APPENDIX 1

EA Statement of Authorship,
Schedule of Lands and
Project Team

STATEMENT OF AUTHORSHIP

EA prepared by	
Name:	Barbara Crossley, Director
Qualifications:	Bachelor of Natural Resources (Honours)
Address:	Umwelt (Australia) Pty Limited 75 York Street Teralba NSW 2284
In respect of:	Proposed modification to the layout of Stage 3 longwalls A7 to A10 as described in the accompanying Environmental Assessment
Applicant Name:	Austar Coal Mine Pty Ltd
Applicant Address:	Middle Road Paxton NSW 2325
Land to be developed:	See Schedule of Lands attached.
Proposed Development:	LWA7-A10 Modification – Stage 3 Area as described in the accompanying Environmental Assessment.
Environmental Assessment	An Environmental Assessment is attached.
Certification	I certify that I have prepared the contents of this environmental assessment and to the best of my knowledge: • it is in accordance with the relevant provisions of the *Environmental Planning and Assessment Act 1979*, and • it is true in all material particulars and does not, by its presentation or omission of information, materially mislead.
Signature:	
Name:	Barbara Crossley
Date:	16 October 2013

Schedule of Lands

LOT	DP	OWNER
117	755215	FREEHOLD
1	852328	FREEHOLD
1	798955	FREEHOLD
1	950221	FREEHOLD
1	1173947	FREEHOLD
2	595102	FREEHOLD
11	1000136	FREEHOLD
521	1003186	FREEHOLD
1	841360	FREEHOLD
4	571638	FREEHOLD
3	575428	FREEHOLD
1	738718	FREEHOLD
10	1000136	FREEHOLD
51	794214	FREEHOLD
3	745656	FREEHOLD
522	1003186	FREEHOLD
2	575428	FREEHOLD
2	747207	FREEHOLD
1	171040	FREEHOLD
1	738726	FREEHOLD
1	170894	FREEHOLD
1	996145	FREEHOLD
10	1093269	FREEHOLD
11	1093269	FREEHOLD
215	1185596	STATE OF NSW
2	1145356	STATE FORESTS OF NSW
1	1145356	AUSTAR COAL MINE PTY LIMITED
4	240664	FREEHOLD
7	240664	FREEHOLD
8	240664	FREEHOLD
973	804896	FREEHOLD
111	859794	FREEHOLD
3	240664	FREEHOLD
54	755254	FREEHOLD
1001	856790	FREEHOLD
101	803246	FREEHOLD
622	1124419	FREEHOLD
621	1124419	FREEHOLD
9	240664	FREEHOLD
10	240664	FREEHOLD
32	755215	FREEHOLD
52	599170	FREEHOLD
51	599170	FREEHOLD
1	240664	FREEHOLD
2	240664	FREEHOLD
140	755215	STATE FORESTS OF NSW

Project Team

Umwelt (Australia) Pty Limited – EA Preparation

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Mine Subsidence Engineering Consultants	Subsidence Assessment

Austar Coal Mine Pty Ltd

The assistance of the following Austar and Yancoal personnel during the preparation of this EA is gratefully acknowledged. In addition, personnel from Austar provided details regarding the project and participated in the consultation process.

Mark Jacobs (Yancoal)	General Manager, Environment, Approvals and Community Relations
Michael Moore (Yancoal)	Manager, Planning and Approvals
Gary Mulhearn (Austar)	Environment and Community Manager
Adrian Moodie (Austar)	Technical Services Manager

APPENDIX 2

Confirmation of Environmental Assessment Requirements

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Mr Mark Jacobs
General Manager Environment
Yancoal Australia Group
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CESSNOCK NSW 2325

Dear Mr Jacobs

Austar Coal Project Stage 3
Longwalls A7 - A10

I refer to our recent meeting, and your letter dated 1 October 2013, regarding the forthcoming Section 75W modification application to allow changes to the extents of LW A7-A10 at the Austar Coal Mine.

The Department has reviewed the information you provided, and I wish to confirm that it will not be issuing Director-General's Requirements for the modification.

I have noted the proposed approach to the assessment of impacts, and consider that this approach is acceptable, given the nature of the modification and the level of study previously undertaken in the Stage 3 area.

Yours sincerely

DKitto 10/10/13

David Kitto
Director
Mining & Industry
As nominee of the Director-General

APPENDIX 3

Subsidence Predictions and
Impact Assessment

REPORT: SUBSIDENCE PREDICTIONS AND IMPACT ASSESSMENTS

AUSTAR COAL MINE:

Stage 3 – Longwalls A7 to A10

The Effects of the Proposed Modified Commencing End of LWA8 and Modified Finishing Ends of LWA7 to LWA10 in Stage 3 at Austar Coal Mine on the Subsidence Predictions and Impact Assessments

DOCUMENT REGISTER

Revision	Description	Author	Checker	Date
01	Draft Issue	JB	-	2nd Oct 13
A	Final Issue	PD	JB	15th Oct 13

Report produced for:- Support the Application for the Proposed Modification to the Commencing End of LWA8 and the Modifications to the Finishing Ends of LWA7 to LWA10 which will be issued to the Department of Trade and Investment, Regional Infrastructure and Services (DTIRIS).

Previous reports:-

MSEC309 (Revision D) – The Prediction of Subsidence Parameters and the Assessment of Mine Subsidence Impacts on Natural Features and Surface Infrastructure Resulting from the Extraction of Proposed Austar Longwalls A6 to A17 in Support of a Part 3A Application (September 2008).

MSEC484 (Revision A) – Stage 3 Longwalls A7 to A19 – Subsidence Predictions and Impact Assessments for Natural Features and Surface Infrastructure in Support of a Modification to the Development Consent (May 2011).

MSEC512 (Revision A) – Stage 2 Longwall A4 End of Panel Subsidence Monitoring Review Report (September 2011).

MSEC565 (Revision A) – Stage 2 Longwall A5 End of Panel Subsidence Monitoring Review Report (July 2012).

MSEC631 (Revision A) – Stage 2 Longwall A5a End of Panel Subsidence Monitoring Review Report (June 2013).

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

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

CONTENTS

LIST OF TABLES, FIGURES AND DRAWINGS

Tables

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

Figures

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 B at the end of this report.

Drawing No.	*Description*	*Revision*
MSEC650-01	General Layout	A
MSEC650-02	Depth of Cover Contours	A
MSEC650-03	Seam Thickness Contours	A
MSEC650-04	Natural Features	A
MSEC650-05	Built Features	A
MSEC650-06	Predicted Total Subsidence due to LWA7 to LWA10	A
MSEC650-07	Predicted Total Subsidence due to LWA7 to LWA19	A

1.0 INTRODUCTION

1.1. Background

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by Austar Coal Mine (Austar) to undertake subsidence predictions and impact assessments for the proposed longwalls in Stage 3 at Austar Coal Mine (the Mine). Report No. MSEC309 (Revision D) was issued on the 18th September 2008 in support of the Part 3A Application for these longwalls. The Department of Planning (DoP), now known as Department of Planning and Infrastructure (DP&I), granted Austar approval for mining in Stage 3 in September 2009 (DA 08_0111).

Austar proposed a modification to the layout of the longwalls in Stage 3 at the Mine. Report No. MSEC484 (Revision A) was issued on the 13th May 2011 in support of the Modification of the Development Consent. The then DoP granted Austar approval for the modification of the Stage 3 longwalls in March 2012.

Austar then proposed to shorten the commencing (i.e. north-eastern) end of LWA7 by 70 metres by varying the approved first workings. A letter was issued by Austar to the DP&I on the 21st Feruary 2013 in support of this variation to first workings. Austar received approval for the modified commencing end of LWA7 on the 21st February 2013. The extraction of Longwall A7 commenced on the 14th June 2013 and, at the time of this report, this longwall had extracted around 540 metres.

Austar now proposes to shorten the commencing (i.e. north-eastern) end of LWA8 and to lengthen the finishing (i.e. south-western) ends of LWA7 to LWA10. The layout of these longwalls, based on both the currently approved and the proposed modified layouts, are shown in Drawing No. MSEC650-01, in Appendix B.

MSEC has been commissioned by Austar to report on the effects of the proposed modifications to LWA7 to LWA10 on the subsidence predictions and impact assessments previously provided in Report No. MSEC484. This report will support the Modification Application to be issued by Austar to the DTRIS and the DoP.

1.2. Mining Geometry

The currently approved layout of LWA7 to LWA10 is referred to as the *Approved Layout* in this report. The *Approved Layout* is similar to the layout adopted in Report No. MSEC484, but without the shortened commencing end of LWA7, which was approved following preparation of the MSEC484 report.. The proposed modified layout of LWA7 to LWA10 is referred to as the *Modified Layout* in this report.

The layouts of the LWA7 to LWA10, based on both the *Approved* and *Modified Layouts*, are shown in Drawing No. MSEC650-01, in Appendix B. The proposed modifications comprise the following:-

- Commencing (i.e. north-eastern) end of LWA8 shortened by 184 metres,
- Finishing (i.e. south-western) end of LWA7 lengthened by 98 metres,
- Finishing end of LWA8 lengthened by 296 metres,
- Finishing end of LWA9 lengthened by 200 metres, and
- Finishing end of LWA10 lengthened by 168 metres.

A summary of the dimensions of these longwalls for both these layouts is provided in Table 1.1.

Table 1.1 Dimensions of the LWA7 to LWA10 Based on the Approved and Modified Layouts

Layout	Longwall	Overall Void Length Including Installation Heading (m)	Overall Void Width Including First Workings (m)	Overall Tailgate Chain Pillar Width (m)
Approved Layout	LWA7	931*	237	-
	LWA8	1,305	237	55
	LWA9	1,634	237	55
	LWA10	1,973	237	55
Modified Layout	LWA7	1,032	237	-
	LWA8	1,417	237	55
	LWA9	1,834	237	55
	LWA10	2,141	237	55

Note: * denotes that length of LWA7 based on the *Approved Layout* includes the previously approved shortened commencing end of this longwall.

The longwalls will be extracted from the Greta Seam using Longwall Top Coal Caving (LTCC) methods. The depths of cover contours and seam thickness contours are shown in Drawing Nos. MSEC650-02 and MSEC650-03, respectively, in Appendix B.

The depths of cover directly above LWA7 to LWA10 varies between a minimum of 455 metres, above the tailgate of LWA7, and a maximum of 575 metres, above the maingate of LWA10. The seam floor within the extents of these longwalls dips from the north to the south with an average gradient of around 6 %.

The seam thickness within the extents of LWA7 to LWA10 varies between 6.0 metres and 7.0 metres. The LTCC equipment will be used to fully extract the bottom 3 metres of the seam and recover approximately 85 % of the remaining top coal.

2.1. Calibration of the Subsidence Prediction Model

The Incremental Profile Method was initially used to predict the conventional subsidence parameters resulting from the extraction of the LWA3 to LWA5a in Stage 2 at the Mine. The model was calibrated for the local conditions using the ground monitoring data from Ellalong Colliery, which was described in Section 3.7 of Report No. MSEC484. Ground monitoring data was subsequently gathered from LWA1 and LWA2 in Stage 1 at the Mine, which was also used to further validate the prediction model.

The comparisons between observed and predicted subsidence parameters for LWA3 to LWA5a were provided in the End of Panel Subsidence Monitoring Review Reports MSEC512 (after LWA4), MSEC565 (after LWA5) and MSEC631 (after LWA5a). The profiles of observed and predicted subsidence are illustrated for the monitoring lines in Stage 2 in Fig. 2.1 to Fig. 2.4 below.

