0	3.0	0.06	0.05
BYR_150_r04	1100	3.0	3.0	0.06	0.09
BYR_152_r01	950	3.0	3.0	0.05	0.04
BYR_152_r02	950	3.0	3.0	0.05	0.04
BYR_152_r03	1000	3.0	3.0	0.06	0.04
BYR_152_r04	1050	3.0	3.0	0.06	0.05
BYR_152_r05	1050	3.0	3.0	0.06	0.05
BYR_152_r06	1100	3.0	3.0	0.06	0.05
BYR_152_r07	1050	3.0	3.0	0.06	0.04
BYR_154_r01	950	3.0	3.0	0.05	0.04
BYR_156_r01	850	2.5	2.5	0.05	0.03
BYR_158_r01	750	1.5	3.5	0.08	0.03
BYR_160_r01	1150	7.0	8.0	0.09	0.07
BYR_160_r02	1100	7.0	8.0	0.09	0.04
Maxima:	**1350**	**9.0**	**9.0**	**0.11**	**0.23**

Table D.05 - Tahmoor South - Predictions for Tanks

Structure Ref.	Maximum Plan Dimension (m)	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BCA_001_t01	7	200	3.5	3.5	0.06	< 0.01
BCA_001_t02	2	450	4.5	4.5	0.03	0.02
BCA_015_t01	4	1250	7.0	7.5	0.05	0.22
BCA_015_t02	3	1050	7.0	8.0	0.09	0.04
BCA_015_t03	3	1050	7.0	8.0	0.09	0.05
BCA_025_t01	1	1000	3.5	3.5	0.04	0.04
BCA_045_t01	3	1350	3.5	3.5	0.06	0.21
BCA_060_t01	2	1100	4.0	4.0	0.05	0.04
BCA_075_t01	4	900	3.0	5.5	0.09	0.02
BCA_080_t01	4	950	3.0	3.0	0.04	0.03
BCA_080_t02	3	950	3.0	3.0	0.04	0.03
BCA_085_t01	3	1100	4.0	4.0	0.04	0.04
BCA_115_t01	2	60	0.5	0.5	< 0.01	< 0.01
BCA_120_t01	3	950	3.0	3.0	0.04	0.03
BCP_040_t01	2	40	< 0.5	< 0.5	< 0.01	< 0.01
BCP_050_t01	3	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_180_t01	2	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_180_t02	2	20	< 0.5	< 0.5	< 0.01	< 0.01
BGR_213_t01	1	350	6.0	6.0	0.10	< 0.01
BGR_218_t01	2	450	8.0	8.0	0.11	0.04
BGR_218_t02	2	650	9.0	9.0	0.11	0.09
BGR_225_t01	2	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_t02	2	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_t03	3	40	< 0.5	< 0.5	< 0.01	< 0.01
BGR_225_t04	2	40	< 0.5	< 0.5	< 0.01	< 0.01
BRE_057_t01	2	1050	4.0	4.0	0.04	0.04
BRE_083_t02	2	1350	6.5	7.5	0.06	0.21
BRE_086_t01	2	1350	6.5	8.0	0.06	0.20
BRE_089_t01	2	1300	6.0	8.0	0.06	0.17
BRE_148_t01	2	1300	2.5	2.5	0.06	0.21
BRE_154_t01	4	1300	6.5	7.5	0.06	0.22
BRE_195_t01	4	60	< 0.5	< 0.5	< 0.01	< 0.01
BRE_515_t01	8	1300	6.0	7.5	0.06	0.20
BRE_515_t02	6	1350	6.0	7.0	0.06	0.20
BRE_644_t01	3	900	3.0	3.0	0.05	0.03
BRE_644_t02	3	900	3.0	3.0	0.05	0.03
BRE_644_t03	3	900	3.0	3.0	0.05	0.03
BRE_665_t01	2	900	4.5	6.5	0.10	0.02
BRE_665_t02	2	900	4.0	6.0	0.10	0.02
BWE_031_t01	2	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_031_t02	3	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BWE_041_t01	3	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BYR_001_t01	1	850	3.5	5.0	0.09	0.02
BYR_001_t02	3	850	3.5	5.5	0.09	0.02
BYR_005_t01	3	1100	3.0	3.0	0.06	0.08
BYR_015_t02	3	1100	3.0	3.0	0.06	0.17
BYR_065_t01	9	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_t02	3	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_t01	3	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_t02	2	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_t03	2	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_075_t04	2	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_t01	3	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_t02	3	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_t03	3	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_085_t04	3	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_t01	3	50	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_t02	3	50	< 0.5	< 0.5	< 0.01	< 0.01

Table D.05 - Tahmoor South - Predictions for Tanks

Structure Ref.	Maximum Plan Dimension (m)	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BYR_105_t01	2	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_t01	4	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_t02	4	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_t03	2	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_t04	2	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_115_t05	2	30	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_t01	2	90	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_t02	2	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_145_t03	2	100	0.5	0.5	< 0.01	< 0.01
BYR_150_t01	2	1100	3.0	3.0	0.06	0.09
BYR_152_t01	2	1100	3.0	3.0	0.06	0.05
BYR_152_t02	2	1100	3.0	3.0	0.06	0.05
BYR_154_t01	2	950	3.0	3.0	0.05	0.04
BYR_156_t01	2	850	2.5	2.5	0.04	0.03
BYR_156_t02	2	850	2.5	2.5	0.04	0.03
BYR_156_t03	2	850	2.5	2.5	0.04	0.03
	Maxima:	**1350**	**9.0**	**9.0**	**0.11**	**0.22**

Table D.06 - Tahmoor South - Predictions for Pools

Structure Ref.	Maximum Plan Dimension (m)	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BCA_035_p01	7	900	2.0	3.0	0.07	0.03
BCA_095_p01	10	1250	6.0	7.5	0.07	0.18
BCA_100_p01	10	950	5.5	7.0	0.07	0.06
BCA_105_p01	9	650	4.0	4.0	0.05	0.03
BCA_115_p01	7	80	1.0	1.0	0.02	< 0.01
BCA_120_p01	9	80	1.0	1.0	0.01	< 0.01
BGR_218_p01	3	650	9.0	9.0	0.11	0.10
BRE_063_p01	7	1300	5.5	7.0	0.06	0.21
BRE_075_p01	9	900	2.0	3.5	0.09	0.03
BRE_080_p01	10	1300	4.0	4.0	0.06	0.07
BRE_089_p01	8	1350	6.0	8.0	0.06	0.20
BRE_148_p01	9	1250	3.5	3.5	0.06	0.05
BRE_167_p01	8	800	4.0	5.5	0.09	0.04
BRE_515_p01	10	1350	6.0	7.5	0.06	0.20
BYR_005_p01	10	1050	3.0	3.0	0.06	0.05
BYR_015_p01	9	1050	8.5	8.5	0.06	0.23
BYR_045_p01	11	125	0.5	0.5	< 0.01	< 0.01
BYR_055_p01	8	90	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_p01	6	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_095_p01	9	40	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_p01	10	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_152_p01	12	1050	3.0	3.0	0.06	0.05
	Maxima:	**1350**	**9.0**	**9.0**	**0.11**	**0.23**

Table D.07 - Tahmoor South - Predictions for Farm Dams

Dam Ref.	Maximum Length (m)	Plan Area (m2)	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)	Predicted Change in Freeboard (mm)
BCA_001_d01	25	345	950	5.0	5.0	0.03	0.06	250
BCA_010_d01	21	251	775	4.0	5.5	0.08	0.04	100
BCA_015_d01	26	342	1200	5.0	5.0	0.04	0.07	250
BCA_055_d01	15	135	1250	4.5	4.5	0.06	0.05	250
BCA_060_d01	46	703	1350	6.5	8.0	0.08	0.22	400
BCA_065_d01	55	1424	1200	4.5	4.5	0.05	0.04	350
BCA_070_d01	20	231	1250	4.5	4.5	0.06	0.06	250
BCA_075_d01	14	124	1300	4.0	4.5	0.06	0.20	100
BCA_080_d01	32	627	1100	6.5	8.0	0.12	0.04	250
BCA_085_d01	13	96	850	3.0	5.5	0.08	0.04	100
BCA_105_d01	12	86	525	5.5	5.5	0.08	0.05	250
BCA_105_d02	30	392	325	4.0	4.0	0.04	0.03	200
BCA_110_d01	24	414	575	6.5	6.5	0.06	0.05	300
BCP_010_d01	37	866	125	1.0	1.0	0.02	0.01	50
BCP_020_d01	31	460	90	1.0	1.0	0.01	< 0.01	< 50
BCP_040_d01	35	628	90	1.0	1.0	0.01	< 0.01	< 50
BGR_193_d01	53	1738	30	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BGR_203_d01	95	5047	50	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BGR_203_d02	35	363	70	0.5	0.5	< 0.01	< 0.01	< 50
BGR_230_d01	27	369	20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BGR_230_d02	16	127	20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BGR_230_d03	8	26	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BRE_016_d01	33	601	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BRE_020_d01	43	1115	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BRE_040_d01	50	369	225	3.5	3.5	0.06	0.01	150
BRE_045_d01	61	1253	50	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BRE_061_d01	9	55	1150	4.5	4.5	0.05	0.04	200
BRE_090_d01	52	1889	875	4.5	6.5	0.09	0.03	150
BRE_090_d02	24	310	925	2.5	3.0	0.07	0.03	100
BRE_090_d03	69	1849	975	3.0	3.0	0.05	0.04	250
BRE_090_d04	36	508	1000	7.5	7.5	0.04	0.21	250
BRE_143_d01	29	534	825	3.5	5.5	0.09	0.03	100
BRE_148_d01	35	693	1000	3.0	3.0	0.05	0.04	200
BRE_148_d02	22	170	1000	3.0	3.0	0.06	0.04	150
BRE_154_d01	76	2658	1300	6.5	7.0	0.06	0.22	200
BRE_154_d02	64	1554	1250	7.5	8.0	0.09	0.20	500
BRE_167_d01	99	2924	925	3.0	5.0	0.09	0.05	200
BRE_167_d02	16	180	1100	3.0	3.0	0.06	0.08	150
BRE_600_d01	18	205	1200	6.5	8.0	0.14	0.09	300
BWE_031_d01	39	955	< 20	< 0.5	< 0.5	< 0.01	< 0.01	< 50
BYR_005_d01	28	404	1050	3.0	3.0	0.06	0.05	200
BYR_005_d02	73	1662	875	3.0	3.5	0.07	0.04	150
BYR_015_d01	50	1415	1100	3.0	3.0	0.06	0.16	200
BYR_065_d01	44	790	325	3.5	3.5	0.07	0.01	150
BYR_095_d01	43	1003	100	< 0.5	< 0.5	< 0.01	< 0.01	< 50
		Maxima:	**1350**	**7.5**	**8.0**	**0.14**	**0.22**	**500**

Table D.08 - Tahmoor South - Predictions for Public Amenities

Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BRE_020_pa01	43	Wollondilly Anglican College - Clifford Warne Auditorium	Building	300	4.0	4.0	0.05	0.02
BRE_020_pa02	24	Wollondilly Anglican College - White Cottage	Building	100	1.5	1.5	0.02	< 0.01
BRE_020_pa03	19	Wollondilly Anglican College - Canteen	Building	90	1.0	1.0	0.01	< 0.01
BRE_020_pa04	29	Wollondilly Anglican College - Sturt Cottage	Building	100	1.0	1.0	0.02	< 0.01
BRE_020_pa05	41	Wollondilly Anglican College - Bradfield Cottage	Building	100	1.0	1.0	0.02	< 0.01
BRE_020_pa06	32	Wollondilly Anglican College - Melba Cottage	Building	80	0.5	0.5	0.01	< 0.01
BRE_020_pa07	59	Wollondilly Anglican College - Rev John Flynn Collegiate	Building	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa08	29	Wollondilly Anglican College - Cook Cottage	Building	60	0.5	0.5	< 0.01	< 0.01
BRE_020_pa09	61	Wollondilly Anglican College - Alfred Deakin Admin Centre	Building	70	1.0	1.0	0.01	< 0.01
BRE_020_pa10	22	Wollondilly Anglican College - Amenities	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa11	15	Wollondilly Anglican College - Fred's Shed	Shed	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa12	33	Wollondilly Anglican College - Hardcourt 1	Tennis Court	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa13	33	Wollondilly Anglican College - Hardcourt 2	Tennis Court	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa14	29	Wollondilly Anglican College - Elizabeth Cottage	Building	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa15	164	Wollondilly Anglican College - WACA	Sports Oval	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa16	43	Wollondilly Anglican College - Shoulder to Shoulder Shelter	Building	80	0.5	0.5	0.01	< 0.01
BRE_020_pa17	30	Wollondilly Anglican College - Johnston Cottage	Building	60	0.5	0.5	< 0.01	< 0.01
BRE_020_pa18	40	Wollondilly Anglican College - Cuthbert Cottage	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa19	48	Wollondilly Anglican College - Banks Cottage	Building	125	1.5	1.5	0.02	< 0.01
BRE_020_pa20	40	Wollondilly Anglican College - Quarmby Cottage	Building	40	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_pa21	2	Wollondilly Anglican College	Shed	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_t01	2	Wollondilly Anglican College	Tank	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_t02	2	Wollondilly Anglican College	Tank	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_t04	8	Wollondilly Anglican College	Tank	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_t05	8	Wollondilly Anglican College	Tank	< 20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_020_t06	3	Wollondilly Anglican College	Tank	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_580_pa05	7	Australian Wildlife Sanctuary - Nursery	Building	900	1.5	3.5	0.08	0.02
BRE_580_pa16	6	Australian Wildlife Sanctuary - Shed	Building	900	1.5	3.5	0.08	0.02
BRE_600_pa01	25	Australian Wildlife Sanctuary - Visitor Centre	Building	900	2.0	4.5	0.08	0.03
BRE_600_pa02	14	Australian Wildlife Sanctuary - Cottage 1	Building	950	3.0	5.5	0.08	0.02
BRE_600_pa03	7	Australian Wildlife Sanctuary - Shade house	Building	900	2.5	4.5	0.08	0.02
BRE_600_pa04	12	Australian Wildlife Sanctuary - Workshop	Building	950	3.0	5.5	0.08	0.02
BRE_600_pa06	6	Australian Wildlife Sanctuary - Glass house	Glass house	900	1.5	4.0	0.08	0.02
BRE_600_pa07	14	Australian Wildlife Sanctuary - Enclosure 1	Enclosure	1000	3.0	3.0	0.05	0.03
BRE_600_pa08	7	Australian Wildlife Sanctuary - Enclosure 2	Enclosure	1000	3.0	3.0	0.04	0.03
BRE_600_pa09	10	Australian Wildlife Sanctuary - Cottage 2	Building	950	3.5	6.5	0.08	0.02
BRE_600_pa10	6	Australian Wildlife Sanctuary - Awning	Awning	950	3.0	5.5	0.08	0.02
			Maxima:	**1000**	**4.0**	**6.5**	**0.08**	**0.03**

Table D.09 - Tahmoor South - Predictions for Public Utilities

Structure Ref.	Location	Description	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BYR_200_pu01	NBN Infrastructure Yarran Rd	Shed	900	3.0	3.0	0.05	0.04
BYR_200_pu02	NBN Infrastructure Yarran Rd	Tower	850	2.5	2.5	0.04	0.04
		Maxima:	**900**	**3.0**	**3.0**	**0.05**	**0.04**

Table D.10 - Tahmoor South - Predictions for Commercial and Business Establishments

Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BRE_030_c01	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	50	0.5	0.5	< 0.01	< 0.01
BRE_030_c02	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c03	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	40	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c04	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	40	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c05	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c06	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c07	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c08	113	Inghams Bargo Chicken Breeder Production Complex	Poultry Shed	20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c25	13	Inghams Bargo Chicken Breeder Production Complex	Shed	20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c26	6	Inghams Bargo Chicken Breeder Production Complex	Shed	20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c27	8	Inghams Bargo Chicken Breeder Production Complex	Shed	30	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_c28	11	Inghams Bargo Chicken Breeder Production Complex	Shed	20	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_t08	6	Inghams Bargo Chicken Breeder Production Complex	Tank - gas	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_030_t09	6	Inghams Bargo Chicken Breeder Production Complex	Tank - gas	50	< 0.5	< 0.5	< 0.01	< 0.01
BRE_040_c01	14	Auto Wreckers	Shed	700	4.0	4.0	0.05	0.04
BRE_040_c02	28	Auto Wreckers	Shed	800	6.0	6.0	0.05	0.06
BRE_040_c03	17	Bargo Petroleum and Hill Top Pit Stop	Awning	900	4.5	4.5	0.06	0.04
BRE_040_c04	26	Bargo Petroleum and Hill Top Pit Stop	Petrol Station	900	4.5	4.5	0.06	0.04
BRE_040_c05	13	Bargo Petroleum and Hill Top Pit Stop	Workshop	1000	4.5	4.5	0.05	0.05
BRE_040_c06	9		Shed	1050	5.0	5.0	0.03	0.05
BRE_040_c07	17		Shed	1050	5.5	5.5	0.02	0.08
BRE_040_c08	14		Shed	1050	6.5	6.5	0.02	0.12
BRE_040_c09	128		Greenhouse	700	7.0	7.0	0.08	0.10
BRE_040_c10	51		Greenhouse	950	7.5	7.5	0.08	0.15
BRE_040_c11	12		Shed	700	7.0	7.0	0.08	0.10
BRE_040_c12	12		Shed	600	7.0	7.0	0.08	0.06
BRE_040_c13	11		Shed	375	5.0	5.0	0.07	0.01
BRE_055_c01	27	Tahmoor Garden Centre	Cafe	950	3.5	3.5	0.05	0.03
BRE_055_c02	9	Tahmoor Garden Centre	Shop	950	3.5	3.5	0.05	0.03
BRE_055_c03	7	Tahmoor Garden Centre	Shed	1000	4.0	4.0	0.05	0.03
BRE_055_c04	17	Tahmoor Garden Centre	Shade structure	1000	4.0	4.0	0.05	0.03
BRE_515_c01	7	MKD Machinery	Shed	1300	6.0	8.0	0.07	0.20
BRE_515_c02	3	MKD Machinery	Hopper	1300	6.0	7.5	0.06	0.20
BRE_515_c03	6	MKD Machinery	Shed	1300	6.0	7.5	0.07	0.18
BRE_515_c04	3	MKD Machinery	Shed	1350	6.0	7.5	0.06	0.20
BRE_515_c05	3	MKD Machinery	Shed	1350	6.0	7.5	0.06	0.20
BRE_515_c06	14	MKD Machinery	Shed	1300	6.0	7.5	0.07	0.20
BYR_055_c01	29	Bargo Valley Produce	Shed	125	0.5	0.5	< 0.01	< 0.01
BYR_055_c02	41	Bargo Valley Produce	Shed	100	0.5	0.5	< 0.01	< 0.01
BYR_055_c03	89	Bargo Valley Produce	Poultry Shed	175	1.0	1.0	0.01	< 0.01
BYR_055_c04	89	Bargo Valley Produce	Poultry Shed	200	1.5	1.5	0.02	< 0.01
BYR_055_c05	89	Bargo Valley Produce	Poultry Shed	250	2.0	2.0	0.03	< 0.01
BYR_055_c06	89	Bargo Valley Produce	Poultry Shed	325	3.5	3.5	0.06	0.01
BYR_055_c07	86	Bargo Valley Produce	Greenhouse	700	8.5	8.5	0.09	0.03
BYR_055_t01	8	Bargo Valley Produce	Tank	100	0.5	0.5	< 0.01	< 0.01

Table D.10 - Tahmoor South - Predictions for Commercial and Business Establishments

Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
BYR_055_t02	3	Bargo Valley Produce	Tank	175	1.0	1.0	0.01	< 0.01
BYR_065_c06	91	Ingham Turkey Farm	Poultry Shed	90	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_c07	96	Ingham Turkey Farm	Poultry Shed	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_c08	83	Ingham Turkey Farm	Poultry Shed	100	0.5	0.5	< 0.01	< 0.01
BYR_065_c09	11	Ingham Turkey Farm	Poultry Shed	100	0.5	0.5	< 0.01	< 0.01
BYR_065_c10	15	Ingham Turkey Farm	Poultry Shed	125	0.5	0.5	< 0.01	< 0.01
BYR_065_c11	26	Ingham Turkey Farm	Poultry Shed	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_c12	91	Ingham Turkey Farm	Poultry Shed	150	1.0	1.0	< 0.01	< 0.01
BYR_065_c13	90	Ingham Turkey Farm	Poultry Shed	150	1.0	1.0	< 0.01	< 0.01
BYR_065_c14	91	Ingham Turkey Farm	Poultry Shed	175	1.0	1.0	0.01	< 0.01
BYR_065_t02	5	Ingham Turkey Farm	Tank	100	< 0.5	< 0.5	< 0.01	< 0.01
BYR_065_t03	4	Ingham Turkey Farm	Tank	80	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c01	14	Canine Country Club and Cattery	Shed	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c02	20	Canine Country Club and Cattery	Shed	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c03	9	Canine Country Club and Cattery	Shed	70	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c04	17	Canine Country Club and Cattery	Shed	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c05	26	Canine Country Club and Cattery	Shed	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c06	3	Canine Country Club and Cattery	Shed	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c07	14	Canine Country Club and Cattery	Shed	60	< 0.5	< 0.5	< 0.01	< 0.01
BYR_135_c08	25	Canine Country Club and Cattery	Awning	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_c01	49	Tahmoor Mine - Administration	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c04	25	Tahmoor Mine - Storage	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c05	37	Tahmoor Mine - Workshop	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c06	24	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c07	32	Tahmoor Mine - Store	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c08	20	Tahmoor Mine - Meeting Room	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c09	14	Tahmoor Mine - OH&S	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c10	12	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c11	12	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c12	21	Tahmoor Mine - Training Room	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c13	25	Tahmoor Mine - Winder House	Building	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_c14	5	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c15	12	Tahmoor Mine - Bath	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c16	66	Tahmoor Mine - Bath House and Mine Office	Building	20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c17	12	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c18	9	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c19	10	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c20	8	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c21	24	Tahmoor Mine - Conveyor Drive	Building	20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c22	8	Tahmoor Mine - Gas	Building	20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c23	18	Tahmoor Mine	Building	20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c24	12	Tahmoor Mine - Contractors Offices	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c25	12	Tahmoor Mine - Contractors Offices	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c26	12	Tahmoor Mine - DOM Room	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c27	12	Tahmoor Mine - Bath	Building	30	< 0.5	< 0.5	< 0.01	< 0.01

Table D.10 - Tahmoor South - Predictions for Commercial and Business Establishments

Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
TM_c28	12	Tahmoor Mine - Bath	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c29	15	Tahmoor Mine - Critical Equipment	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c30	15	Tahmoor Mine - Fire Services	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c31	9	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c32	6	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c33	15	Tahmoor Mine - Bath	Building	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_c34	7	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c35	3	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c36	3	Tahmoor Mine	Building	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_c37	19	Tahmoor Mine - Washery Equipment	Building	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_c38	35	Tahmoor Mine - Bath House and Workshop	Building	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_c39	3	Tahmoor Mine	Building	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_c40	12	Tahmoor Mine - CHPP Contractors Crib Room	Building	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_c41	12	Tahmoor Mine - CHPP Contractors Training Room	Building	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_c42	78	Tahmoor Mine - Washery and Control Room	Building	80	< 0.5	< 0.5	< 0.01	< 0.01
TM_c43	8	Tahmoor Mine	Building	80	< 0.5	< 0.5	< 0.01	< 0.01
TM_c44	6	Tahmoor Mine	Building	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c45	8	Tahmoor Mine	Building	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c46	7	Tahmoor Mine	Building	125	1.5	1.5	0.01	< 0.01
TM_c47	8	Tahmoor Mine	Building	125	1.5	1.5	0.01	< 0.01
TM_c48	6	Tahmoor Mine - CHPP Stockpile Contractor Crib Room	Building	175	2.0	2.0	0.02	0.01
TM_c49	2	Tahmoor Mine	Building	200	2.0	2.0	0.02	0.01
TM_c50	4	Tahmoor Mine	Building	200	2.0	2.0	0.02	0.01
TM_c54	10	Tahmoor Mine	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c57	24	Tahmoor Mine - Longwall Shed	Building	< 20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c60	30	Tahmoor Mine - Equipment	Building	20	< 0.5	< 0.5	< 0.01	< 0.01
TM_c70	8	Tahmoor Mine	Shed	50	< 0.5	< 0.5	< 0.01	< 0.01
TM_c71	5	Tahmoor Mine	Shed	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_c72	6	Tahmoor Mine	Shed	50	< 0.5	< 0.5	< 0.01	< 0.01
TM_c73	5	Tahmoor Mine	Shed	50	< 0.5	< 0.5	< 0.01	< 0.01
TM_c74	22	Tahmoor Mine - 6000t Bin	Bin	50	0.5	0.5	< 0.01	< 0.01
TM_c75	12	Tahmoor Mine - 1250t Raw Coal Bin	Bin	60	0.5	0.5	< 0.01	< 0.01
TM_c76	12	Tahmoor Mine - 1250t Raw Coal Bin	Bin	60	0.5	0.5	< 0.01	< 0.01
TM_c77	18	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c78	4	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c79	6	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c80	12	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c81	2	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_c82	1	Tahmoor Mine	Thickeners	70	< 0.5	< 0.5	< 0.01	< 0.01
TM_d01	109	Tahmoor Mine - Dam M1	Dam	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_d02	51	Tahmoor Mine - Dam M2	Dam	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_d03	114	Tahmoor Mine - Dam M3	Dam	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_d04	106	Tahmoor Mine - Dam M4	Dam	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_d05	74	Tahmoor Mine - Tailings Dam	Dam	60	< 0.5	< 0.5	< 0.01	< 0.01
TM_d06	51	Tahmoor Mine - Tailings Dam	Dam	60	< 0.5	< 0.5	< 0.01	< 0.01

Table D.10 - Tahmoor South - Predictions for Commercial and Business Establishments

