REPORT: END OF PANEL SUBSIDENCE MONITORING REPORT

mine subsidence ENGINEERING CONSULTANTS

South32

Illawarra Metallurgical Coal

SOUTH32 ILLAWARRA METALLURGICAL COAL:

Dendrobium – Area 3B – Longwall 17

End of Panel Subsidence Monitoring Review Report for Dendrobium Longwall 17

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Associated reports:

WKA77 (January 2001) – Dendrobium Mine Project – Report on the prediction of mining subsidence parameters and the assessment of impacts on surface infrastructure – Longwalls 1 to 18 (in support of the EIS).

MSEC311 (October 2007) – The prediction of subsidence parameters and the assessment of mine subsidence impacts on natural features and surface infrastructure resulting from the extraction of proposed Longwalls 6 to 10 in Area 3A and future longwalls in Areas 3B and 3C at Dendrobium Mine (in support of the SMP Application and the Modification to the Development Consent).

MSEC459 (September 2012) – Dendrobium Area 3B – Longwalls 9 to 18 – subsidence predictions and impact assessments for natural features and surface infrastructure in support of the SMP Application.

MSEC792 (December 2015) – Dendrobium Area 3B – Longwalls 12 to 18 – Review of the subsidence predictions and impact assessments for natural and built features in Dendrobium Area 3B based on observed movements and impacts during Longwalls 9 and 10.

MSEC865 (November 2016) – The effects of the proposed modifications to the ends of Longwalls 12 to 18 in Area 3B at Dendrobium Mine on the subsidence predictions and impact assessments.

MSEC914 (August 2017) – The effects of the proposed modified commencing ends of Longwalls 15 to 18 in Area 3B at Dendrobium Mine on the subsidence predictions and impact assessments.

MSEC992 (November 2018) – Subsidence predictions and impact assessments for the natural and built features due to the extraction of Longwalls 17 and 18 in Area 3B at Dendrobium Mine.

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

Introduction to Longwall Mining and Subsidence (Revision A)

General Discussion of Mine Subsidence Ground Movements (Revision A)

Mine Subsidence Damage to Building Structures (Revision A)

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Drawings

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

1.1. Introduction

Illawarra Metallurgical Coal (IMC) has completed the extraction of Longwall 17 (LW17) at Dendrobium Mine, which is in the Southern Coalfield of New South Wales. The locations of the longwalls in Area 3B at Dendrobium Mine are shown in Drawing No. MSEC1225-01, in Appendix A. The extraction of LW17 commenced on 12 December 2020 and it was completed on 13 October 2021.

Mine Subsidence Engineering Consultants (MSEC) was previously commissioned by IMC to prepare subsidence predictions and impact assessments for Dendrobium Longwalls 9 to 18 (LW9 to LW18) in Area 3B. Report No. MSEC459 (Revision B) was issued in September 2012 in support of the SMP Application for these longwalls.

The subsidence prediction model was reviewed and re-calibrated, based on the updated monitoring data from LW7 and LW8 in Area 3A and LW9 and LW10 in Area 3B. The subsidence predictions and impact assessments for the natural and built features were reviewed and updated based on the re-calibrated subsidence model and are provided in Report No. MSEC792 (Rev. C). The predictions provided in this End of Panel subsidence review report are based on the re-calibrated subsidence prediction model.

IMC shortened the finishing (i.e. eastern) end of LW17 by 236 m from the extent that was indicated in the SMP Application. The maximum height of extraction in the Wongawilli Seam for LW15 to LW18 was also reduced from 4.6 m to 3.9 m. Reports Nos. MSEC865 (Rev. A) and MSEC914 (Rev. A) were issued in support of the applications for these modifications.

IMC submitted a Subsidence Management Plan (SMP) Application for LW17 and LW18. MSEC prepared Report No. MSEC992 (Rev. B) in support of that application. The SMP Application for LW17 was approved by the Department of Planning, Industry and Environment on 11 July 2019.

LW17 finished at maingate cut-through 3 which is approximately 105 m inbye of the approved finishing end at maingate cut-through 2. The as-extracted overall void length of this longwall is approximately 1910 m. The longwall was finished at the earlier cut-through so as to reduce the subsidence effects at Waterfall 54 located along Wongawilli Creek.

In accordance with Condition 9 End of Panel Reporting of the Development Consent (Schedule 3) for the Area 3B longwalls, this report provides:

- comparisons between the measured and predicted subsidence effects at the monitoring lines and points in Dendrobium Area 3B due to the mining of LW17; and
- comparisons between the observed and predicted effects and impacts on the natural and built features within the SMP Area due to the mining of LW17.

Further details on the observed and assessed impacts for natural features, due to the mining of LW17, are provided in the reports by other consultants. The discussions provided in this report should be read in conjunction with those and all other relevant reports.

Chapter 2 of this report describes the locations of the ground monitoring lines and points which were surveyed during the mining of LW17. This section provides comparisons between the measured and predicted effects due to the mining of this longwall.

Chapter 3 of this report describes the natural and built features near LW17. This section provides comparisons between the observed and assessed impacts for these features due to the mining of this longwall.

Chapter 4 of this report provides a summary of the comparisons between the measured and predicted ground movements and the observed and assessed surface impacts due to the mining of LW17.

Appendix A includes all drawings associated with this report.

1.2. Mining geometry

The layout of the longwalls in Area 3B at Dendrobium Mine is shown in Drawing No. MSEC1225-01, in Appendix A. A summary of the as-extracted dimensions for LW9 to LW17 is provided in Table 1.1.

Table 1.1 Mining geometry of the as-extracted longwalls

Location	Longwall	Overall void length including installation heading (m)	Overall void width including first workings (m)	Overall tailgate chain pillar width (m)
Area 3B	LW9	2162	305	-
	LW10	2219	305	45
	LW11	2204	305	45
	LW12	2602	305	45
	LW13	2223	305	45
	LW14	1980	305	45
	LW15	1963	305	45
	LW16	1874	305	45
	LW17	1910	305	45

The mined lengths of the longwalls excluding the installation headings are approximately 9 m shorter than the overall void lengths provided in Table 1.1. The length of extraction for LW17, therefore, is approximately 1901 m. The longwall face widths excluding the first workings are approximately 294 m.

The longwalls in Area 3B have been extracted from the Wongawilli Seam, from the west towards the east, i.e. towards Wongawilli Creek. The natural surface and the seam levels along the centreline of LW17 are illustrated in Fig. 1.1.

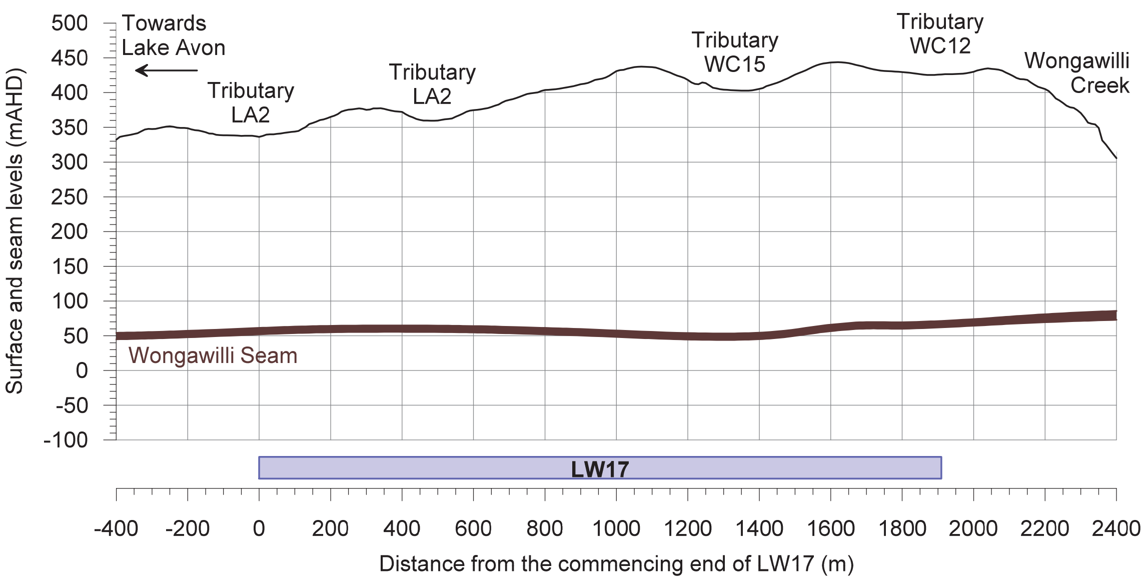

Fig. 1.1 Surface and seam levels along the centreline of LW17

The depth of cover to the Wongawilli Seam, directly above the as-extracted extent of LW17, varies between a minimum of 280 m above the commencing (i.e. western) end of the longwall and a maximum of 390 m near the middle of the longwall. The seam floor within the mining area generally dips from the south to the north, having an average dip around 2 %, or 1 in 50.

The extraction height varies along the length of LW17, depending on the local roof conditions, with a maximum mining height of 3.9 m. The predictions provided in this report have been based on the maximum proposed extraction height of 3.9 m, as adopted in Reports Nos. MSEC459, MSEC792, MSEC865 and MSEC992.

2.1. Introduction

The mine subsidence effects due to the mining of Dendrobium LW17 were monitored along several monitoring lines and monitoring points including the following:

- Wongawilli Creek closure lines;
- Avon Dam closure lines;
- Area 3B and Avon Dam 3D monitoring points;
- Tributary cross lines;
- Swamp cross lines;
- Waterfall 54; and
- Airborne laser scans of the area.

The locations of these survey lines and survey points are shown in Drawing No. MSEC1225-01, in Appendix A. Comparisons between the measured and predicted subsidence effects at these monitoring lines and points are provided in the following sections. The predicted subsidence effects have been obtained using the re-calibrated subsidence model presented in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.2. Wongawilli Creek closure lines

The closure movements across Wongawilli Creek have been measured by IMC using 2D survey techniques at the Wong X D-Line and Wong X E-Line. The Wong X A-Line, Wong X B-Line and Wong X C-Line were not measured at the completion of LW17 due to their distances from that longwall.

The locations of the Wongawilli Creek closure lines are shown in Drawing No. MSEC1225-01. The survey dates for these monitoring lines are provided in Table 2.1.

Table 2.1 Survey dates for the Wongawilli Creek closure lines for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Completion of LW17	13 February 2013 (base survey) 4 March 2016 (end of LW11) 28 April 2017 (end of LW12) 14 June 2018 (end of LW13) 28 March 2019 (end of LW14) 28 March 2020 (end of LW15) 10 December 2020 (end of LW16) 11 December 2021 (end of LW17)	Completion of LW18

The monitoring lines each comprise two survey marks, with the marks located on either side of Wongawilli Creek and, therefore, they measure closure between the valley sides. Survey marks could not be installed near the base of the valley due to the difficult terrain and safety concerns with access. The upsidence in the base of the valley, therefore, could not be measured.

The development of total closure for the Wongawilli Creek closure lines, due to the mining of LW6 to LW17, is illustrated in Fig. 2.1. The base survey for the Wong X D-Line was carried out after the completion of LW12 and, therefore, this line measured the additional movements due to LW13 to LW17 only. The base survey for the Wong X E-Line was carried out after the completion of LW14 and, therefore, this line measured the additional movements due to LW15 to LW17 only.