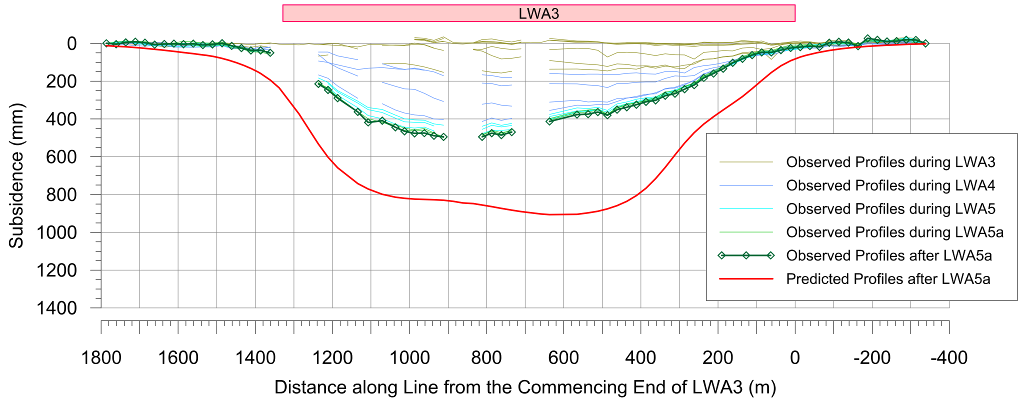


Fig. 2.1 Observed and Predicted Subsidence along the A3 Line due to LWA3 to LWA5a

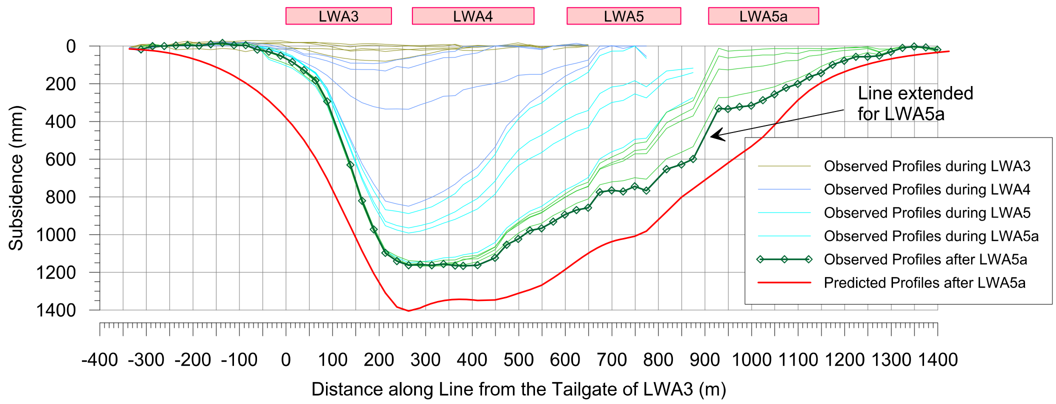


Fig. 2.2 Observed and Predicted Subsidence along the A3X Line due to LWA3 to LWA5a

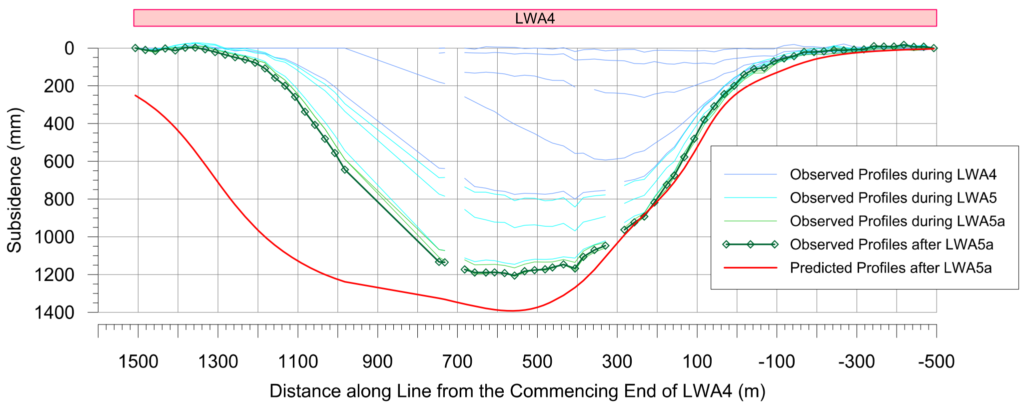


Fig. 2.3 Observed and Predicted Subsidence along the A4 Line due to LWA4 to LWA5a

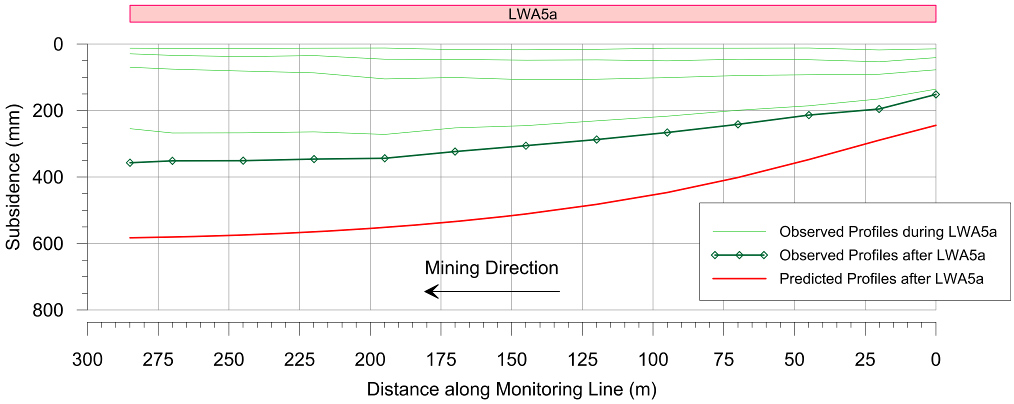


Fig. 2.4 Observed and Predicted Subsidence along the A5a Line due to LWA5a

The comparisons of the observed versus predicted movements for the longwalls in Stage 2 of the Mine were discussed in each of the End of Panel Subsidence Monitoring Review reports. In the latest review report (MSEC631 after the completion of LWA5a), it was stated that:

> "*The ground movements measured along Lines A3, A3X, A4 and A5a indicate that the observed subsidence and tilt, resulting from the extraction of Longwalls A3 to A5a, were reasonably similar to those predicted. The maximum observed tilt along Line A3X was greater than the maximum predicted over a portion of Longwall A3, however, this exceedance was small and appears to be the result of reduced subsidence above the tailgate of Longwall A3.*
>
> *The ground strains were typically in the order of those predicted based on conventional ground movements. There were some localised ground strains which exceeded the maximum predicted conventional strains, however, these generally developed during the extraction of the earlier longwalls. In most cases, these localised strains occurred prior to the longwall extraction faces mining directly beneath them and, therefore, appear to be the result of disturbed survey marks.*
>
> *It has been considered, therefore, that the Incremental Profile Method has provided adequate predictions of the mine subsidence movements for Austar Stage 2 Longwalls A3 to A5a. It has also been considered that it is not necessary to undertake any further calibration of the prediction model...*"

Consequently no further calibration of the prediction model has been undertaken since the initial calibration undertaken prior to the extraction of the longwalls in Stage 2 at the Mine.

LWA7 in Stage 3 at the Mine is currently being extracted. Two ground monitoring lines have been established above this longwall, being the LWA7 Line (along the centreline of the longwall) and the XL3 Line (transverse to the longwall).

In the latest survey for the LWA7 Line, carried out on 2nd September 2013, the maximum observed movements were 72 mm vertical subsidence, 0.5 mm/m tilt, 0.6 mm/m tensile strain and 0.5 mm/m compressive strain. In the latest survey for the XL3 Line, carried out on the 23rd September 2013, the maximum observed movements were 110 mm vertical subsidence, 3.6 mm/m tilt (possible bumped mark), 0.3 mm/m tensile strain and 0.5 mm/m compressive strain. At this stage, therefore, only low levels of vertical subsidence and strain have been measured, as expected, due to the extraction of LWA7.

2.2. Maximum Predicted Conventional Subsidence Parameters for Stage 3

The Incremental Profile Method was previously used to predict the conventional subsidence parameters resulting from the extraction of the approved LWA7 to LWA19 in Stage 3 at the Mine, which were provided in Report No. MSEC484.

The Incremental Profile Method has now been used to predict the conventional subsidence parameters resulting from the extraction of LWA7 to LWA19, based on the *Modified Layout.*

The predicted total subsidence contours due to the extraction of LWA7 to LWA10, based on the *Modified Layout*, are shown in Drawing No. MSEC650-06. The predicted total subsidence contours due to the extraction of LWA7 to LWA19, based on the *Modified Layout*, are shown in Drawing No. MSEC650-07. The predicted total 20 mm subsidence contours, based on the *Approved Layout*, are also shown in these drawings for comparison.

Summaries of the maximum predicted conventional subsidence, tilt and curvature due to the extraction of LWA7 to LWA10 and due to the extraction of LWA7 to LWA19 are provided in Table 2.1 and Table 2.2, respectively. The values in these tables are the maxima anywhere within the Study Area, which is defined in Section 3.1 of this report.

Table 2.1 Maximum Predicted Conventional Subsidence, Tilt and Curvature within the Study Area Resulting from the Extraction of LWA7 to LWA10

Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Approved Layout	1,500	5.5	0.04	0.09
Modified Layout	1,500	6.0	0.05	0.09

Table 2.2 Maximum Predicted Conventional Subsidence, Tilt and Curvature within the Study Area Resulting from the Extraction of LWA7 to LWA19

Layout	Maximum Predicted Total Subsidence (mm)	Maximum Predicted Total Tilt (mm/m)	Maximum Predicted Total Hogging Curvature (km^{-1})	Maximum Predicted Total Sagging Curvature (km^{-1})
Approved Layout	1,650	6.0	0.04	0.09
Modified Layout	1,675	6.0	0.05	0.09

It can be seen from the above tables, that the predicted maxima within the Study Area, based on the *Modified Layout*, are similar to or slightly greater than those based on the *Approved Layout*. The differences in the predicted parameters due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

Although the predicted maxima are reasonably similar, the locations of the predicted maximum longitudinal tilts and longitudinal curvatures change as a result of the proposed modifications. This is illustrated in Figs. A.01 to A.04, in Appendix A, which show the profiles of the predicted total subsidence, tilt and curvature along Prediction Lines 1 to 4, respectively. These prediction lines have been taken along the centrelines of LWA7 to LWA10, as shown in Drawing Nos. MSEC650-06 and MSEC650-07.

The maximum predicted subsidence and tilt within the Study Area are less than the maxima anywhere above the longwalls (i.e. outside the Study Area) in Stage 3, which are 1,800 mm subsidence and 6.5 mm/m. The maximum predicted hogging and sagging curvatures within the Study Area are the same as the maxima outside the Study Area.

2.3. Predicted Strains

The prediction of strain is more difficult than the prediction of subsidence, tilt and curvature. The reason for this is that strain is affected by many factors, including ground curvature and horizontal movement, as well as local variations in the near surface geology, the locations of pre-existing natural joints at bedrock, and the depth of bedrock. Survey tolerance can also represent a substantial portion of the measured strain, in cases where the strains are of a low order of magnitude. The profiles of observed strain, therefore, can be irregular even when the profiles of observed subsidence, tilt and curvature are relatively smooth.

In previous MSEC subsidence reports, predictions of conventional strain were provided based on the best estimate of the relationship between curvature and strain. Similar relationships have been proposed by other authors. The reliability of the strain predictions was highlighted in these reports, where it was stated that measured strains can vary considerably from the predicted conventional values. Adopting a linear relationship between curvature and strain provides a reasonable prediction for the maximum conventional tensile and compressive strains. The locations that are predicted to experience hogging or convex curvature are expected to be net tensile strain zones and locations that are predicted experience sagging or concave curvature are expected to be net compressive strain zones.

At Austar, it has been found that a factor of 15 provides a reasonable relationship between the maximum predicted curvatures and the maximum predicted conventional strains. The maximum predicted conventional strains due to the extraction of LWA7 to LWA10, based on applying a factor of 15 to the maximum predicted conventional curvatures, are 0.8 mm/m tensile and 1.4 mm/m compressive, based on the *Modified Layout*.

At a point, however, there can be considerable variation from the linear relationship, resulting from non-conventional movements or from the normal scatters which are observed in 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, we have provided a statistical approach to account for the variability, instead of just providing a single predicted conventional strain.

The range of potential strains above LWA7 to LWA10 has been determined using monitoring data from the previously extracted longwalls at the Mine. There are three monitoring lines in Stage 1, being the 1A Line, 1B Line and the 2 Line, and there are four monitoring lines in Stage 2, being the A3 Line, A3X Line, A4 Line and A5a Line.

The survey database has been analysed to extract the maximum total tensile and compressive strains that have been measured at any time during mining, for survey bays that were located directly above goaf or the chain pillars that are located between the extracted longwalls. It was found that a Generalised Pareto Distribution (GPD) provided a good fit to the raw strain data.

The histogram of the maximum observed total tensile and compressive strains measured in survey bays above goaf, for the previously extracted longwalls at the Mine, is provided in Fig. 2.5. The probability distribution functions, based on the fitted GPDs, have also been shown in this figure.

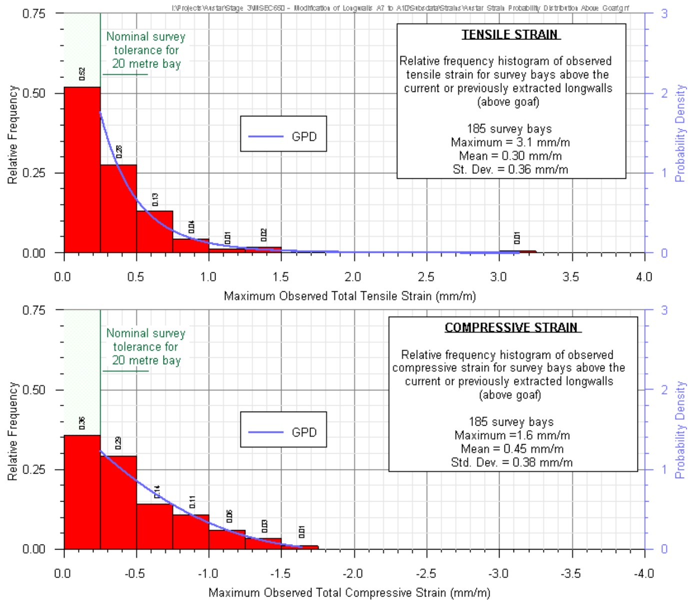


Fig. 2.5 Distributions of the Maximum Observed Total Tensile and Compressive Strains during the Extraction of Previous Longwalls at the Mine for Survey Bays Located Above Goaf

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).

The 95 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 1.0 mm/m tensile and 1.2 mm/m compressive. The 99 % confidence levels for the maximum total strains that the individual survey bays experienced at any time during mining were 1.6 mm/m tensile and 1.5 mm/m compressive.

2.4. Maximum Predicted Valley Related Movements

The predicted valley related movements along the watercourses in Stage 3 have been determined using the methods outlined in ACARP Research Project No. C9067, which were published in the handbook entitled "*Management Information Handbook on the Undermining of Cliffs, Gorges and River Systems*", issued in September 2002. Details on the ACARP Method are provided in the background report entitled "*General Discussion on Mine Subsidence Ground Movements*" which can be obtained from *www.minesubsidence.com*.