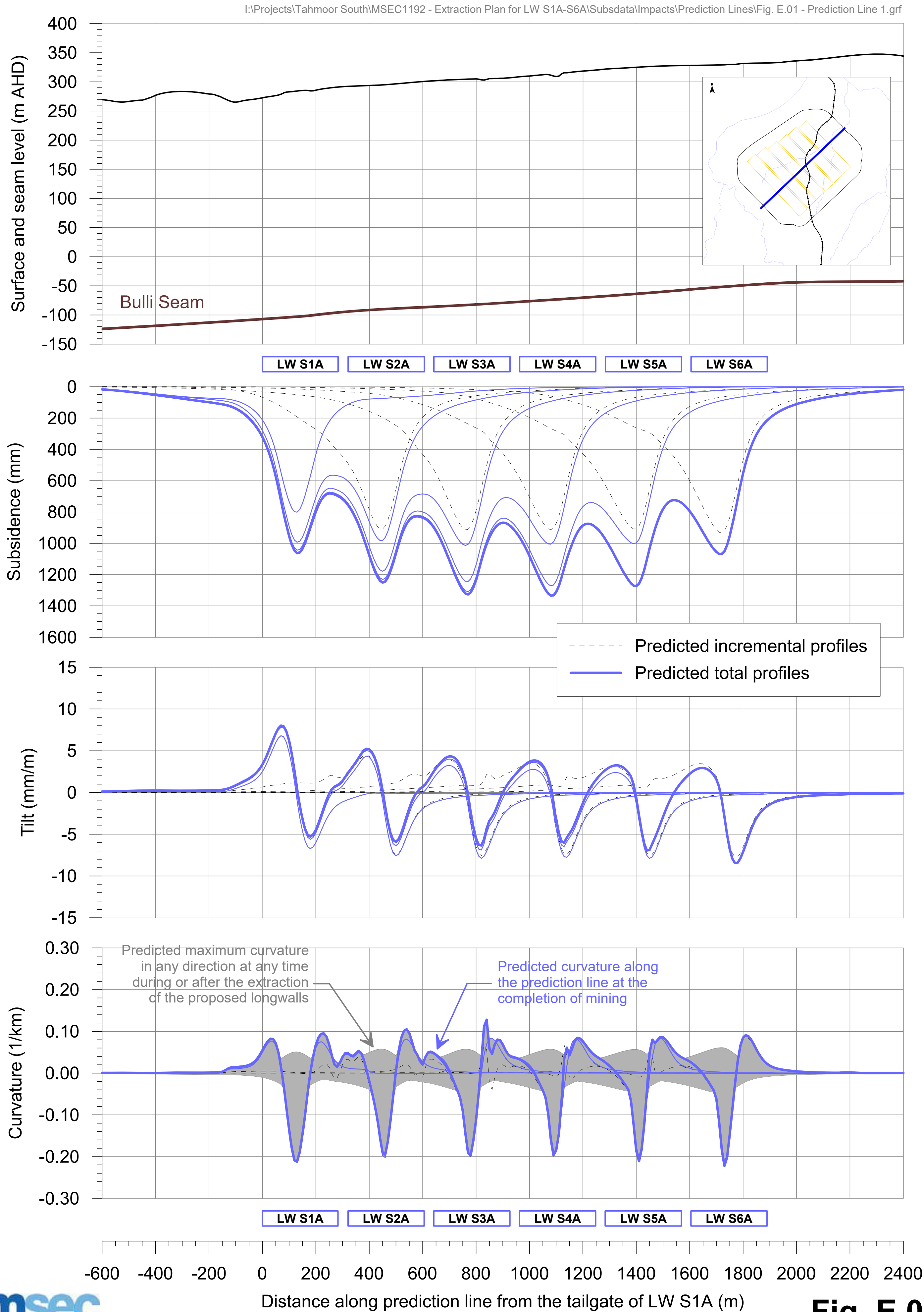
Structure Ref.	Maximum Plan Dimension (m)	Description	Structure Type	Predicted Total Subsidence (mm)	Predicted Final Tilt after all Longwalls (mm/m)	Predicted Maximum Tilt after any Longwall (mm/m)	Predicted Total Hogging Curvature (1/km)	Predicted Total Sagging Curvature (1/km)
TM_d07	24	Tahmoor Mine - Dam	Dam	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_d08	24	Tahmoor Mine - Dam	Dam	40	< 0.5	< 0.5	< 0.01	< 0.01
TM_d09	35	Tahmoor Mine - Dam	Dam	50	< 0.5	< 0.5	< 0.01	< 0.01
TM_d10	35	Tahmoor Mine - Dam	Dam	90	< 0.5	< 0.5	< 0.01	< 0.01
TM_d11	144	Tahmoor Mine - Dam	Dam	125	1.0	1.0	0.01	< 0.01
TM_d12	109	Tahmoor Mine	Building	200	1.5	1.5	0.02	< 0.01
TM_d13	11	Tahmoor Mine - Dam	Dam	30	< 0.5	< 0.5	< 0.01	< 0.01
TM_t03	10	Tahmoor Mine - Tank	Tank	70	< 0.5	< 0.5	< 0.01	< 0.01
			Maxima:	**1350**	**8.5**	**8.5**	**0.09**	**0.20**

Table D.11 - Tahmoor South - Predictions for Archaeological Sites

Site ID	Type	Significance	Predicted Total Subsidence after all Longwalls (mm)	Predicted Total Tilt after all Longwalls (mm/m)	Predicted Total Hogging Curvature after all Longwalls (1/km)	Predicted Total Sagging Curvature after all Longwalls (1/km)
52-2-3968	Open camp site	Low	550	5.0	0.05	0.02
52-2-4471	Rockshelter with art and deposit	Low	900	4.5	0.06	0.03
48-2-0275	Isolated find	Low	70	< 0.5	< 0.01	< 0.01
		Maxima:	**900**	**5.0**	**0.06**	**0.03**

APPENDIX E. FIGURES SHOWING PREDICTED SUBSIDENCE PARAMETERS OVER THE TAHMOOR SOUTH PROJECT

Predicted profiles of conventional subsidence, tilt and curvature along Prediction Line 1 resulting from the extraction of Longwalls S1A to S6A



msec

Fig. E.01

Predicted profiles of subsidence, upsidence and closure along Teatree Hollow resulting from the extraction of Longwalls S1A to S6A

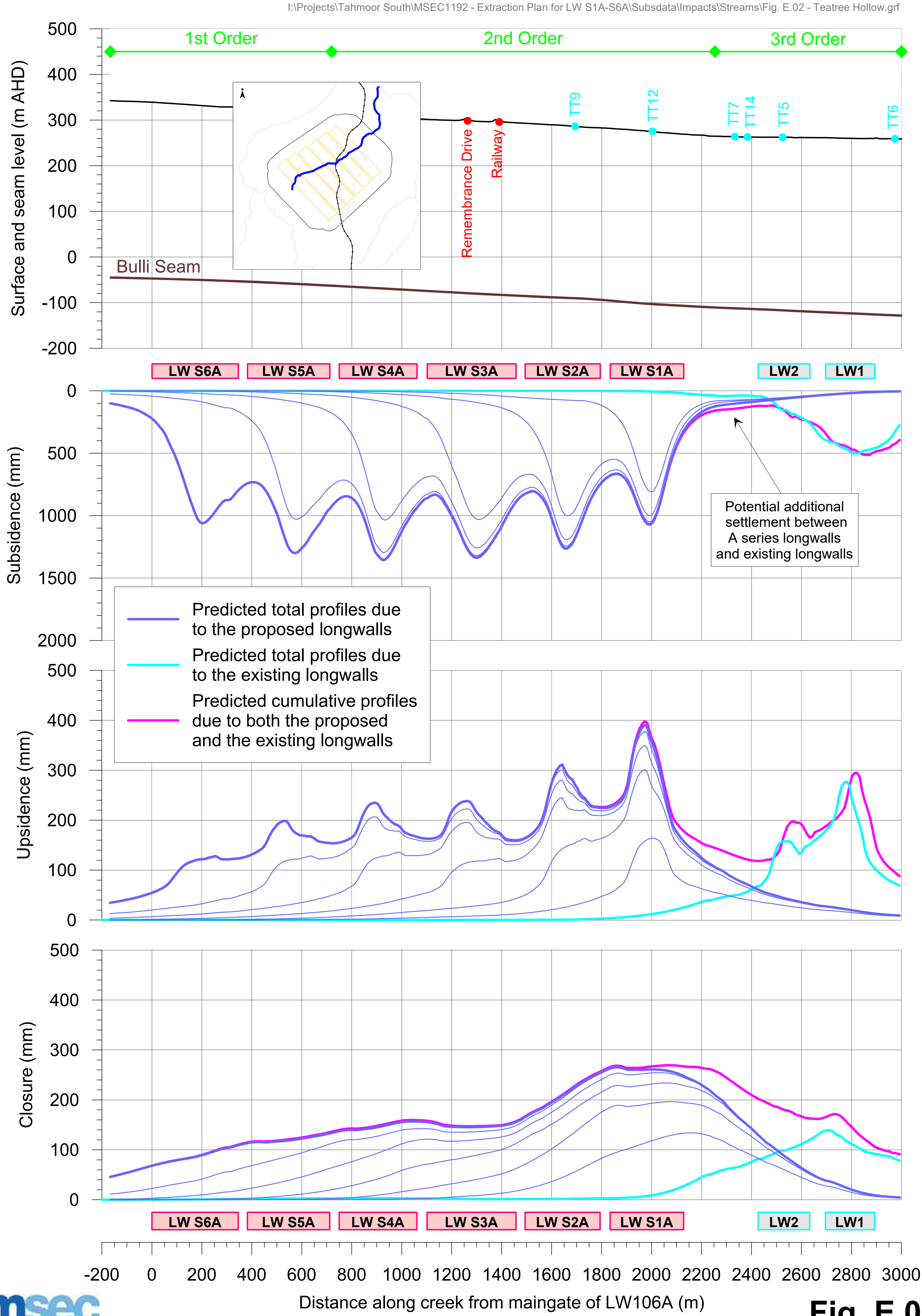
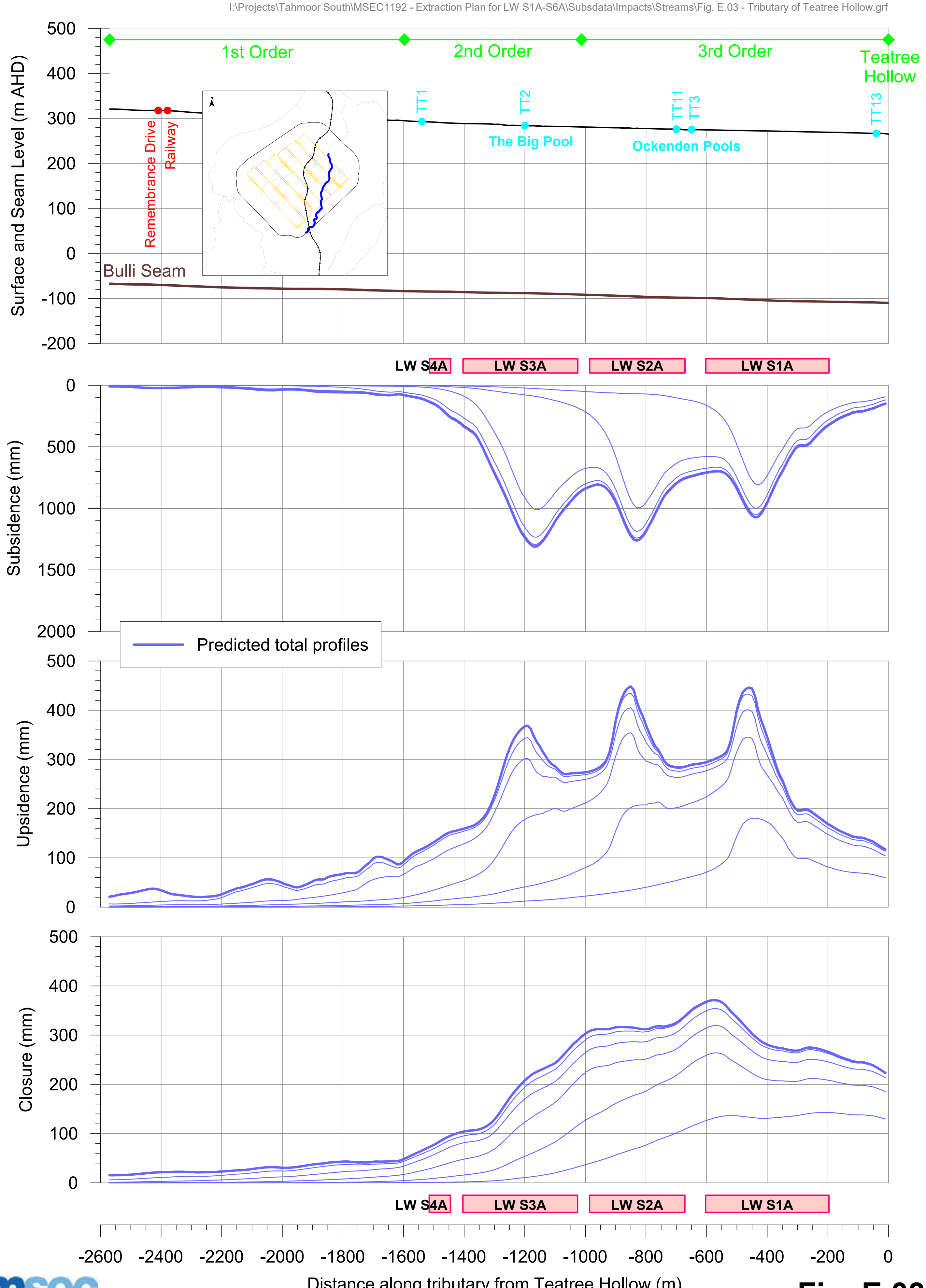


Fig. E.02

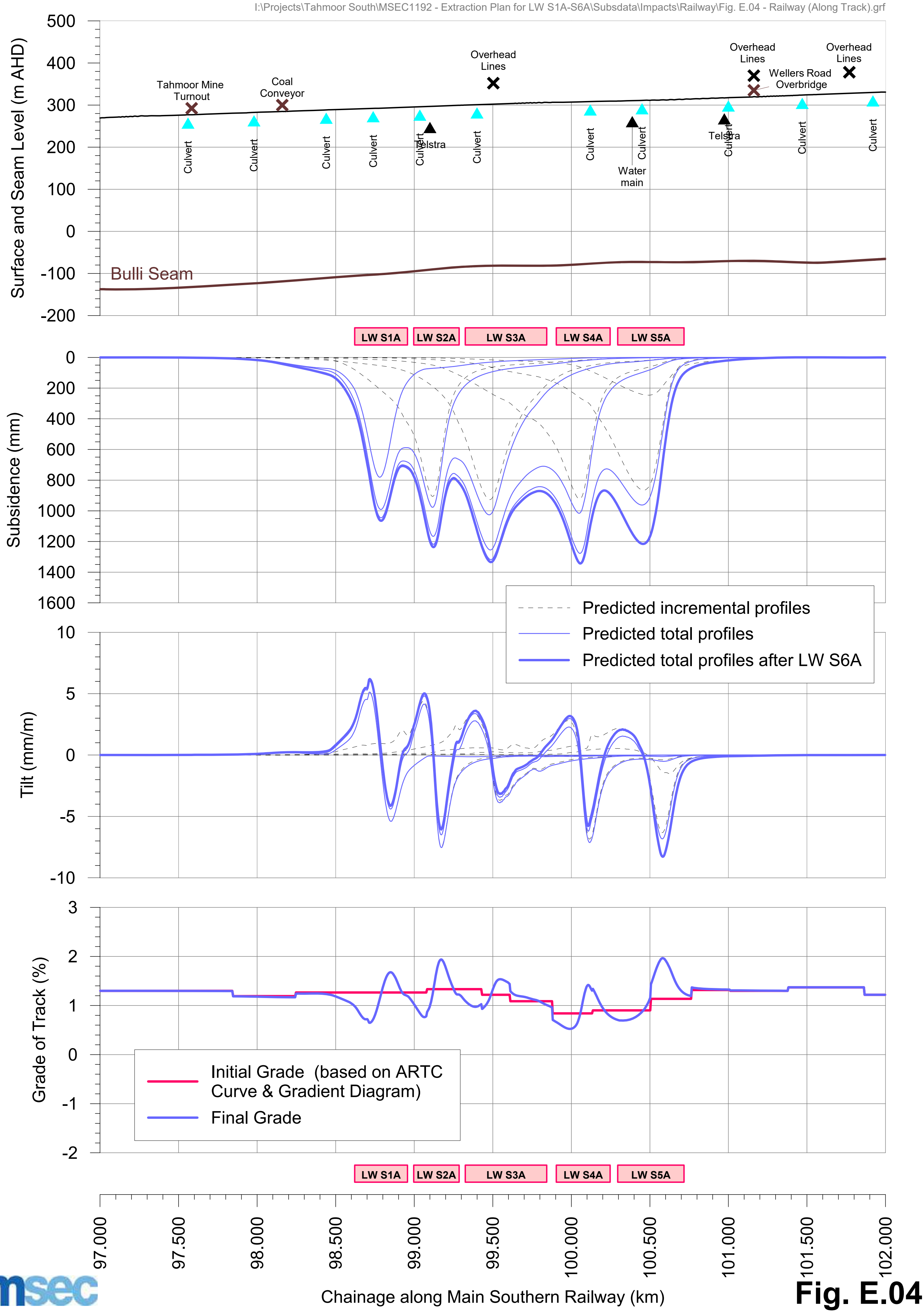
Predicted profiles of subsidence, upsidence and closure along Tributary of Teatree Hollow resulting from the extraction of Longwalls S1A to S6A



msec

Fig. E.03

Predicted profiles of conventional subsidence, tilt and change in grade along the Main Southern Railway due to the extraction of Longwalls S1A to S6A

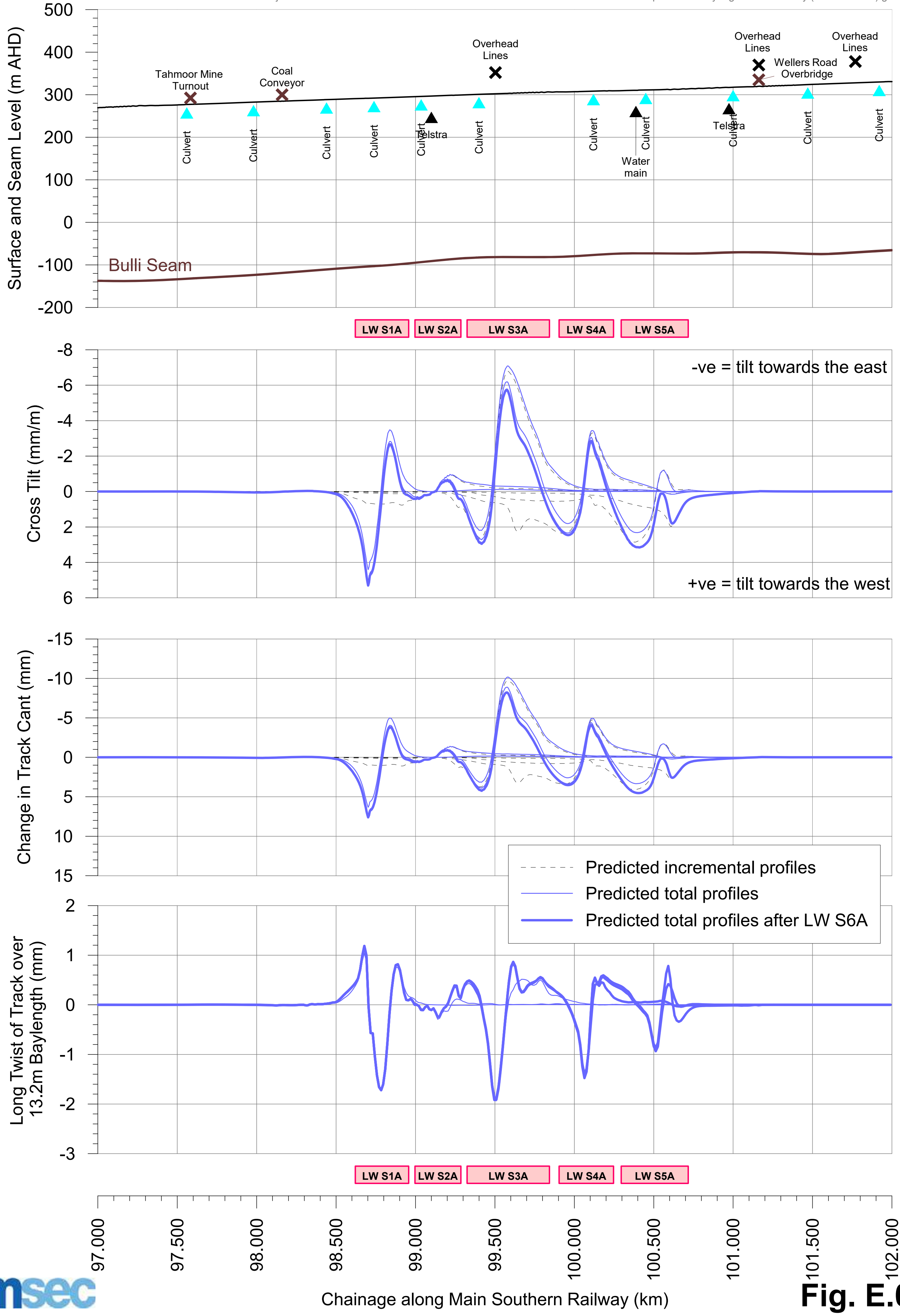


msec

Fig. E.04

Predicted profiles of conventional cross tilt, change in track cant and long twist along the Main Southern Railway due to the extraction of Longwalls S1A to S6A

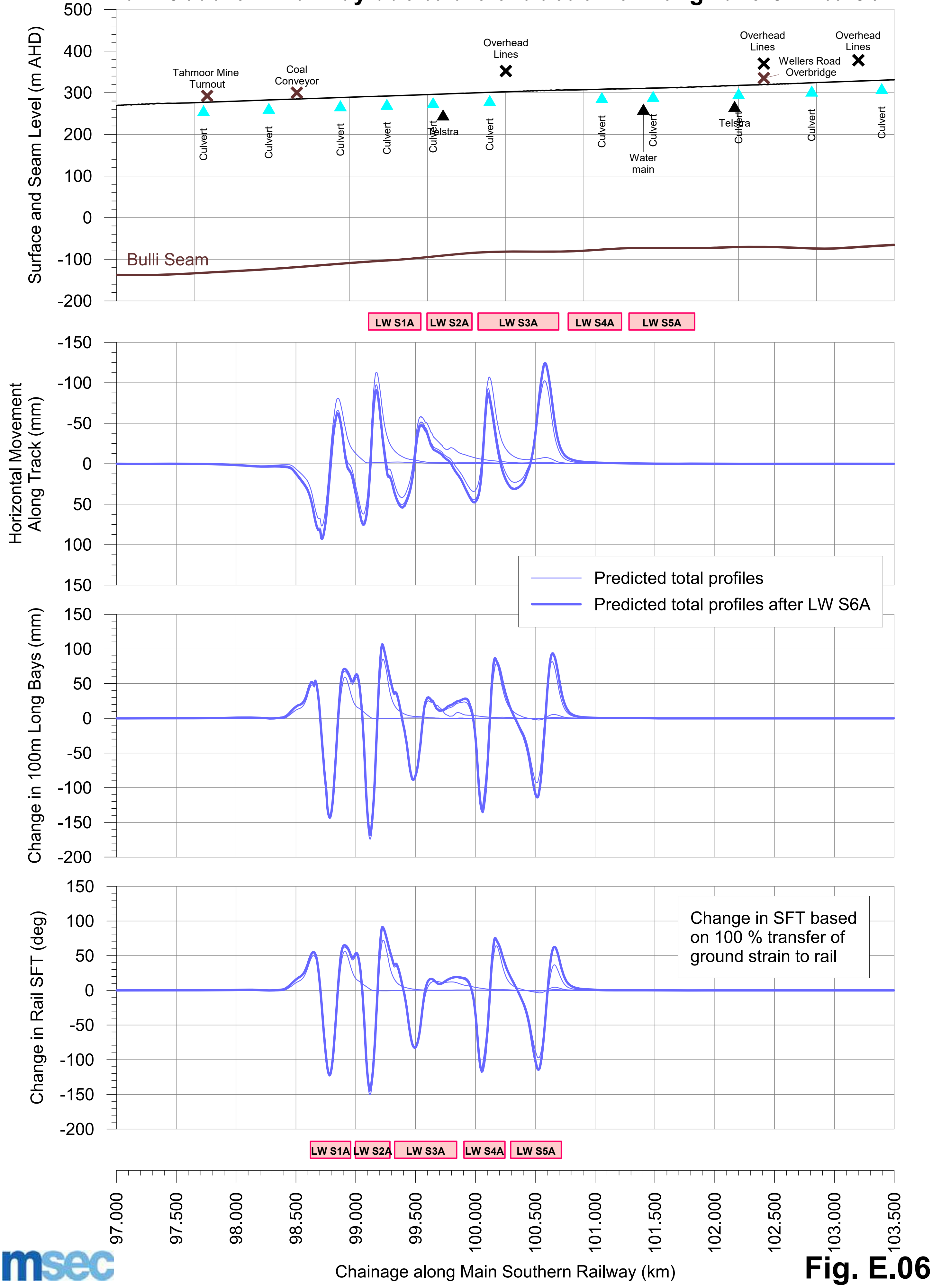
I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\Subsdata\Impacts\Railway\Fig. E.05 - Railway (Across Track).grf



msec

Fig. E.05

Predicted profiles of conventional horizontal movement along track, change in 100 metre long bay length and change in SFT for the Main Southern Railway due to the extraction of Longwalls S1A to S6A