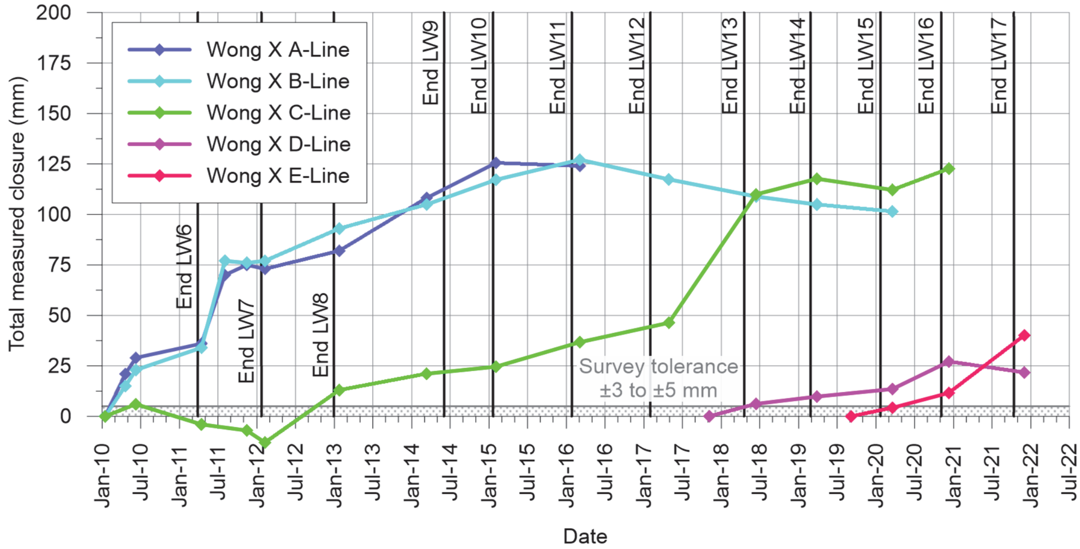

Fig. 2.1 Development of total closure for the Wongawilli Creek closure lines

The predictions of vertical subsidence, upsidence and closure for Wongawilli Creek, due to the mining of Dendrobium LW6 to LW19, are provided in Report No. MSEC865. The measured and predicted total closures along Wongawilli Creek after the completion of LW17 are illustrated in Fig. 2.2.

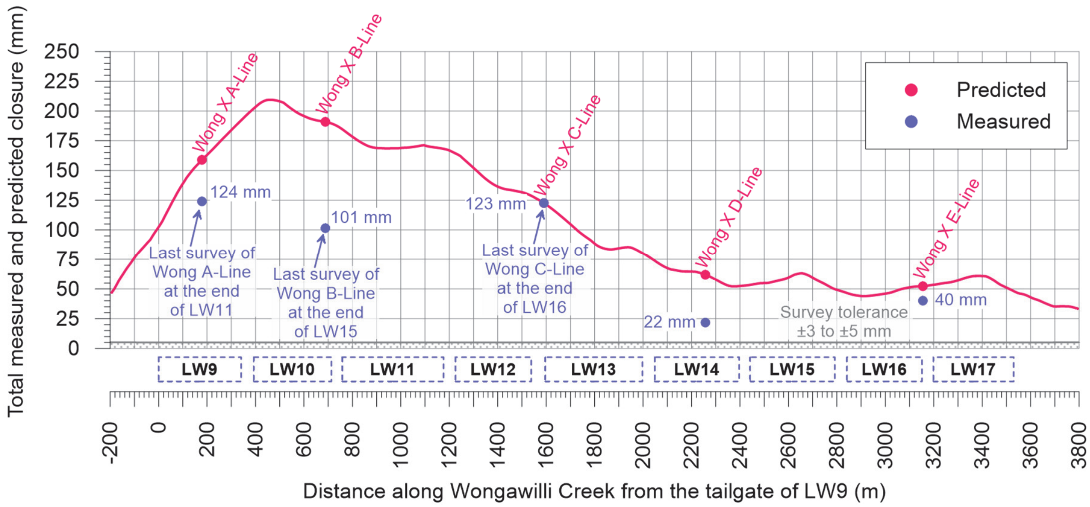

Fig. 2.2 Measured and predicted total closure along Wongawilli Creek after LW17

A summary of the maximum measured and maximum predicted total closure movements for each of the Wongawilli Creek closure lines, due to the mining of LW6 to LW17, is provided in Table 2.2. The predicted total closures consider the shortened finishing ends of LW11, LW12, LW14, LW15 and LW16 but adopts the approved finishing end of LW17 at maingate cut-through 2.

Table 2.2 Measured and predicted total closure at the Wongawilli Creek closure lines due to the mining of LW6 to LW17

Location	Longwalls	Measured total closure (mm)	Predicted total closure (mm)
Wong X A-Line	LW6 to LW11	124	160
Wong X B-Line	LW6 to LW15	101	190
Wong X C-Line	LW6 to LW16	123	120
Wong X D-Line	LW13 to LW17	22	60
Wong X E-Line	LW15 and LW17	40	50

The accuracies of the measured closure movements are in the order of ±5 mm.

The measured total closure at the Wong X C-Line of 123 mm is similar to but slightly greater than the predicted total closure of 120 mm. The exceedance of 3 mm represents less than 3 % of the predicted value and it is in the order of survey tolerance. The maximum measured total closures at the remaining Wongawilli Creek closure lines are less than the predicted values at the completion of LW17.

It is considered that the movements measured using the Wongawilli Creek closure lines are reasonably consistent with the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.3. Avon Dam closure lines

The closure across the Avon Dam has been measured by IMC using the Avon Dam A-Line to E-Line. The locations of these monitoring lines are shown in Drawing No. MSEC1225-01. The discussions on the Avon Dam 3D monitoring points are included in Section 2.4.

The survey dates for the Avon Dam closure lines are provided in Table 2.3. The base surveys were carried out just prior to the commencement of LW12 and, therefore, the closure lines have measured the accumulated movements due to the mining of LW12 to LW17.

Table 2.3 Survey dates for the Avon Dam closure lines during LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Completion of LW17	12 February 2016 (base survey) 30 August 2016 (end of LW12) 23 May 2018 (end of LW13) 2 April 2019 (end of LW14) 5 February 2020 (end of LW15) 9 December 2020 (end of LW16) 16 April 2021 24 June 2021 21 October 2021 (end of LW17)	Completion of LW18

The monitoring lines each comprise two survey marks, with the marks located on either side of the Avon Dam and, therefore, they measure closure or opening between the valley sides. Survey marks could not be installed near the base of the valley due to the stored water in the dam and high water levels impeding access. The upsidence in the base of the valley, therefore, could not be measured.

The development of the measured accumulated movements across the Avon Dam closure lines during the mining of LW12 to LW17 are illustrated in Fig. 2.3. The mining of LW17 has resulted in a 2 mm increase in the closure measured at the A-Line, 4 mm decreases in the opening movements measured at the B-Line and C-Line, and 7 mm and 8 mm increases in the opening movements of 7 mm and 8 mm at the D-Line and E-Line, respectively.

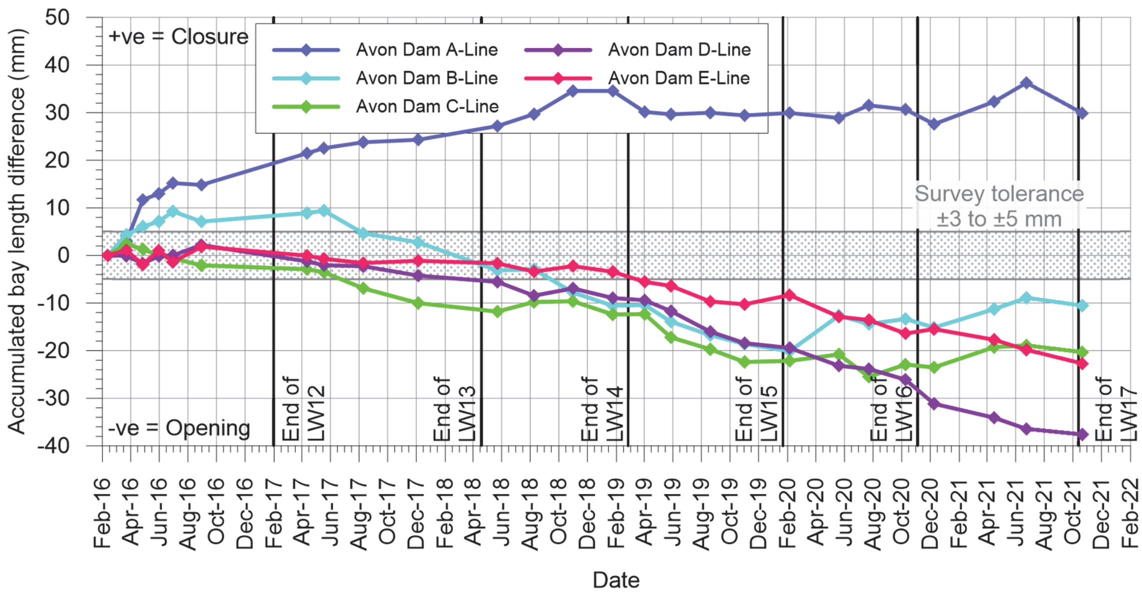

Fig. 2.3 Measured accumulated closure for the Avon Dam closure lines

A summary of the maximum measured and maximum predicted accumulated movements for each of the Avon Dam closure lines, due to the mining of LW12 to LW17, is provided in Table 2.4. The predicted closures due to the earlier extracted LW9 to LW11 are negligible, i.e. less than 20 mm. The measured values are based on the latest survey dated 21 October 2021. The vertical subsidence was not measured using these monitoring lines.

Table 2.4 Maximum measured and maximum predicted accumulated movements for the Avon Dam closure lines due to the mining of LW12 to LW17

Location	Measured accumulated closure (mm)	Predicted accumulated closure (mm)
Avon Dam A-Line	30	70
Avon Dam B-Line	-11 (opening)	90
Avon Dam C-Line	-20 (opening)	90
Avon Dam D-Line	-38 (opening)	60
Avon Dam E-Line	-23 (opening)	60

The accuracies of the measured closure movements are in the order of ±5 mm.

The measured total closure at the Avon Dam A-Line is less than the predicted value at the completion of LW17. Net opening movements have been measured at the Avon Dam B-Line to E-Line due to the conventional subsidence effects (i.e. horizontal movements towards the mining area) being greater that the valley-related effects (i.e. closure). The absolute magnitudes of the measured opening movements are less than the absolute magnitudes of the predicted closure movements.

The movements across Avon Dam and two tributaries to the dam (Refs. LA4A and LA4B) have also been measured by IMC using the Avon Dam GPS (Marks DA3B-05A, DA3B-06 and DA3B-07). The base survey was carried out on the 26 February 2013, i.e. prior to the commencement of LW9. Subsequent surveys were carried out on the same dates as the Avon Dam closure lines, as summarised in Table 2.3.

The development of the measured accumulated movements across LA4A (DA3B-06 to DA3B-07), LA4B (DA3B-05A to DA3B-06) and the Avon Dam (DA3B-05A to DA3B-07) during the mining of LW12 to LW17 are illustrated in Fig. 2.4. The extraction of LW17 has resulted in a 5 mm increase in the closure measured at the LA4A monitoring line, a 9 mm reduction in the opening measured at the LA4B monitoring line and negligible change (i.e. less than 2 mm) at the Avon Dam monitoring line.