The predicted upsidence and closure movements along the watercourses have been determined from the empirical database based on their lateral and longitudinal distances from the extracted longwalls, the depths of the valleys and the maximum predicted incremental subsidence resulting from the extraction of each longwall. The predicted upsidence and closure for the watercourses near LWA7 to LWA10 are provided in Chapter 3.

3.0 THE EFFECTS OF THE PROPOSED MODIFICATIONS TO LWA7 TO LWA10 ON THE PREDICTIONS AND IMPACT ASSESSMENTS FOR THE NATURAL AND BUILT FEATURES

3.1. The Study Area

The *Study Area* has been defined as the zone where the predicted conventional subsidence parameters, based on the *Modified Layout*, are different to those predicted based on the *Approved Layout*. The Study Area has been based on the following:-

- 26.5 degree angle of draw lines from the commencing end of LWA8 and the finishing ends of LWA7 to LWA10, based on both the approved and modified positions, and
- The limit where the change in the predicted vertical subsidence, resulting from the proposed modifications, is greater than 20 mm.

The extent of the Study Area is shown in Drawing No. MSEC650-01, in Appendix B. There are a number of natural and built features located within this area, which are shown in Drawing Nos. MSEC650-04 and MSEC650-05, respectively. There are also some features which are located outside the Study Area, which could experience far-field or valley related movements, and could be sensitive to such movements, and these features have also been included as part of the assessments.

The natural and built features which have been included in the assessments provided in this report include:-

- Watercourses,
- Steep slopes,
- Local roads,
- 11 kV and consumer powerlines,
- Optical Fibre and Copper telecommunications cables,
- Rural structures,
- Farm dams,
- Houses,
- Archaeological sites, and
- Historical sites.

The effects of the proposed modifications to LWA7 to LWA10 on the subsidence predictions and impact assessments for these features are provided in the following sections. The predicted subsidence parameters are based on the maxima at each of the features located within the Study Area resulting from the extraction of LWA7 to LWA19.

3.2. Watercourses

The locations of the watercourses are shown in Drawing No. MSEC650-04. The watercourses within the Study Area are ephemeral first or second order drainage lines having shallow incisions into the natural surface soils.

The drainage lines are located across the Study Area and, therefore, could experience the full range of predicted movements up to the maxima summarised in Chapter 2. The maximum predicted subsidence parameters for the drainage lines within the Study Area are similar to the maxima for the drainage lines located elsewhere above the longwalls (i.e. outside the Study Area).

The ephemeral drainage lines within the Study Area are predicted to experience vertical subsidence up to 1,675 mm and tilts up to 6.0 mm/m (i.e. 0.6 %, or 1 in 167). The effects of the vertical subsidence and tilt on the potential for flooding, based on the *Modified Layout*, have been assessed by Umwelt (2013).

The ephemeral drainage lines within the Study Area are predicted to experience curvatures up to 0.05 km^{-1} hogging and 0.09 km^{-1} sagging. The discussions on the range of potential ground strains within the Study Area are provided in Section 2.3.

The maximum predicted curvatures and strains for the drainage lines within the Study Area are the same as the maxima for the drainage lines located elsewhere above the longwalls (i.e. outside the Study Area). The potential for surface cracking along the drainage lines within the Study Area, therefore, is similar to that for drainage lines located elsewhere above the approved longwalls in Stage 3.

It is possible that minor and isolated cracking in the surface soils could develop as a result of mining. It is unlikely, however, that the cracking would result in any adverse impacts on the ephemeral surface water flows or water quality.

This is supported by the experience in Stage 2 at the Mine, where LWA3 to LWA5a were extracted directly beneath Cony Creek, Quorrobolong Creek and a number of ephemeral drainage lines. There were no observed adverse changes in the surface water flows and surface water quality in the streams in Stage 2 as a result of mining.

Cony Creek is located 400 metres south of the finishing end of LWA10, at its closest point to the modified LWA7 to LWA10. At this distance, the changes in the predicted conventional and valley related movements for the creek, due to the proposed modifications, are negligible.

The impact assessments and proposed management strategies for the watercourses within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any adverse impacts on the watercourses.

3.3. Steep Slopes

The locations of the steep slopes are shown in Drawing No. MSEC650-04. A steep slope was defined in Report No. MSEC484 as "*an area of land having a natural gradient greater than 1 in 3 (i.e. a grade of 33 %, or an angle to the horizontal of 18°)*". The steep slopes were identified from the 1 metre surface contours which were generated from an airbourne laser scan of the area. There are no identified cliffs located within the Study Area.

There are steep slopes located above the commencing end of LWA8 and near the finishing ends of LWA8 and LWA9. The natural surface gradients typically vary between 1 in 3 and 1 in 2 (i.e. a grade of 50 %, or an angle to the horizontal of 27°), with isolated areas having natural surface gradients of up to 1 in 1.5 (i.e. a grade of 67 %, or an angle to the horizontal of 34°).

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the steep slopes, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.1. The values are the maxima for the steep slopes within the Study Area resulting from the extraction of LWA7 to LWA19.

Table 3.1 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Steep Slopes within the Study Area Resulting from the Extraction of Longwall A7 to A19

Layout	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})
Approved Layout	1,525	5.0	0.04	0.09
Modified Layout	1,600	5.5	0.05	0.09

It can be seen from the above table that the maximum predicted total conventional subsidence at the steep slopes, based on the *Modified Layout*, is similar to but slightly greater than those based on the Approved Layout. The differences in the predicted parameters due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

The potential for surface cracking on the steep slopes, based on the *Modified Layout* is, therefore, similar to that based on the *Approved Layout*. It is noted, however, that the total area of the steep slopes located directly above the longwalls reduces as a result of the proposed modification. That is the area of steep slopes located above the lengthened finishing end of LWA8 is less than the area of steep slopes located above the shortened commencing end of this longwall.

Periodic visual inspections have been undertaken above and adjacent to LWA1 and LWA2 in stage 1 and LWA3 to LWA5a in Stage 2 at the Mine. No significant surface cracking has been identified along the steep slopes within the *Werakata State Conservation Area* (formerly known as Aberdare State Forest). Also no fracturing in the rock outcrops and no rock falls have been identified in this area.

The impact assessments and proposed management strategies for the steep slopes within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the steep slopes.

3.4. Local Roads

The locations of the local roads are shown in Drawing No. MSEC650-05. *Quorrobolong Road* is located directly above the modified finishing ends of LWA7 to LWA10. *Big Hill Road* is located above the finishing end of LWA9 and the commencing end of LWA8 within the Study Area. *Coney Creek Lane* and *Nash Lane* are located to the south of the modified finishing end of LWA10.

The predicted profiles of subsidence, tilt and curvature along *Quorrobolong Road* and *Big Hill Road*, based on the *Approved* and *Modified Layouts*, are illustrated in Figs. A.05 and A.06, respectively, in Appendix A. It can be seen from these figures that the predicted subsidence parameters along *Quorrobolong Road* increase as a result of the proposed modifications. The predicted subsidence parameters along *Big Hill Road* do not increase substantially, however the locations of the predicted maxima move as a result of the proposed modifications.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the local roads, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.2. The values are the maxima anywhere along each of the roads resulting from the extraction of LWA7 to LWA19.

Table 3.2 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Local Roads Resulting from the Extraction of Longwall A7 to A19

Location	Layout	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})
Quorrobolong Road	Approved Layout	325	2.0	0.01	< 0.01
	Modified Layout	1,250	5.0	0.02	0.07
Big Hill Road	Approved Layout	1,625	5.0	0.02	0.05
	Modified Layout	1,675	5.0	0.04	0.06
Coney Creek and Nash Lanes	Approved Layout	1,550	5.0	0.02	0.03
	Modified Layout	1,550	5.0	0.02	0.03

It can be seen from the above table, that the maximum predicted subsidence parameters for *Big Hill Road, Coney Creek Lane* and *Nash Lane*, based on the *Modified Layout*, are similar to or slightly greater than those predicted based on the *Approved Layout*. The impact assessments and proposed management strategies for these unsealed roads are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan.

The maximum predicted subsidence parameters for *Quorrobolong Road*, based on the *Modified Layout*, are greater than those based on the *Approved Layout*. The maximum predicted subsidence parameters for this road are similar to those typically experienced in the Southern Coalfield, where there is extensive experience of mining beneath bitumen sealed local roads.

The extraction of the longwalls beneath *Quorrobolong Road* is likely to result in minor cracking in the road surface, typically less than 25 mm in width. It is also possible that localised heaving of the road surface could develop due to concentrations of compressive strain. The extensive experience from the Southern Coalfield indicates that the road could be maintained in safe and serviceable conditions using normal road maintenance techniques.

It is recommended that a ground monitoring line is established along *Quorrobolong Road* to measure the actual movements and to identify any irregular or non-conventional ground movements. It is also recommended that periodic visual inspections are carried out during active subsidence. With the implementation of any necessary management strategies, it would be expected that *Quorrobolong Road* could be maintained in a safe and serviceable condition during mining.

3.5. Electrical Infrastructure

The locations of the electrical infrastructure are shown in Drawing No. MSEC650-05. There are 11 kV powerlines within the Study Area which follow the general alignments of *Quorrobolong Road*, *Big Hill Road* and *Coney Creek Lane*. There are also consumer lines which supply power to the rural properties within the Study Area. The powerlines comprise aerial copper cables supported by timber poles.

The 11 kV powerlines are predicted to experience mine subsidence movements similar to the adjacent local roads, which is discussed in Section 3.4. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the 11 kV powerlines, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.3. The values are the maxima anywhere along the powerlines resulting from the extraction of LWA7 to LWA19.

Table 3.3 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the 11 kV Powerlines Resulting from the Extraction of Longwall A7 to A19

Layout	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})
Approved Layout	1,625	5.0	0.02	0.05
Modified Layout	1,675	5.0	0.03	0.07

It can be seen from the above table, that the maximum predicted subsidence parameters for the powerlines, based on the *Modified Layout*, are similar to or slightly greater than those predicted based on the *Approved Layout*. It is noted, that the differences in the predicted parameters due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

Whilst the maximum predicted subsidence parameters do not change significantly, due to the proposed modifications, the 11 kV powerline located adjacent to *Quorrobolong Road* is predicted to experience greater movements, as illustrated in Fig. A.05, in Appendix A.

The powerlines 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 tilts, and by changes in the catenary profiles of the cables.

The maximum predicted tilts and horizontal movements for the powerlines within the Study Area are similar to those observed in Stage 2 at the Mine. There were no adverse impacts on the aerial powerlines in Stage 2 resulting from the extraction of LWA3 to LWA5a.

The predicted movements for the powerlines within the Study Area are also similar to those typically experienced in the Southern Coalfield. There is extensive experience of mining directly beneath timber pole powerlines in the Southern Coalfield which indicates that incidences of impacts are very low and that these impacts are readily repairable. In some cases, remedial measures were required for the powerlines, which included the adjustments of cable catenaries, pole tilts, or the lengthening of consumer cables which connect between the powerlines and building structures.

The impact assessments and proposed management strategies for the 11 kV and consumer powerlines within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the powerlines.

3.6. Telecommunications Cables

The locations of the telecommunications infrastructure are shown in Drawing No. MSEC650-05.

There is an optical fibre cable which is located to the east of the approved commencing end of LWA8. The predicted subsidence parameters for this cable, based on the shortened commencing end of this longwall, are less than those based on the *Approved Layout*. The impact assessments and proposed management strategies for the optical fibre cable, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan.

There are also direct buried copper telecommunications cables within the Study Area located along the alignments of *Quorrobolong Road*, *Coney Creek Lane* and *Nash Lane*. The copper cables are predicted to experience mine subsidence movements similar to the adjacent roads, which is discussed in Section 3.4.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the copper telecommunications cables, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.4. The values are the maxima anywhere along the cables resulting from the extraction of LWA7 to LWA19.

Table 3.4 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Copper Telecommunications Cables Resulting from the Extraction of Longwall A7 to A19

Layout	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})
Approved Layout	1,625	5.0	0.02	0.05
Modified Layout	1,675	5.0	0.03	0.07

It can be seen from the above table, that the maximum predicted subsidence parameters for the copper telecommunications cables, based on the *Modified Layout*, are similar to or slightly greater than those predicted based on the *Approved Layout*. It is noted, that the differences in the predicted parameters due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

Whilst the maximum predicted subsidence parameters do not change significantly, due to the proposed modifications, the copper telecommunications cable located adjacent to *Quorrobolong Road* is predicted to experience greater movements, as illustrated in Fig. A.05, in Appendix A.

The direct buried copper telecommunications cables are unlikely to be impacted by vertical subsidence or tilt. The cables are also unlikely to be impacted by curvature, as the cables are flexible and would be expected to tolerate the predicted minimum radius of curvature within the Study Area of 20 kilometres. The copper telecommunications cables could, however, be affected by the ground strains resulting from the extraction of the proposed longwalls.

The predicted conventional strains for the copper telecommunications cables within the Study Area are similar to those observed in Stage 2 at the Mine. There were no adverse impacts on the direct buried copper telecommunications cables resulting from the extraction of LWA3 to LWA5a.

The predicted movements for the copper telecommunications cables within the Study Area are also similar to those typically experienced in the Southern Coalfield. There is extensive experience of mining beneath direct buried telecommunications in the Southern Coalfield which indicates that incidences of impacts are extremely rare are readily repairable.