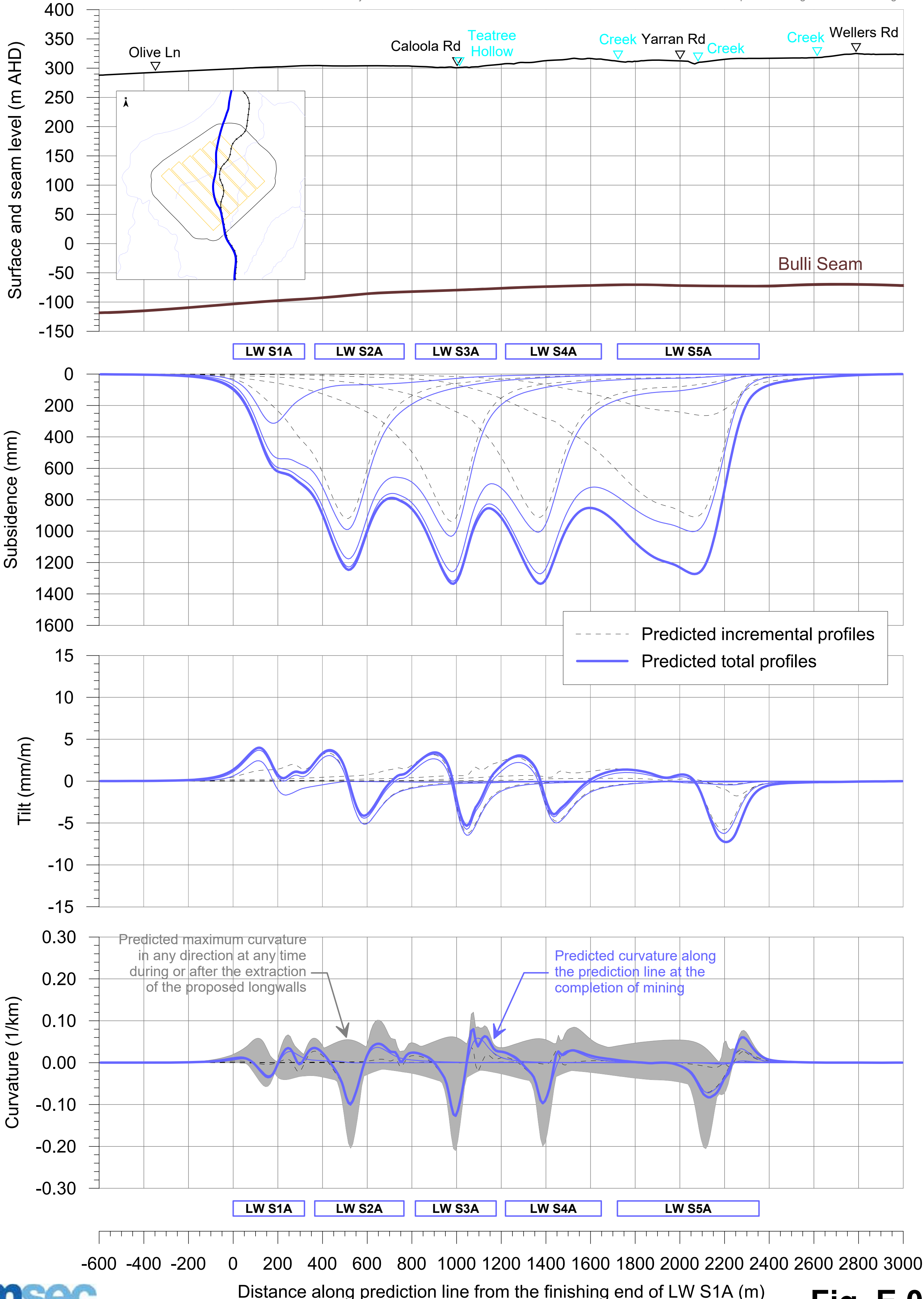


msec

Fig. E.06

Predicted profiles of conventional subsidence, tilt and curvature along Remembrance Drive and the 150mm steel gas main resulting from the extraction of Longwalls S1A to S6A

I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\Subsdata\Impacts\Gas\Fig. E.07 - Gas Main.grf

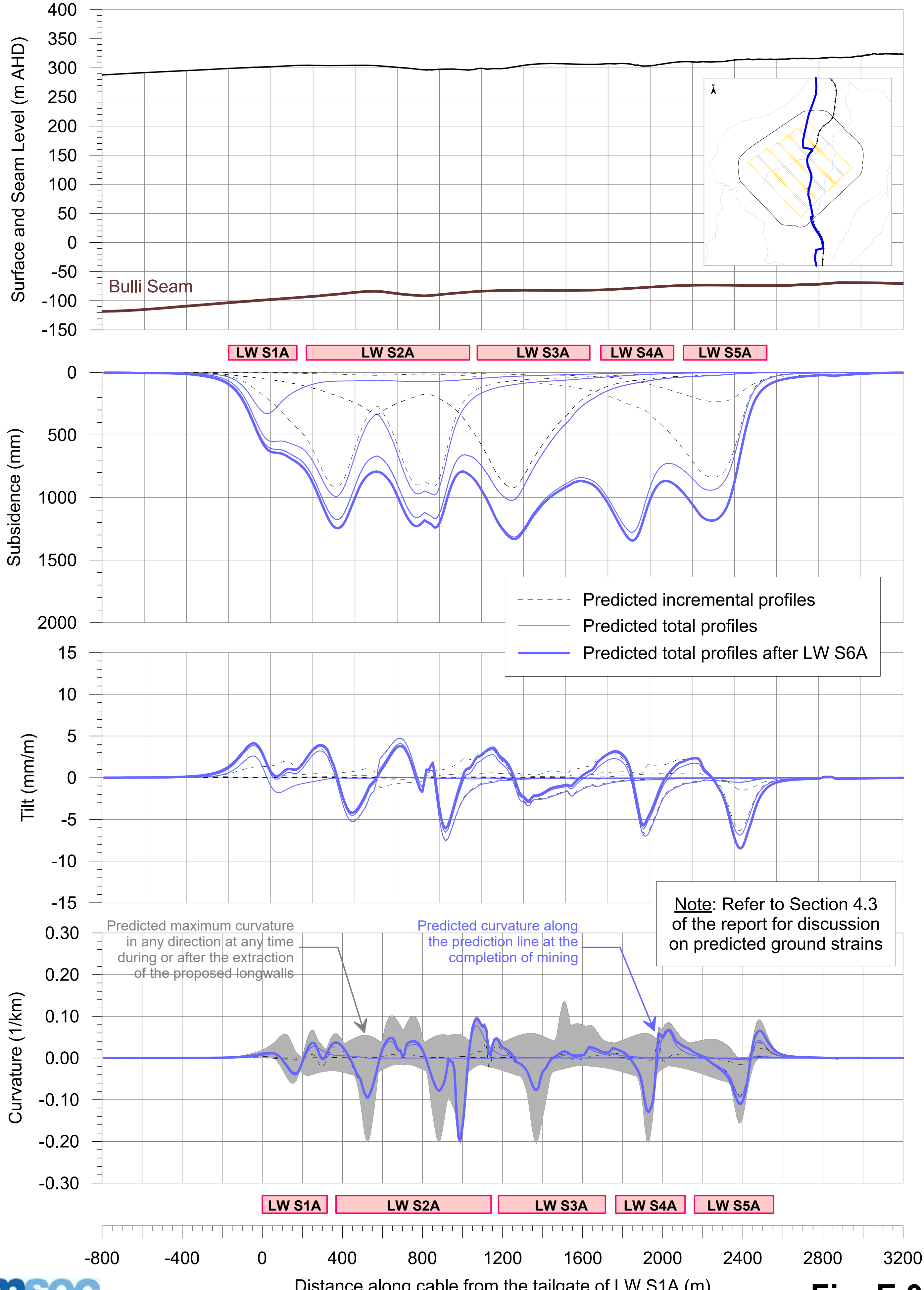


msec

Fig. E.07

Predicted profiles of conventional subsidence, tilt and curvature along Optical Fibre Cable resulting from the extraction of Longwalls S1A to S6A

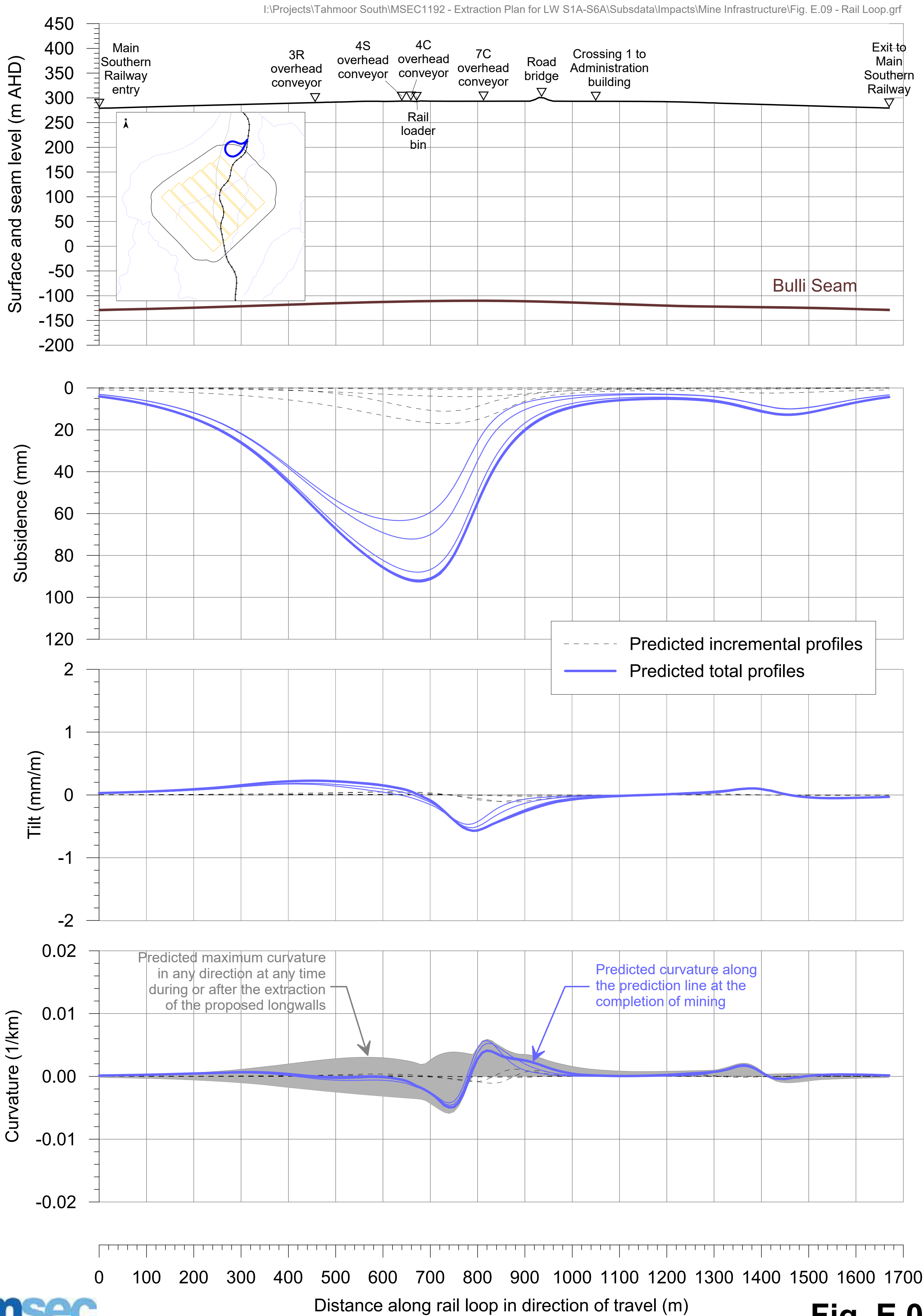
I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\Subsdata\Impacts\Telecommunications\Fig. E.08 - Optical Fibre Cable.grf



msec

Fig. E.08

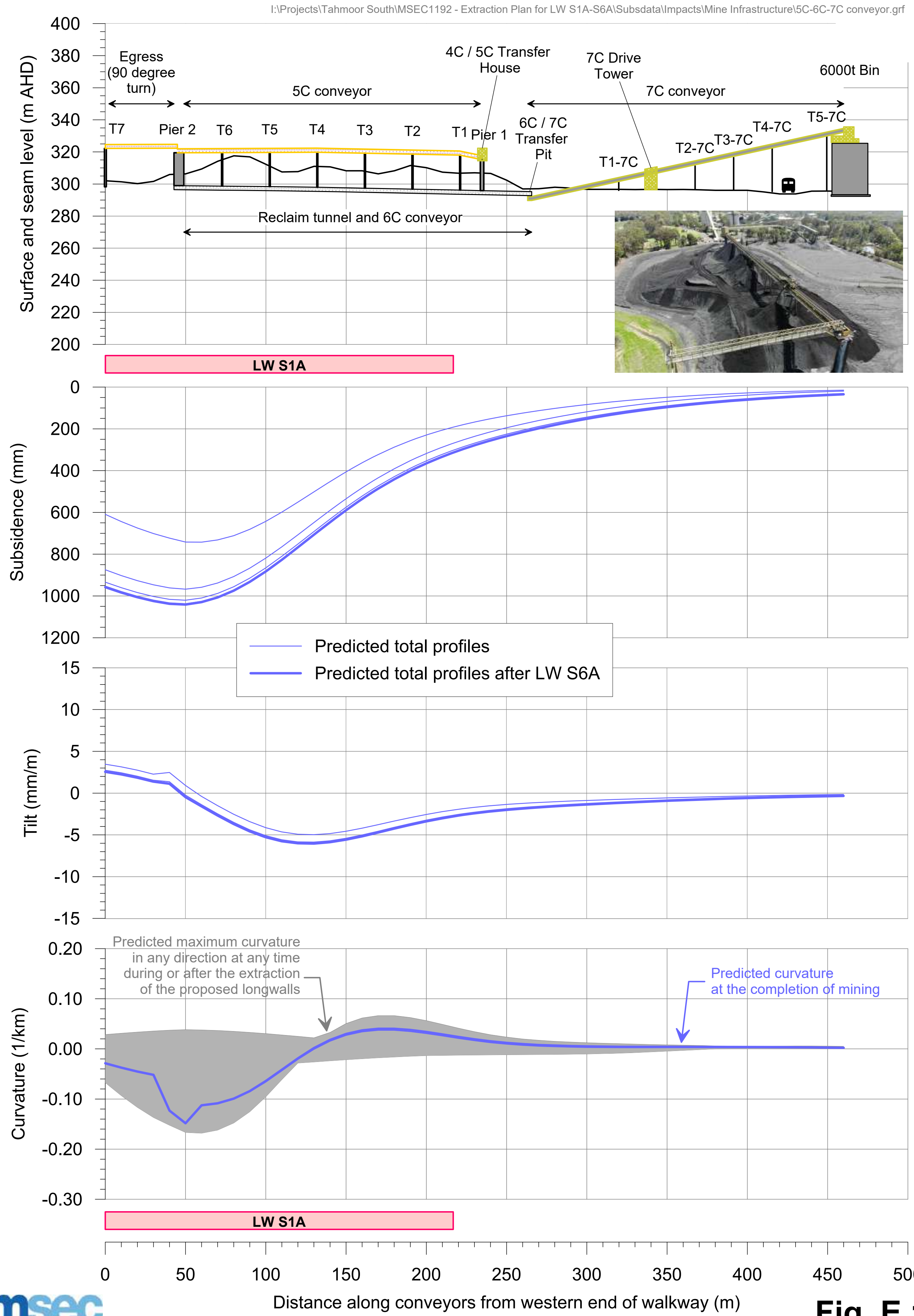
Predicted profiles of conventional subsidence, tilt and curvature along Tahmoor Mine rail loop resulting from the extraction of Longwalls S1A to S6A



msec

Fig. E.09

Predicted profiles of conventional subsidence, tilt and curvature along 5C-6C-7C conveyors resulting from the extraction of Longwalls S1A to S6A



msec

Fig. E.10

APPENDIX F. DRAWINGS

I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\AcadData\MSEC1192-01 General Layout (LWS1A to LWS6A).dwg

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TAHMOOR SOUTH PROJECT EXTRACTION PLAN LW S1A TO LW S6A

GENERAL LAYOUT

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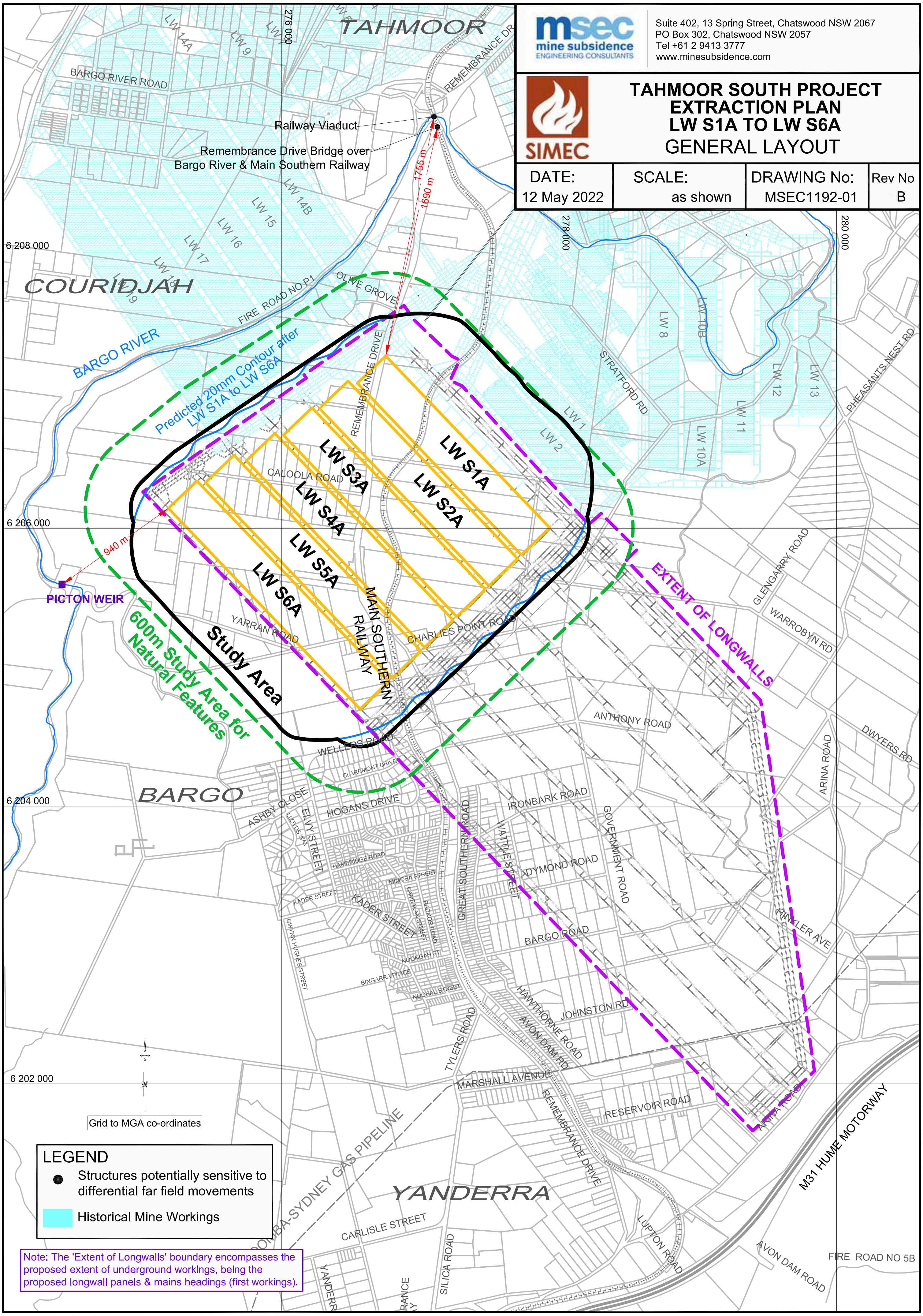
12 May 2022	as shown	MSEC1192-01	B



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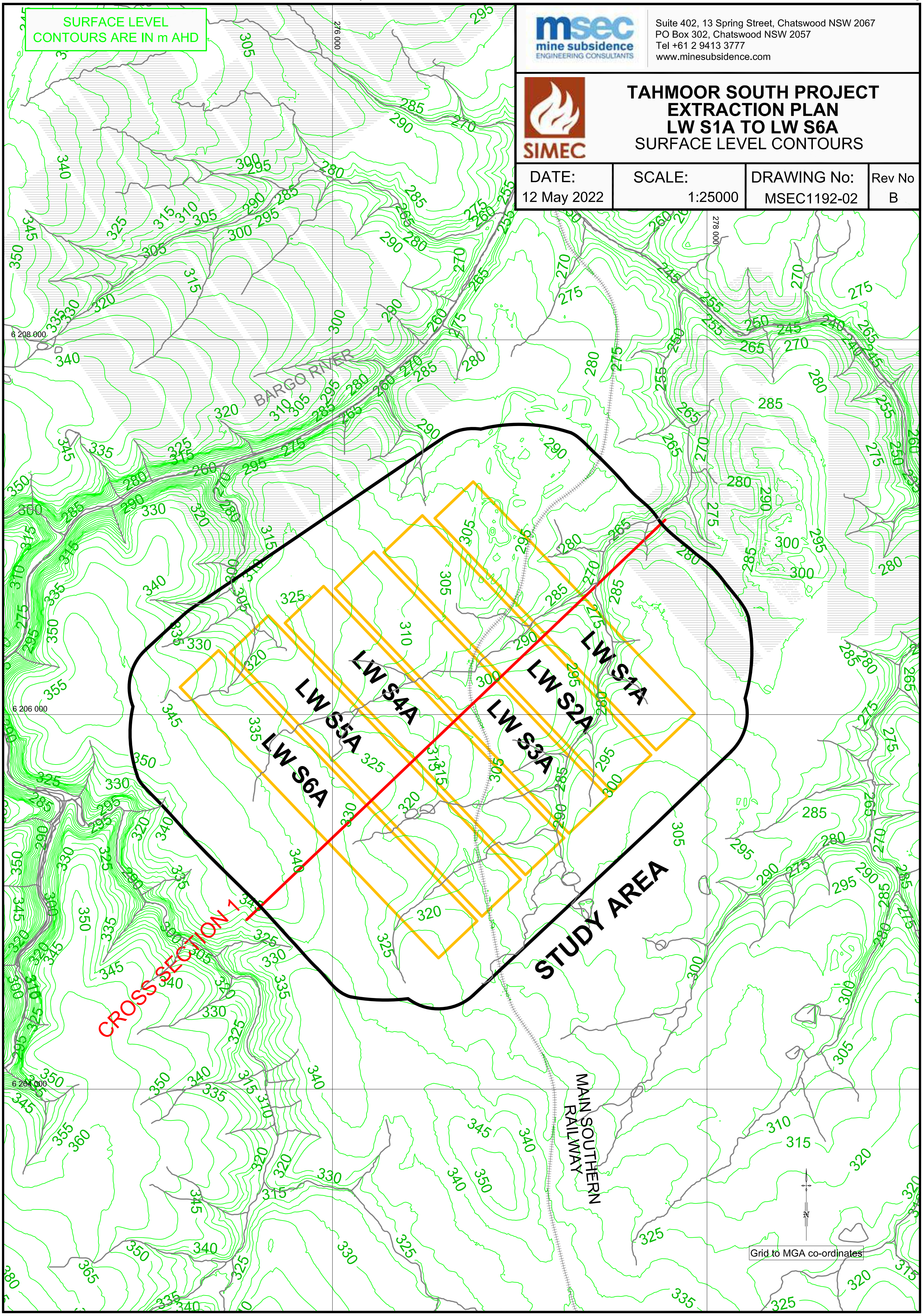

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TAHMOOR SOUTH PROJECT
EXTRACTION PLAN
LW S1A TO LW S6A
SURFACE LEVEL CONTOURS

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12 May 2022	1:25000	MSEC1192-02	B

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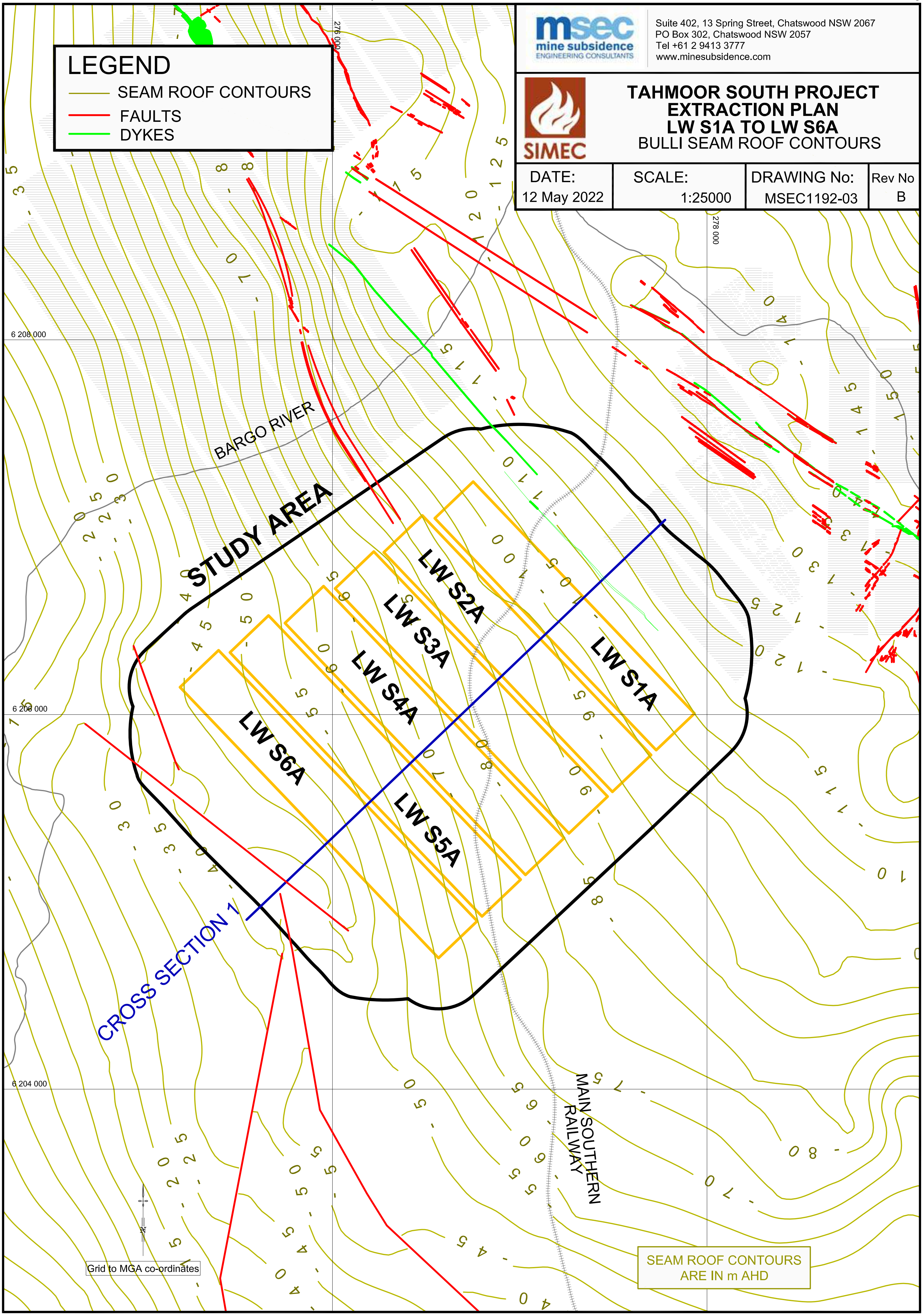