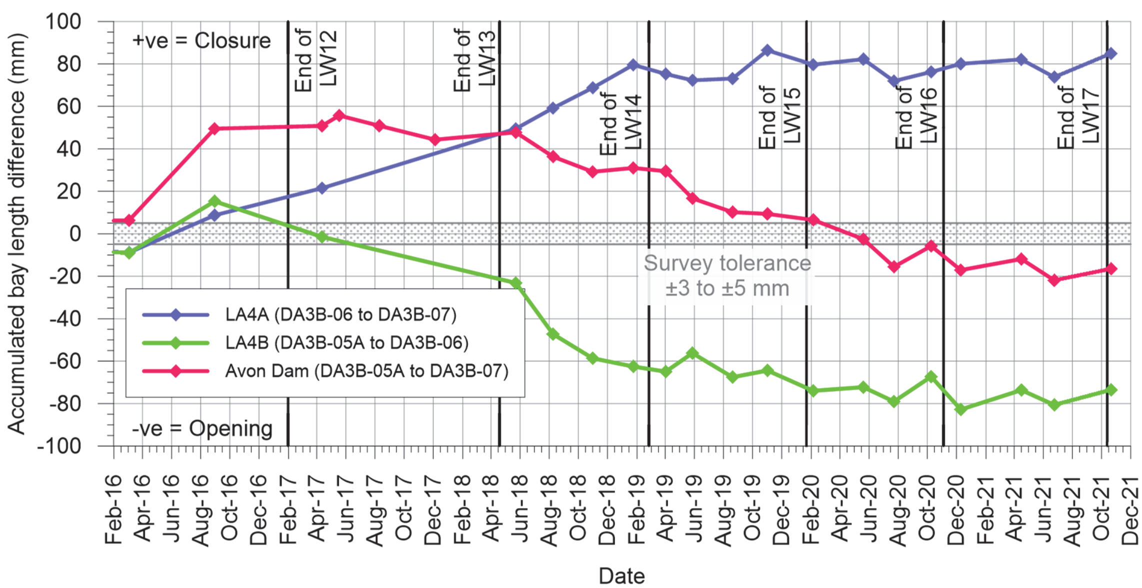

Fig. 2.4 Measured accumulated closure for Tributaries LA4A and LA4B and Avon Dam

A summary of the total measured and total predicted closures across LA4A, LA4B and Avon Dam, due to the mining of LW9 to LW17, is provided in Table 2.5. The measured values are based on the latest survey dated 9 December 2020. The vertical subsidence was not measured using these monitoring lines.

Table 2.5 Maximum measured and predicted total closure across LA4A, LA4B and Avon Dam due to the mining of LW9 to LW17

Location	Measured accumulated closure (mm)	Predicted accumulated closure (mm)
LA4A (DA3B-06 to DA3B-07)	85	170
LA4B (DA3B-05A to DA3B-06)	-74 (opening)	170
Avon (DA3B-05A to DA3B-07)	-16 (opening)	80

The accuracies of the measured closure movements are in the order of ±5 mm.

The measured total closure at the LA4A monitoring line is less than the predicted value at the completion of LW17. Net opening movements have been measured at the LA4B and Avon monitoring lines due to the conventional subsidence effects (i.e. horizontal movements towards the mining area) being greater that the valley-related effects (i.e. closure). The absolute magnitudes of the measured opening movements are less than the absolute magnitudes of the predicted closure movements.

The maximum measured total closure across Lake Avon is less than the maximum predicted value at the completion of LW17. It is considered that the ground movements measured using these monitoring lines are consistent with the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.4. Dendrobium Area 3B and the Avon Dam three-dimensional monitoring points

The far-field horizontal movements near LW17 have been measured by IMC using the Dendrobium Area 3B 3D monitoring points (DA3B 3D) and the Avon Dam 3D monitoring points. The locations of these monitoring points are shown in Drawing No. MSEC1225-01.

The survey dates for the DA3B 3D monitoring points for LW17 are provided in Table 2.6. The survey dates and monitoring commitments for the Avon Dam 3D monitoring points (not shown in the table below) are the same as the Avon Dam closure lines provided in Table 2.3.

Table 2.6 Survey dates for the DA3B 3D monitoring points for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Completion of LW17	26 February 2013 (base survey) 4 March 2016 (end of LW11) 9 March 2017 (end of LW12) 15 May 2018 (end of LW13) 23 April 2019 (end of LW14) 24 April 2020 (end of LW15) 10 December 2020 (end of LW16) 4 November 2021 (end of LW17)	Completion of each of the future longwalls in Area 3B

The measured incremental horizontal movement vectors for DA3B 3D and the Avon Dam 3D monitoring points, due to the mining of LW17, are shown in Drawing No. MSEC1225-04. The accuracies of the measured absolute positions (i.e. eastings and northings) are in the order of ±20 mm.

The greatest incremental horizontal movements occur directly above LW17 and, to a lesser extent, above the adjacent LW16. The maximum measured incremental value due to the mining of LW17 is 353 mm at Mark DA3b-50 which is located directly above that longwall.

The vectors of incremental horizontal movement located above LW17 are orientated towards the south and towards the east, i.e. towards the longwall finishing end or in the downslope direction. The vectors located above the previously mined longwalls are orientated towards the south, i.e. towards LW17. Only low level incremental horizontal movements have been measured outside the extents of the mining area.

The comparison between the maximum measured incremental horizontal movements at the DA3B 3D and Avon Dam 3D monitoring points with those previously measured in Dendrobium Area 1 (DA1 3D) and Dendrobium Area 2 (DA2 3D), Dendrobium Area 3A (DA3A 3D), as well as other collieries in the Southern Coalfield, is provided in Fig. 2.5. The mean and the 95 % confidence level for the 3D monitoring data at Dendrobium Mine are also shown in this figure.

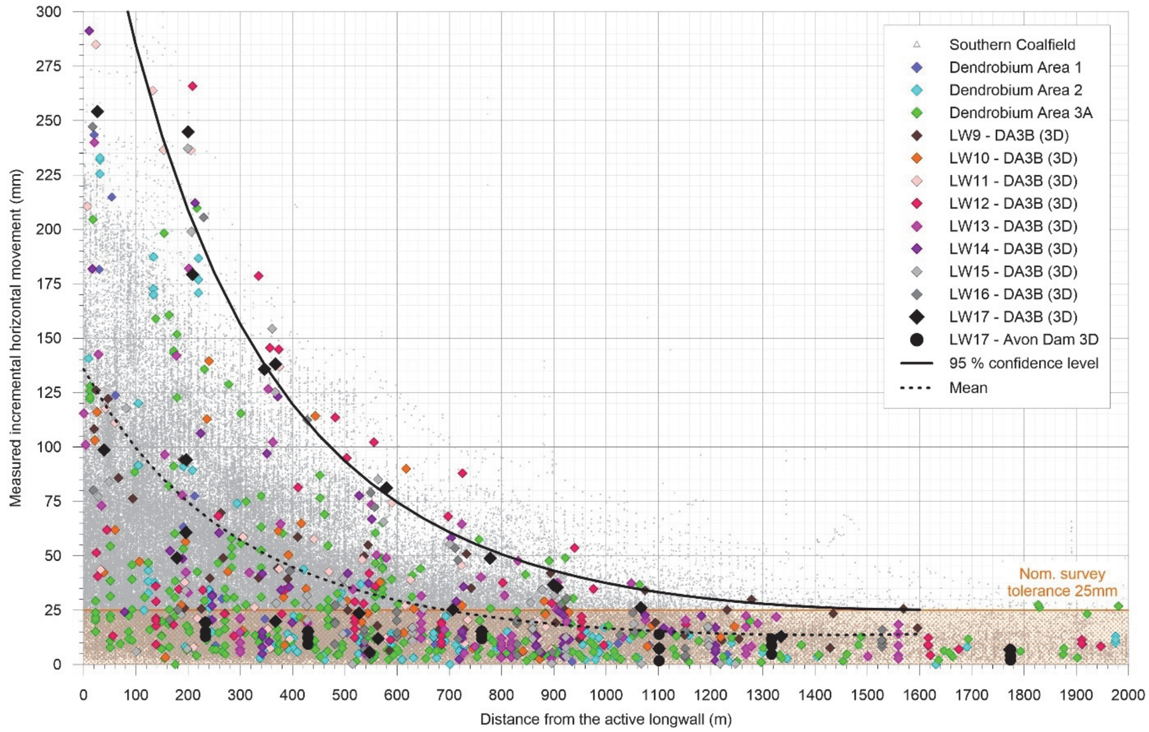

Fig. 2.5 Measured incremental horizontal movements at Dendrobium Mine

The measured incremental horizontal movements due to the mining of LW17 (i.e. black diamonds and circles) are typically within the range of those measured at similar distances from previously extracted longwalls at Dendrobium Mine (i.e. blue, cyan, green, brown, orange, red, magenta, purple and grey diamonds) and elsewhere in the Southern Coalfield (i.e. grey triangles).

2.5. LA2 cross lines

The mine subsidence effects for LA2 (a tributary to Lake Avon) have been measured by IMC using 2D survey techniques using the LA2 RB2-Line and LA2 RB13-Line. The locations of these monitoring lines are shown in Drawing No. MSEC1225-01. The survey dates for the LA2 cross lines for LW17 are provided in Table 2.7.

Table 2.7 Survey dates for the LA2 cross lines for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
First survey 100 m before lines, then monthly surveys. Final survey when mining 400 m past lines	6 September 2019 (base survey) 10 December 2020 (end of LW16) 18 February 2021 15 April 2021 1 December 2021 (end of LW17)	First survey 100 m before lines, then monthly surveys. Final survey when mining 400 m past lines

The development of the measured total closures at the LA2 cross lines are illustrated in Fig. 2.6. These two monitoring lines were established during the mining of LW15 and, therefore, they do not include the effects of LW9 to LW14 and part of LW15. These monitoring lines have short lengths and are located near the valley base and, therefore, they may not measure the maximum closure within the valley.

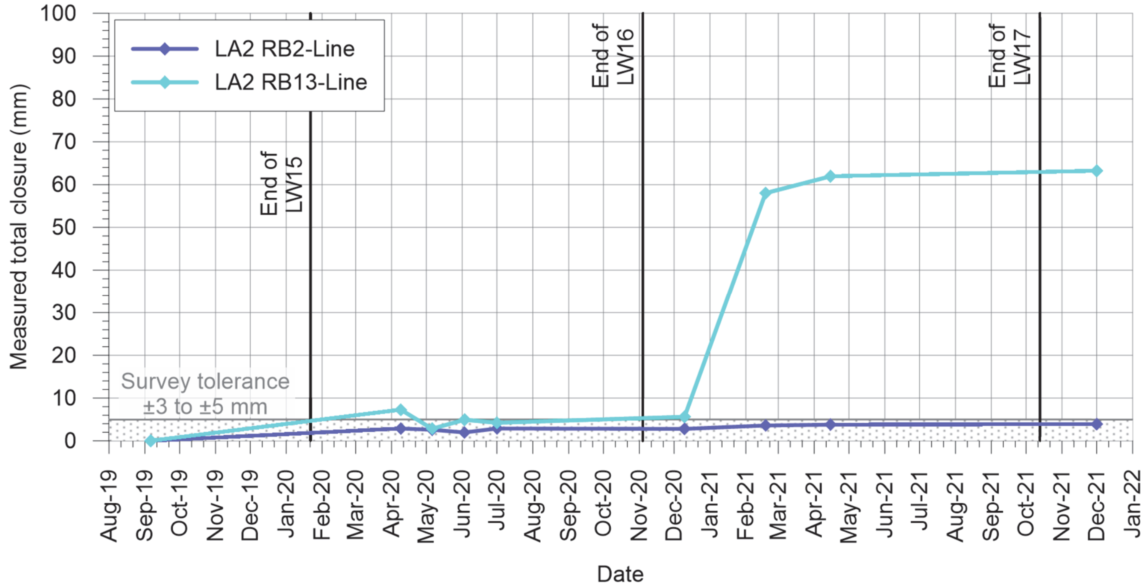

Fig. 2.6 Measured total closure for the LA2 cross lines due part LW15 to LW17

Only low-level closure has been measured at the LA2 RB2-Line due to the mining of part LW15 to LW17. This movement is similar to the order of survey tolerance.

Summaries of the maximum measured and predicted total subsidence and closure at the LA2 cross lines, after the completion of LW17, are provided in Table 2.8 and Table 2.9. The predicted subsidence values have been derived from the predicted subsidence contours illustrated in Report No. MSEC865. The predicted closures are based on a combination of the conventional horizontal movements and valley related movements, taking the equivalent heights of the valleys within half-depths of cover from the valley bases.

Table 2.8 Maximum measured and predicted total subsidence and closure at the LA2 RB2-Line due to the mining of part LW15 to LW17

Type	Maximum total subsidence (mm)	Maximum total closure (mm)
Measured	6	4
Predicted	< 20	50

Table 2.9 Maximum measured and predicted total subsidence and closure at the LA2 RB13-Line due to the mining of part LW15 to LW17

Type	Maximum total subsidence (mm)	Maximum total closure (mm)
Measured	1404	63
Predicted	1750	350

The accuracies of the measured absolute levels of the survey marks are in the order of ±30 mm. The accuracies of the measured closures are in the order of ±5 mm.