The impact assessments and proposed management strategies for the copper telecommunications cables within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the copper telecommunications cables.

3.7. Rural Structures

The locations of the rural structures are shown in Drawing No. MSEC650-05. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the rural structures, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.5. The values are the maxima within 20 metres of each of the structures resulting from the extraction of LWA7 to LWA19.

Table 3.5 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Rural Structures within the Study Area Resulting from the Extraction of Longwall A7 to A19

Property	Layout	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})
A09	Approved Layout	<20	< 0.5	< 0.01	< 0.01
	Modified Layout	25	0.5	< 0.01	< 0.01
A12	Approved Layout	925	6.0	0.04	< 0.01
	Modified Layout	1,250	5.0	0.04	0.01
A16	Approved Layout	225	2.0	0.01	< 0.01
	Modified Layout	300	2.5	0.02	< 0.01
A52	Approved Layout	< 20	< 0.5	< 0.01	< 0.01
	Modified Layout	60	0.5	0.01	< 0.01

The predicted vertical subsidence at the rural structures, based on the *Modified Layout*, are greater than those based on the *Approved Layout*. The additional predicted values of vertical subsidence are 10 mm for Property Ref. A09, 325 mm for Property Ref. A12, 75 mm for Property Ref. A16 and around 50 mm for Property Ref. A52, which are relatively small when compared with the maximum subsidence anywhere above the longwalls.

The potential for impacts on rural structures are not dependant on vertical subsidence, but rather differential subsidence which includes tilt, curvature and ground strain. It can be seen from the above table, that the maximum predicted subsidence tilts and curvatures, based on the *Modified Layout*, are similar to those predicted based on the *Approved Layout*. It is noted, that the differences in the predicted parameters due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

The predicted conventional tilts, curvatures and strains for the rural structures within the Study Area, based on the *Modified Layout*, are similar to those observed in Stage 2 at the Mine. There were a total of 14 rural structures located directly above LWA3 to LWA5a and there were no reported impacts on these structures resulting from the mining.

The predicted movements for the rural structures within the Study Area are also similar to those typically experienced in the Southern Coalfield. 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. In all cases, the rural building structures remained in safe and serviceable conditions.

The impact assessments and proposed management strategies for the rural structures within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the rural structures.

3.8. Farm Dams

The locations of the farm dams are shown in Drawing No. MSEC650-05.

The predicted subsidence movements for the farm dams located near the commencing end of LWA8 reduce as a result of the proposed modifications. The predicted subsidence movements for the farm dams located near the finishing ends of LWA9 and LWA10 increase as a result of the proposed modifications. These farm dams could experience the full range of predicted movements up to the maxima summarised in Chapter 2.

The maximum predicted movements for the farm dams in the Study Area are 1,675 mm subsidence and 6.0 mm/m tilt (i.e. 0.6 %, or 1 in 165). The predicted changes in freeboard for the dams are less than 500 mm and, therefore, are unlikely to have a significant impact on the storage capacities of these dams.

The maximum predicted curvatures and strains for the farm dams within the Study Area are the same as the maxima for the farm dams located elsewhere above the longwalls (i.e. outside the Study Area). The potential for surface cracking for the farm dams within the Study Area, therefore, is similar to that for farm dams located elsewhere above the approved longwalls in Stage 3.

The predicted movements for the farm dams within the Study Area are also similar to those typically experienced in the Southern Coalfield. There is extensive experience of mining directly beneath farm dams in the Southern Coalfield which indicates that incidences of impacts are extremely rare.

The management strategies for the farm dams within the Study Area, based on the *Modified Layout*, are the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the farm dams.

3.9. Houses

The locations of the houses are shown in Drawing No. MSEC650-05. There are four houses that are located within the Study Area and a summary of these structures is provided in Table 3.6 below.

Table 3.6 Details of the Houses within the Study Area

Reference	Location	Construction
A09a	Located approximately 270 metres to the south west of the commencing end of LWA10.	Single storey with attic
A12a	Located directly above the chain pillar between LWA10 and LWA11, just east of the approved finishing end of LWA10.	Single storey timber framed structure
A16a	Located outside the extents of the longwalls, approximately 90 metres south of the modified finishing end of LWA10 and 135 metres west of the approved finishing end of LWA11.	Single storey timber framed structure on pier footings
A52a	Located outside the extents of the longwalls, approximately 270 metres west of the modified commencing ends of LWA8 and LWA9.	Single storey timber framed structure on pier footings

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the houses, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.7. The values are the maxima within 20 metres of each of the houses resulting from the extraction of LWA7 to LWA19.

Table 3.7 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Houses within the Study Area Resulting from the Extraction of Longwall A7 to A19

Reference	Layout	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})
A09a	Approved Layout	<20	<0.5	< 0.01	< 0.01
	Modified Layout	35	<0.5	< 0.01	< 0.01
A12a	Approved Layout	875	5.5	0.04	< 0.01
	Modified Layout	925	4.5	0.03	0.01
A16a	Approved Layout	175	1.5	0.01	< 0.01
	Modified Layout	250	2.5	0.02	< 0.01
A52a	Approved Layout	< 20	< 0.5	< 0.01	< 0.01
	Modified Layout	60	0.5	0.01	< 0.01

The following provides the impact assessments for the houses within the Study Area:-

Potential Impacts Resulting from Vertical Subsidence

The predicted vertical subsidence at the houses within the Study Area, based on the *Modified Layout*, are slightly greater than those based on the *Approved Layout*. The additional predicted values of vertical subsidence are 15 mm at Structure Ref. A09a, 50 mm at Structure Ref. A12a, 75 mm at Structure Ref. A16a and around 50 mm at Structure Ref. A52a, which are small when compared with the maximum subsidence anywhere above the longwalls.

Vertical subsidence does not directly affect the stability or serviceability of houses. The potential impacts on houses are affected by differential subsidence, which includes tilt, curvature and ground strain, and the impact assessments based on these parameters are described in the following sections.

Vertical subsidence in this case, however, could affect the heights of the houses above the flood level. The potential impacts on the houses resulting from the changes in flood level, due to the proposed modifications, are assessed by Umwelt (2013).

Potential Impacts Resulting from Tilt

The predicted tilts at the houses within the Study Area, based on the *Modified Layout*, are slightly greater or slightly less than those based on the *Approved Layout*. The changes in tilt due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

It has been found from past longwall mining experience that tilts of less than 7 mm/m generally do not result in any significant impacts on houses. The maximum predicted tilt for the houses within the Study Area, based on the *Modified Layout*, is 4.5 mm/m (i.e. 0.5 %), which represents a change in grade of 1 in 180.

Some minor serviceability impacts could 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. It is expected that the houses within the Study Area will remain in safe conditions as the result of the mining induced tilts.

Potential Impacts Resulting from Curvature and Strain

The predicted curvatures at the houses within the Study Area, based on the *Modified Layout*, are slightly greater or slightly less than those based on the *Approved Layout*. The changes in curvature due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

The probability of impacts for the houses has been assessed using the method developed as part of ACARP Research Project C12015, which is described in Appendix C of Report No. MSEC484. This method uses the primary parameters of ground curvature and type of construction. The distribution of the assessed impacts for the houses within the Study Area is provided in Table 3.8. The impact categories (R0 to R5) are described in Appendix C in Report No. MSEC484.

Table 3.8 Assessed Impacts for the Houses within the Study Area

Reference	Repair Category			
	No Claim or R0	R1 or R2	R3 or R4	R5
A09a	95 %	4 %	1 %	< 0.1 %
A12a	87 %	11 %	2 %	< 0.5 %
A16a	90 %	9 %	1 %	< 0.5 %
A52a	95 %	4 %	1 %	< 0.1 %

The assessed impacts for the houses within the Study Area, based on the *Modified Layout*, are similar to those assessed based on the *Approved Layout*. It is expected that the houses within the Study Area would remain safe and serviceable at all times.

The management strategies for the houses within the Study Area, based on the *Modified Layout*, are the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any adverse impacts on the safety and serviceability of the houses.

3.10. Swimming Pools

The locations of the pools are shown in Drawing No. MSEC650-05. A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the swimming pools, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.5. The values are the maxima within 20 metres of each of the structures resulting from the extraction of LWA7 to LWA19.

Table 3.9 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Swimming Pools within the Study Area Resulting from the Extraction of Longwall A7 to A19

Property	Layout	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})
A09p01	Approved Layout	<20	< 0.5	< 0.01	< 0.01
	Modified Layout	25	< 0.5	< 0.01	< 0.01

The predicted vertical subsidence at the swimming pool, based on the *Modified Layout*, is slightly greater than that based on the *Approved Layout*. The additional predicted vertical subsidence is 10 mm which is negligible when compared with the maximum subsidence anywhere above the longwalls.

The potential for impacts on swimming pools are not dependant on vertical subsidence, but rather differential subsidence which includes tilt, curvature and ground strain. It can be seen from the above table, that the maximum predicted subsidence tilts and curvatures, based on the *Modified Layout*, do not change from those predicted for the *Approved Layout*.

The impact assessments and proposed management strategies for the swimming pools within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any long term impacts on the swimming pools resulting from the longwall modifications.

3.11. Archaeological Sites

The locations of the archaeological sites are shown in Drawing No. MSEC650-05. There are five archaeological sites which have been identified within the Study Area, being Sites *37-6-2756, 37-6-2757, 37-6-2753, 37-6-1892, 37-6-1895*. These sites were numbered respectively in previous reports as *ACM21*, *ACM22*, *Discovery 6 IF*, *Discovery 11 AS* and *Discovery 14 IF*.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the archaeological sites, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.10. The values are the maxima at these sites resulting from the extraction of LWA7 to LWA19.

Table 3.10 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Archaeological Sites Resulting from the Extraction of Longwall A7 to A19

AHIMS Reference	Layout	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})
37-6-2756	Approved Layout	900	6.0	0.03	0.02
	Modified Layout	1225	5.0	0.02	0.04
37-6-2757	Approved Layout	325	2.5	0.03	< 0.01
	Modified Layout	450	3.0	0.02	0.01
37-6-2753	Approved Layout	125	1.0	0.01	<0.01
	Modified Layout	225	2.0	0.01	0.01
37-6-1892	Approved Layout	1200	5.0	< 0.01	0.03
	Modified Layout	1075	4.5	0.02	0.03
37-6-1895	Approved Layout	1650	1.0	< 0.01	0.07
	Modified Layout	1625	1.5	0.02	0.07

Site 37-6-2756 is a scarred tree which is located near the finishing end of LWA10. The predicted vertical subsidence and sagging curvature increase as a result of the proposed modifications. The predicted final tilt and hogging curvature, however, decrease as a result of the proposed modifications.

The surface cracking resulting from mining is expected to be minor and isolated and not result in adverse impacts on trees. As described in Report No. MSEC484, impacts on trees as a result of longwall mining have only been observed at very shallow depths of cover (i.e. less than 100 metres) and/or in very steep terrain. It is unlikely, therefore, that the scarred tree would experience any adverse impacts as a result of mining in Stage 3.

The remaining archaeological sites within the Study Area are artefact scatters or isolated finds. The predicted subsidence movements at these sites, based on the *Modified Layout*, are greater or lesser than those predicted based on the *Approved Layout*, depending on their locations relative to the longwalls.

Surface cracking is unlikely to directly impact on the artefact scatters or isolated finds themselves. It is recommended that Austar seek the required approvals from the appropriate authorities, prior to the remediation of any surface cracking in the locations of the artefact scatters and isolated finds

The management strategies for the archaeological sites within the Study Area, based on the *Modified Layout*, are the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any adverse impacts on the archaeological sites.

Further discussions on the archaeological sites are provided in the report by Umwelt (2013).

3.12. Historical Sites

The locations of the historical (i.e. European heritage) sites are shown in Drawing No. MSEC650-05. There are six historical sites located within the Study Area, being *Culvert 1*, *Culvert 2*, *Culvert 3*, *Fencing 2*, *Quarry 1* and *Quarry 2*.

A summary of the maximum predicted values of total conventional subsidence, tilt and curvature for the historical sites, based on both the *Approved* and *Modified Layouts*, is provided in Table 3.11. The values are the maxima within 20 metres of each of the sites resulting from the extraction of LWA7 to LWA19.

Table 3.11 Maximum Predicted Total Conventional Subsidence, Tilt and Curvature for the Historical Sites within the Study Area Resulting from the Extraction of Longwall A7 to A19

Reference	Layout	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})
Culvert 1	Approved Layout	300	2.5	0.02	< 0.01
	Modified Layout	825	3.5	0.02	0.02
Culvert 2	Approved Layout	350	3.0	0.02	< 0.01
	Modified Layout	875	4.0	0.02	0.04
Culvert 3	Approved Layout	350	3.0	0.01	< 0.01
	Modified Layout	775	5.0	0.03	0.01
Fencing 2	Approved Layout	25	< 0.5	< 0.01	< 0.01
	Modified Layout	275	3.0	0.03	< 0.01
Quarry 1	Approved Layout	50	0.5	< 0.01	< 0.01
	Modified Layout	300	2.5	0.01	0.01
Quarry 2	Approved Layout	50	0.5	< 0.01	< 0.01
	Modified Layout	375	3.5	0.02	0.01

The impact assessments for the historic sites, based on the *Modified Layout*, are provided below.