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TAHMOOR SOUTH PROJECT EXTRACTION PLAN LW S1A TO LW S6A

EXTRACTION HEIGHT

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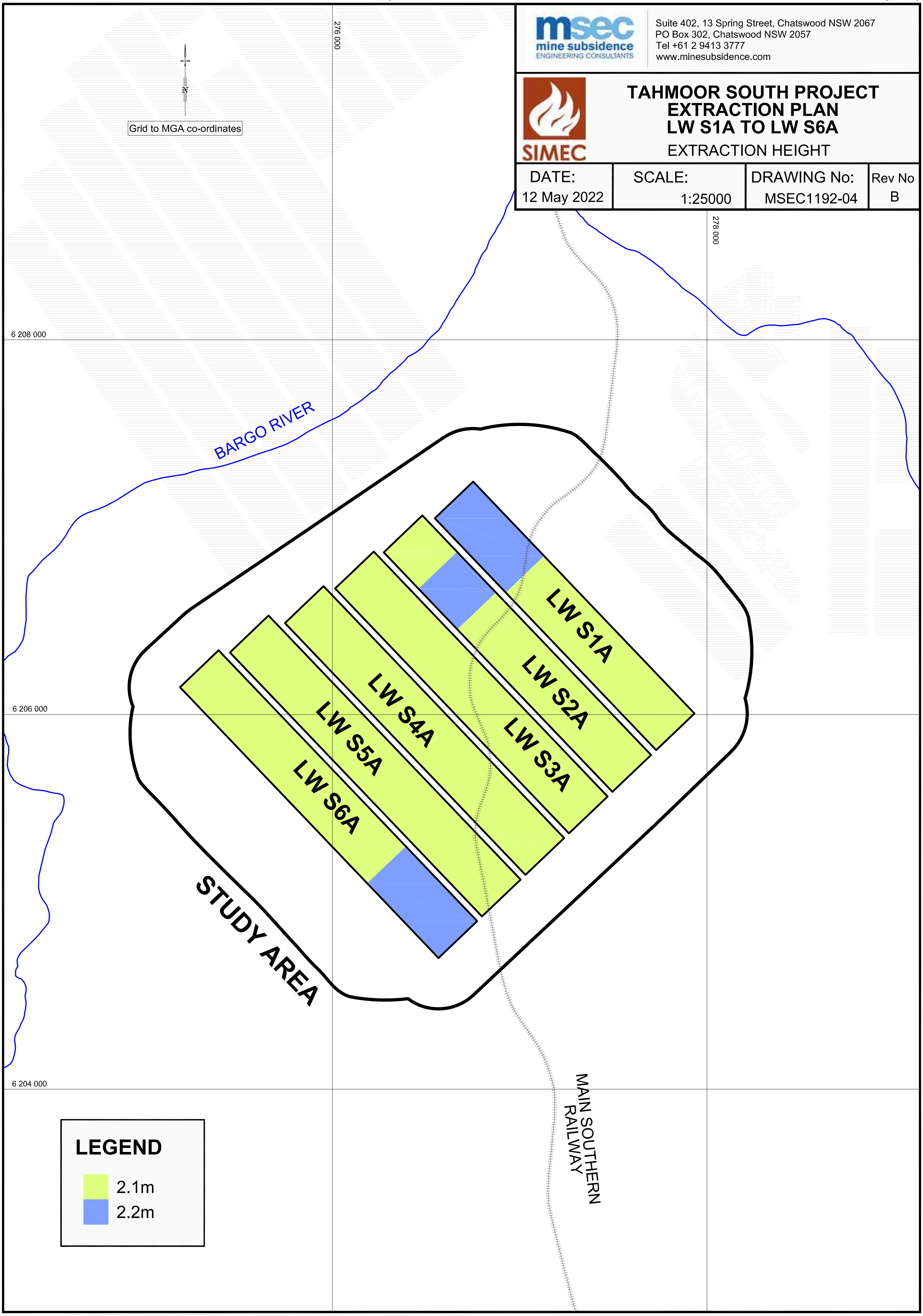
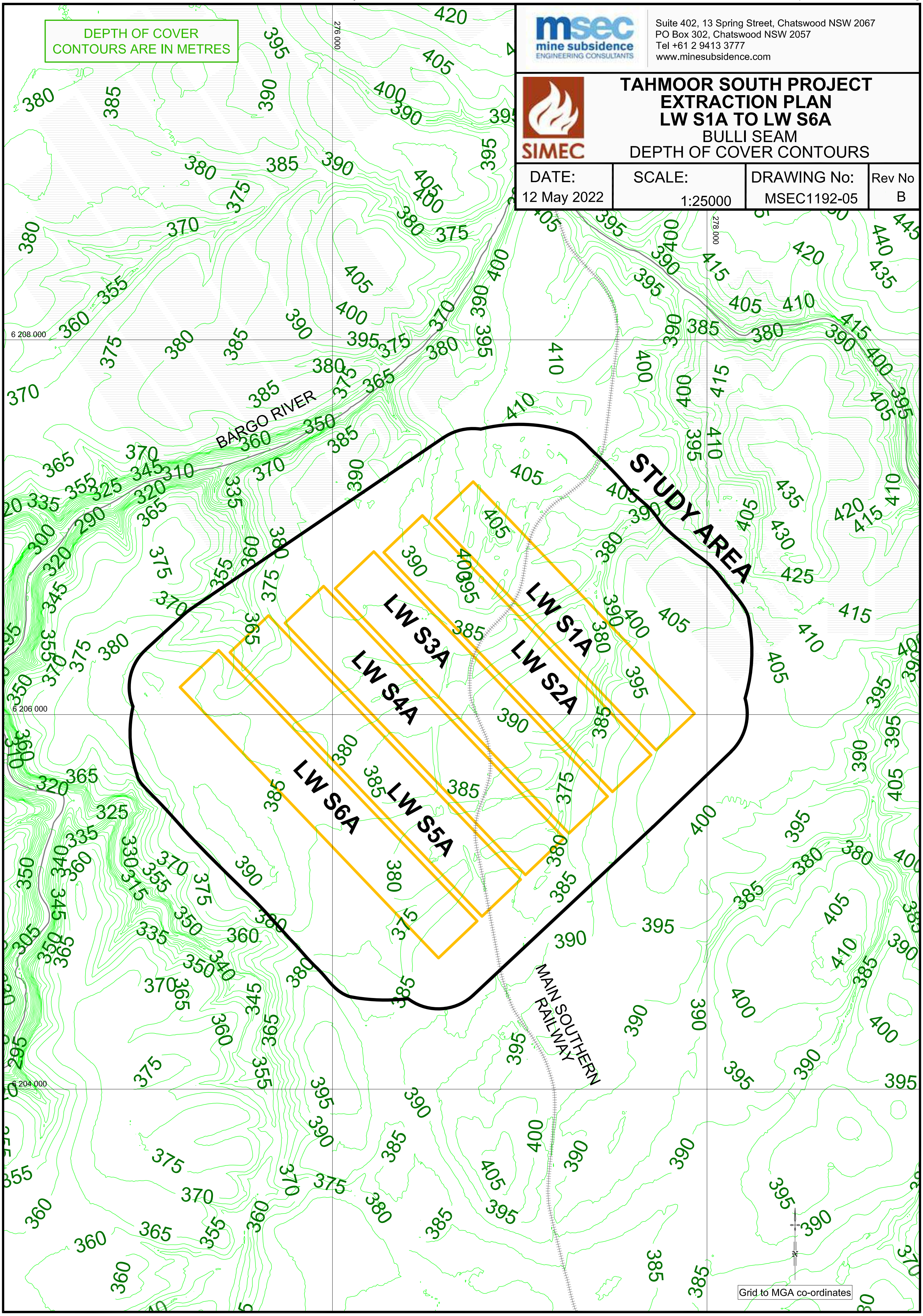


LEGEND

- 2.1m
- 2.2m

I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\AcadData\MSEC1192-05 Depth of Cover Contours.dwg



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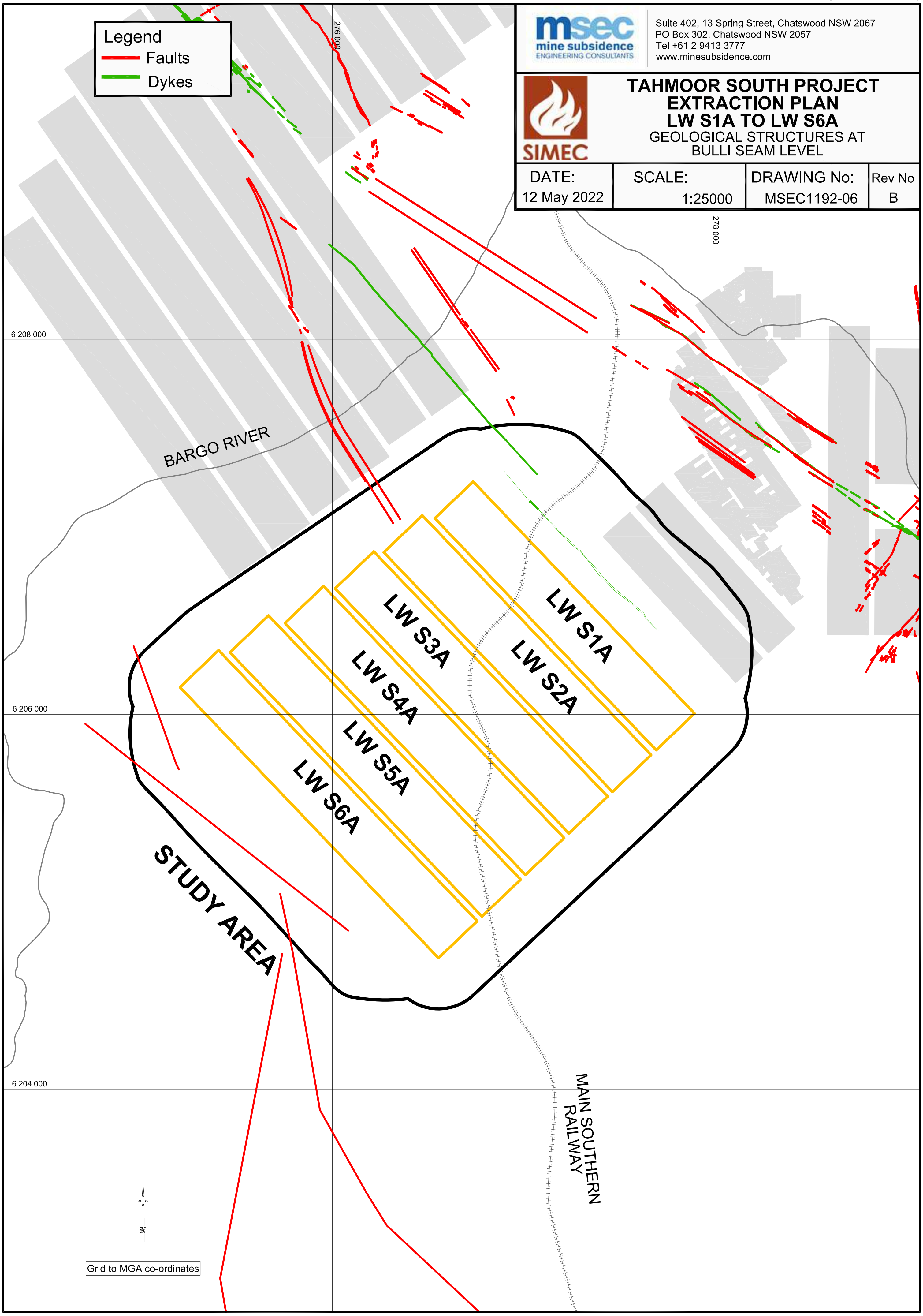

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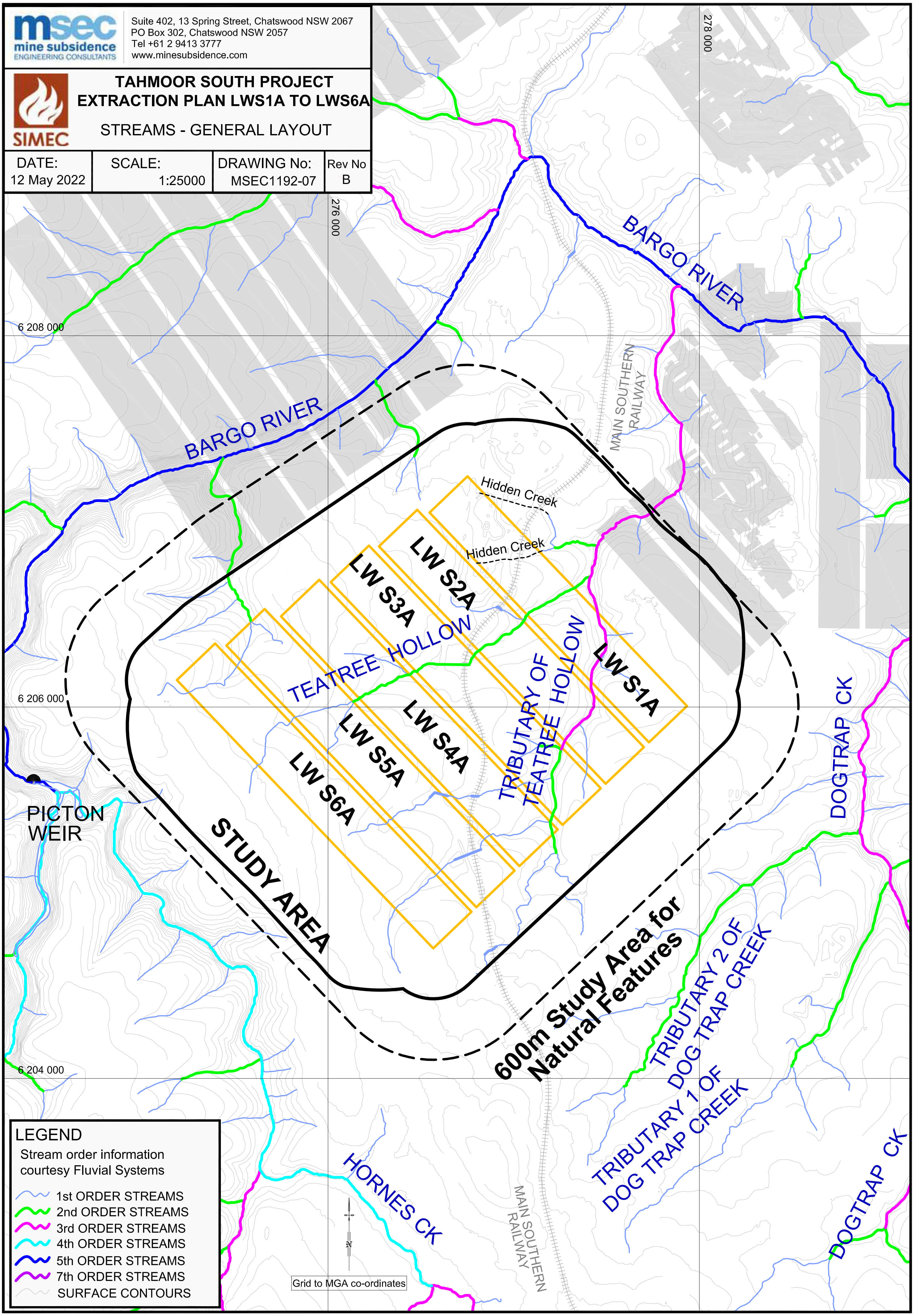

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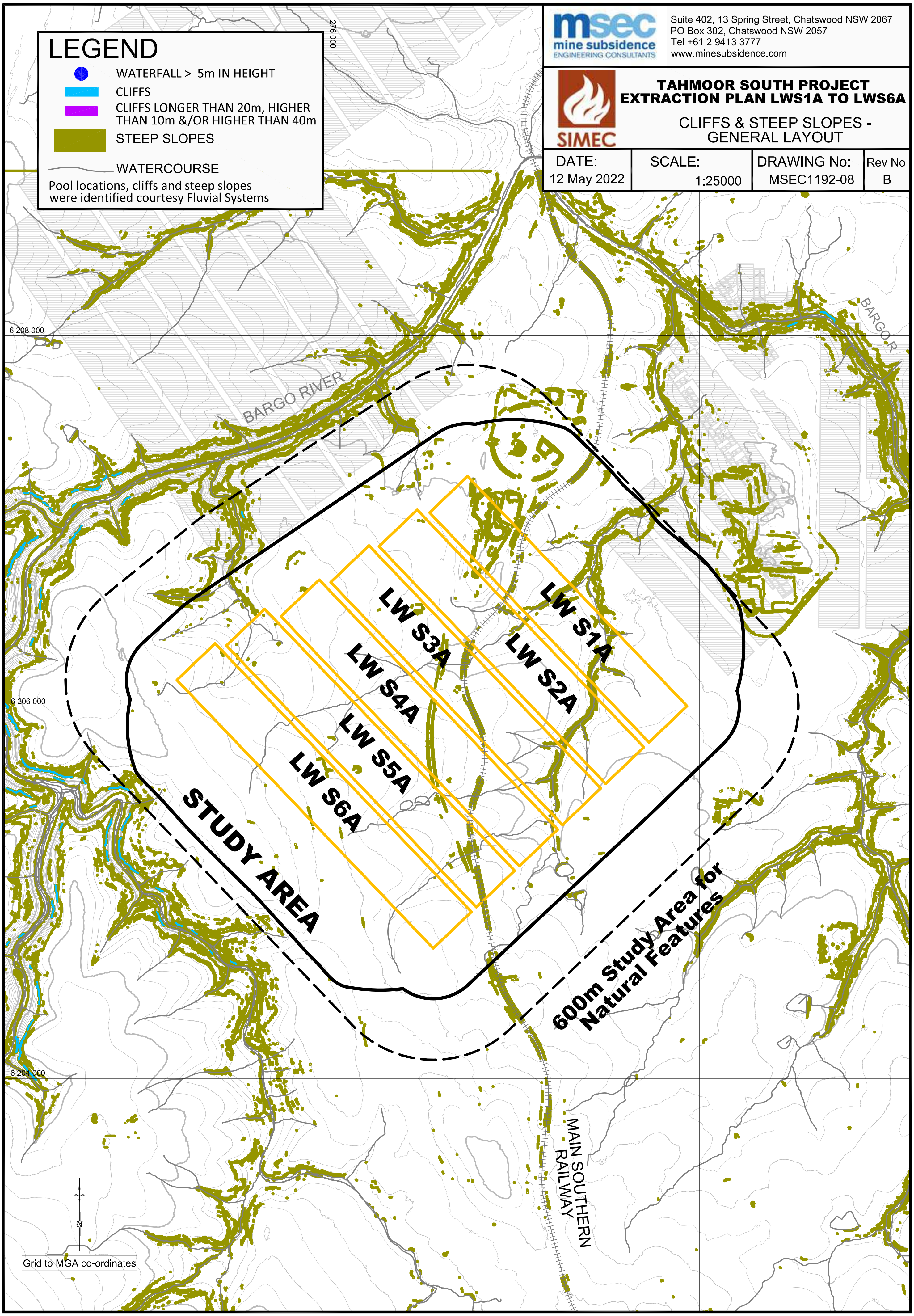

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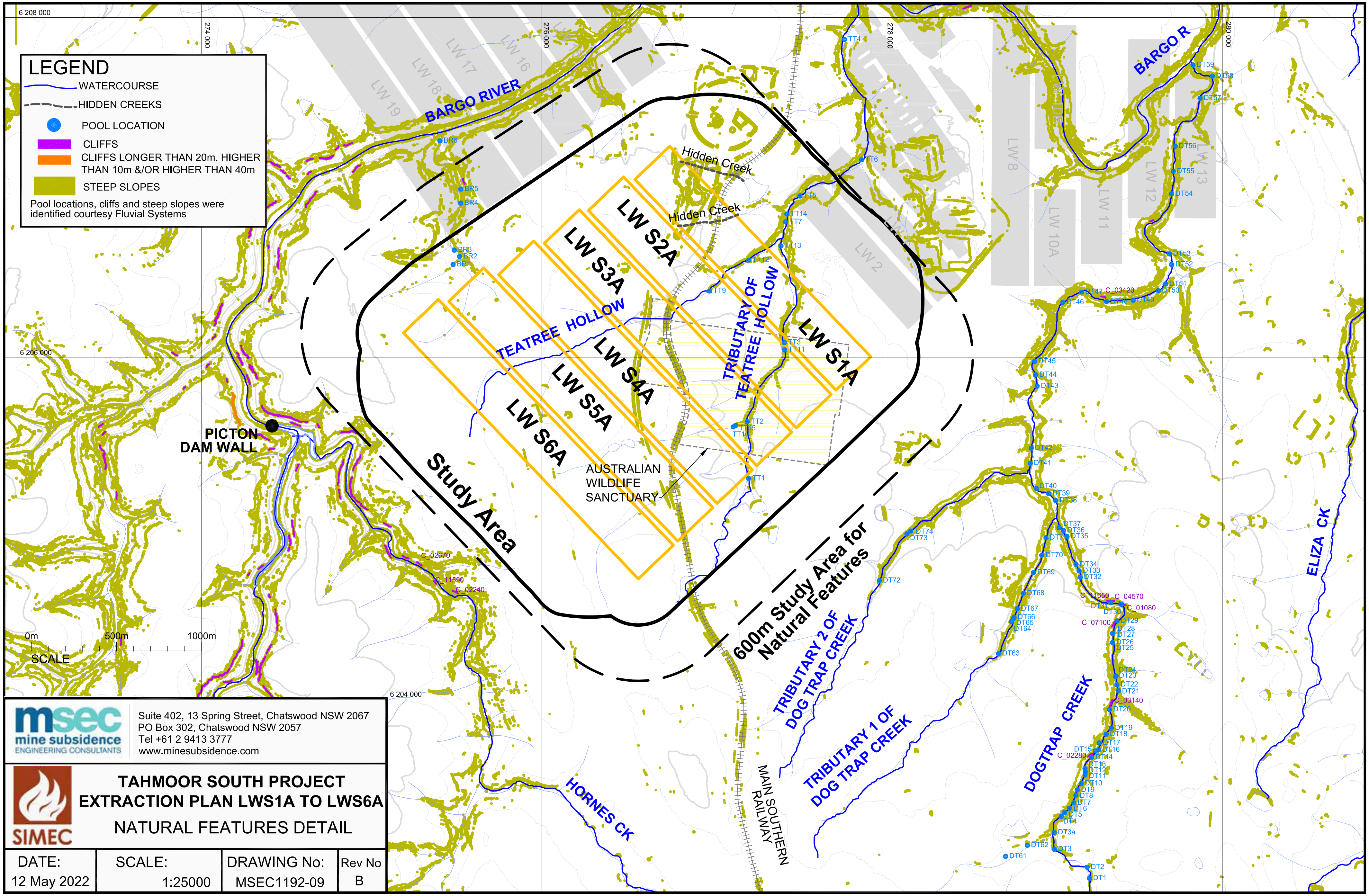

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TAHMOOR SOUTH PROJECT
EXTRACTION PLAN LWS1A TO LWS6A
NATURAL FEATURES DETAIL

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I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\AcadData\MSEC1192-10 Rail.dwg

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TAHMOOR SOUTH PROJECT EXTRACTION PLAN LWS1A TO LWS6A

RAILWAYS & ASSOCIATED INFRASTRUCTURE

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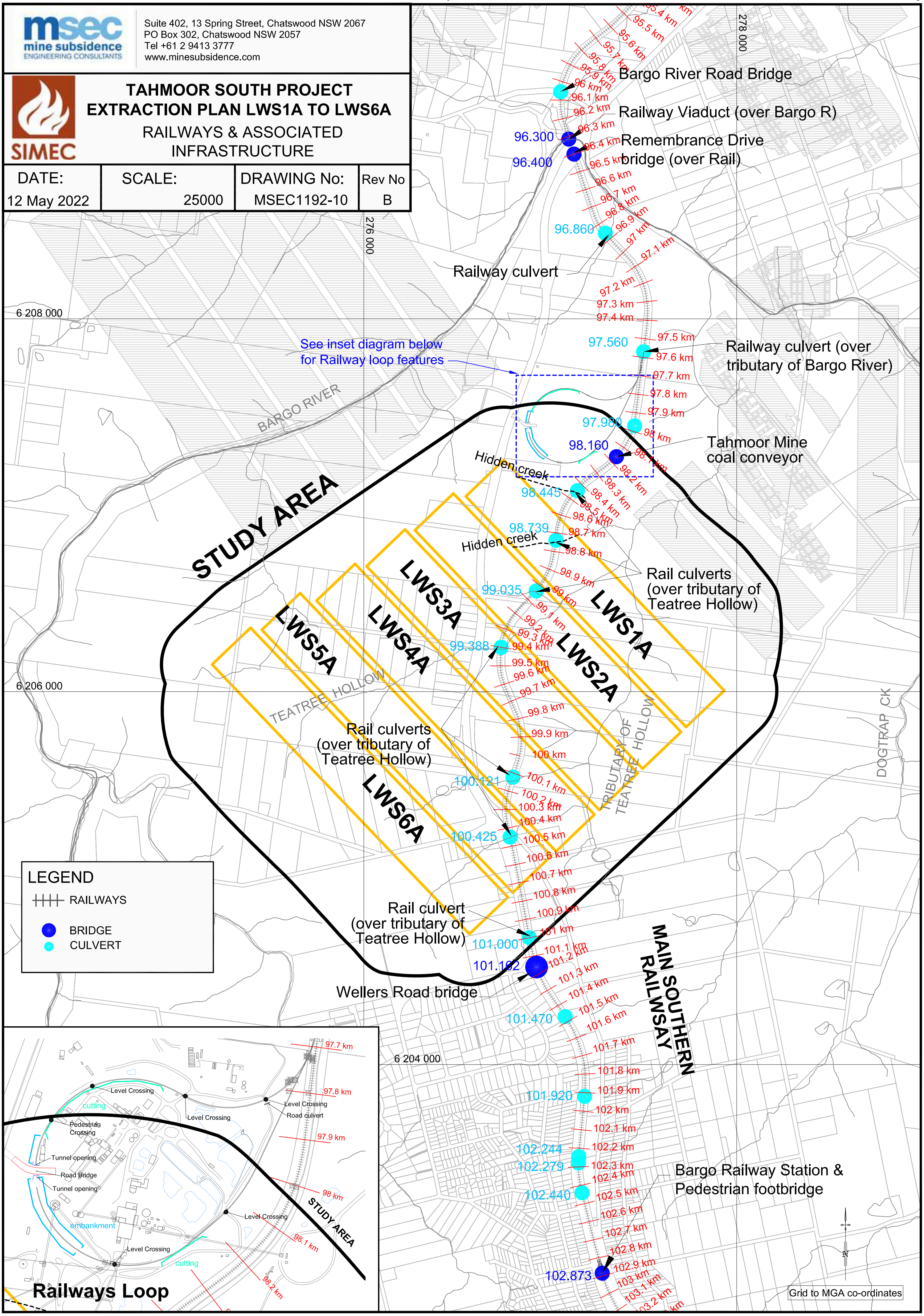