Only low-level vertical subsidence and closure have been measured at the LA2 RB2-Line which are similar to the order of survey tolerance. The ground movements measured using LA2 RB13-Line are less than the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.6. WC7 and WC12 cross lines

The mine subsidence effects for WC7 and WC12 (tributaries to Wongawilli Creek) have been measured by IMC using 2D survey techniques using the WC7 RB7-Line and WC12 RB18-Line, respectively. The locations of these monitoring lines are shown in Drawing No. MSEC1225-01. The survey dates for the WC7 and WC12 cross lines for LW17 are provided in Table 2.10.

Table 2.10 Survey dates for the WC7 and WC12 cross lines for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
	6 September 2019 (base survey) 10 December 2020 (end of LW16)	
Monthly once the longwall face is nominally 100 m before the cross line until it is 400 m past	29 July 2021 20 August 2021 3 September 2021 6 September 2021 8 September 2021 10 September 2021 13 September 2021 15 September 2021 17 September 2021 20 September 2021 23 September 2021 27 September 2021 30 September 2021 7 October 2021 19 October 2021 28 October 2021 18 November 2021 1 December 2021 (end of LW17)	Monthly once the longwall face is nominally 100 m before the cross line until it is 400 m past

The development of the measured accumulated closure at the WC7 and WC12 cross lines are illustrated in Fig. 2.7. The WC7 cross line was established during the mining of LW17 and, therefore, it does not include the effects of the previous longwalls. The WC12 cross line was established during the mining of LW15 and, therefore, it does not include the effects of LW9 to LW14 and part of LW15. These two monitoring lines have short lengths and they are located near the valley base and, therefore, they may not measure the maximum closure within the valley.

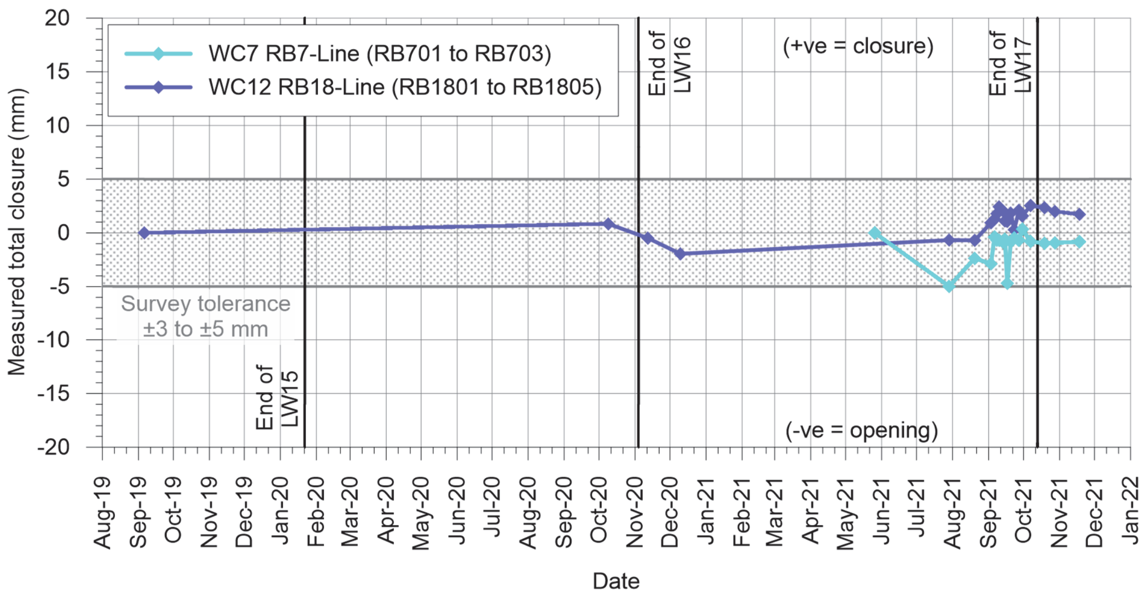

Fig. 2.7 Measured accumulated closure for the WC7 and WC12 cross lines

The extraction of LW17 has resulted in negligible change (i.e. less than 2 mm) in the closure measured at the WC7 RB7-Line and WC12 RB18-Line. The measured movements are in the order of survey tolerance.

Summaries of the maximum measured and predicted subsidence and closure at the WC7 and WC12 cross lines, after the completion of LW17, are provided in Table 2.11 and Table 2.12, respectively. The predicted subsidence value has been derived from the predicted subsidence contours illustrated in Report No. MSEC865. The predicted closure is based on a combination of the conventional horizontal movements and valley related movements, taking the equivalent height of the valley within half-depth of cover from the valley base.

Table 2.11 Maximum measured and predicted incremental subsidence and closure at the WC7 RB7-Line due to the mining of LW17 only

Type	Maximum accumulated subsidence (mm)	Maximum accumulated closure (mm)
Measured	-3 (uplift)	-1 (opening)
Predicted	< ±20	80

Table 2.12 Maximum measured and predicted accumulated subsidence and closure at the WC12 RB18-Line due to the mining of part LW15, LW16 and LW17

Type	Maximum accumulated subsidence (mm)	Maximum accumulated closure (mm)
Measured	25	2
Predicted	80	270

The accuracies of the measured absolute levels of the survey marks are in the order of ±30 mm. The accuracies of the measured closures are in the order of ±5 mm.

Only low-level vertical subsidence and closure have been measured at the WC7 RB7-Line which are similar to the order of survey tolerance. The ground movements measured at the WC12 RB18-Line are less than the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.7. WC15 cross lines

The mine subsidence effects for WC15 (a tributary to Wongawilli Creek) have been measured by IMC using 2D survey techniques using the WC15 RB9-Line, WC15 RB28-Line and WC15 RB34-Line. The locations of the WC15 cross lines are shown in Drawing No. MSEC1225-01. The survey dates for these monitoring lines for LW17 are provided in Table 2.13.

Table 2.13 Survey dates for the WC15 cross lines for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
Monthly once the longwall face is nominally 100 m before the cross line until it is 400 m past	13 December 2018 (base survey) 28 March 2019 (end of LW14) 18 March 2020 (end of LW15) 10 December 2020 (end of LW16) 26 May 2021 29 July 2021 20 August 2021 17 September 2021 19 October 2021 1 December 2021 (end of LW17)	Monthly once the longwall face is nominally 100 m before the cross line until it is 400 m past

The development of the measured accumulated closures at the WC15 cross lines are illustrated in Fig. 2.8. The monitoring lines were established during the mining of LW14 and, therefore, they do not include the effects of LW9 to LW13 and part of LW14. These monitoring lines have short lengths and they are located near the valley base and, therefore, they may not measure the maximum closure within the valley.

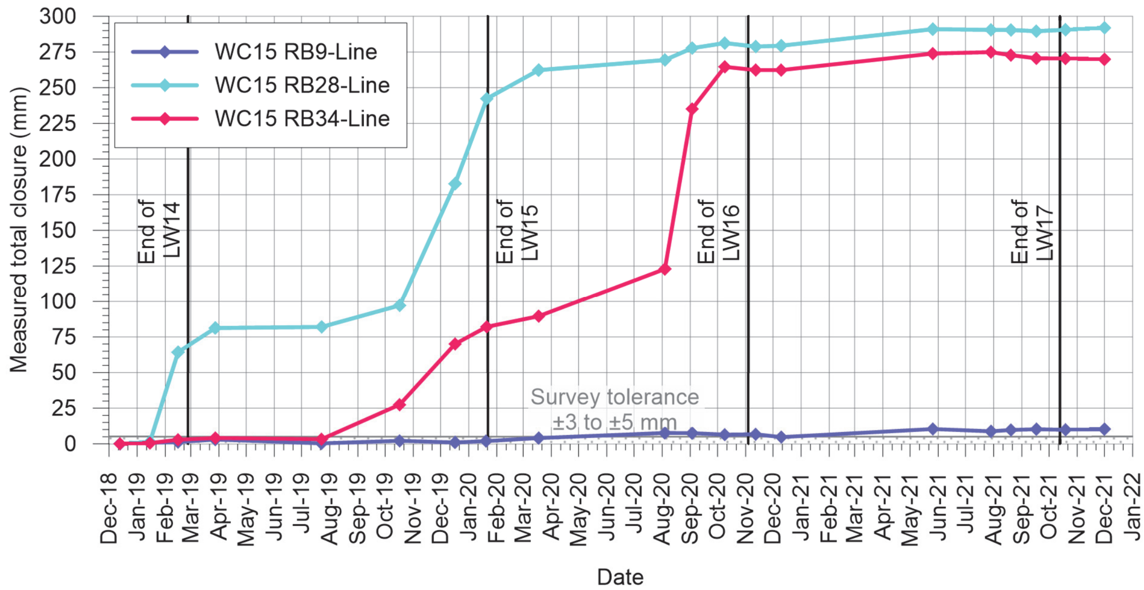

Fig. 2.8 Measured accumulated closure for the WC15 cross lines due to LW14 to LW17

The measured closures at the WC15 RB9-Line, WC15 RB28-Line and W15 RB34-Line increased by values ranging between 6 mm and 12 mm due to the mining of LW17. There were only small changes in the measured movements due to the distances of these monitoring lines from LW17.

Summaries of the maximum measured and predicted accumulated subsidence and closure at the WC15 closure lines, due to the mining of LW14 to LW17, are provided in Table 2.14 to Table 2.16. The predicted subsidence values have been derived from the predicted subsidence contours illustrated in Report No. MSEC865. The predicted closures are based on a combination of the conventional horizontal movements and valley related movements, taking the equivalent heights of the valleys within half-depths of cover from the valley bases.

Table 2.14 Maximum measured and predicted accumulated subsidence and closure at the WC15 RB9-Line due to the mining of LW14 to LW17

Type	Maximum accumulated subsidence (mm)	Maximum accumulated closure (mm)
Measured	-13 (Uplift)	10
Predicted	< ±20	290

Table 2.15 Maximum measured and predicted accumulated subsidence and closure at the WC15 RB28-Line due to the mining of LW14 to LW17

Type	Maximum accumulated subsidence (mm)	Maximum accumulated closure (mm)
Measured	369	292
Predicted	500	390

Table 2.16 Maximum measured and predicted incremental subsidence and closure at the WC15 RB34-Line due to the mining of LW14 to LW17

Type	Maximum accumulated subsidence (mm)	Maximum accumulated closure (mm)
Measured	684	270
Predicted	1250	510

The accuracies of the measured absolute levels of the survey marks are in the order of ±30 mm. The accuracies of the measured closures are in the order of ±5 mm.

The subsidence measured at WC15 RB28-Line and WC15 RB34-Line of 369 mm and 684 mm, respectively, are less than the predicted values. Low-level net uplift was measured at WC15 RB9-Line which is in the order of the survey tolerance for absolute height.

The closures measured at the WC15 RB9-Line, WC15 RB28-Line and WC15 RB28-Line are less than the predicted values at the completion of LW17. While the measured closure at WC15 RB34-Line previously exceeded the prediction at the completion of LW16, the measured value is now less than the predicted value at the completion of LW17.

The ground movements measured using the WC15 cross lines are less than the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.8. Swamp cross lines

The mine subsidence effects at the swamps and their associated drainage lines have been measured by IMC using 2D survey techniques. Only the SW23-Line across Swamp 23 was measured during the mining of LW17. Other swamp monitoring lines are located outside the zone of influence for LW17.

The locations of the swamp cross lines are shown in Drawing No. MSEC1225-01. The survey dates for the SW23-Line are provided in Table 2.17.