Culverts 1 to 3 are each single concrete culverts located along Quorrobolong Road. The predicted final tilts for these culverts are 3.0 mm/m to 5.0 mm/m which are orientated obliquely to their alignments. The reducing tilts orientated along the alignments of the culverts are less than 0.5 % and unlikely, therefore, to have any adverse impacts on their serviceability. *Culverts 1 and 2* are located above solid coal and *Culvert 3* is located directly above the modified finishing end of LWA7. It is expected, therefore, that only minor and isolated cracking would occur in these culverts as a result of mining.

Fencing 2 is a single timber post located 30 metres west of the modified finishing end of LWA8. The predicted final tilt at this site is 3.0 mm/m (i.e. 0.3 %, or 1 in 330) which is unlikely to be noticeable to the human eye. The single timber post will not be impacted by the mining induced curvatures and strains, as the differential movements over the width of the post will be negligible.

Quarry 1 and 2 are former quarry sites located near the modified finishing end of LWA8. It is possible that mining could result in minor fracturing in the exposed rock outcrop and dislodge any rocks which are marginally stable.

The management strategies for the historic sites within the Study Area, based on the *Modified Layout*, are the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any adverse impacts on the historic sites.

3.13. Summary

The maximum predicted subsidence parameters within the Study Area, based on the *Modified Layout*, are similar to or slightly greater than those based on the *Approved Layout*. The differences in the predicted maxima due to the proposed modifications are considered to be within the limits of accuracy of the method of prediction and are not considered to be significant.

The predictions for the natural and built features located near the commencing end of LWA8, based on the *Modified Layout*, are similar to or less than those based on the *Approved Layout*. The predictions for the features located near the finishing ends of LWA7 to LWA10 generally increase as a result of the proposed modifications.

The maximum predicted subsidence parameters for the natural and built features within the Study Area, based on the *Modified Layout*, are similar to or less than the maxima at similar features located elsewhere above the proposed longwalls (i.e. outside the Study Area).

The impact assessments and management strategies for the natural and built features within the Study Area, based on the *Modified Layout* are, therefore, the same as those provided in Report No. MSEC484 and the Extraction Plan. With these management strategies in place, it is unlikely that there would be any adverse impacts as a result of the proposed modifications.

APPENDIX A. FIGURES

Predicted Profiles of Total Subsidence, Tilt and Curvature along Prediction Line 1 Resulting from the Extraction of LWA7 to LWA19

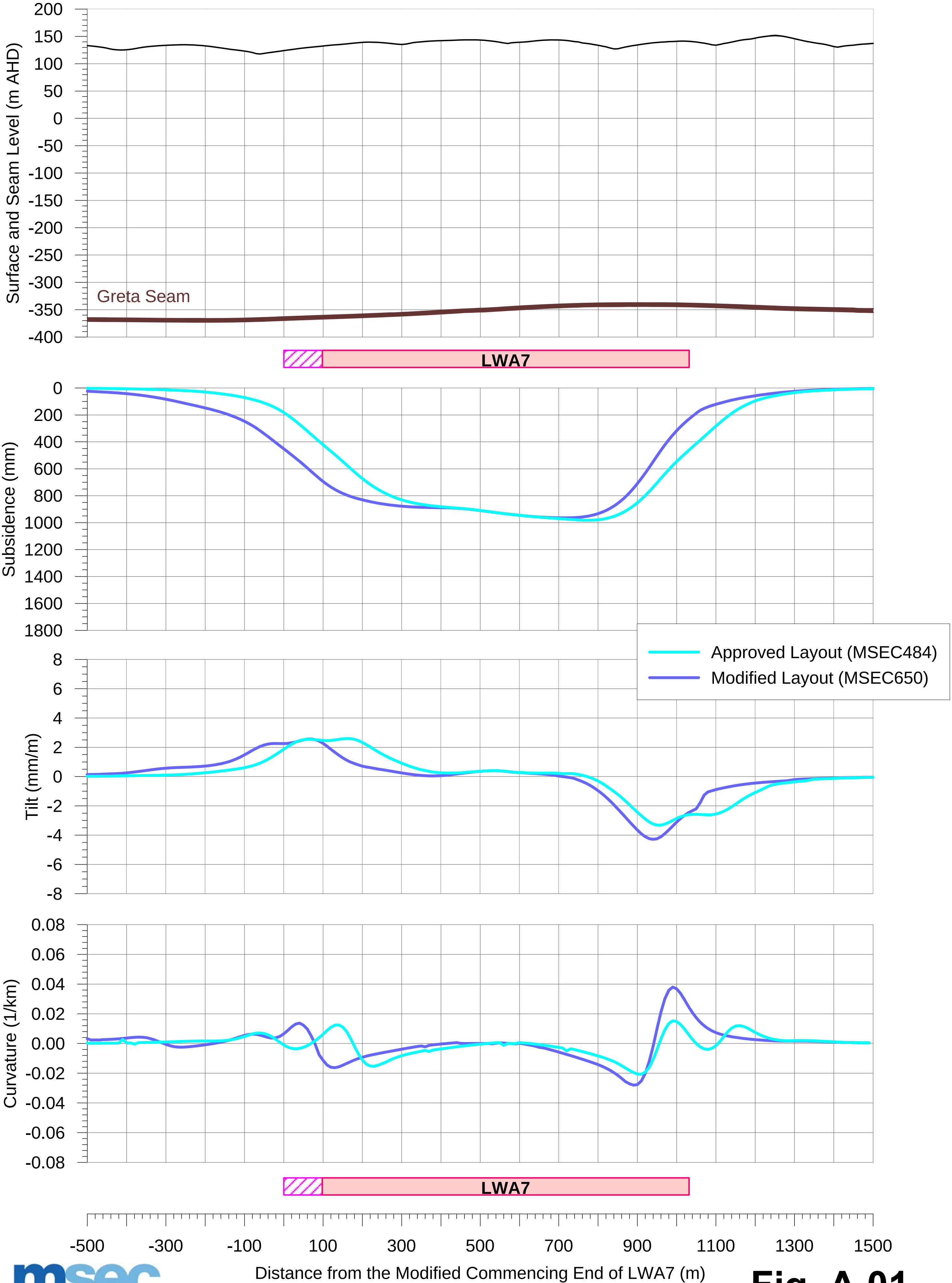
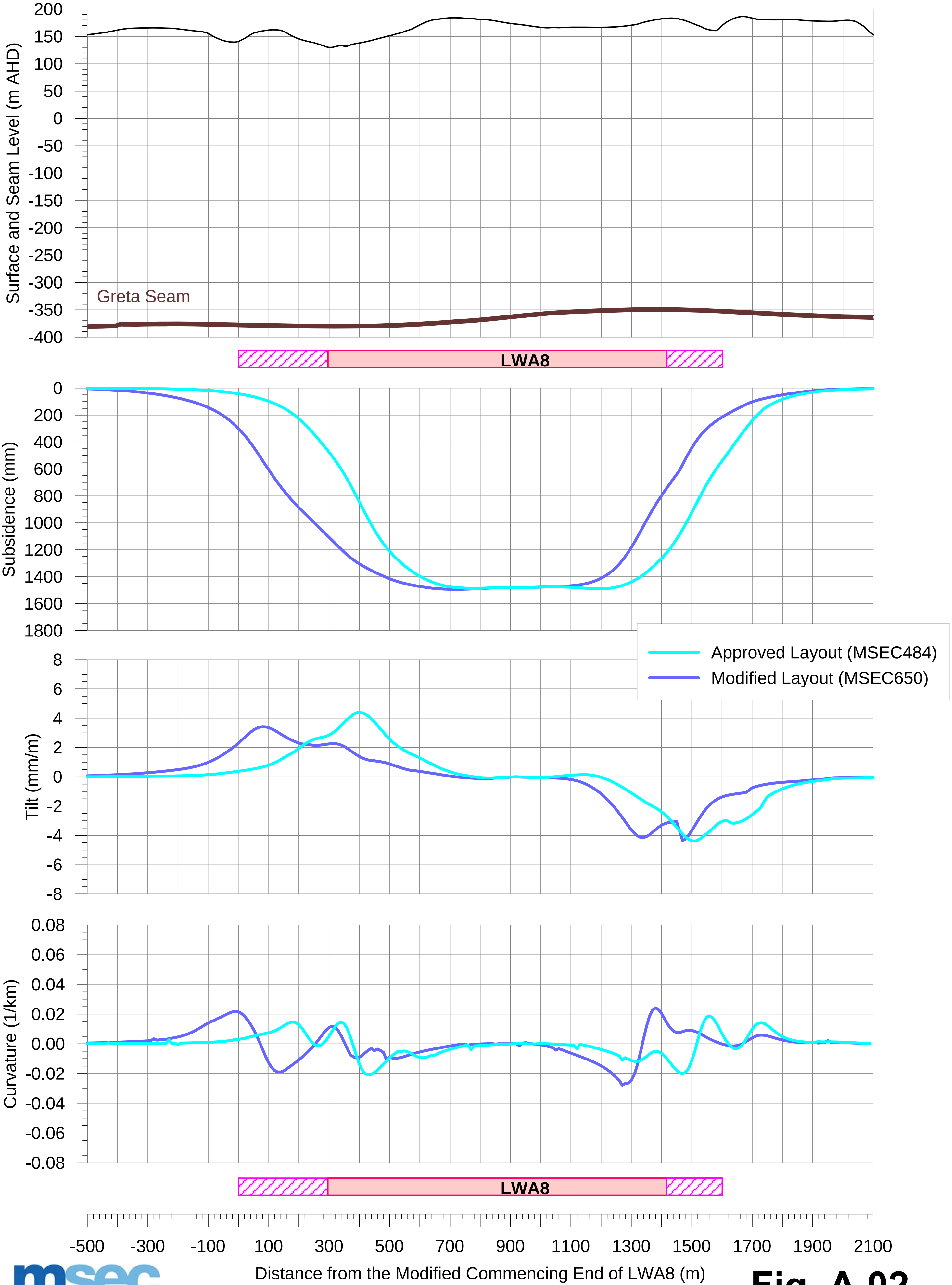


Fig. A.01

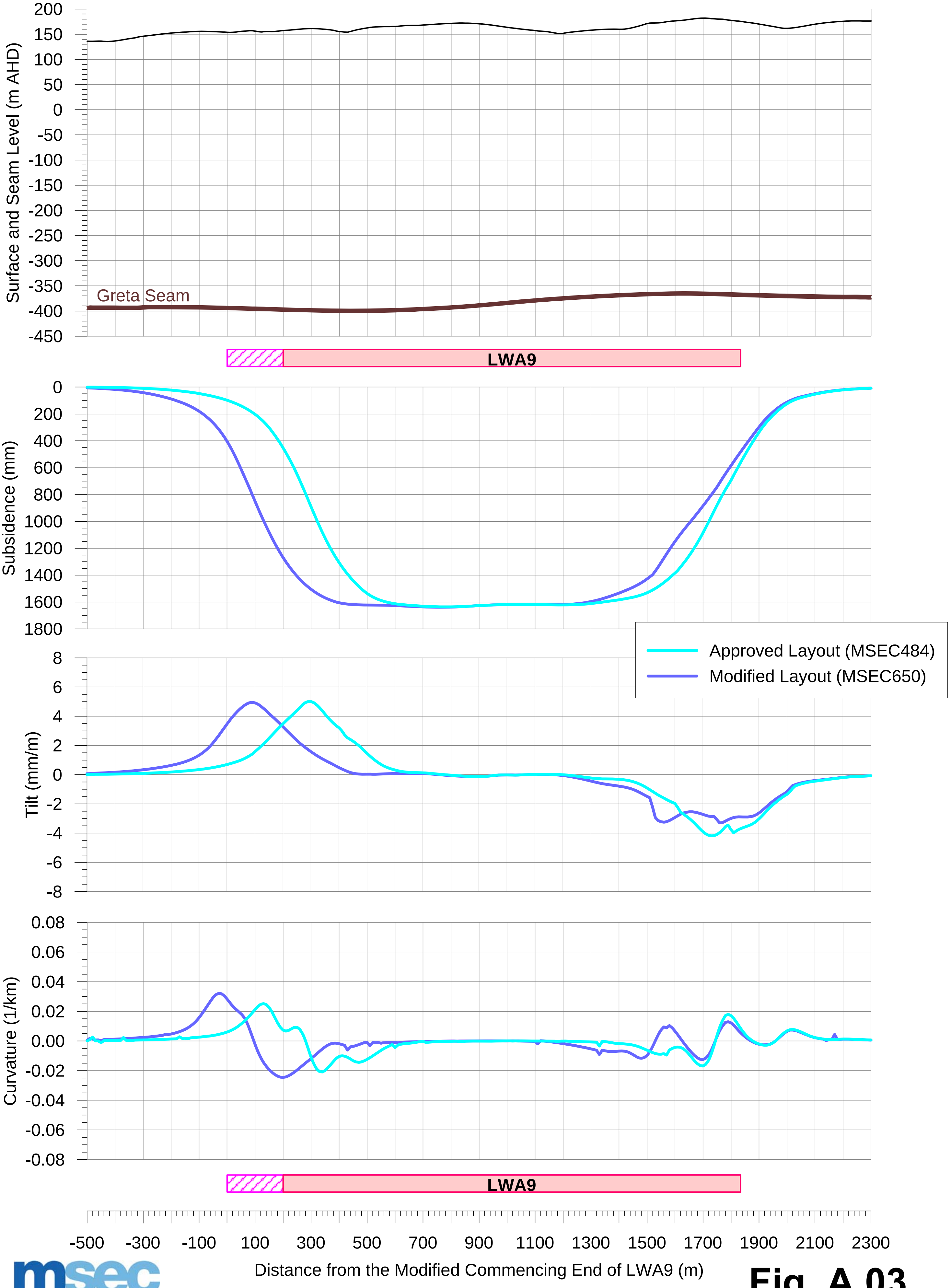
Predicted Profiles of Total Subsidence, Tilt and Curvature along Prediction Line 2 Resulting from the Extraction of LWA7 to LWA19



msec

Fig. A.02

Predicted Profiles of Total Subsidence, Tilt and Curvature along Prediction Line 3 Resulting from the Extraction of LWA7 to LWA19



msec

Fig. A.03

Predicted Profiles of Total Subsidence, Tilt and Curvature along Prediction Line 4 Resulting from the Extraction of LWA7 to LWA19