I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\AcadData\MSEC1192-11 Roads.dwg

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ROADS & ASSOCIATED INFRASTRUCTURE

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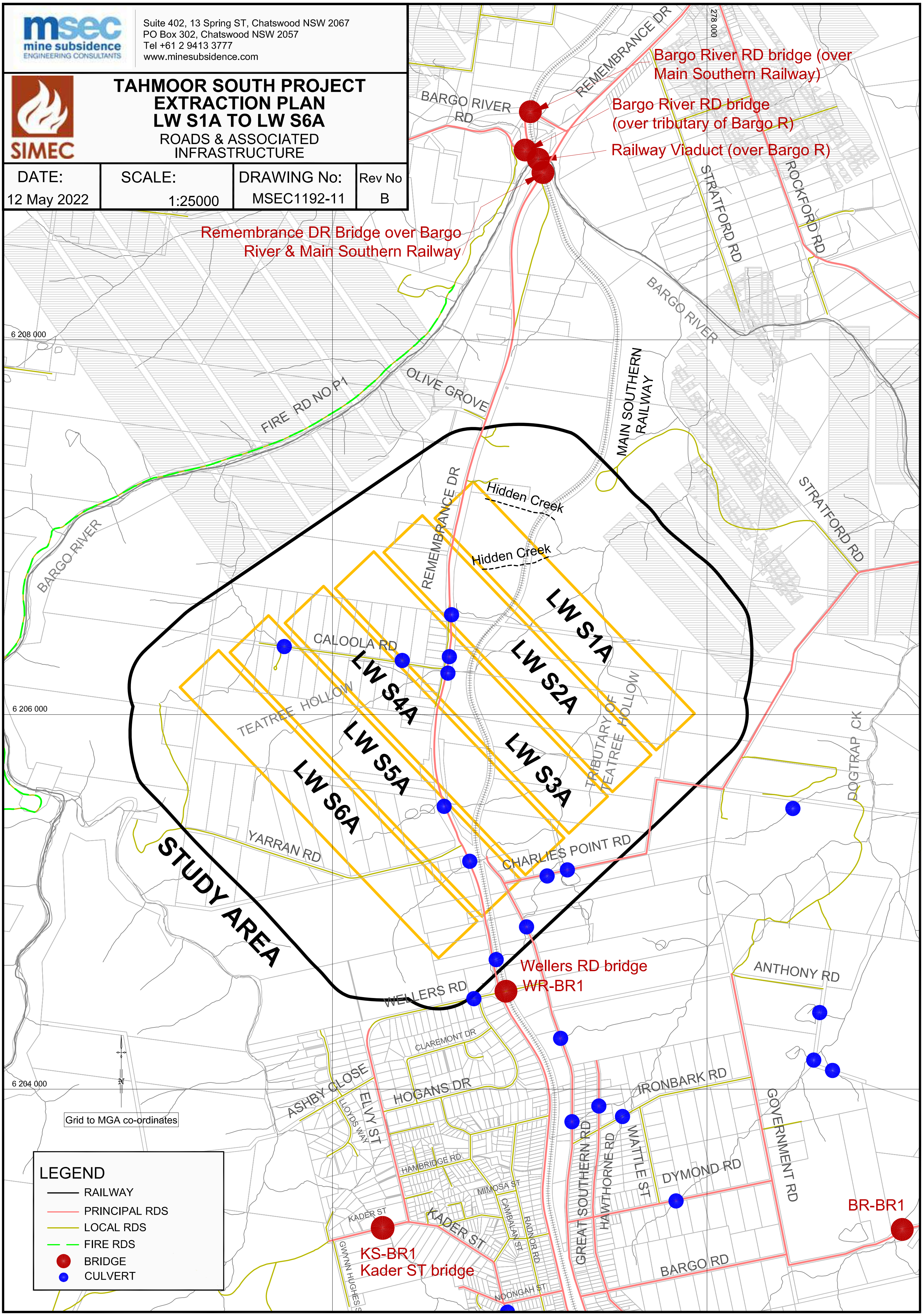
12 May 2022	1:25000	MSEC1192-11	B



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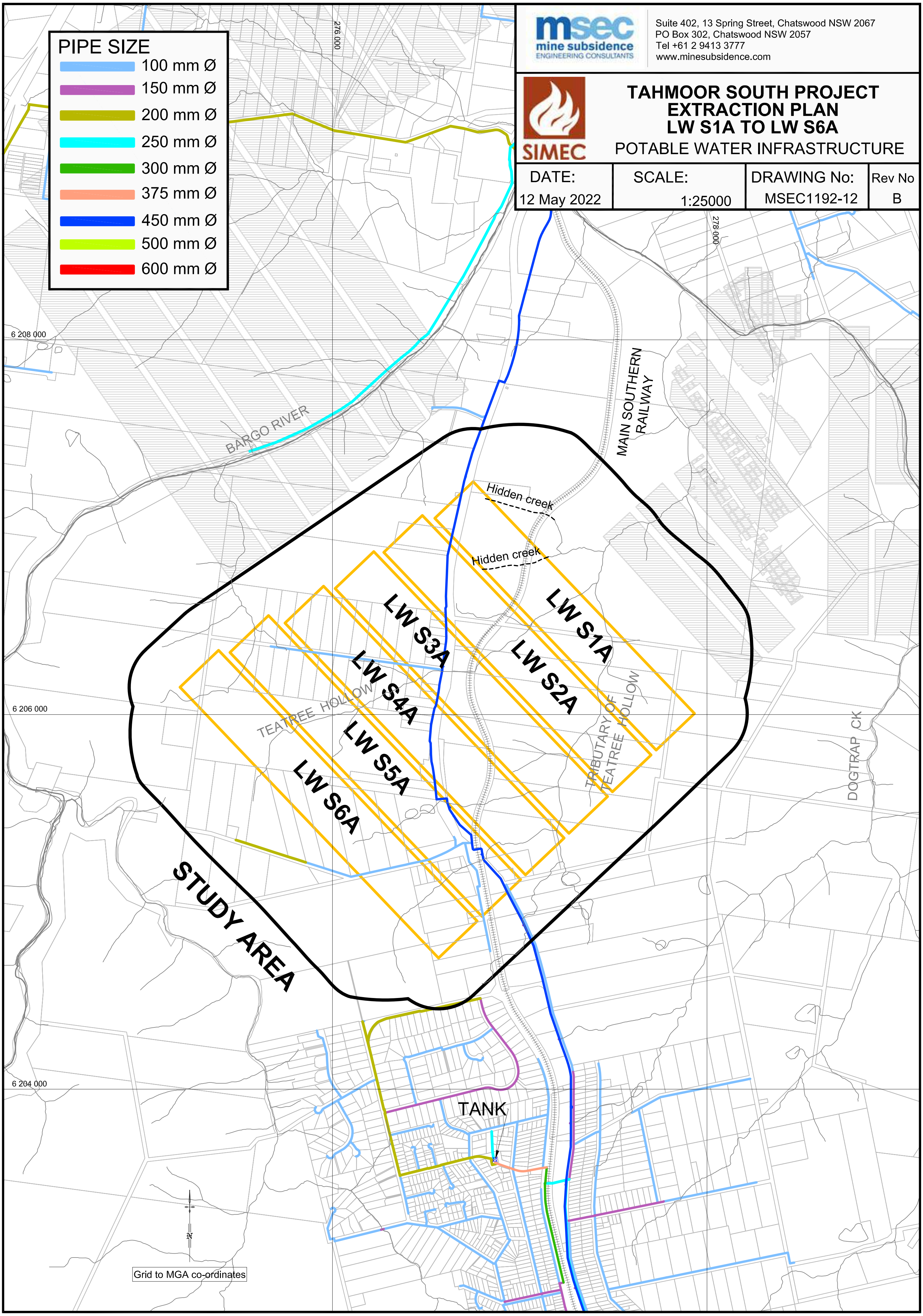

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POTABLE WATER INFRASTRUCTURE

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I:\Projects\Tahmoor South\MSEC1192 - Extraction Plan for LW S1A-S6A\AcadData\MSEC1192-13 Sewer Infrastructure.dwg

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EXTRACTION PLAN
LW S1A TO LW S6A
SEWER INFRASTRUCTURE

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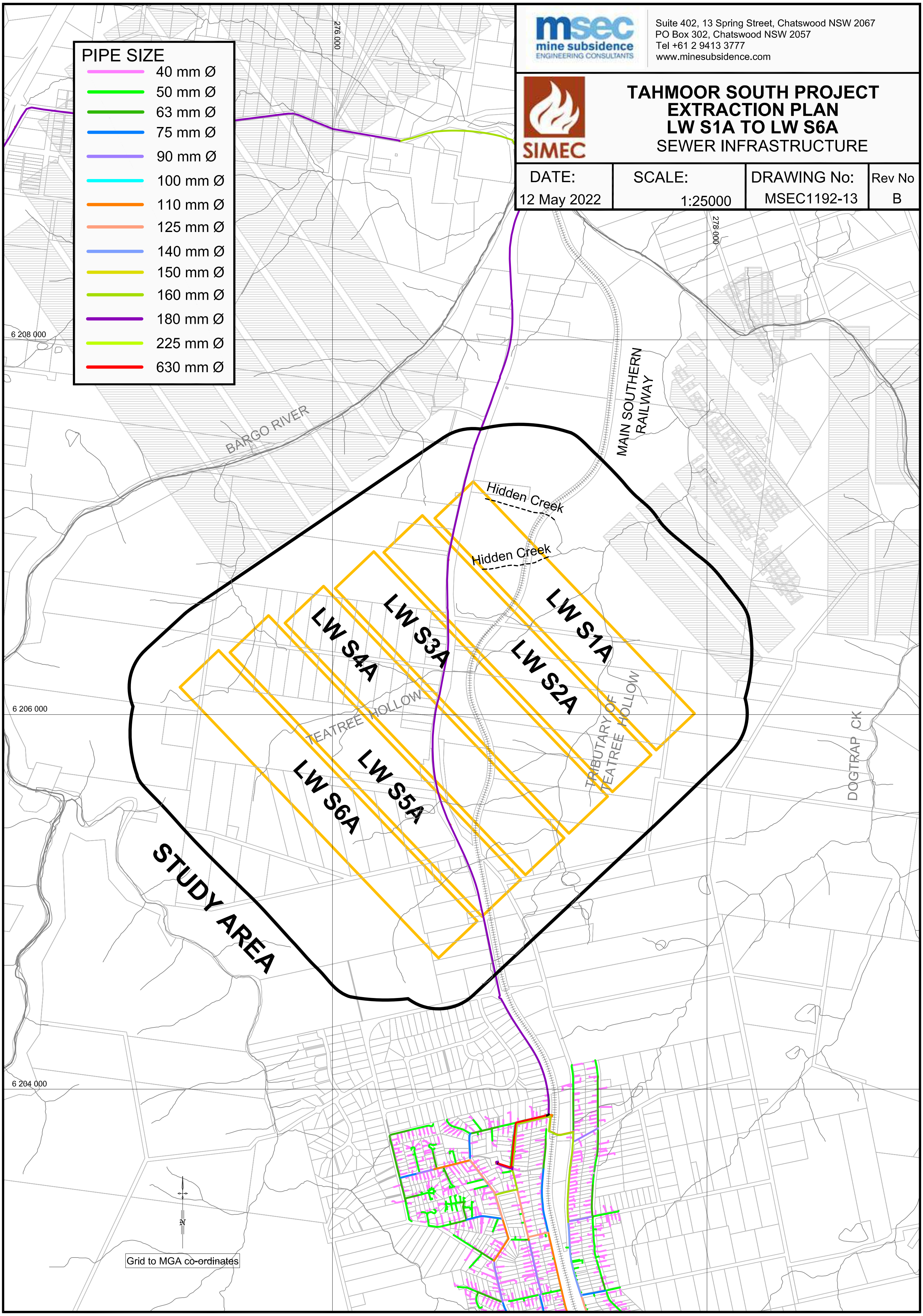

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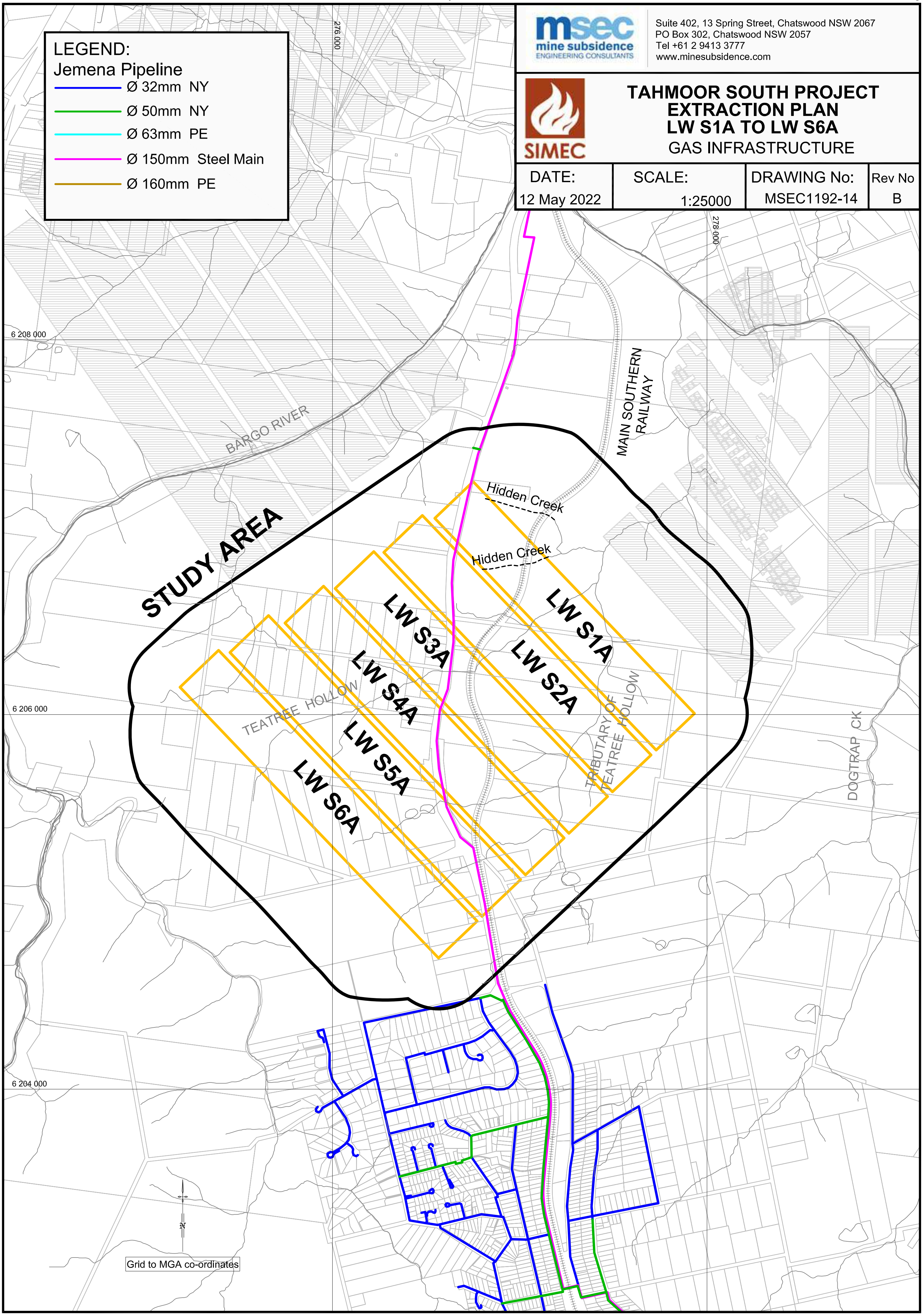

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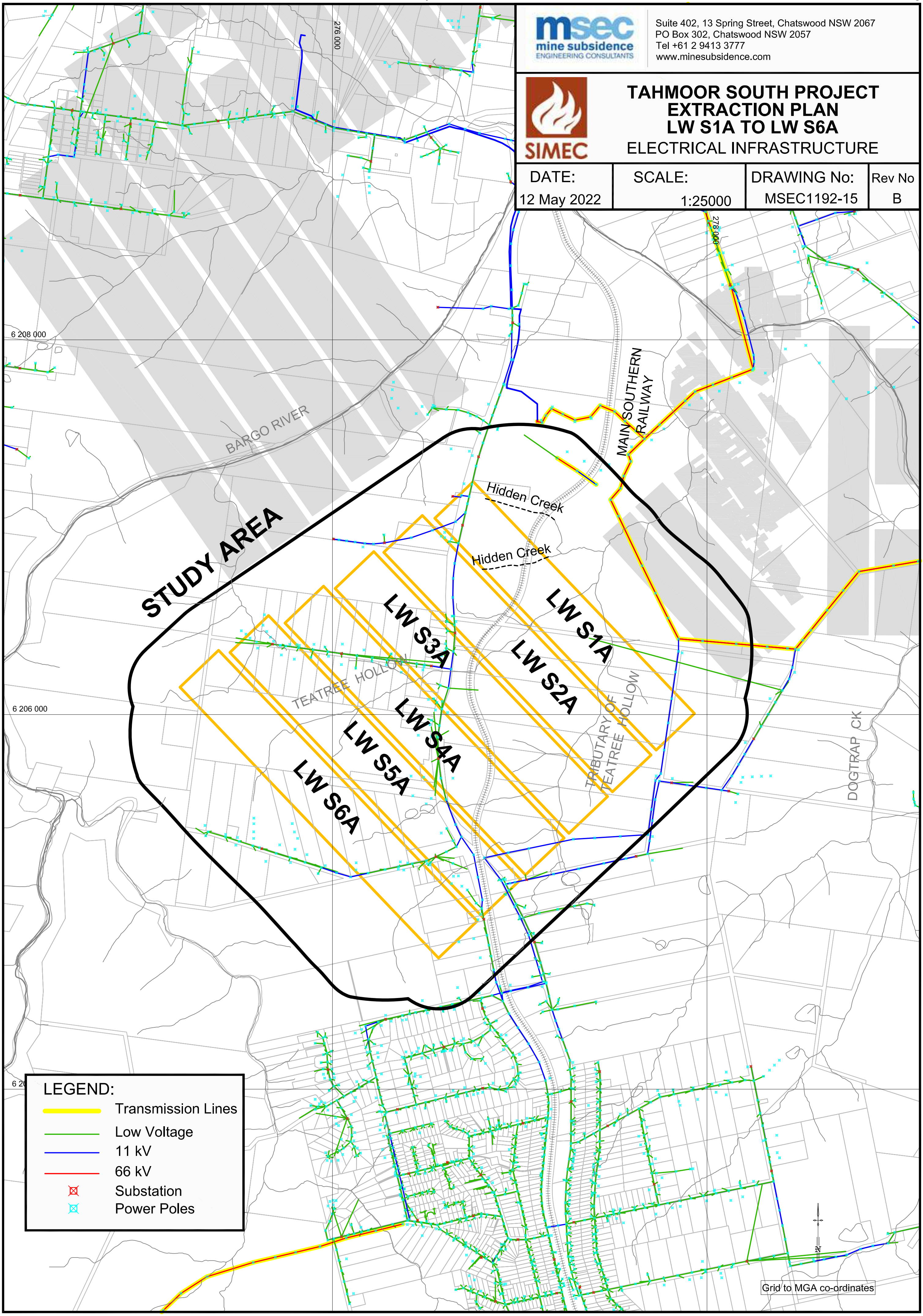

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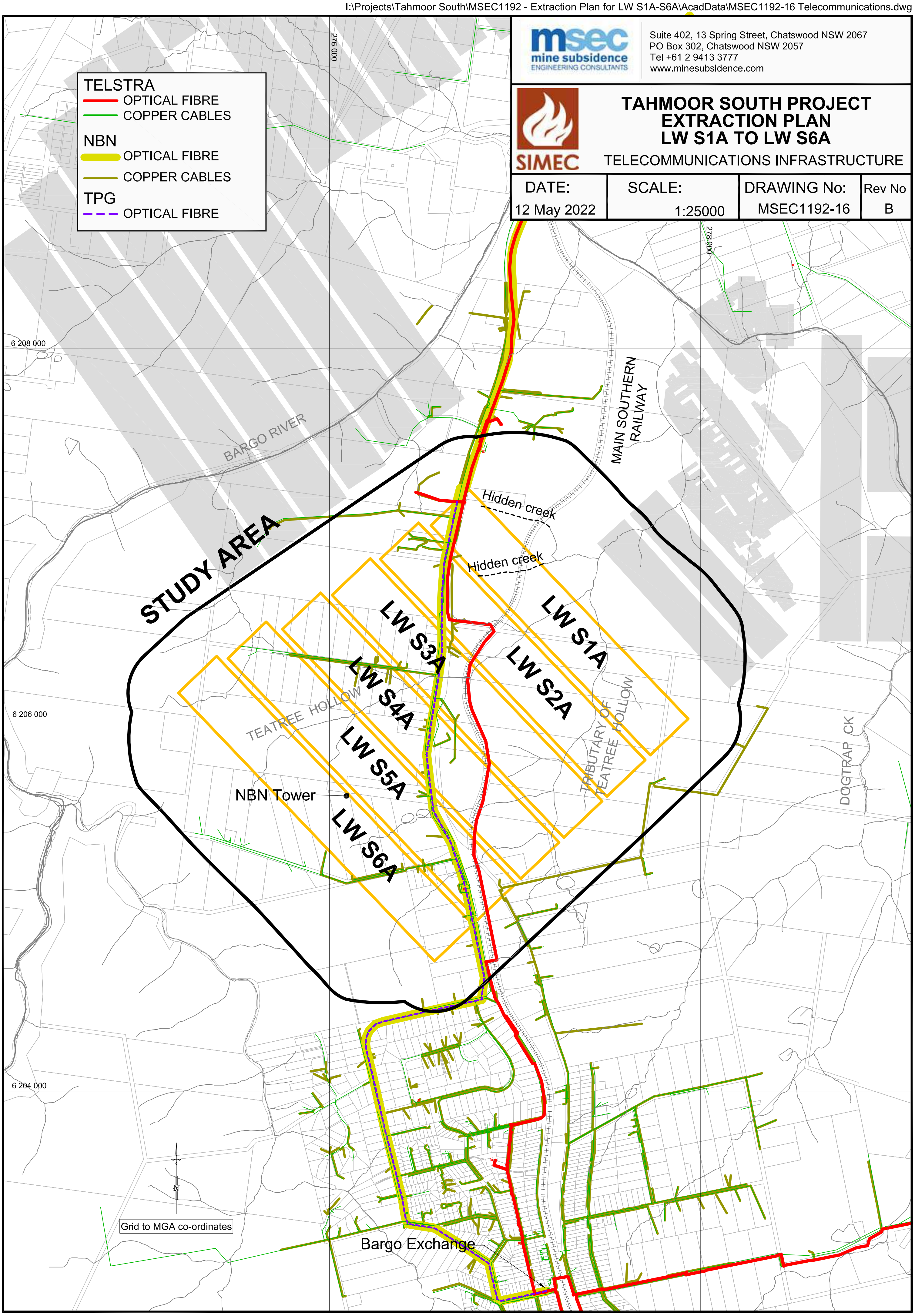

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This information has been retracted

- For more information contact Tahmoor Coal

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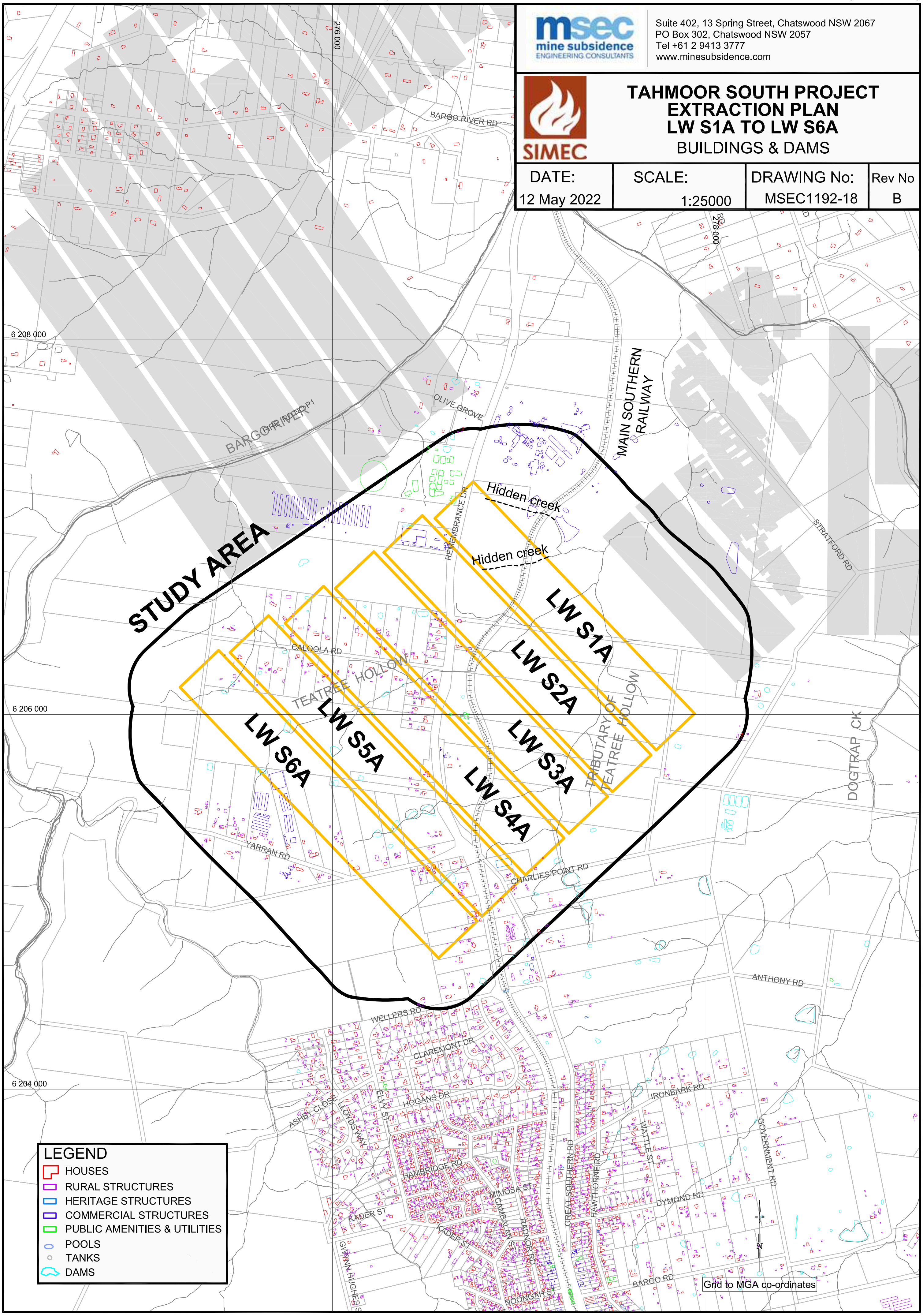