Table 2.17 Survey dates for the SW23-Line during LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
First survey 100 m before lines then monthly surveys, final survey when mining 400 m past lines	26 June 2018 (base survey)	First survey 100 m before lines then monthly surveys, final survey when mining 400 m past lines
	26 March 2019 (end of LW14) 18 March 2020 (end of LW15) 11 December 2020 (end of LW16)	
	3 May 2021 28 October 2021 (end of LW17)	

A summary of the maximum measured and predicted total subsidence and closure for the SW23-Line is provided in Table 2.18. The base survey was carried out after the completion of LW13 and, therefore, the results for this monitoring line are due to LW14 to LW17 only.

The predicted subsidence values have been derived from the predicted subsidence contours illustrated in Report No. MSEC865. The predicted closures are based on a combination of the conventional horizontal movements and valley related movements, taking the equivalent heights within half-depths of cover from the valley bases.

Table 2.18 Maximum measured and predicted total subsidence and closure at the SW23-Line due to the mining of LW14 to LW17

Type	Maximum total subsidence (mm)	Maximum total closure (mm)
Measured	*Not measured*	0 (net opening)
Predicted	< 20	180

The accuracies of the measured absolute levels of the survey marks are in the order of ±30 mm. The accuracies of the measured closures are in the order of ±5 mm.

The measured closured between Marks SW2301 to SW2304 is 0 mm after the completion of LW17. Low level net opening developed between other marks. The measured closure at the SW23-Line is therefore considerably less than the predicted value provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

2.9. Waterfall 54 monitoring

The mine subsidence effects for Waterfall 54 (WF54) along Wongawilli Creek have been measured by IMC using 2D survey techniques using the WF54 A-Line, B-Line and C-Line. The locations of these monitoring lines are shown in Drawing No. MSEC1225-01. The survey dates for the WF54 cross lines for LW17 are provided in Table 2.19.

Table 2.19 Survey dates for the WF54 cross lines for LW17

Mining phase commitments	Mining phase survey dates	Post-mining phase commitments
	26 September 2019 (base survey) 12 November 2020 (end of LW16)	
Monthly between 600 m and 200 m remaining, weekly between 200 m and 100 m remaining and twice-weekly between 100 m remaining and completion of longwall	26 February 2021 12 April 2021 14 May 2021 25 June 2021 29 July 2021 20 August 2021 27 August 2021 01 September 2021 03 September 2021 06 September 2021 08 September 2021 10 September 2021 13 September 2021 15 September 2021 17 September 2021 20 September 2021 23 September 2021 27 September 2021 30 September 2021 07 October 2021 19 October 2021 28 October 2021 18 November 2021 1 December 2021 (end of LW17)	Monthly between 200 m remaining and the completion of LW18

The development of the measured accumulated closure at the WF54 A-Line to C-Line are illustrated in Fig. 2.9. These cross lines were established before the commencement of mining of LW16 and, therefore, they include the effects of both LW16 and LW17. These monitoring lines have short lengths and they are located near the valley base and, therefore, they may not measure the maximum closure within the valley.

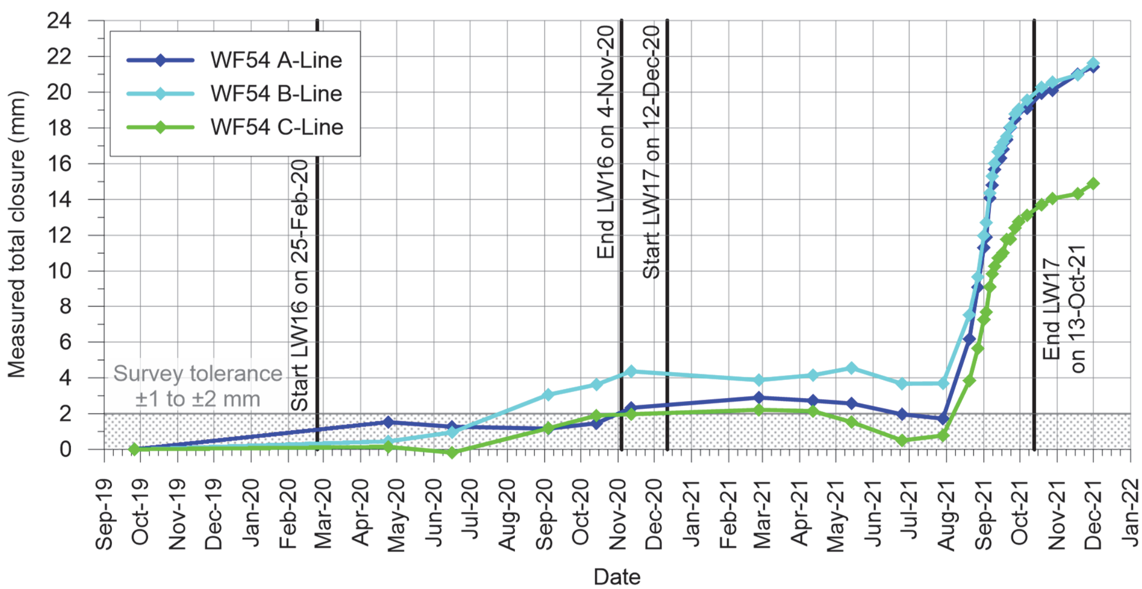

Fig. 2.9 Measured accumulated closure for the WF54 A-Line to C-Line

A summary of the maximum measured and predicted total closure at the WF54 A-Line to C-Line, after the completion of LW17, is provided in Table 2.20. The predicted closure is based on the equivalent height of the valley within half-depth of cover from the valley base.

Table 2.20 Maximum measured and predicted total closure at the WF54 cross lines due to the mining of LW16 and LW17

Type	Location	Maximum total closure (mm)
Measured	WF54 A-Line	21
	WF54 B-Line	22
	WF54 C-Line	15
Predicted	WF54 A-Line	27
	WF54 B-Line	
	WF54 C-Line	

The accuracies of the measured closures are in the order of ±1 mm.

The ground movements measured using these monitoring lines are less than the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992. However, LW17 finished at maingate cut-through 3 which is approximately 105 m inbye of the approved finishing end at maingate cut-through 2, so as to reduce the closure at the waterfall.

The changes in distance on the western valley side of Wongawilli Creek, adjacent to Waterfall 54, have been measured using Global Navigation Satellite System (GNSS) units. The distances have been measured between the GNSS unit located near the waterfall (DA3b-66) and three GNSS units near the top of the western valley side (DA3b-65, DA3b-52, DA3b-53 and DA3b-54, from northernmost to southernmost).

The locations of the GNSS are shown in Drawing No. MSEC1225-01. The measured incremental changes in distances between the GNSS units due to the mining of LW17 are illustrated in Figure 10.

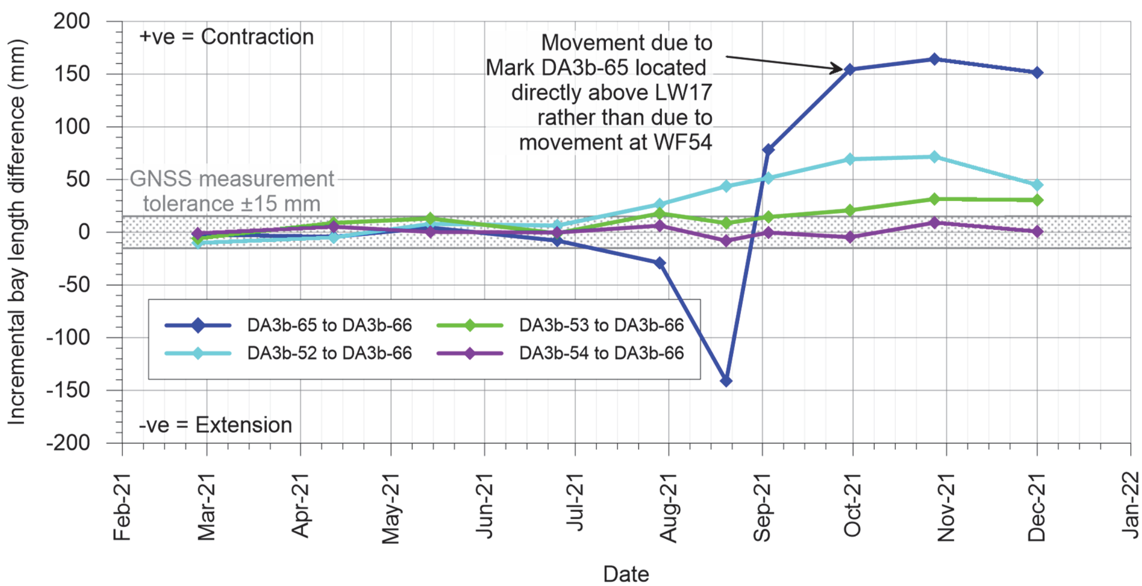

Fig. 2.10 Measured incremental changes in distance between the GNSS units due to LW17

Net incremental contraction of 164 mm has been measured between DA3b-65 and DA3b-66 due to the mining of LW17. This contraction has occurred due to the movement of Mark DA3b-65 directly above LW17 rather than due to movement at WF54. The absolute horizontal movement of Mark DA3b-66 near the waterfall is within the order of survey tolerance for absolute position and, therefore, it is not measurable.

Mark DA3b-66 initially moved towards the west as the active longwall face was mining towards it and the subsequently this mark moved back towards the east following the face as it mined away from it. The incremental bay length difference between DA3b-65 and DA3b-66 therefore initially when through an extension phase followed by a contraction phase.

Net incremental contraction of 45 mm has been measured between Marks DA3b-52 and DA3b-66. The net incremental closure between Marks DA3b-53 and DA3b-66 is 30 mm. The net movement between DA3b-54 and DA3b-66 is in the order of survey tolerance and, therefore, is not measurable

Time Domain Reflectometry (TDR) monitoring was carried out in borehole S2478 near the waterfall (refer to Drawing No. MSEC1225-01). The latest TDR data was downloaded on 28 October 2021.

The results and interpretation of the TDR data are in the report by HGEO ("*Time Domain Reflectometry monitoring at S2478 (Waterfall 54) as of 28/10/2021*", Report Ref. D21160) which states that "*no significant or persistent TDR reflectance anomalies are apparent at S2478 relative to the baseline period. The status of TDR monitoring is assessed to be at Level 1 (no measurable movement post-baseline)*".

2.10. ALS / LiDAR surveys

The changes in surface level due to the mining in Area 3B have been measured using Airborne Laser Scan (ALS) / Light Detection and Ranging (LiDAR) surveys.

The original survey carried out in January 2013 (i.e. prior to the extraction of LW9) does not cover the full extent of LW17. Hence, the survey carried out in January 2016 (i.e. prior to the mining of LW12) has been adopted as the base survey. The post-mining surface level contours have been determined from the subsequent surveys carried out in March 2017 after LW12, May 2018 after LW13, March 2019 after LW14, February 2020 after LW15, November 2020 after LW16 and November 2021 after LW17.

The measured incremental changes in surface level due to the mining of LW17 only are shown in Fig. 2.11. These contours have been determined by taking the differences between the surface levels measured before and after the extraction of this longwall. The data located outside the predicted limit of vertical subsidence (i.e. incremental 20 mm subsidence contour) have been removed for clarity.