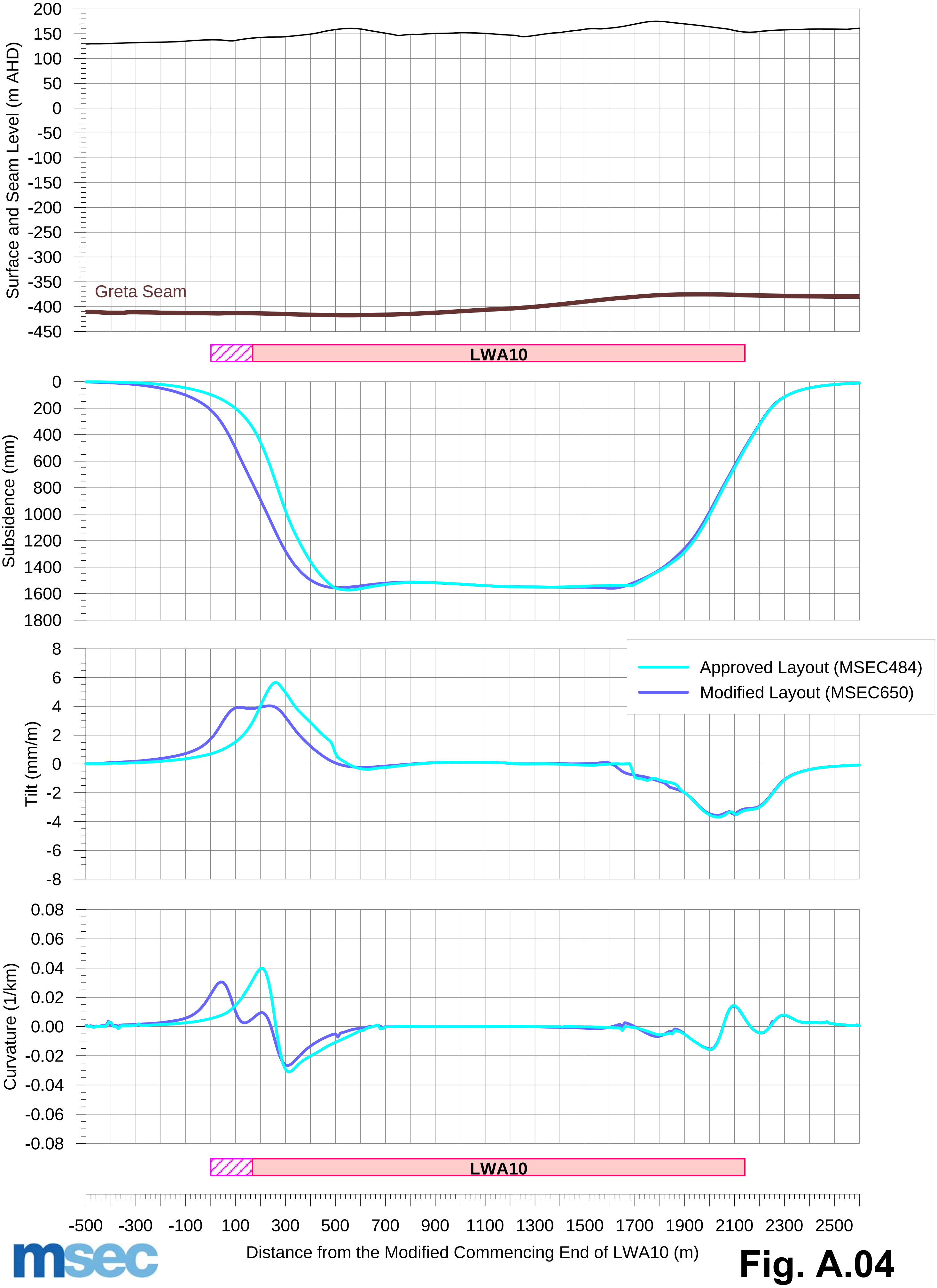


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Fig. A.04

Predicted Profiles of Total Subsidence, Tilt and Curvature along Quorrobolong Road Resulting from the Extraction of LWA7 to LWA19

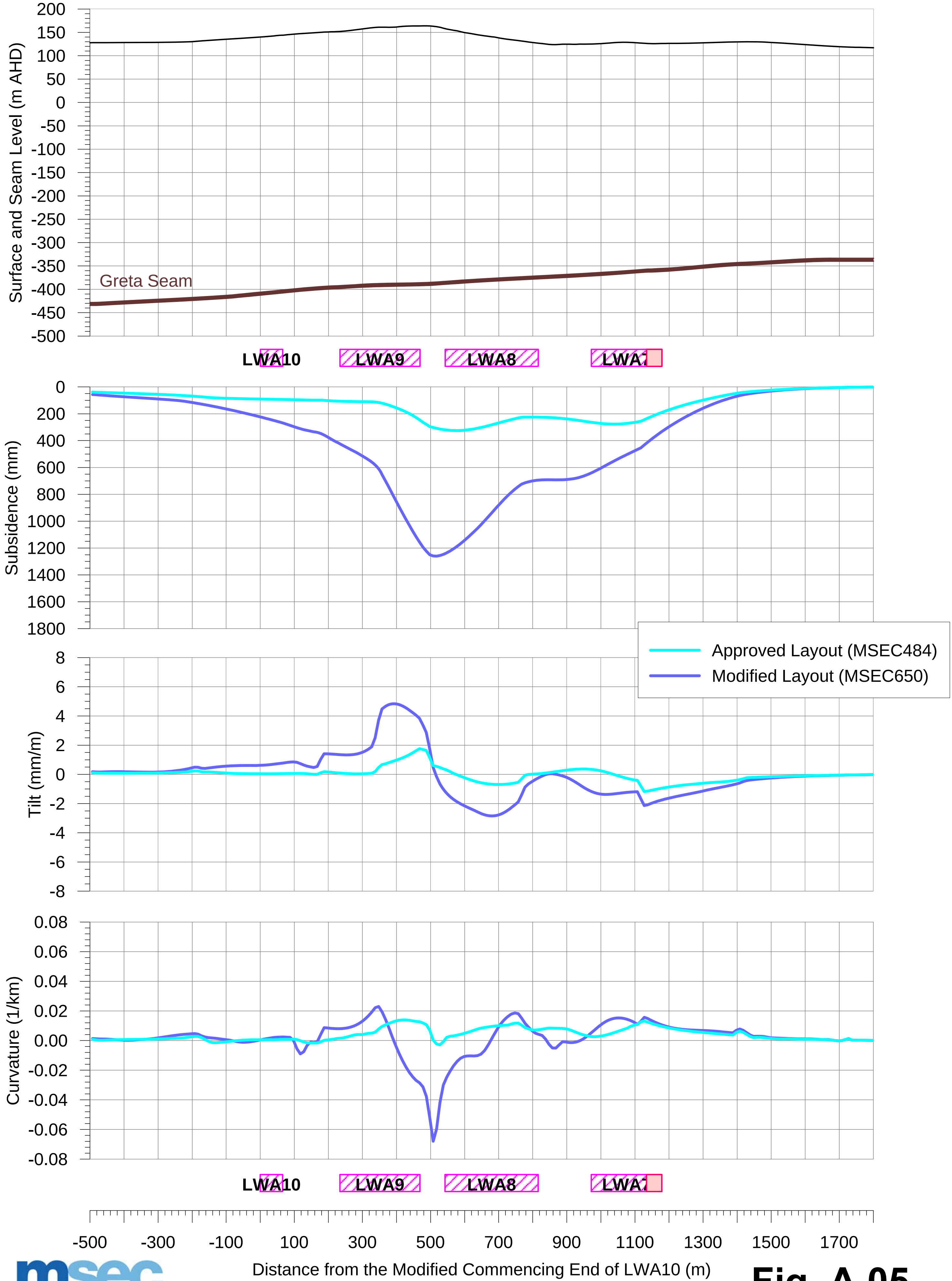

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Fig. A.05

Predicted Profiles of Total Subsidence, Tilt and Curvature along Big Hill Road Resulting from the Extraction of LWA7 to LWA19