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TAHMOOR SOUTH PROJECT EXTRACTION PLAN LW S1A TO LW S6A

PUBLIC AMENITIES & COMMERCIAL PREMISES

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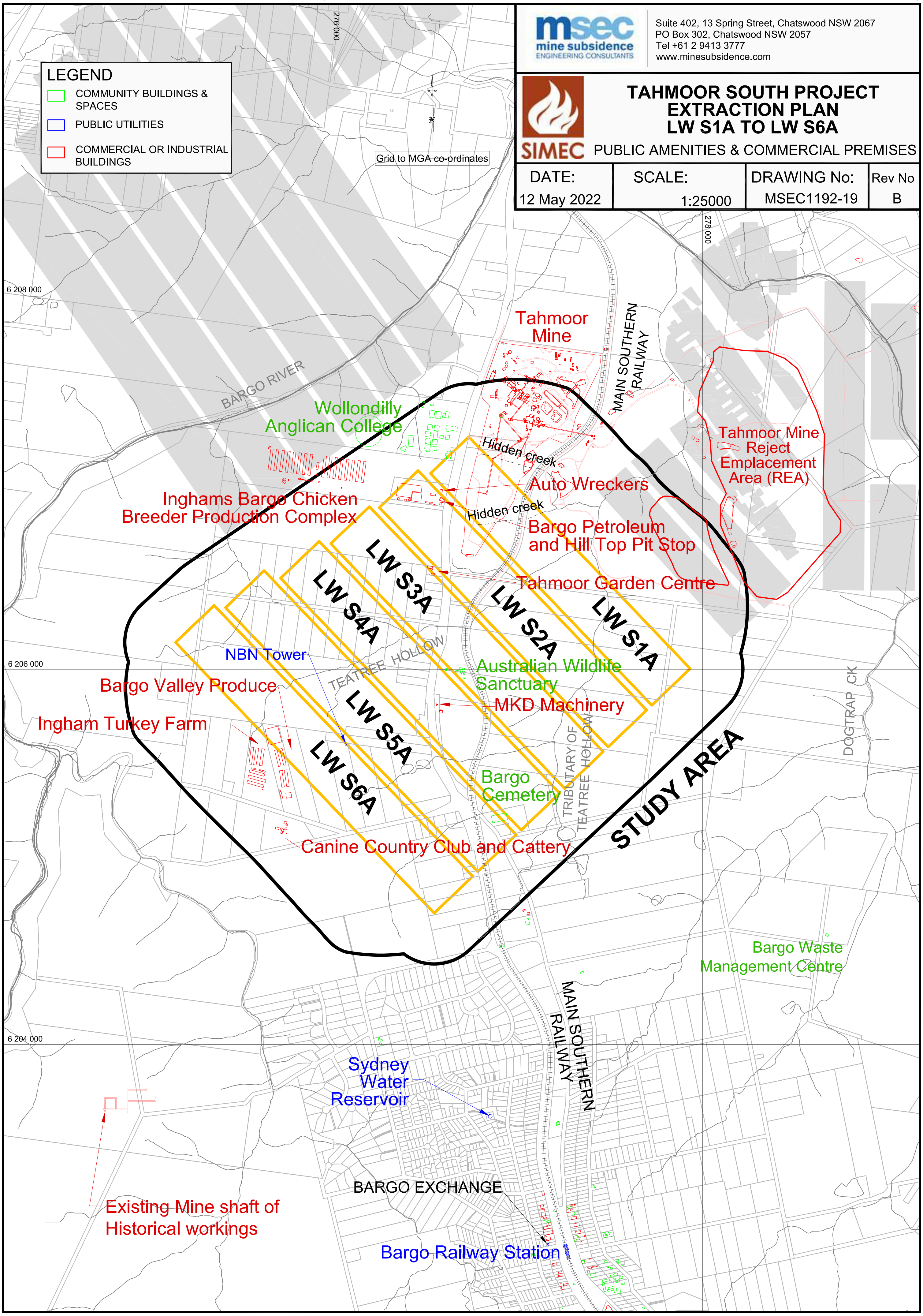

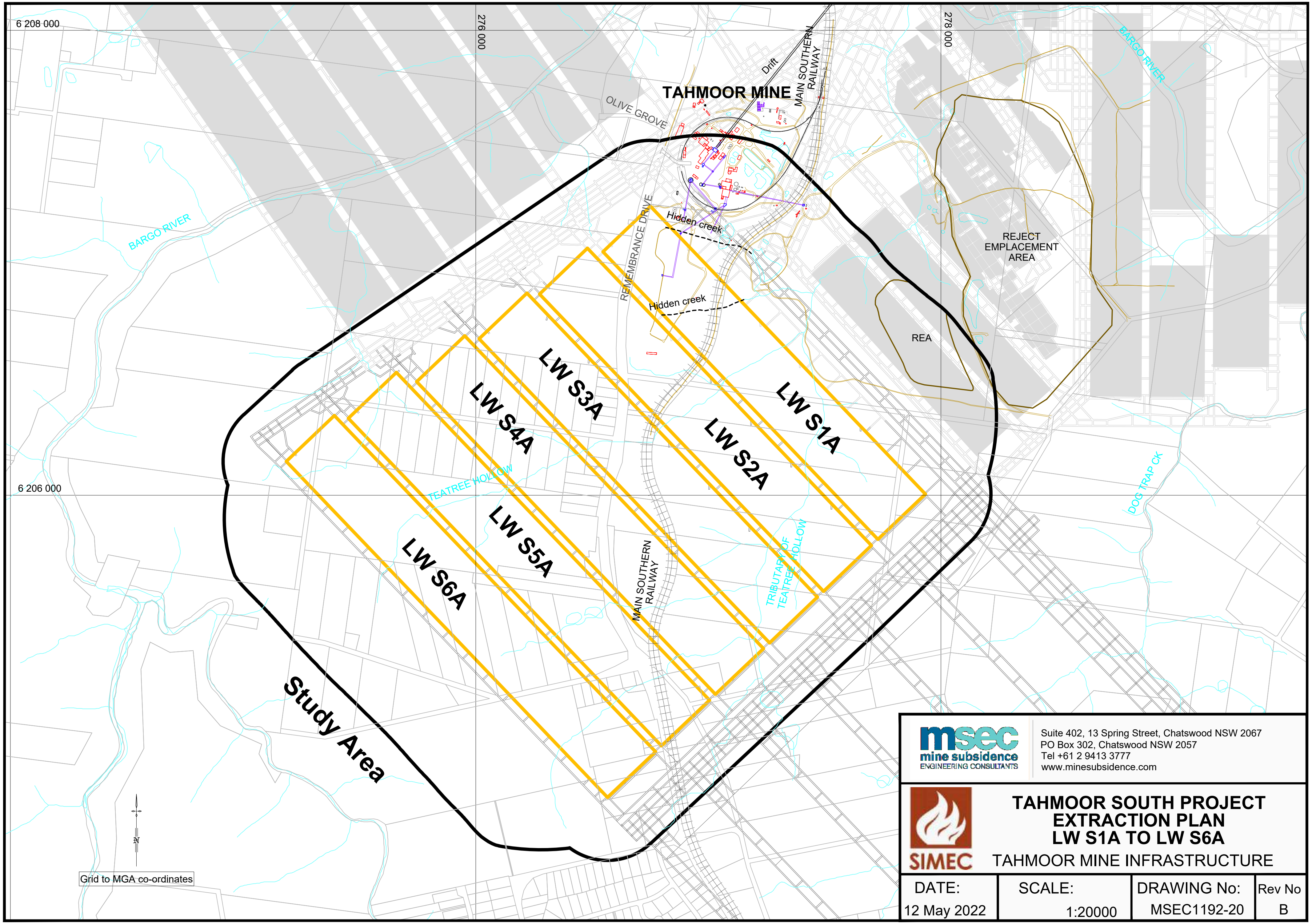

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TAHMOOR MINE INFRASTRUCTURE

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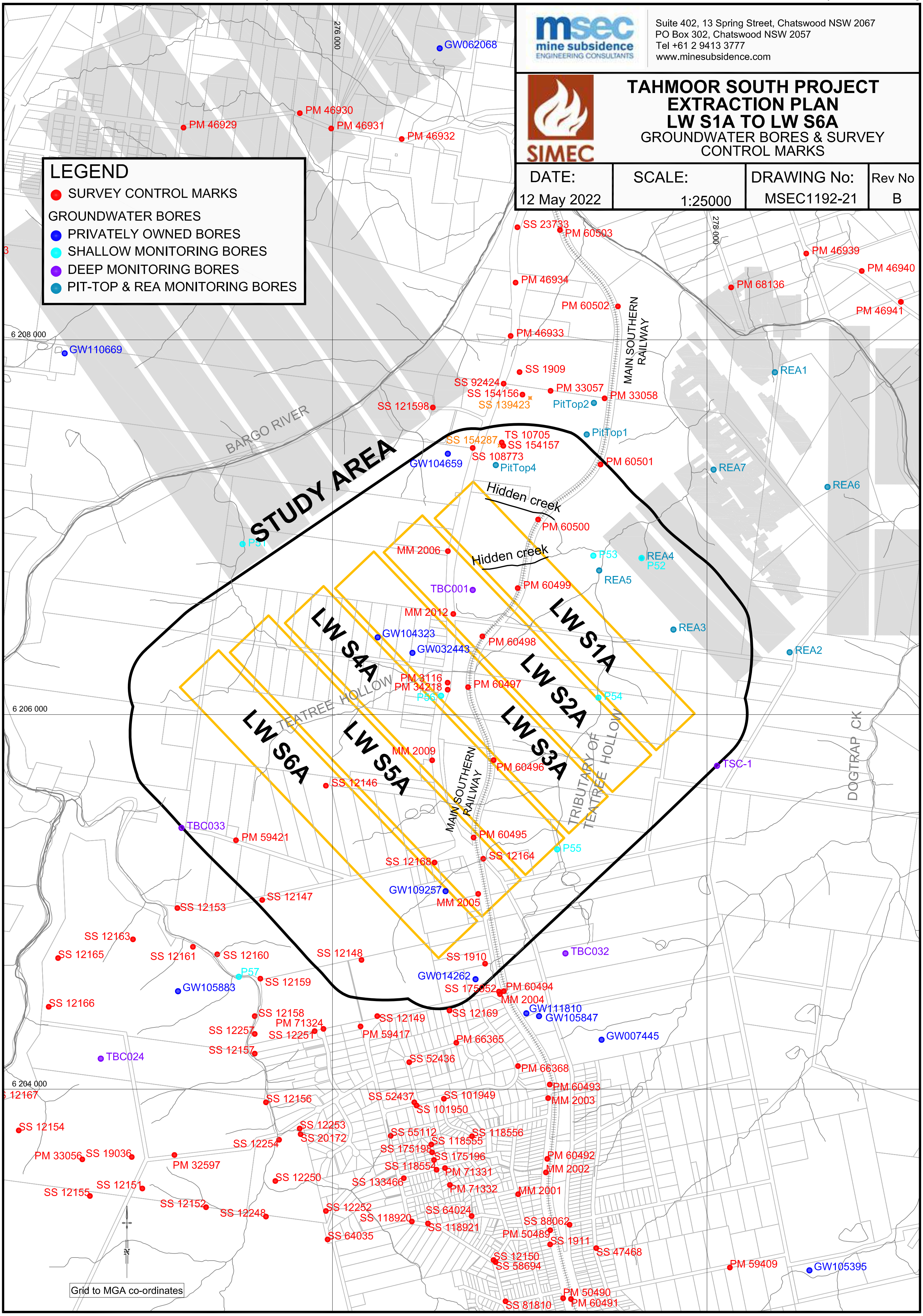

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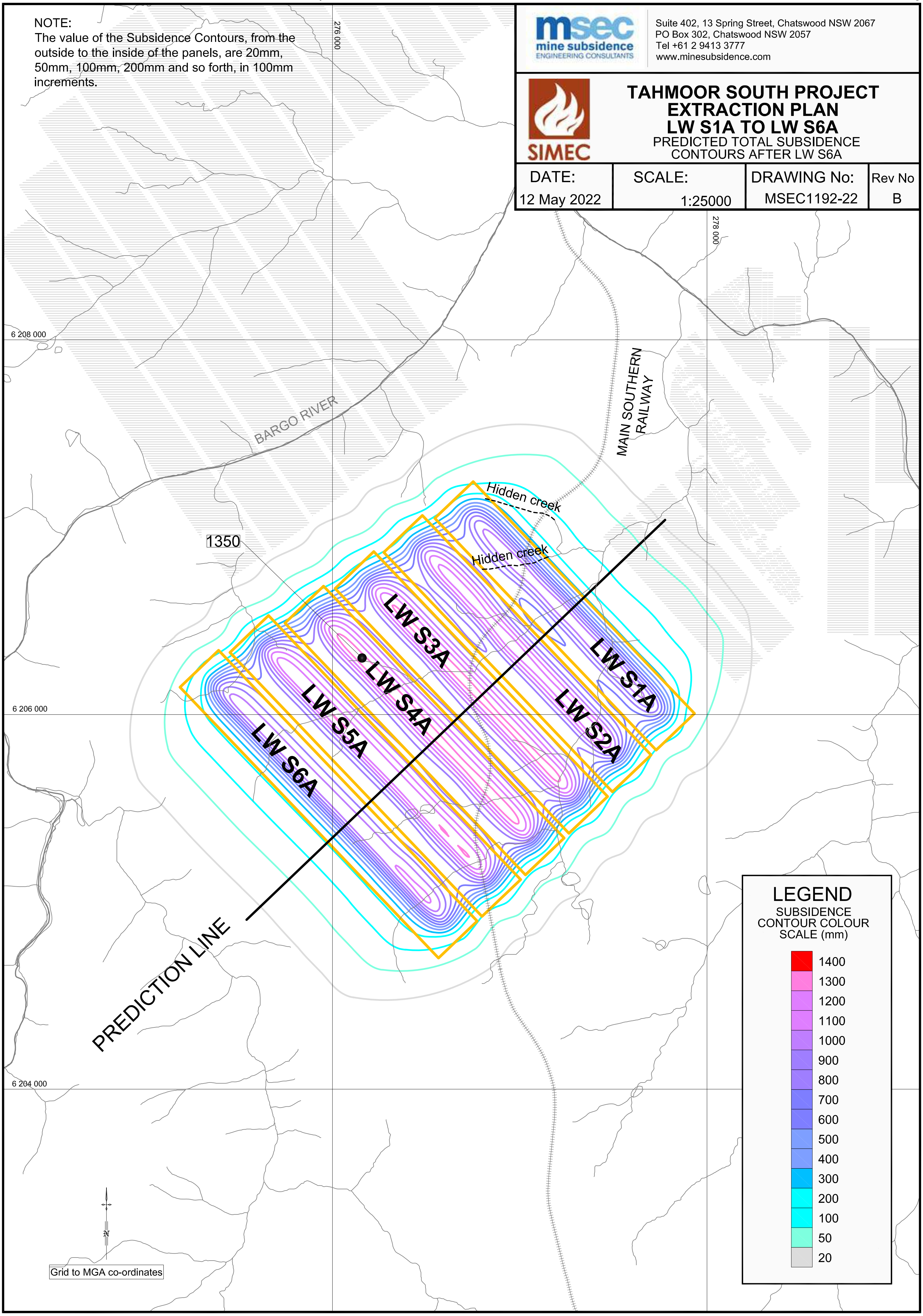

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TAHMOOR SOUTH PROJECT EXTRACTION PLAN LW S1A TO LW S6A

PROPOSED MONITORING

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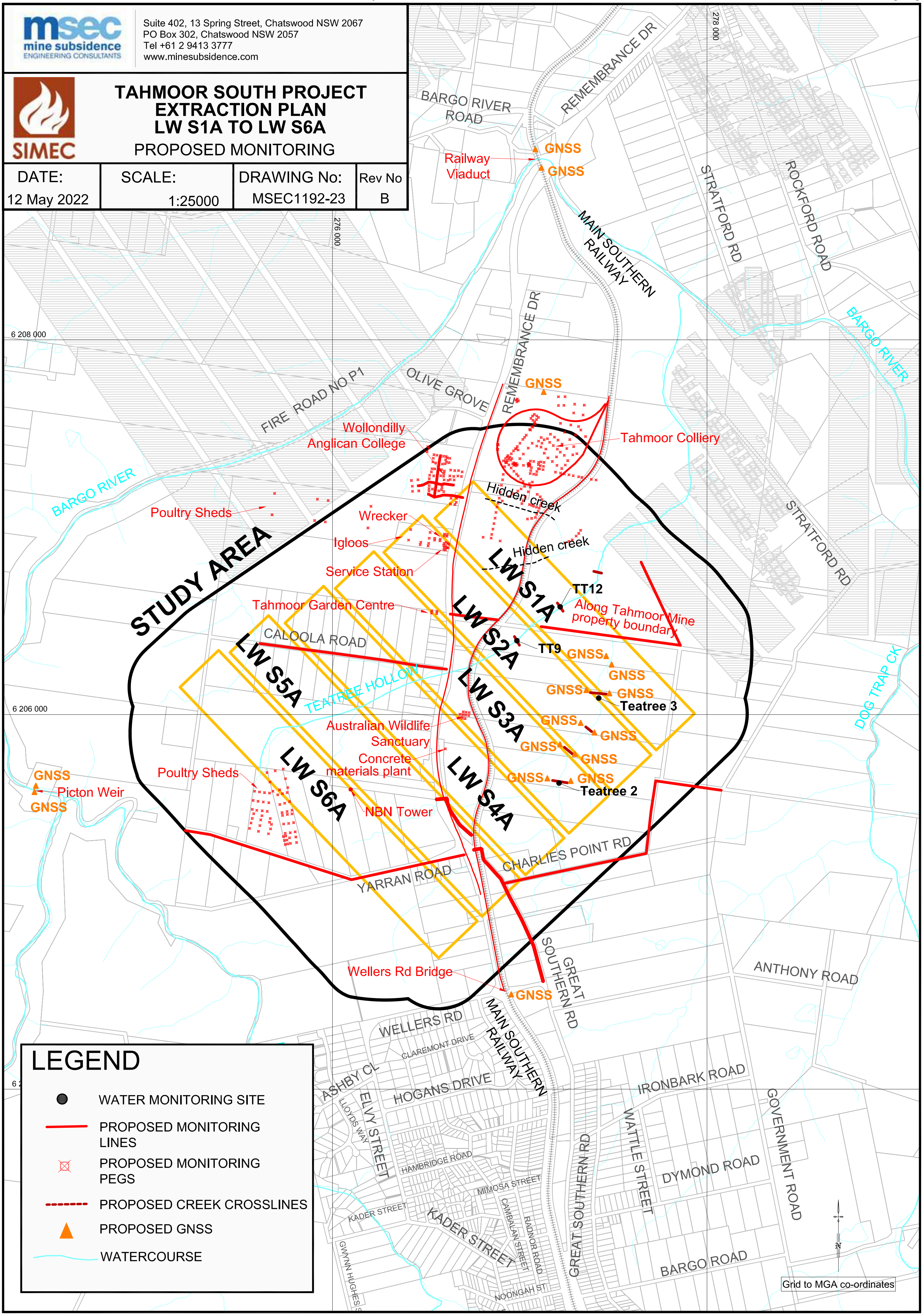
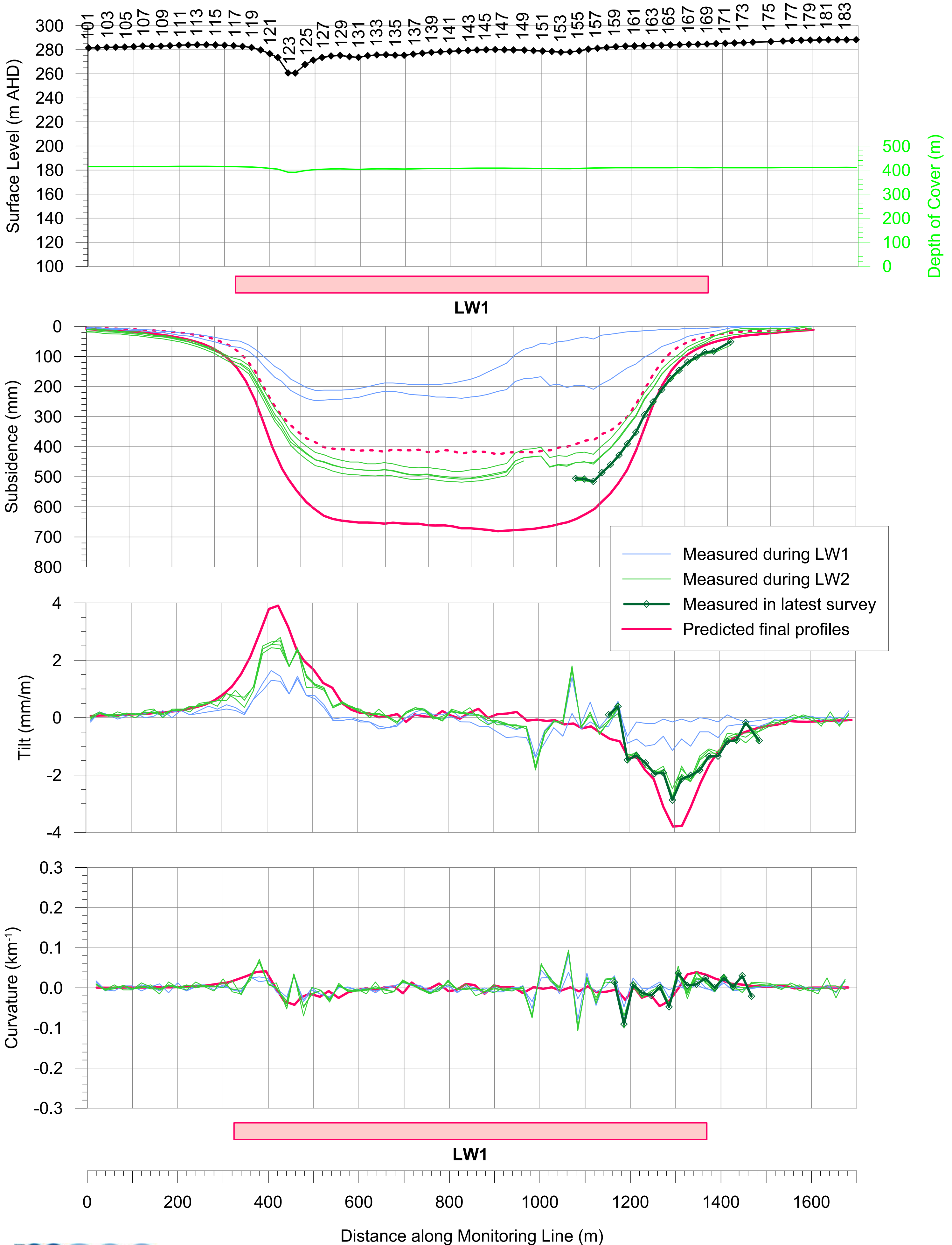


APPENDIX G. FIGURES COMPARING OBSERVED AND PREDICTED SUBSIDENCE PARAMETERS OVER PREVIOUSLY EXTRACTED LONGWALLS AT TAHMOOR MINE

I:\Projects\Tahmoor South\MSEC606 - Tahmoor South EIS\Subsdata\Calibration\Tahmoor South West\Fig. G.01 - 100-Line.grf.....17-Feb-14

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 100-Line due to Tahmoor LW1 and LW2



msec

Fig. G.01

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 200-Line due to Tahmoor LW2