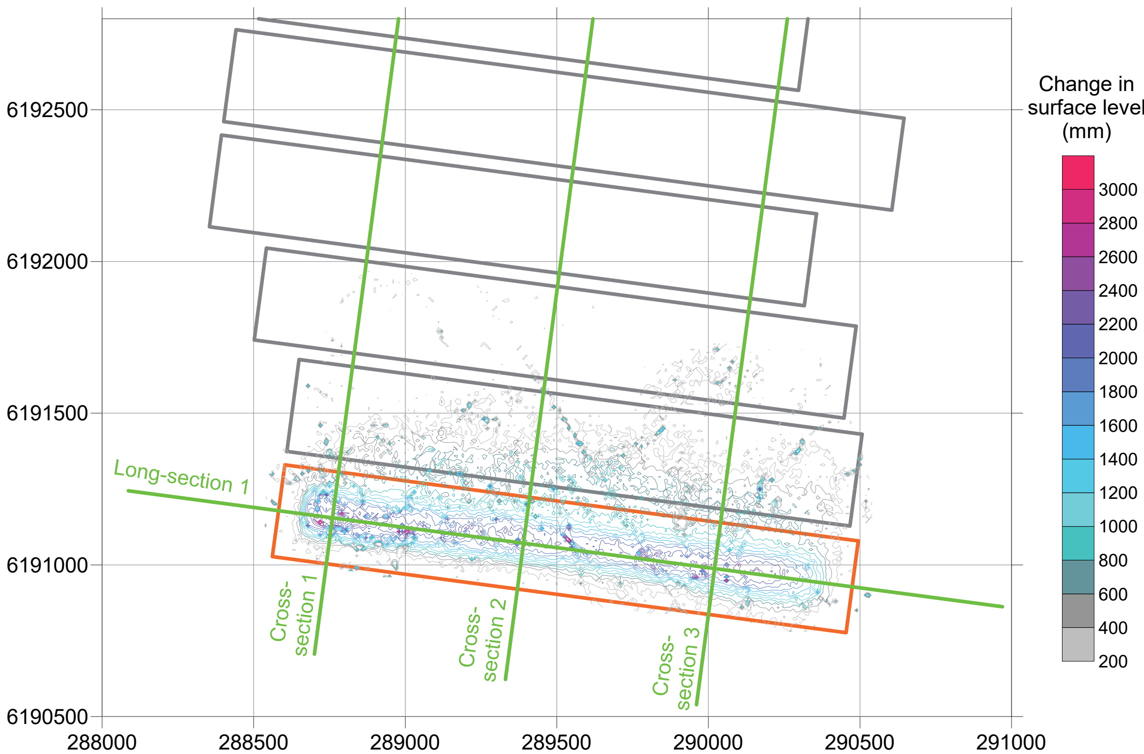

Fig. 2.11 Measured incremental changes in surface level due to the mining LW17

The measured total changes in surface level due to the mining of LW12 to LW17 are shown in Fig. 2.12. These contours have been determined by taking the differences between the surface levels measured after the completion of LW11 and after the completion of LW17. The data located outside the predicted limit of vertical subsidence (i.e. total 20 mm subsidence contour) have been removed for clarity. The extent of the latest ALS survey covers the area above LW13 to LW17 and, therefore, the contours are not shown above the earlier longwalls.

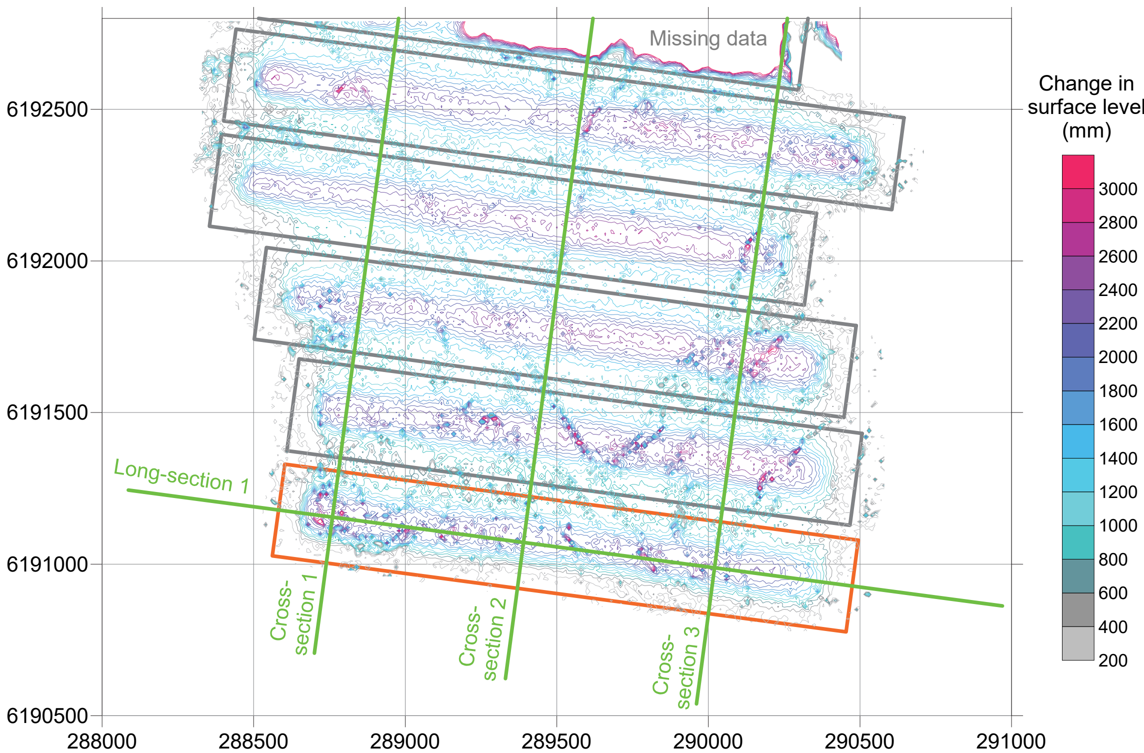

Fig. 2.12 Measured total changes in surface level due to the mining of LW12 to LW17

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

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

The contours can contain artefacts (i.e. locally increased or decreased movements), particularly in the locations of steeply incised terrain, such as at the cliffs and steep slopes. These artefacts can be seen in Fig. 2.11 and Fig. 2.12 as the localised areas of dark purple to red contours above the longwalls and the lower level subsidence outside the extents of the longwalls.

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

The comparisons of the measured changes in surface level and the predicted vertical subsidence along Cross-sections 1 to 3 and Long-section 1 are provided in Fig. 2.13 to Fig. 2.16. The locations of these sections are indicated in Fig. 2.11 and Fig. 2.12. The extent of the latest ALS survey covers the area above LW13 to LW17 and, therefore, the profiles are not shown above the earlier longwalls. The predicted profiles of vertical subsidence have been derived from the predicted subsidence contours illustrated in Report No. MSEC865.

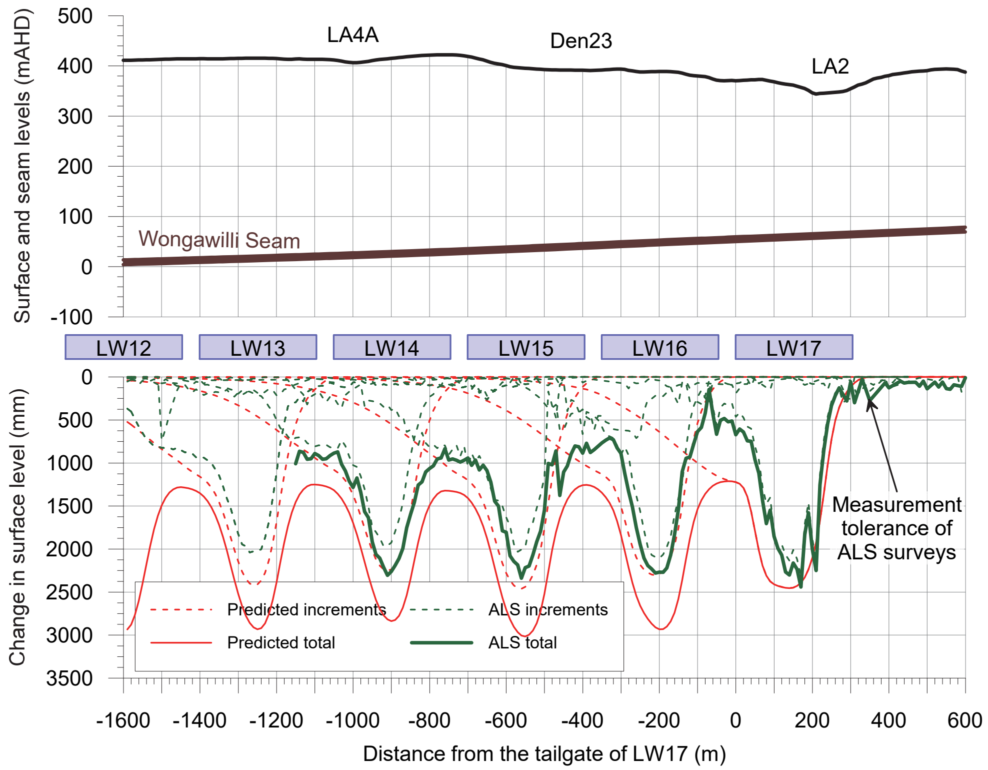

Fig. 2.13 Measured changes in surface level and predicted vertical subsidence along Cross-section 1

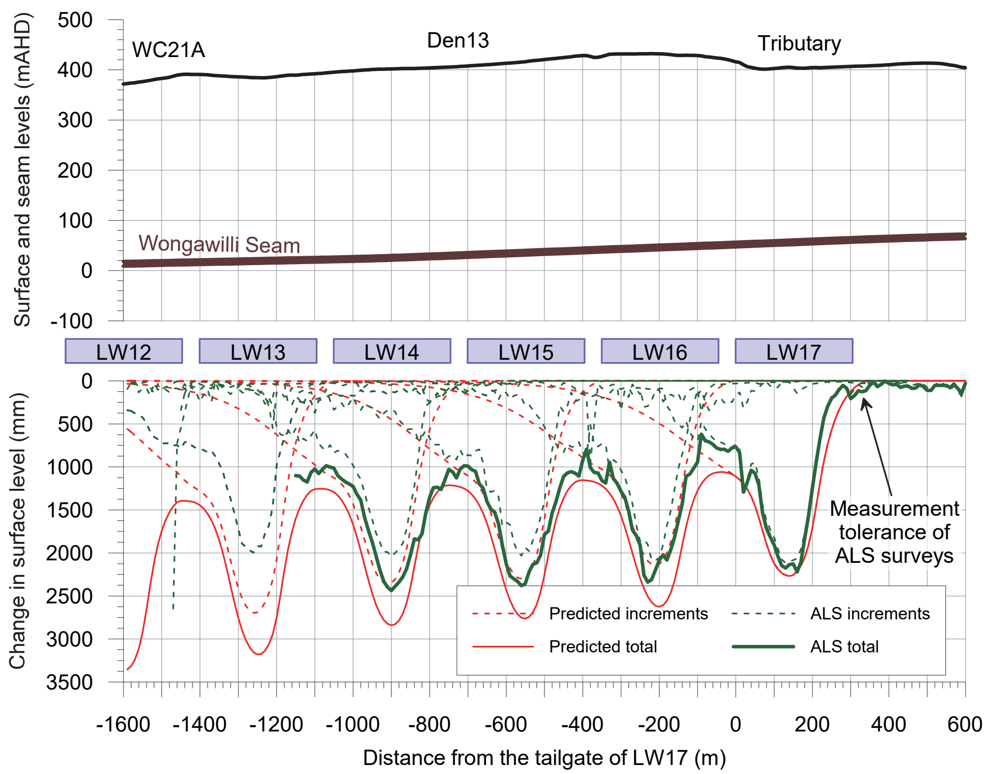

Fig. 2.14 Measured changes in surface level and predicted vertical subsidence along Cross-section 2