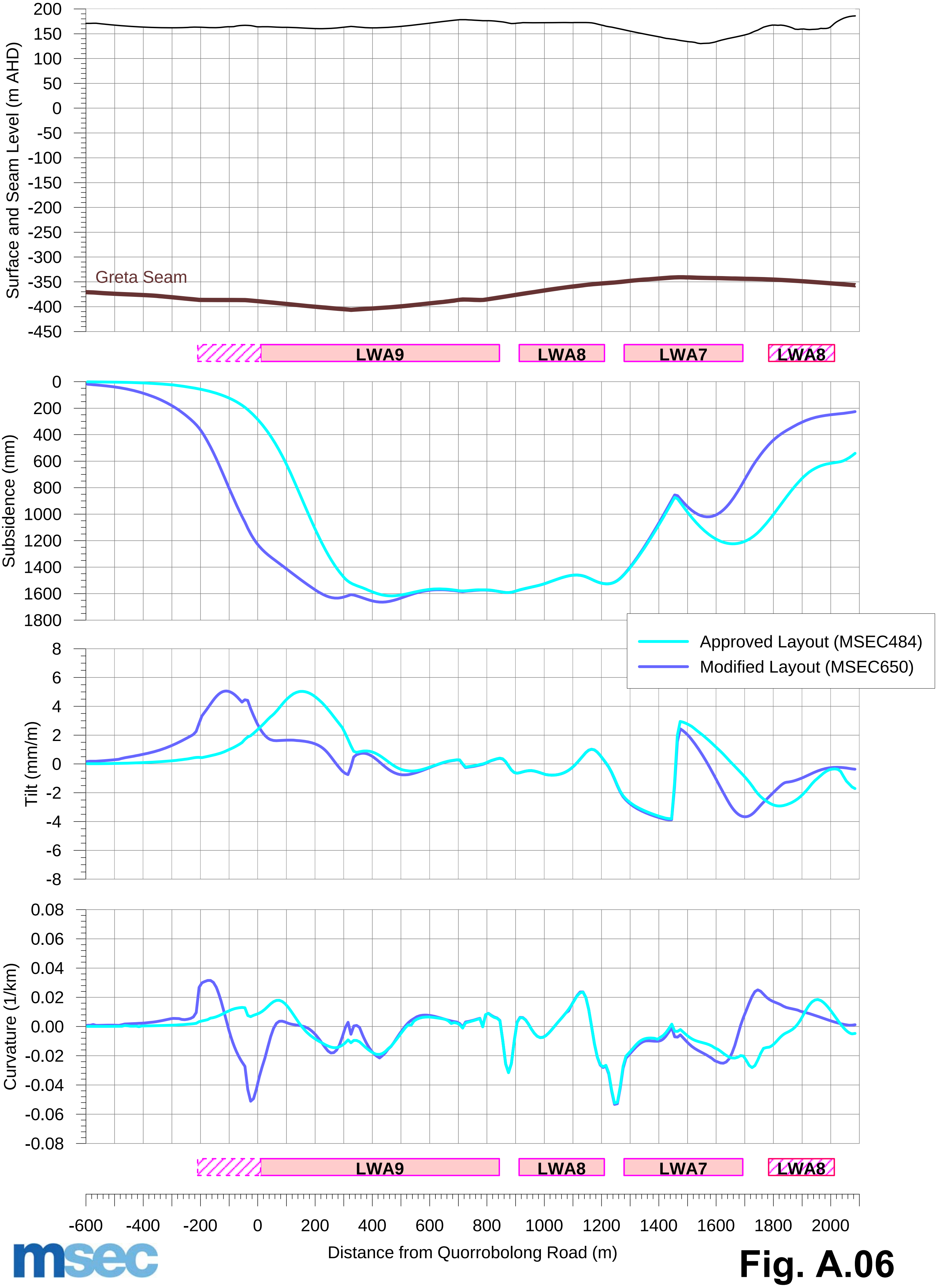

Fig. A.06

APPENDIX B. DRAWINGS

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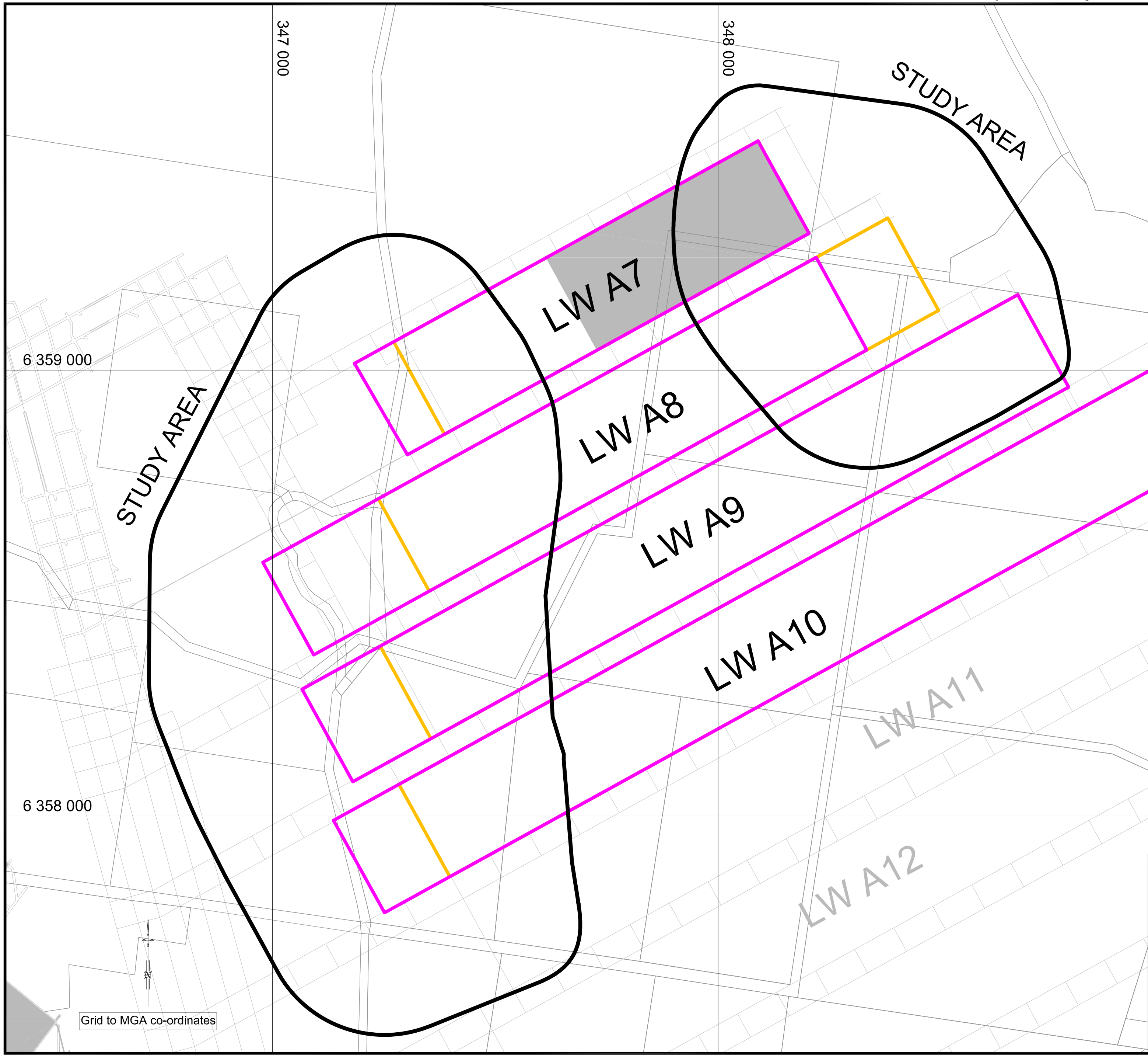

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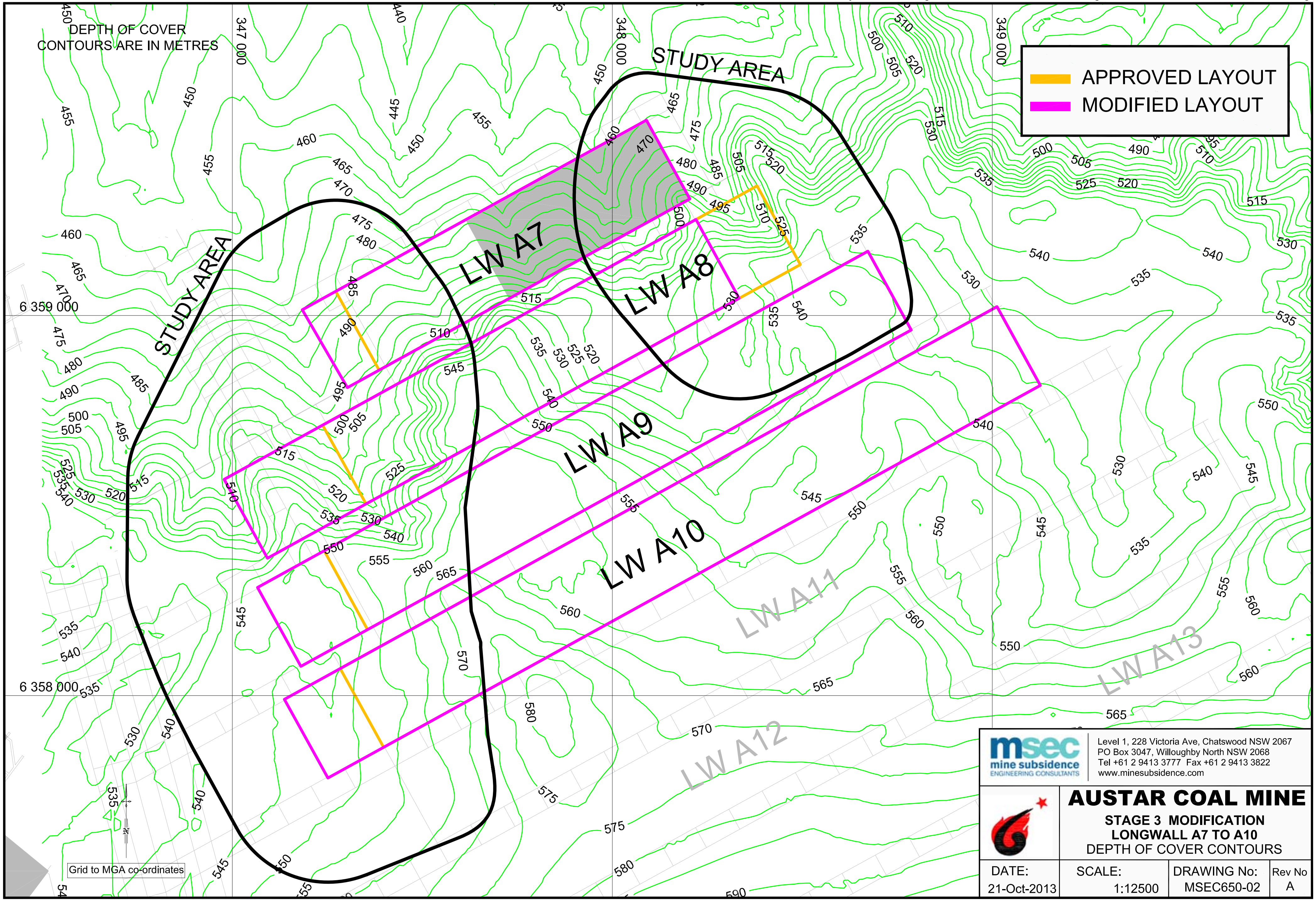
AUSTAR COAL MINE

STAGE 3 MODIFICATION
LONGWALL A7 TO A10
GENERAL LAYOUT

DATE:	SCALE:	DRAWING No:	Rev No
21-Oct-2013	1:12500	MSEC650-01	A



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STAGE 3 MODIFICATION
LONGWALL A7 TO A10
DEPTH OF COVER CONTOURS

DATE:	SCALE:	DRAWING No:	Rev No
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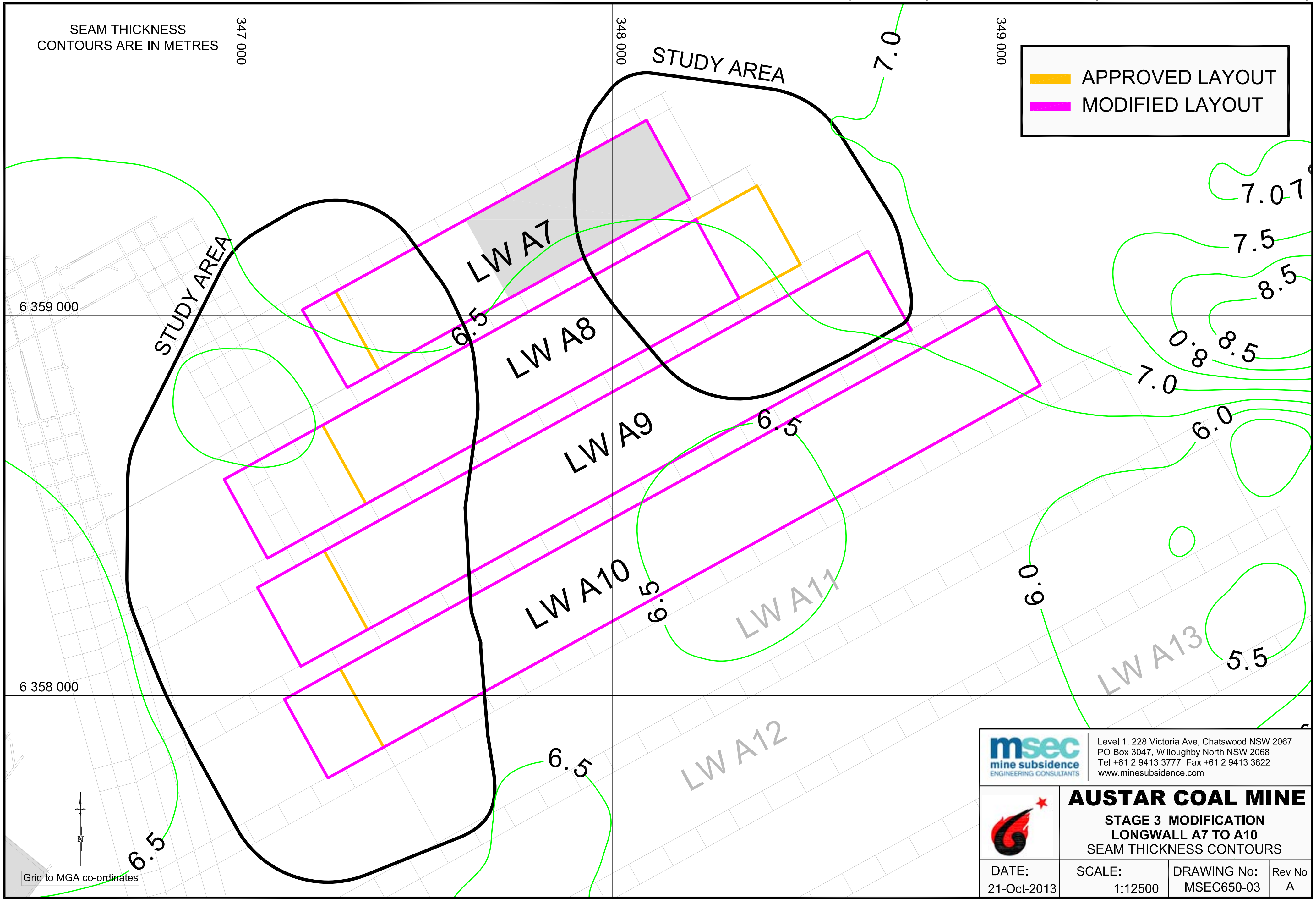

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STAGE 3 MODIFICATION
LONGWALL A7 TO A10
SEAM THICKNESS CONTOURS

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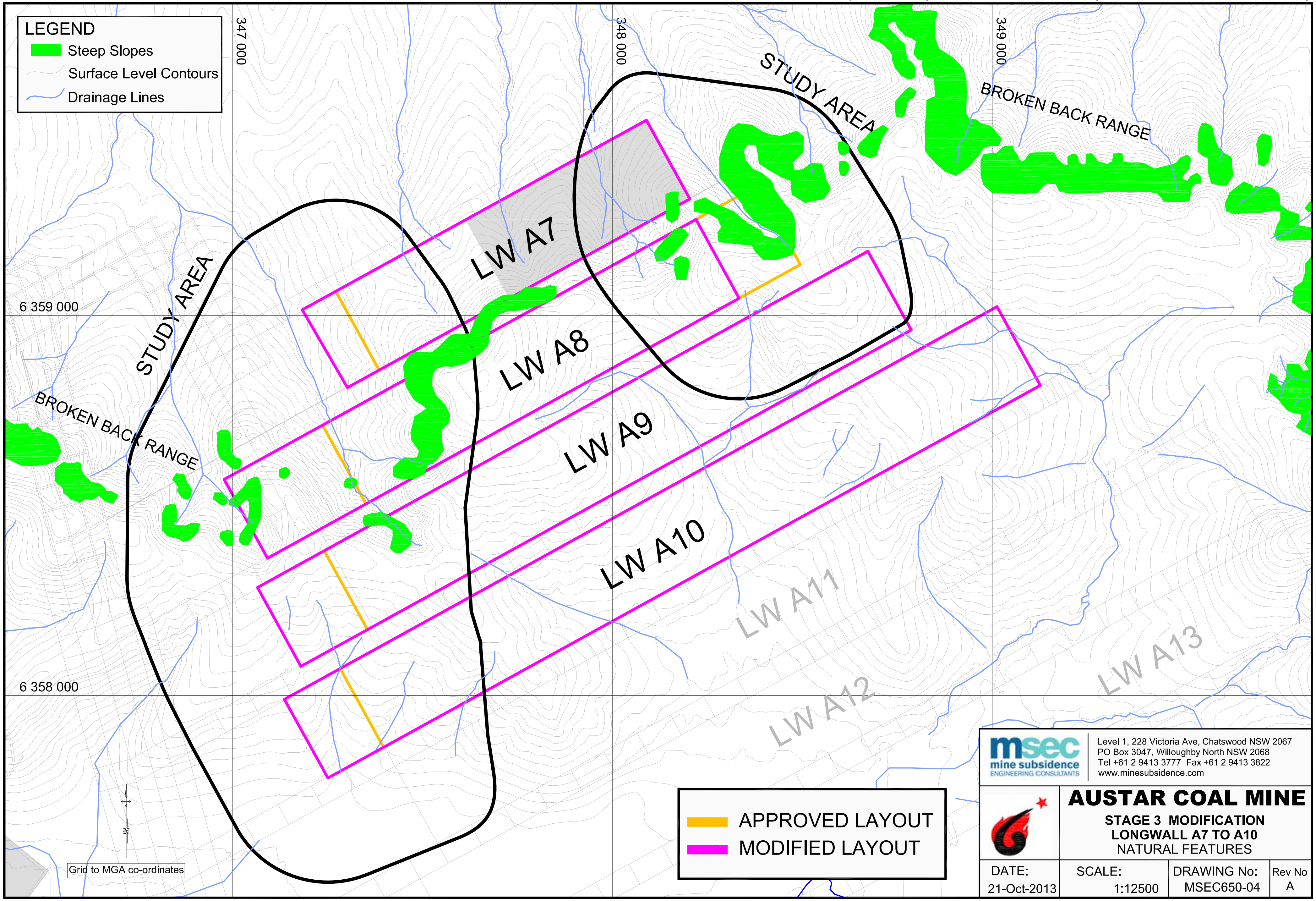