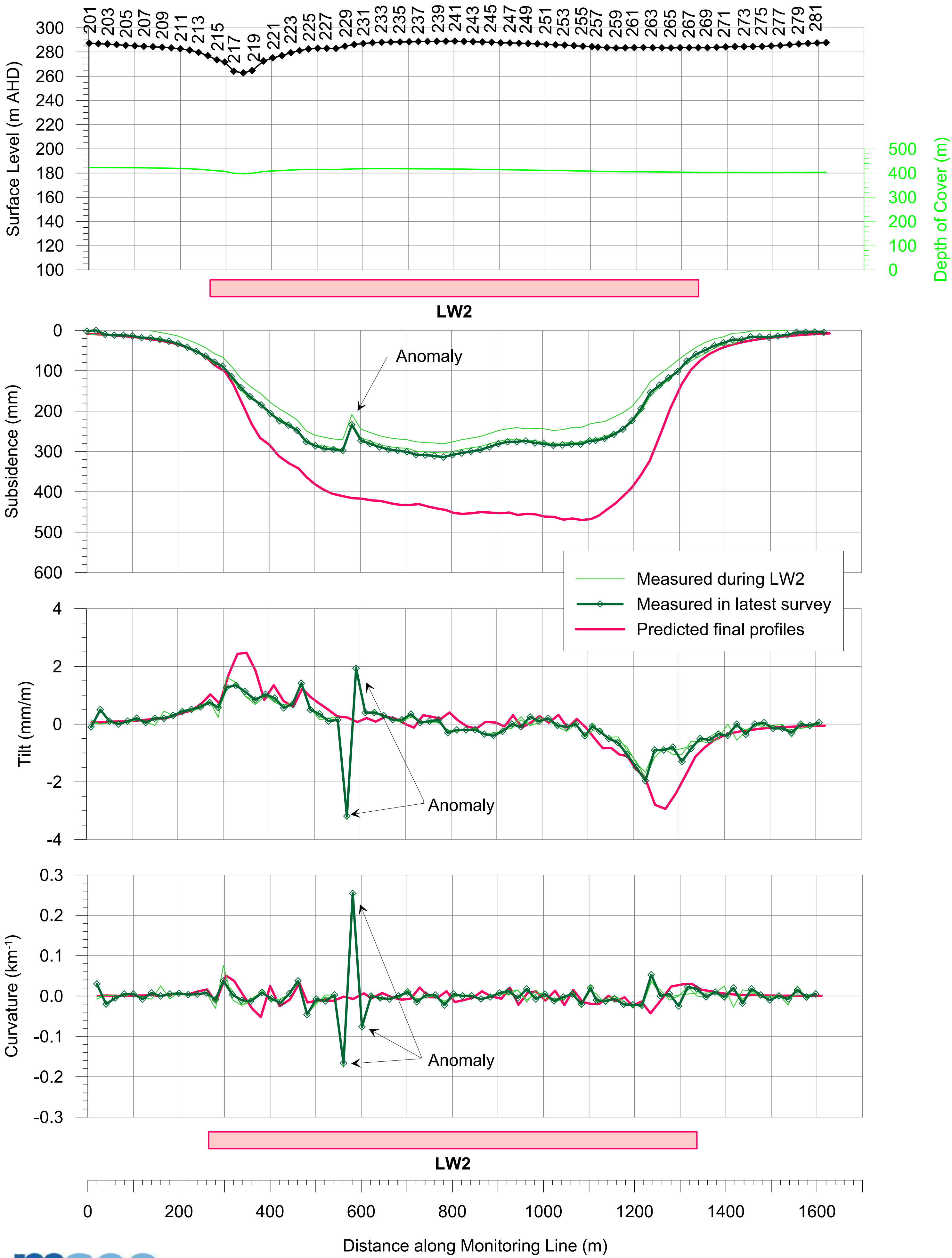
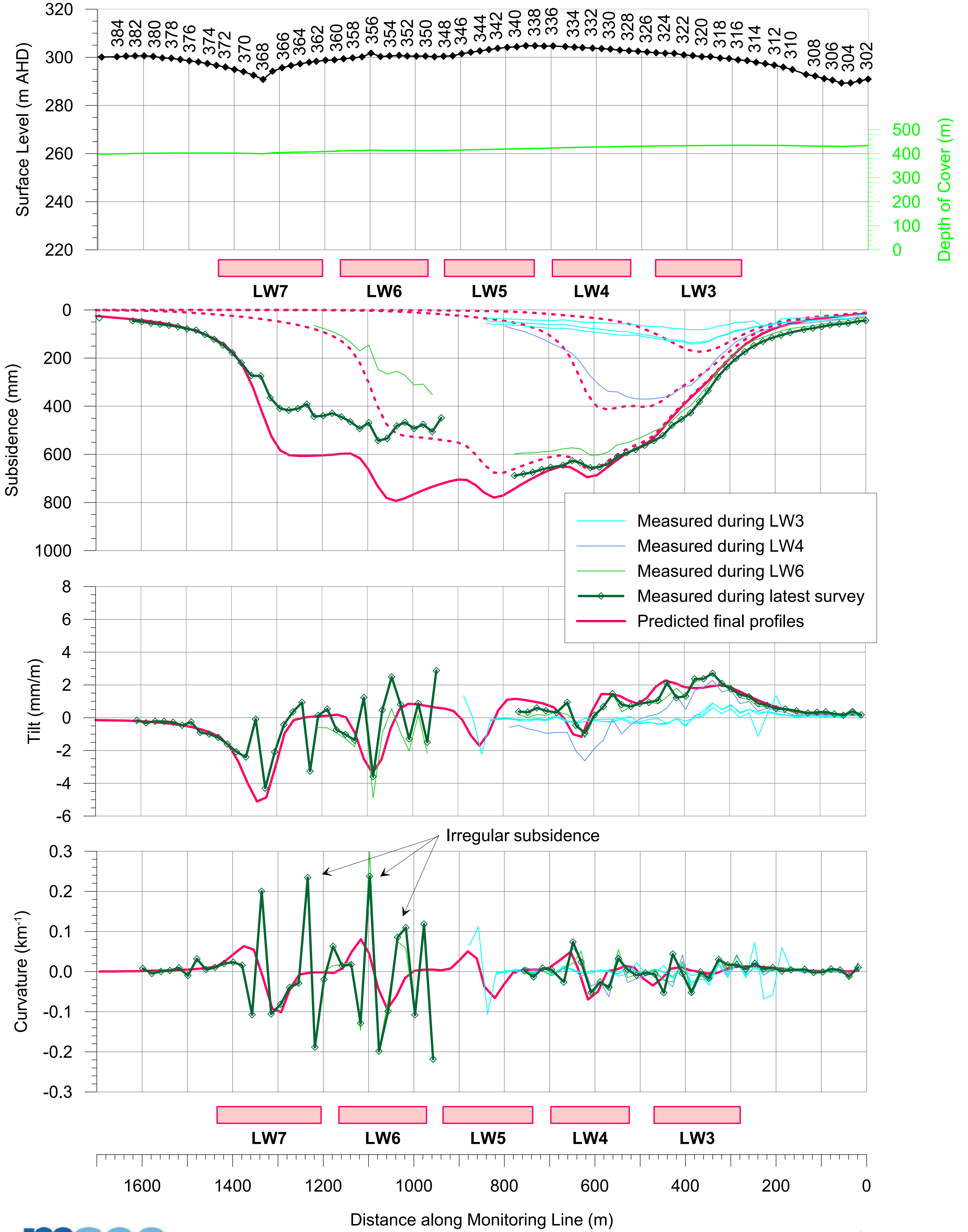


Fig. G.02

I:\Projects\Tahmoor South\MSEC606 - Tahmoor South EIS\Subsdata\Calibration\Tahmoor South West\Fig. G.03 - 300-Line.grf.....17-Feb-14

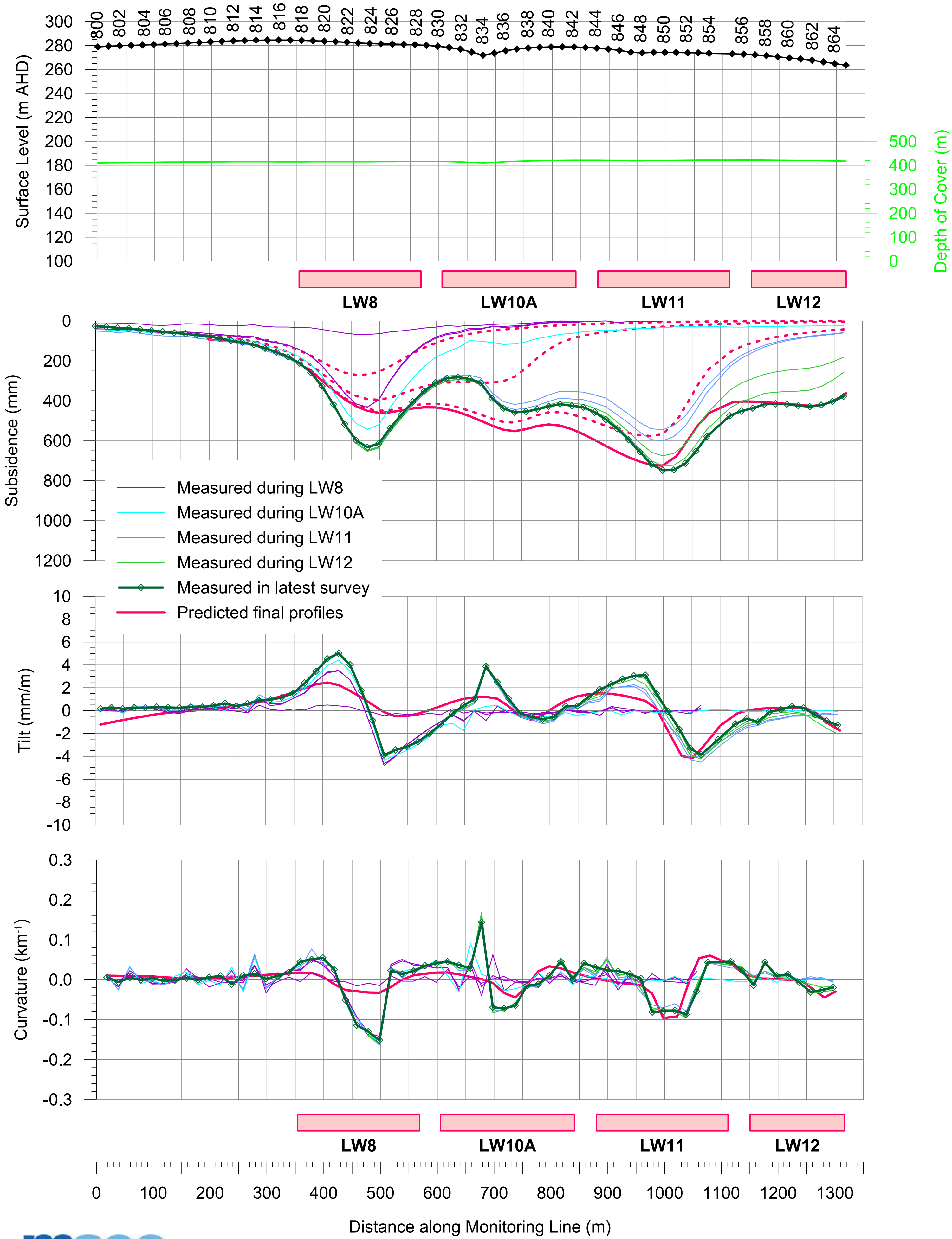
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 300-Line due to Tahmoor LW3 to LW7



msec

Fig. G.03

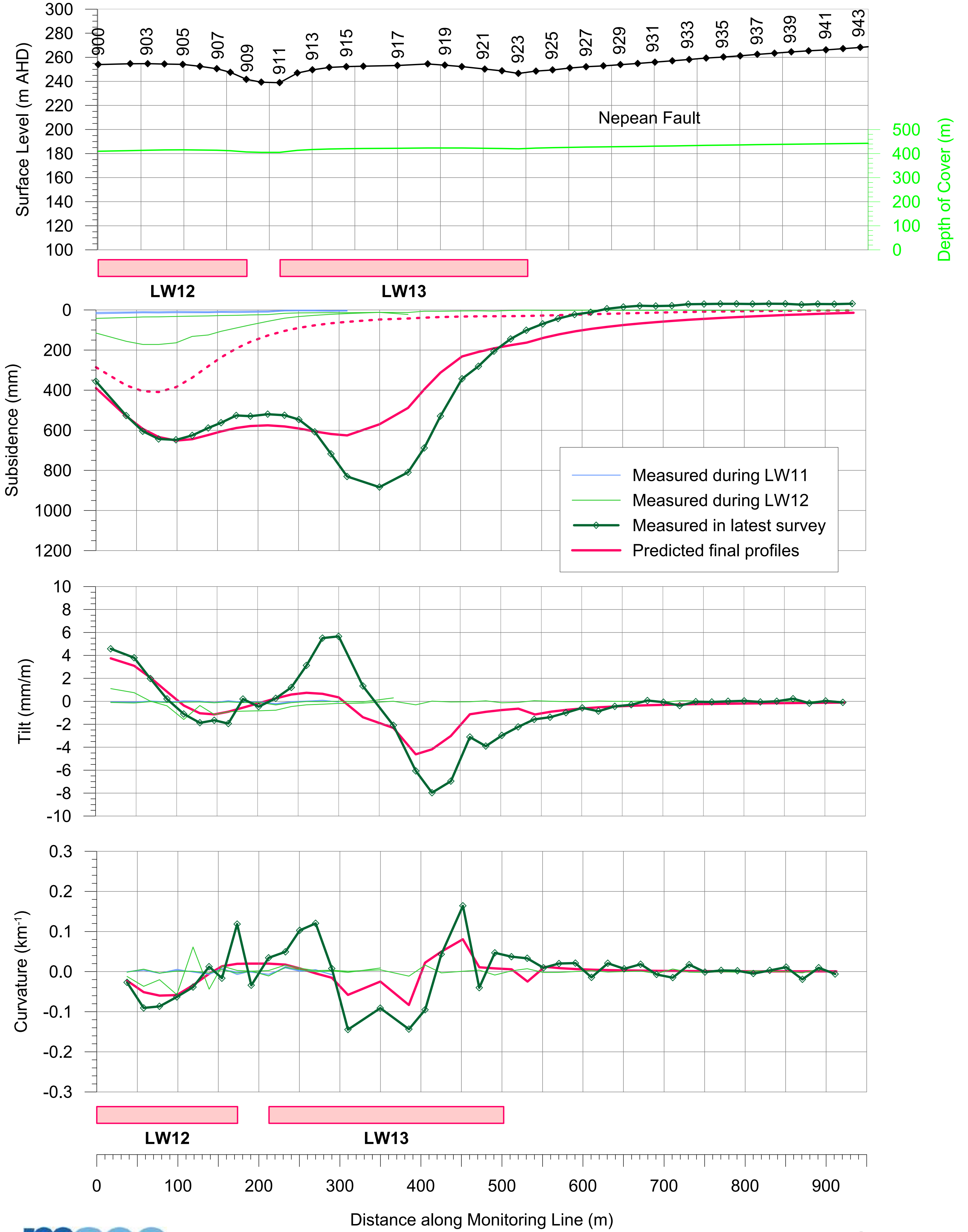
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 800-Line due to Tahmoor LW8 to LW12



msec

Fig. G.04

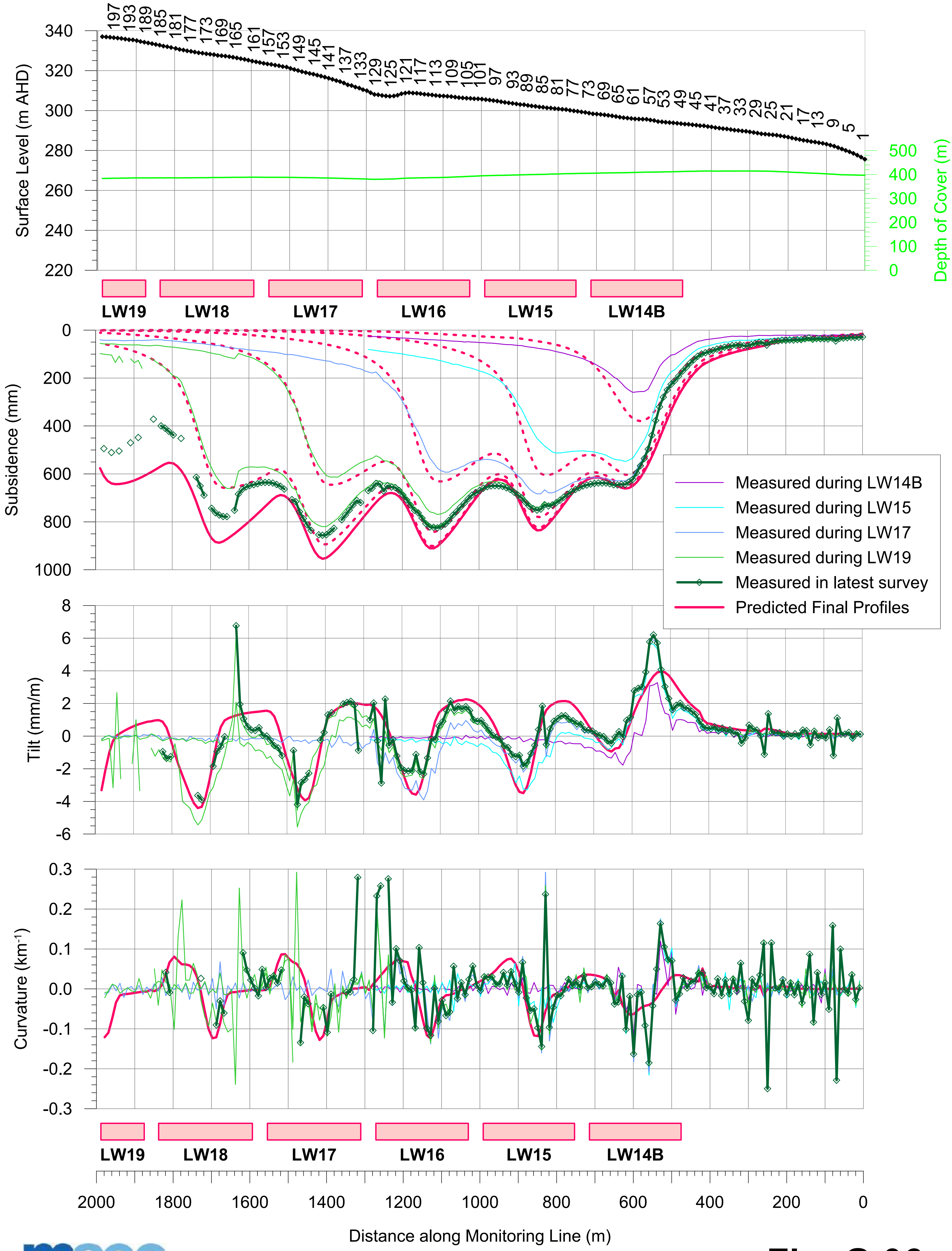
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 900-Line due to Tahmoor LW10A to LW13



msec

Fig. G.05

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the 1000-Line due to Tahmoor LW14B to LW19

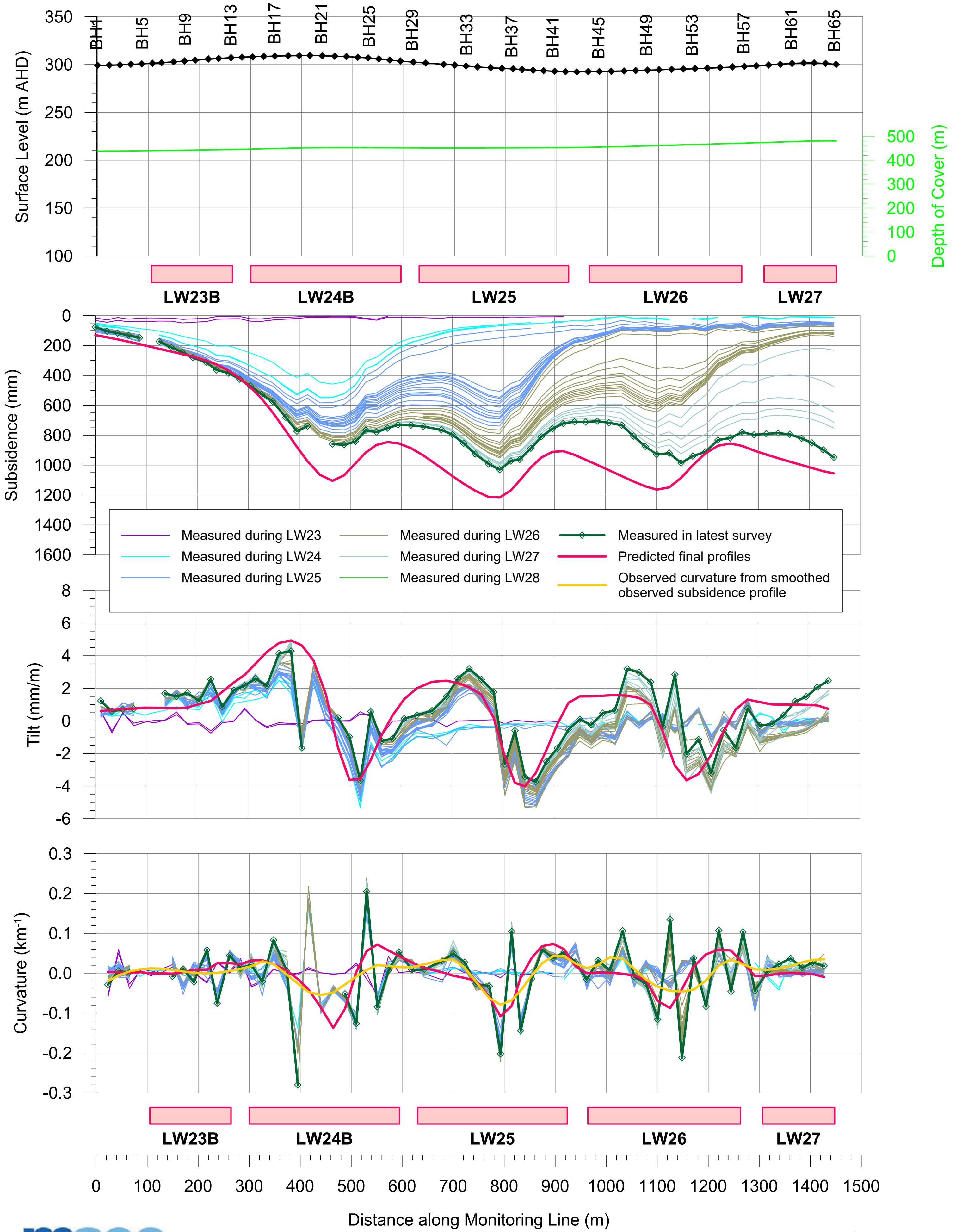


msec

Fig. G.06

I:\Projects\Tahmoor South\MSEC606 - Updated EIS\Subsdata\Calibration\Tahmoor North\Fig. G.07 - Brundah Road.grf.....15-Nov-17

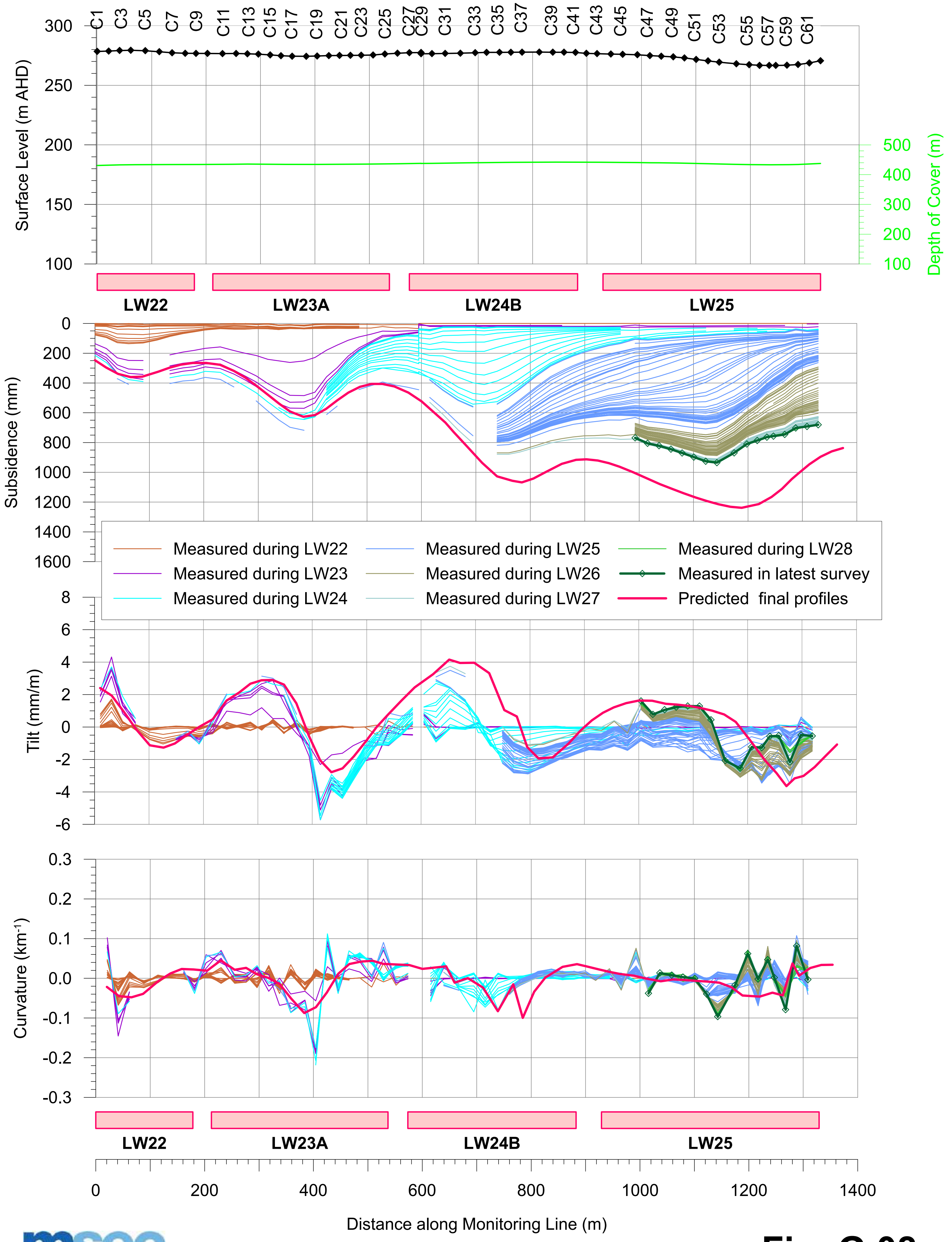
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the Brundah Road Line due to Tahmoor North LW23B to LW28



msec

Fig. G.07

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the Castlereagh Street Line due to Tahmoor North LW22 to LW28