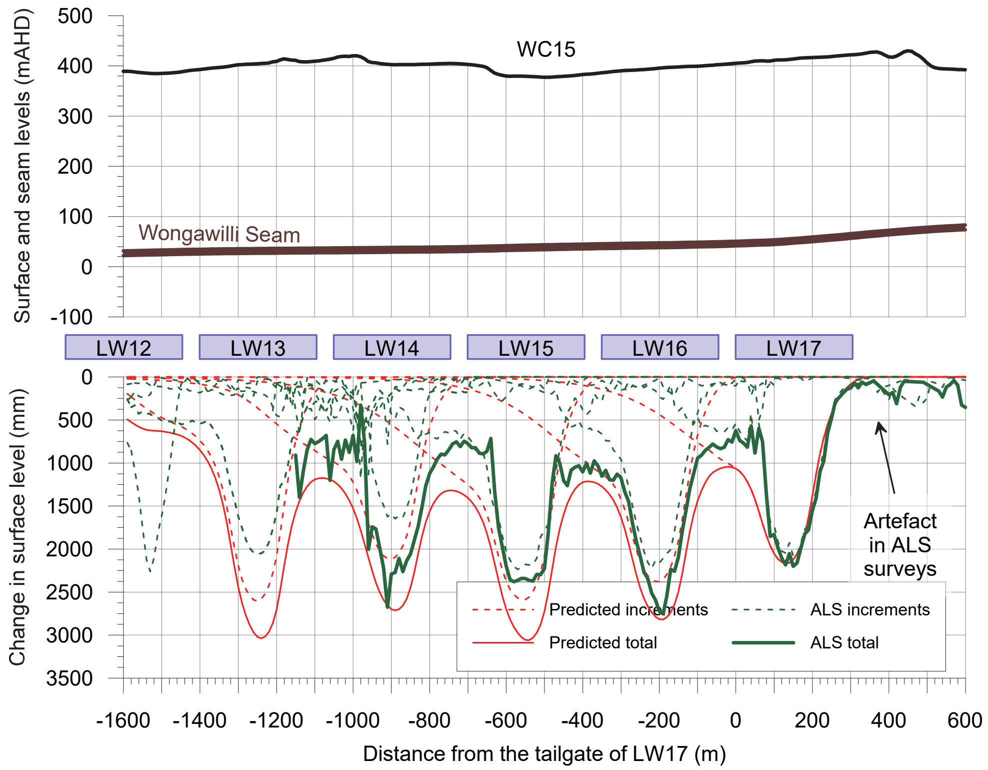

Fig. 2.15 **Measured changes in surface level and predicted vertical subsidence along Cross-section 3**

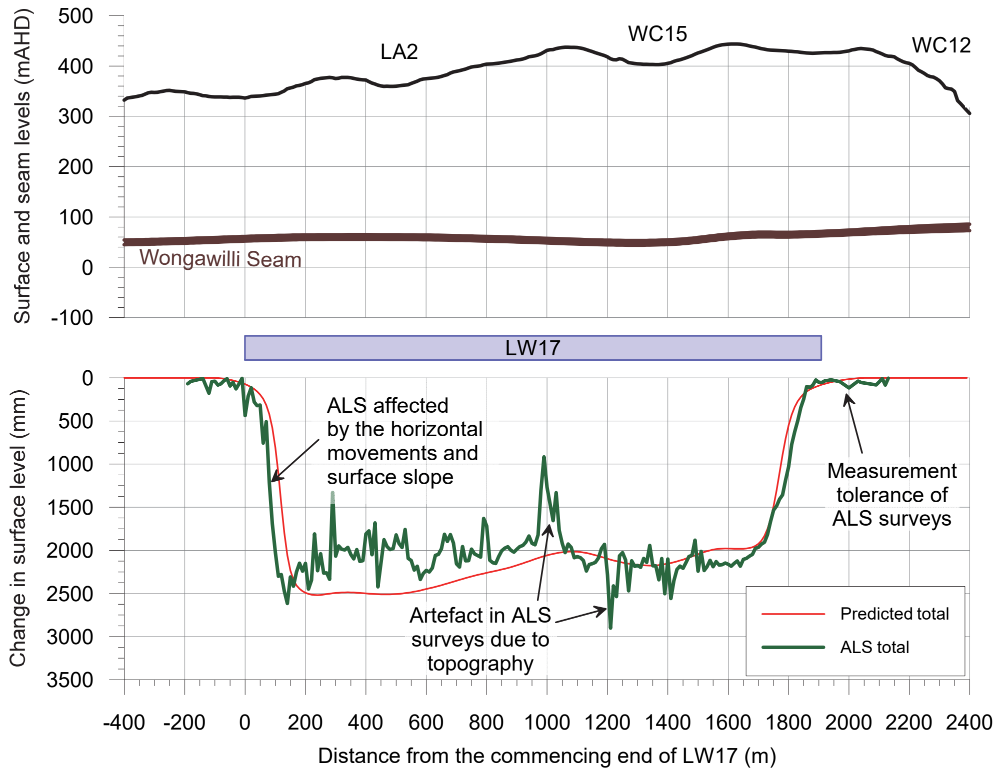

Fig. 2.16 **Measured changes in surface level and predicted vertical subsidence along Long-section 1**

The profiles of the measured changes in surface level reasonably match the predicted profiles of vertical subsidence along each of the cross-sections and long-section. The maximum measured changes in surface level above each of the longwalls are similar to or less than the maximum predicted values. Also, the measured changes in surface level above each of the chain pillars are similar to or less than the predicted values in these locations.

The measured change in surface level along Long-section 1 (refer to Fig. 2.16) is greater than the predicted vertical subsidence above the commencing end of LW17 (i.e. left-hand side of the figure). However, this may be partly due to the surveying tolerance and the effects of the horizontal movements and sloping terrain on the LiDAR surveys. The ground directly above the commencing end of LW17 has moved towards the longwall (i.e. following the extraction face). The natural surface dips towards the west in this location (i.e. towards Lake Avon). The mining-induced horizontal movement, therefore, results in the measured changes in level at a fixed position to be greater than the true vertical subsidence above the commencing end of LW17.

The measured change in surface level along Long-section 1 (refer to Fig. 2.16) is also greater than the predicted vertical subsidence above the eastern end of LW17 (i.e. right-hand side of the figure). There are areas with localised increased measured movements and other areas with localised reduced measured movements which appear to be affected by the surface topography at drainage line WC15. Elsewhere, the difference between the measured and predicted movements are typically in the order of accuracy of the measurement method.

There are localised areas outside of the longwalls where the measured changes in surface level exceed the predicted vertical subsidence. However, these are artefacts of the LiDAR surveys and are not real movements. Elsewhere, the low-level movements are in the order of accuracy of the measurement method.

It can be inferred from the slopes of the profiles, that the measured changes in grade are similar to the predicted tilts along each of the cross-sections and long-section. It is not possible to derive the curvature nor the horizontal movements from the LiDAR surveys.

It is considered that the ground movements measured using the LiDAR surveys are consistent with the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

3.1. Surface deformations

The surface deformations due to the mining of LW17 have been identified by the IMC Environmental Field Team and are described in the accompanying IMC landscape report. The locations of the surface deformations identified during the mining of LW17 are illustrated in Fig. 3.1.

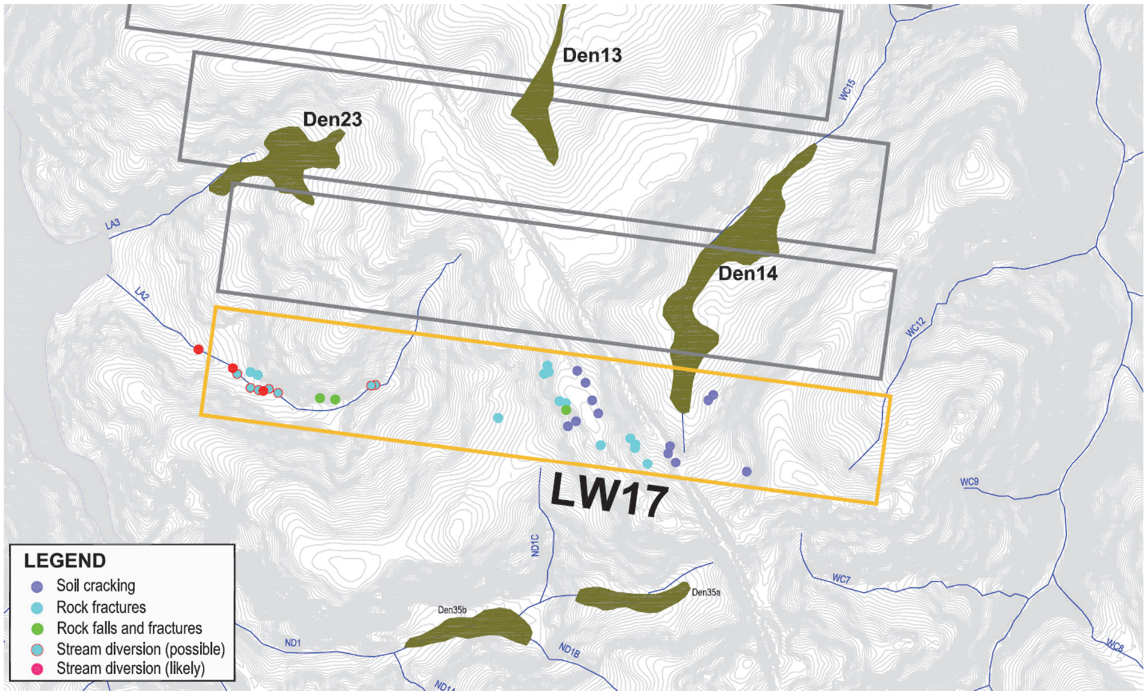

Fig. 3.1 Surface deformations due to the mining of LW17

Soil cracking (i.e. blue circles) was identified above LW17 along Fire Trail 6A, the access tracks, seismic lines, railway corridor and nearby steep slopes. Rock fracturing (i.e. cyan circles) was also identified along Drainage Line LA2 and at the rock outcrops on the sides of the ridgeline. The fracturing occurred directly above LW17 apart from one site along Drainage Line LA2 located approximately 30 m downstream of the commencing (i.e. western) end of the longwall.

The soil crack and rock fracture widths were generally less than 50 mm representing 74 % of the recorded cases. The crack and fracture widths ranged between 50 mm and 100 mm in 15 % of cases, between 100 mm and 300 mm in 7 % of cases and greater than 300 mm in 4 % of cases. Localised erosion occurred at one site causing surface deformations with widths up to 600 mm. Elsewhere, the maximum crack width was 220 mm.

Rockfalls (i.e. green circles) were identified above LW17 along Drainage Line LA2 and at the rock outcrops along the ridgeline. The largest rockfall occurred on the northern valley side of Drainage Line LA2 and had an estimated volume of 245m^2 (20m x 3.5m x 3.5m). The other three rockfalls had volumes of 80 m^2 or less.

Increased iron staining (not shown in Fig. 3.1) was identified along Drainage Line WC21 (Pool 11), Drainage Line LA5 (extending to Lake Avon) and Wongawilli Creek (between Pool 50 and RB12, approximately 2.9 km in length). Iron stain initially developed at these sites during the mining of previous longwalls.

Fracturing likely to cause surface water diversions (i.e. red circles) were identified in three locations (CH6B, CH8 and P13) along Drainage Line LA2. There was also fracturing in seven other locations (P9, RB10, P12, P14, RB14, P24 and RB25) along this drainage line (i.e. red circles with cyan fill) that could possibly cause surface water diversions.

Summaries of the sites along Drainage Line LA2 with fracturing and rockfalls recorded due to the mining of LW17 are provided in Table 3.1 and Table 3.2, respectively. The locations of these sites are also illustrated in Fig. 3.2.