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STAGE 3 MODIFICATION
LONGWALL A7 TO A10
NATURAL FEATURES

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21-Oct-2013	1:12500	MSEC650-04	A

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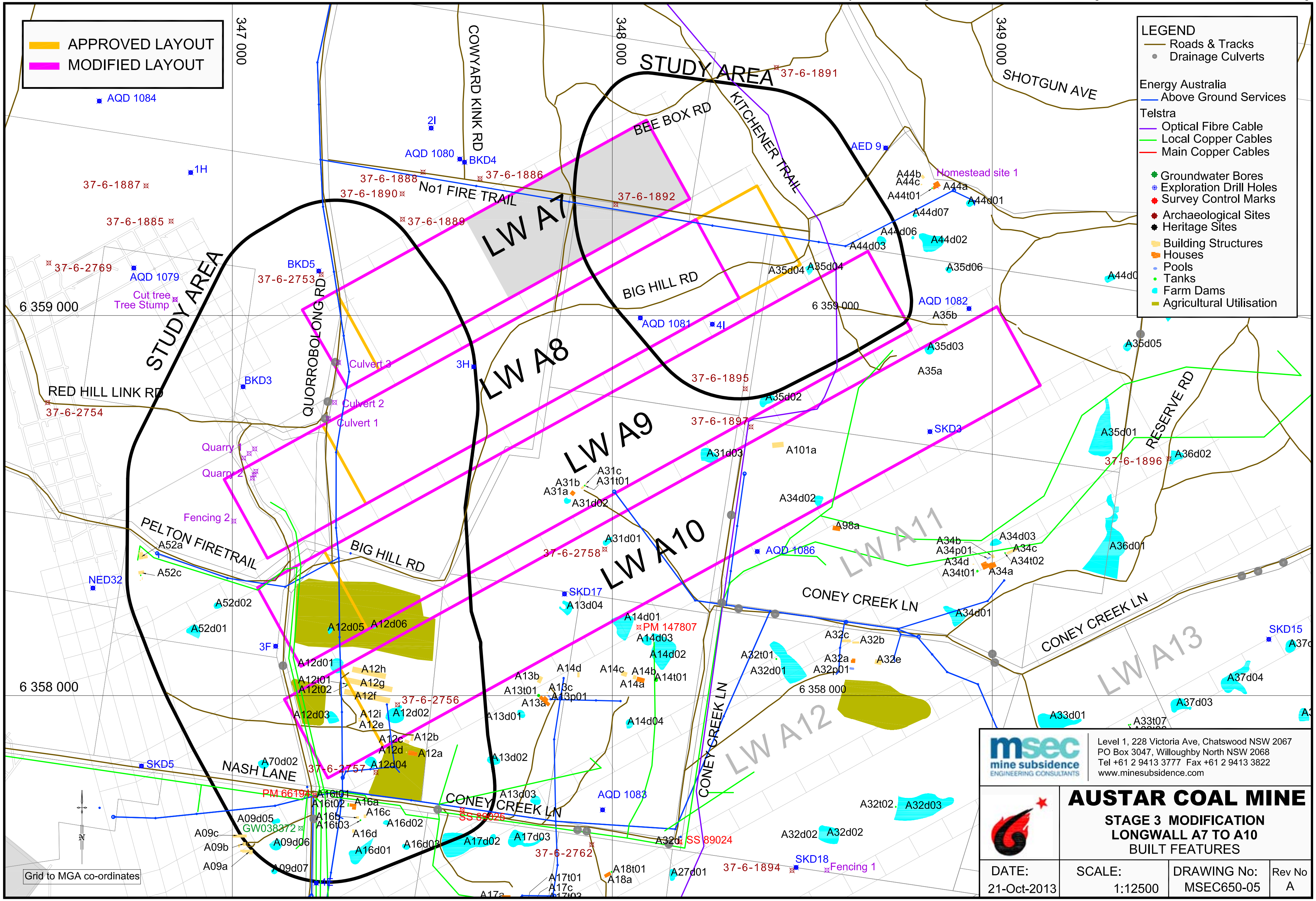

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STAGE 3 MODIFICATION
LONGWALL A7 TO A10
BUILT FEATURES

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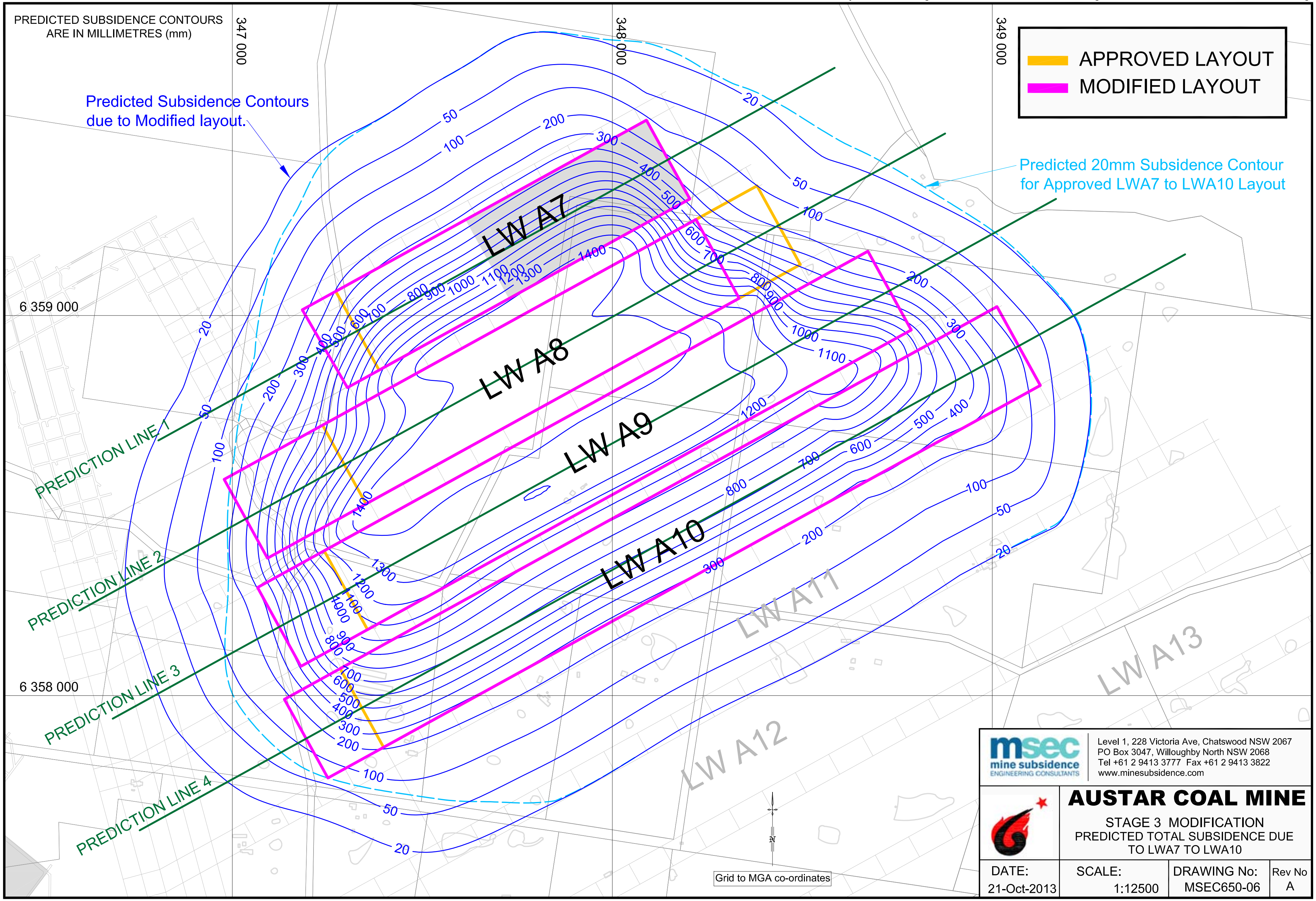

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STAGE 3 MODIFICATION
PREDICTED TOTAL SUBSIDENCE DUE TO LWA7 TO LWA10

DATE:	SCALE:	DRAWING No:	Rev No
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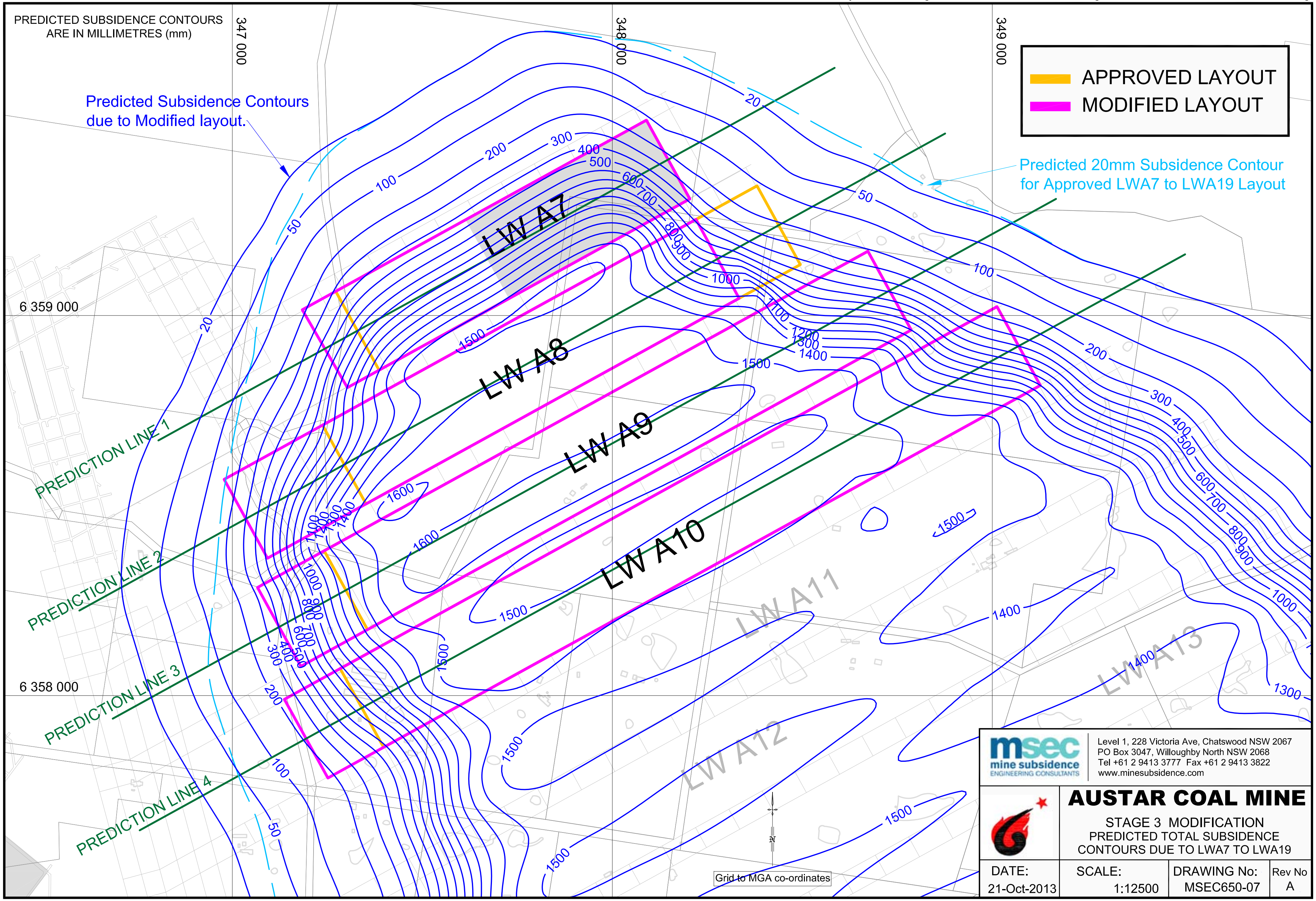

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STAGE 3 MODIFICATION
PREDICTED TOTAL SUBSIDENCE CONTOURS DUE TO LWA7 TO LWA19

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