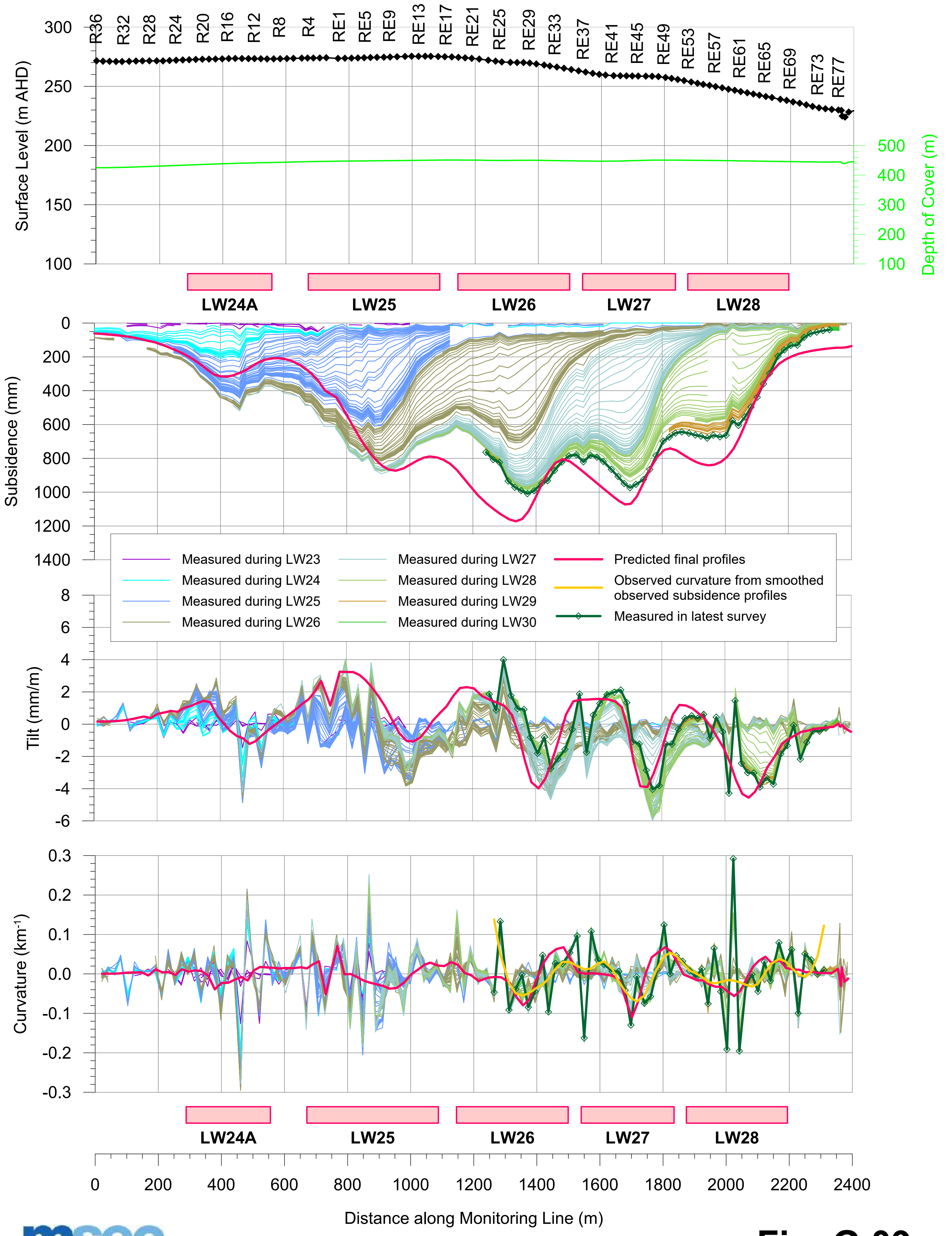


msec

Fig. G.08

I:\Projects\Tahmoor South\MSEC606 - Updated EIS\Subsdata\Calibration\Tahmoor North\Fig. G.09 - Remembrance Drive.grf.....15-Nov-17

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the Remembrance Drive Line due to Tahmoor North LW23A to LW30

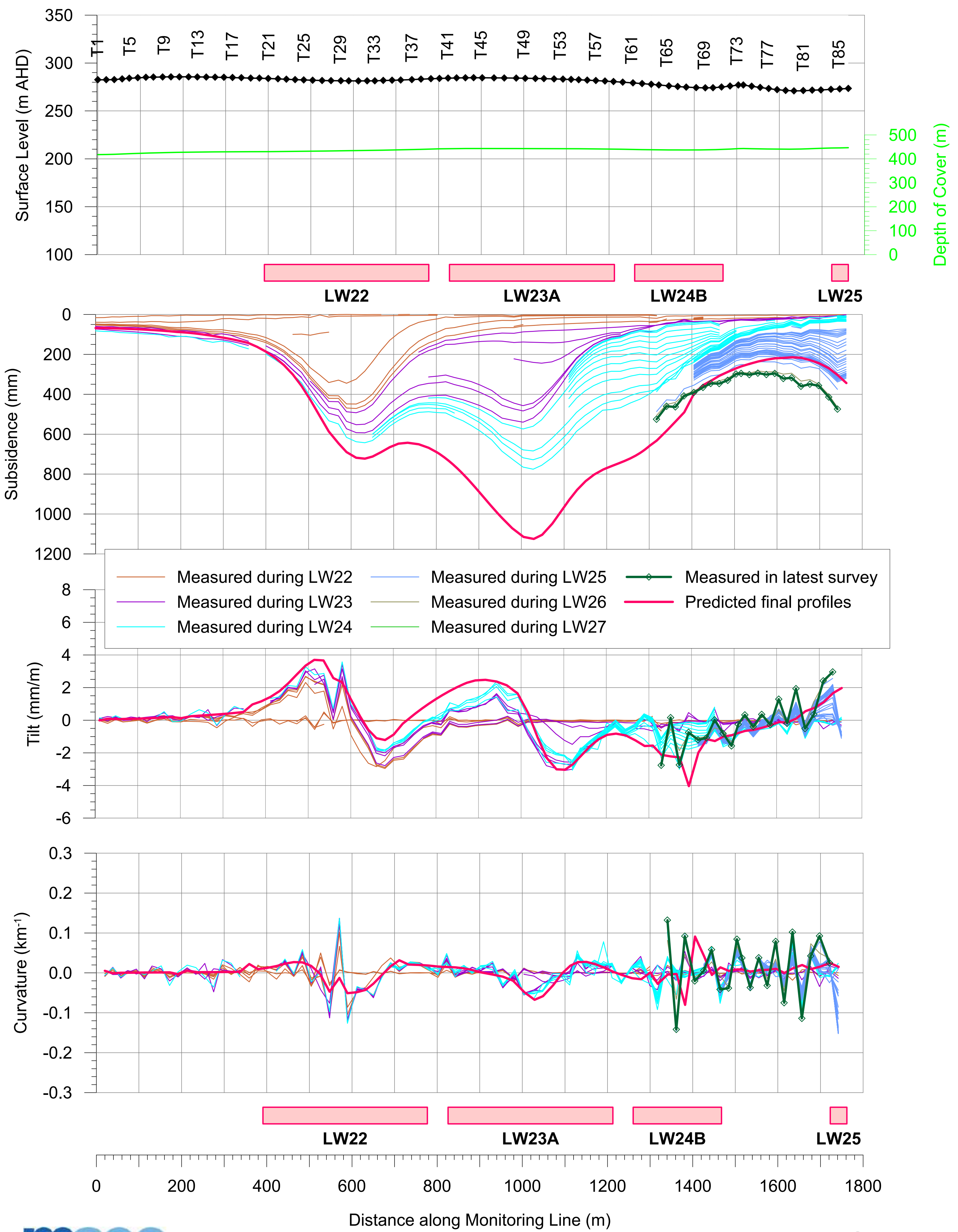


msec

Fig. G.09

I:\Projects\Tahmoor South\MSEC606 - Updated EIS\Subsdata\Calibration\Tahmoor North\Fig. G.10 - Thirlmere Way.grf.....15-Nov-17

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the Thirlmere Way Line due to Tahmoor North LW22 to LW27

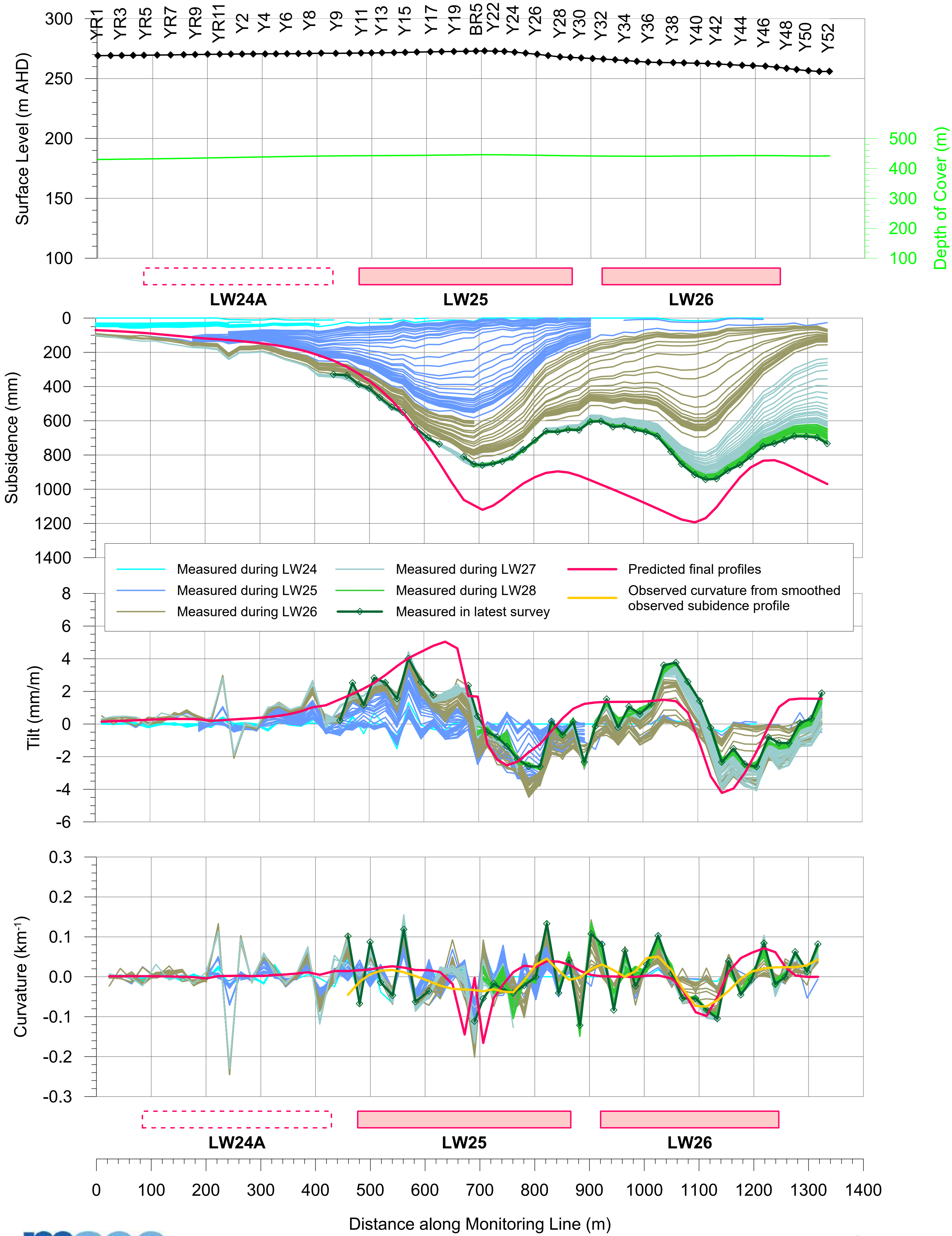


msec

Fig. G.10

I:\Projects\Tahmoor South\MSEC606 - Updated EIS\Subsdata\Calibration\Tahmoor North\Fig. G.11 - York Street.grf.....15-Nov-17

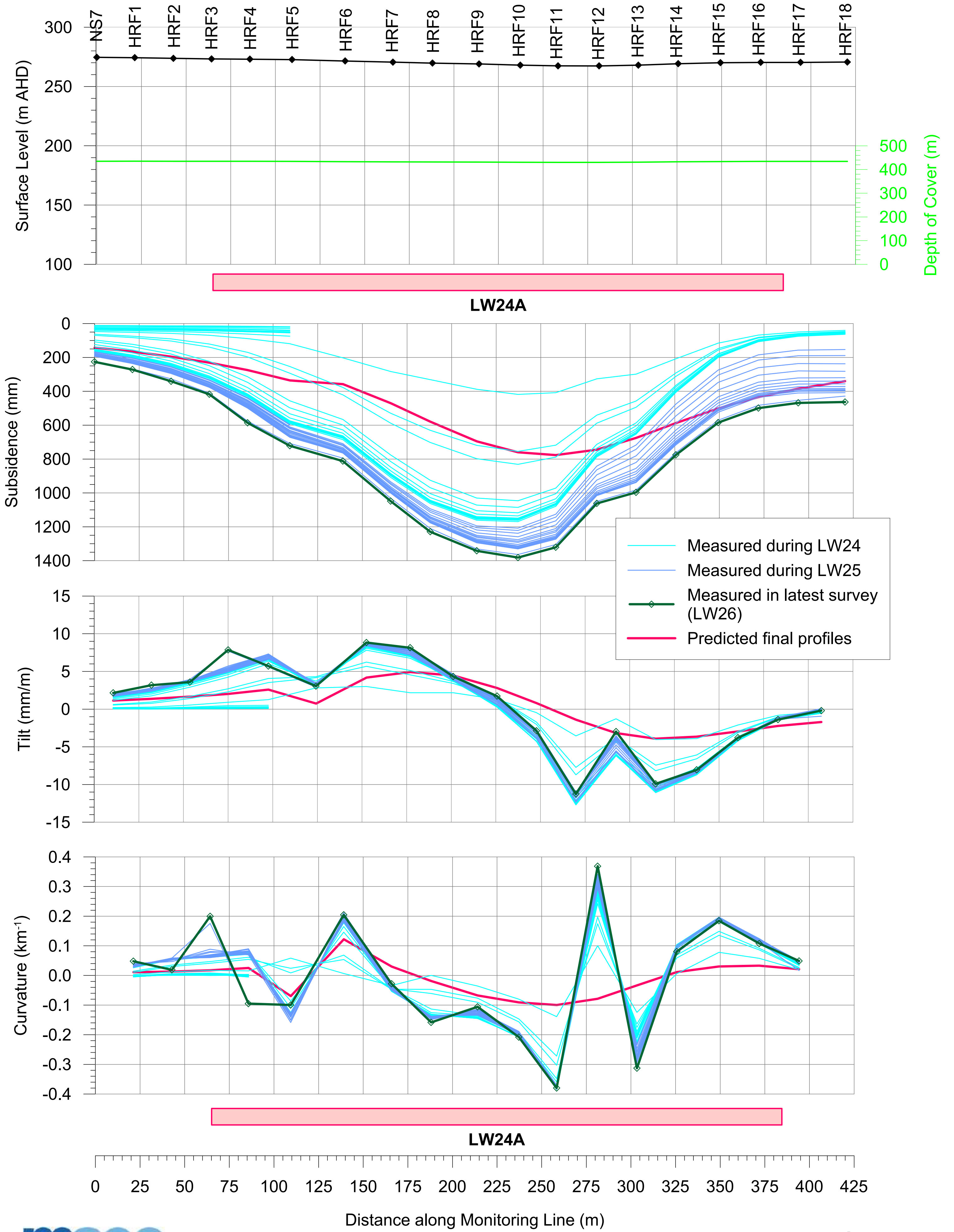
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the York Street Line due to Tahmoor North LW24A to LW28



msec

Fig. G.11

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the HRF Line due to Tahmoor North LW24A and LW25

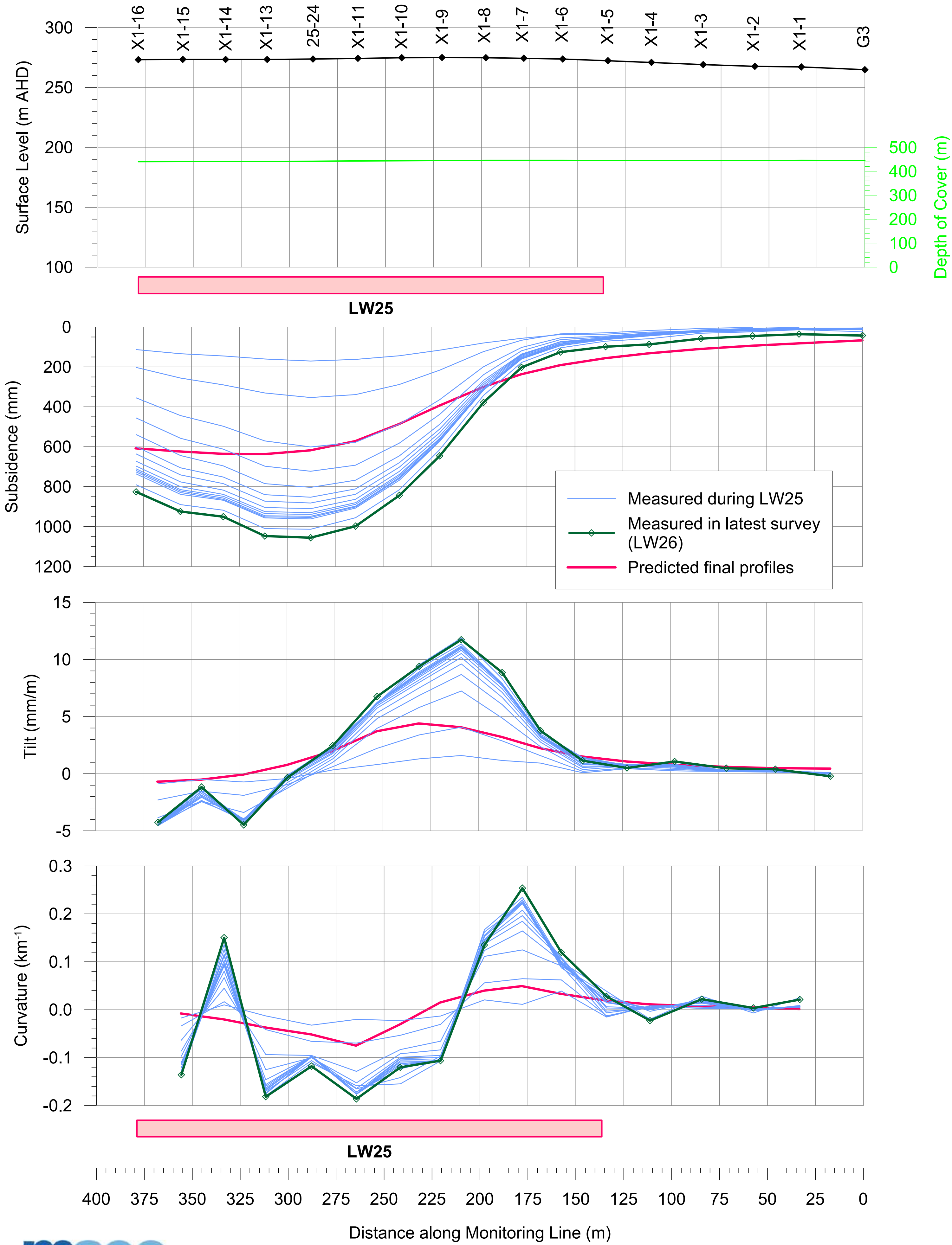


msec

Fig. G.12

I:\Projects\Tahmoor South\MSEC606 - Tahmoor South EIS\Subsdata\Calibration\Tahmoor North\Fig. G.13 - LW25 XS1 Line.grf.....17-Feb-14

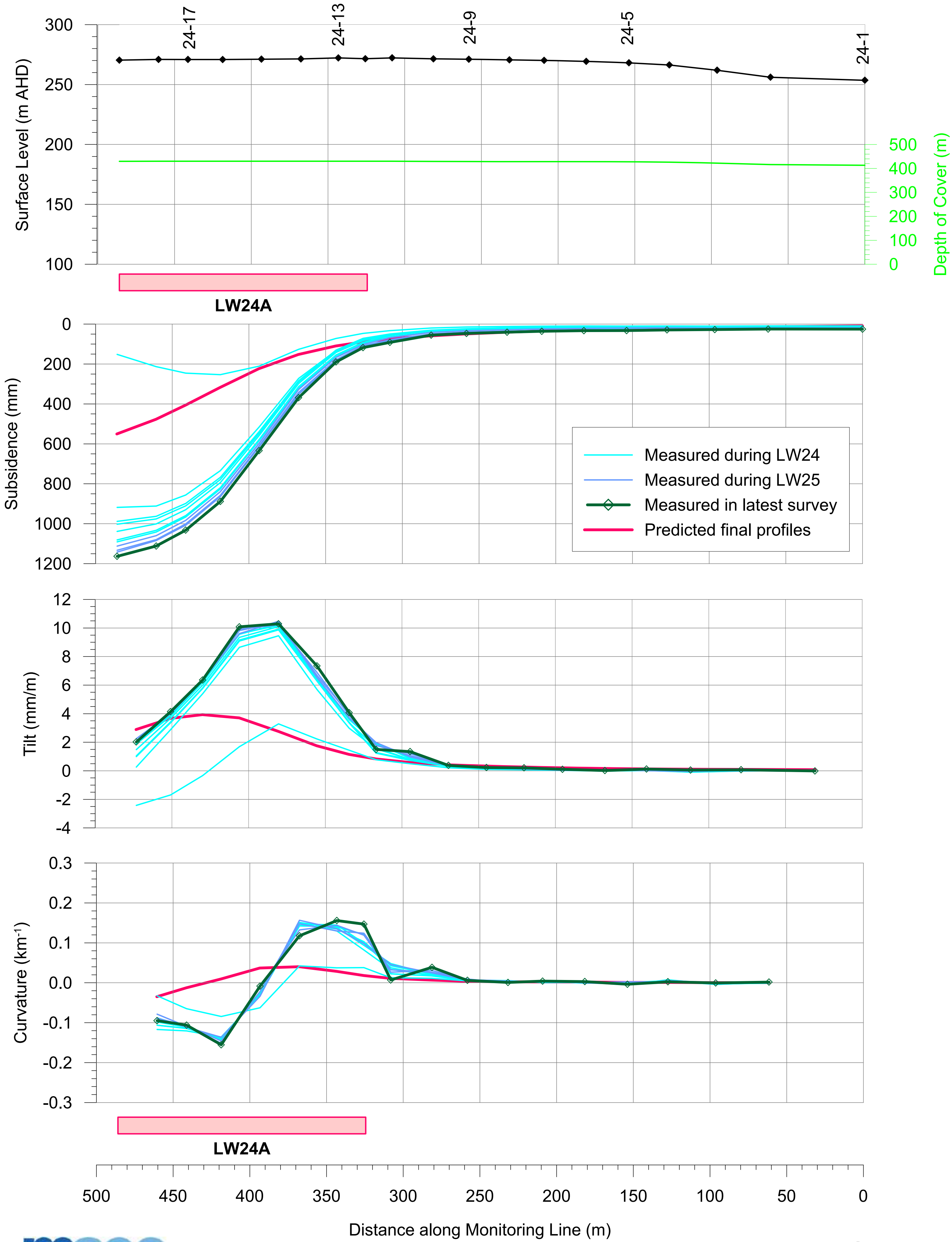
Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW25 XS1 Line due to Tahmoor North LW25



msec

Fig. G.13

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW24A Draw Line due to Tahmoor North LW24A and LW25



msec

Fig. G.14

Observed and Predicted Profiles of Total Subsidence, Tilt and Curvature along the LW25 Centreline due to Tahmoor North LW25

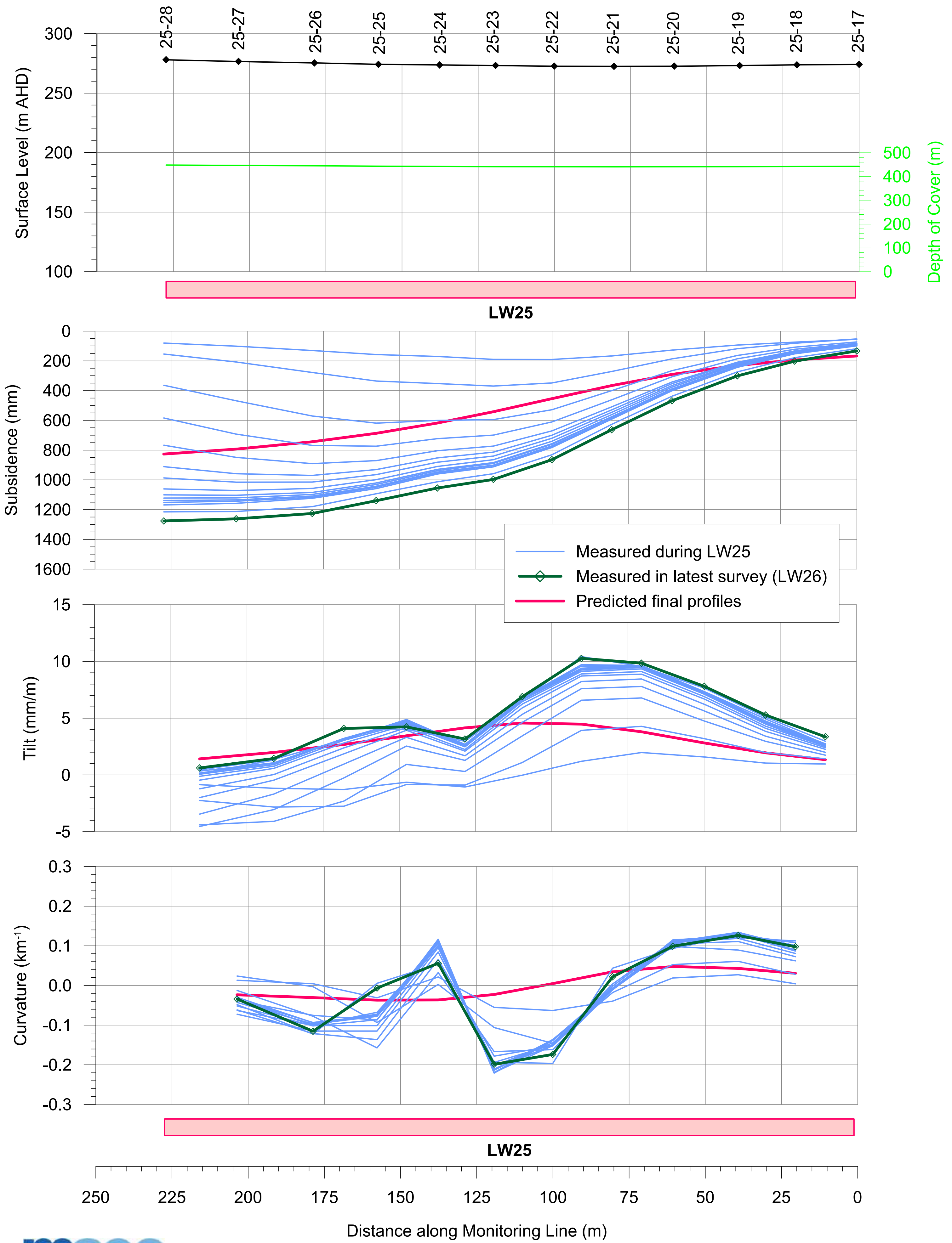


Fig. G.15