Table 3.1 Fracturing sites observed along Drainage Line LA2

Stream	Site ID	Location	Maximum fracture width (mm)	Loss of surface water flow
Drainage Line LA2	DA3B_LW17_001	CH6B	10	Likely
	DA3B_LW17_002	RB25	136	Possible
	DA3B_LW17_003	P24	300	Possible
	DA3B_LW17_004	RB10	60	Possible
	DA3B_LW17_005	P12	5	Possible
	DA3B_LW17_006	P14	45	Possible
	DA3B_LW17_007	RB14	35	Possible
	DA3B_LW17_012	P9	20	Possible
	DA3B_LW17_013	CH8	35	Likely
	DA3B_LW17_034	P13	4	Likely

Table 3.2 Rockfall sites observed along Drainage Line LA2

Stream	Site ID	Location	Volume (m^3)
Drainage Line LA2	DA3B_LW17_003	Downstream of P25	6
	DA3B_LW17_008	Adjacent CH19	245
	DA3B_LW17_009	Adjacent CH20A	80

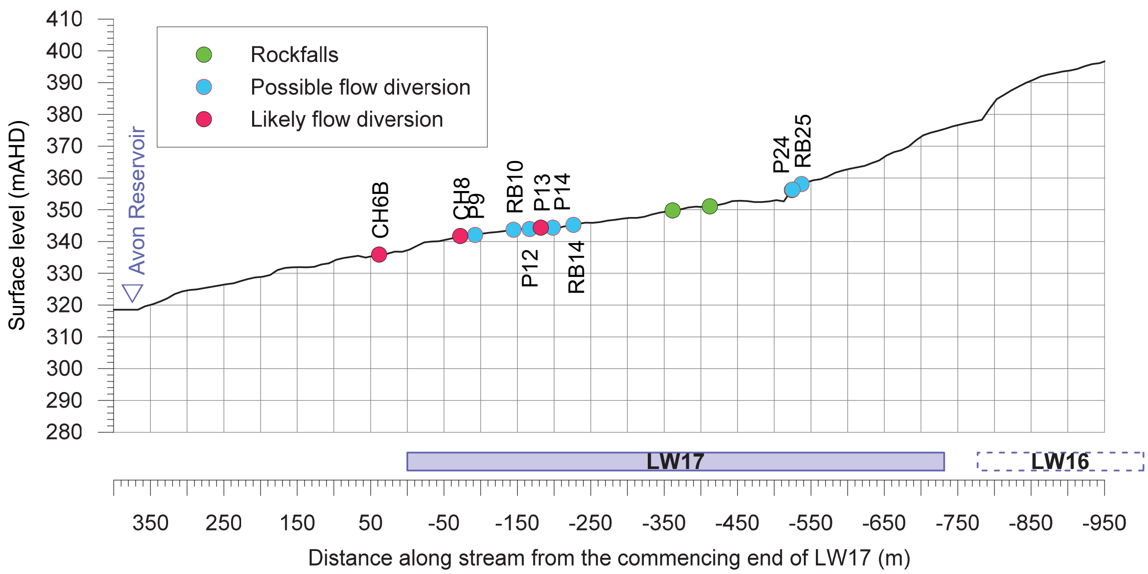

Fig. 3.2 Rock fracturing identified along Drainage Line LA2

Further details of these surface deformations are provided in the accompanying IMC landscape report.

3.2. Natural features

The natural features near LW17 are shown in Drawing No. MSEC1225-02, in Appendix A, and include:

- Wongawilli Creek;
- tributaries;
- cliffs;
- rock outcrops;
- steep slopes;
- swamps; and
- Aboriginal heritage sites.

The MSEC assessed impacts for the natural features due to the mining of LW9 to LW18 are provided in Report No. MSEC459, which supported the SMP Application. These assessments have been reviewed and updated based on the re-calibrated subsidence model and are provided in Reports Nos. MSEC792, MSEC865 and MSEC992. More detailed assessments for the natural features are also provided in other consultants' reports supporting the SMP Application.

Comparisons between the MSEC assessments and the reported impacts for the natural features listed above due to the mining of LW17 are provided in Table 3.3. The reported impacts are based on those recorded by IMC Environmental Field Team, that are described in the accompanying landscape report.

Table 3.3 Assessed and reported impacts for the natural features due to LW17

Natural feature	MSEC assessed impacts	Reported impacts
Wongawilli Creek	Very localised additional **ponding** or **flooding** developing in the locations of existing pools, steps or cascades due to vertical subsidence or tilt.	No reported impacts due to the mining-induced vertical subsidence or tilt.
	Minor **fracturing** of the bedrock within 400 m of the longwalls due to strain.	No new fracturing identified along the creek due to the mining of LW17. Fracturing was previously observed between LW6 and LW9, first observed during the mining of LW9. Further iron staining has been observed along the creek between P50 and RB12 over a length of approximately 2.9 km.
	Low-likelihood that **surface water flow diversions** would occur due to fracturing of the bedrock.	No new surface water flow diversions (i.e. Type 3 impacts) identified along the creek due to the mining of LW17. One Type 3 impact was previously observed between LW6 and LW9, where fracturing was first observed during the mining of LW9.
Drainage lines (tributaries)	Localised additional **ponding**, **flooding** or **scouring** along sections of the drainage lines located directly above the longwall.	No reported impacts.
	Buckling and **fracturing** of the bedrock along the drainage lines above or within 400 m of the longwalls.	Rock fracturing identified at nine sites along Drainage Line LA2 due to the mining of LW17. Rockfalls also identified at three locations along alignment of the drainage line. All impact sites are located directly above LW17 except for one fracturing site which is located immediately downstream of the longwall commencing end (refer Section 3.1 for further details).
	Surface water flow diversions into the dilated strata beneath the drainage lines which are directly mined beneath.	Surface water diversions likely in three locations and possibly in seven other locations along Drainage Line LA2 due to the mining of LW17. Refer to Section 3.1 and to the IMC landscape report for further details.
	Water quality – refer to the accompanying water quality report. **Terrestrial ecology** – refer to the accompanying terrestrial ecology report. **Aquatic ecology** – refer to the accompanying aquatic ecology report.	

Natural feature	MSEC assessed impacts	Reported impacts
Cliffs	Fracturing resulting in isolated **rockfalls** for the cliffs that are located within and just outside the mining area. Large-scale cliff instabilities are not expected.	No reported impacts to cliffs within the valley of Wongawilli Creek.
Rock outcrops	Fracturing of bedrock which could result in **rockfalls** along the exposed rockfaces. Fracture widths up to approximately 300 mm previously observed at the Mine.	Fracturing and rock falls at the minor cliffs and rock outcrops within the valley of LA2 (two locations) and the ridgeline along the railway corridor (one location). Refer to the IMC landscape report for further details.
Steep slopes	**Soil slippage** resulting in tension cracks and compression ridges. Soil cracks between approximately 100 mm and 400 mm previously observed at the Mine.	Soil cracking observed on or near the fire trails, seismic tracks and railway corridor. Crack widths typically less than 50 mm (70 % of cases) and elsewhere between 50 mm and 300 mm. However, localised erosion in one location has caused surface deformations over a width of 600 mm. Refer to the IMC landscape report for further details.
Swamps	**Fracturing** of the underlying strata which could result in the **diversion of surface water**.	No reported physical impacts or triggers. Refer to the IMC landscape report for further details.
Aboriginal heritage sites	Impacts on overhang sites including fracturing of sandstone, rock falls, or water seepage through joints which may affect artwork.	No reported physical impacts. Refer to the accompanying cultural heritage report.

The extraction of LW6 to LW17 has resulted in one Type 3 impact along Wongawilli Creek. A Type 3 impact is defined as *fracturing in a rockbar or upstream pool resulting in reduction in standing water level based on current rainfall and surface water flow*. The total length of Wongawilli Creek located within a distance of 400 m of the as-extracted longwalls is more than 2 km. The rate of Type 3 impacts along the creek due the mining of LW6 to LW17, therefore, is considered to be very low.

The longwalls at Dendrobium Mine were setback from Wongawilli Creek so that the predicted closure is less than 200 mm. It was assessed that the likelihood of significant fracturing resulting in surface water flow diversions along Wongawilli Creek would be very low, i.e. affecting less than 10 % of the pools and channels. It is considered that the observed rate of impact (i.e. one Type 3 impact along the 2 km length of Wongawilli Creek) is similar to the MSEC assessments provided in Reports Nos. MSEC459, MSEC792, MSEC865 and MSEC992.

Rock fracturing was observed along LA2 causing likely loss of surface water flow (Type 3 impact) in three locations and possible loss of surface water flow in another seven locations. The fracturing occurred predominately above LW17 with only one physical impact site (i.e. fracturing or cracking) occurring outside the mining area and adjacent to the longwall commencing end. It was assessed that surface water diversions would occur along the drainage lines that are directly mined beneath with fracturing up to 400 m outside the mining area.

It is considered, therefore, that the observed impacts on the natural features due to the mining of LW17 are consistent with the MSEC assessments provided in Reports Nos. MSEC459, MSEC792, MSEC865 and MSEC992. Further assessments of natural features have been provided by other specialist consultants on the project, which are described in the relevant reports accompanying the *End of Panel* report.

3.3. Built features

The built features near LW17 are shown in Drawing No. MSEC1225-03, in Appendix A, and include:

- Fire trails and four-wheel drive tracks;
- Disused Maldon Dombarton Railway Corridor;
- Avon Dam; and
- Survey control marks.

Cordeaux Dam Wall is located more than 5 km north of LW17, at its closest point. The Upper Cordeaux No. 2 Dam Wall is located more than 6 km south-east of LW17, at its closest point. It is unlikely that these dam walls would experience measurable far-field horizontal movements due to the mining of LW17 and, therefore, they have not been assessed further.

The MSEC assessed impacts for the built features due to the mining of Dendrobium LW9 to LW18 are provided in Report No. MSEC459, which supported the SMP Application. These assessments were reviewed and updated based on the re-calibrated subsidence model and are provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

Comparisons between the MSEC assessments and the reported impacts for the built features due to the mining of LW17 are provided in Table 3.4. The reported impacts are based on those recorded by IMC Environmental Field Team, that are described in the accompanying landscape report.

Table 3.4 Assessed and reported impacts for the built features due to LW17

Built feature	MSEC assessed impacts	Reported impacts
Fire trails and four-wheel drive tracks	Cracking of unsealed road surfaces.	Soil / surface cracking observed on or near the fire trails, seismic tracks and railway corridor, with widths ranging between approximately 20 mm and 70 mm. Refer to the IMC landscape report for further details.
Disused Maldon-Dombarton Railway	Possible fracturing of rock cuttings, spalling, and/or mobilisation of rock joints.	Surface cracking and rock fracturing along the alignment of the railway corridor above LW17.
Avon Dam	Adverse impacts not anticipated.	No reported impacts on the dam walls. Refer to associated groundwater report for further details on impacts to the stored water.
Survey control marks	Vertical and horizontal movements which could require re-establishment.	No reported damage to the survey control marks. The marks to be re-established after completion of mining, as required.

It is considered that the observed impacts on the surface infrastructure due to the mining of LW17 are similar to or less than the MSEC assessments provided in Reports Nos. MSEC459, MSEC792, MSEC865 and MSEC992.

4.0 SUMMARY

The mine subsidence effects due to the mining of LW17 were measured using the Wongawilli Creek closure lines, Avon Dam closure lines, Area 3B and Avon Dam 3D monitoring points, tributary cross lines, swamp cross lines, Waterfall 54 monitoring lines and airborne laser scans of the area.

The measured ground movements after the extraction of LW17 are generally similar to or less than the predicted values based on the re-calibrated subsidence model outlined in Reports Nos. MSEC792, MSEC865 and MSEC992. The measured closure at the Wong X C-Line is slightly greater than the predicted value; however, the exceedance is in the order of survey tolerance. The changes in surface level measured using the LiDAR surveys locally exceeded the predicted values in some locations; however, this was largely due to the measurement tolerance and the influence of the surface topography on the surveys.

It is considered, therefore, that the ground movements measured due to the mining of LW17 are consistent with the predictions provided in Reports Nos. MSEC792, MSEC865 and MSEC992.

Soil cracking and rock fracturing were observed directly above LW17. The crack and fracture widths were typically less than 50 mm (70 % of cases) and elsewhere between 50 mm and 300 mm. Localised erosion occurred in one location causing surface deformations over a width of approximately 600 mm. It was assessed that soil and fracture widths between approximately 100 mm and 400 mm could occur directly above the extracted longwalls and that more isolated surface impacts could occur up to 400 m outside of the longwalls.

Surface water diversions (i.e. Type 3 impact) were observed along LA2 due to the mining of LW17. It was assessed that surface water diversions could occur along the streams that are directly mined beneath.

It is considered, therefore, that the observed surface impacts on the natural and built features, due to the mining of LW17, are consistent with the MSEC assessments provided in Reports Nos. MSEC792, MSEC865 and MSEC992. Further assessments for the natural features have been provided by the specialist consultants on the project and the findings in this report should be read in conjunction with the findings provided in the accompanying specialist reports.

APPENDIX A.   DRAWINGS

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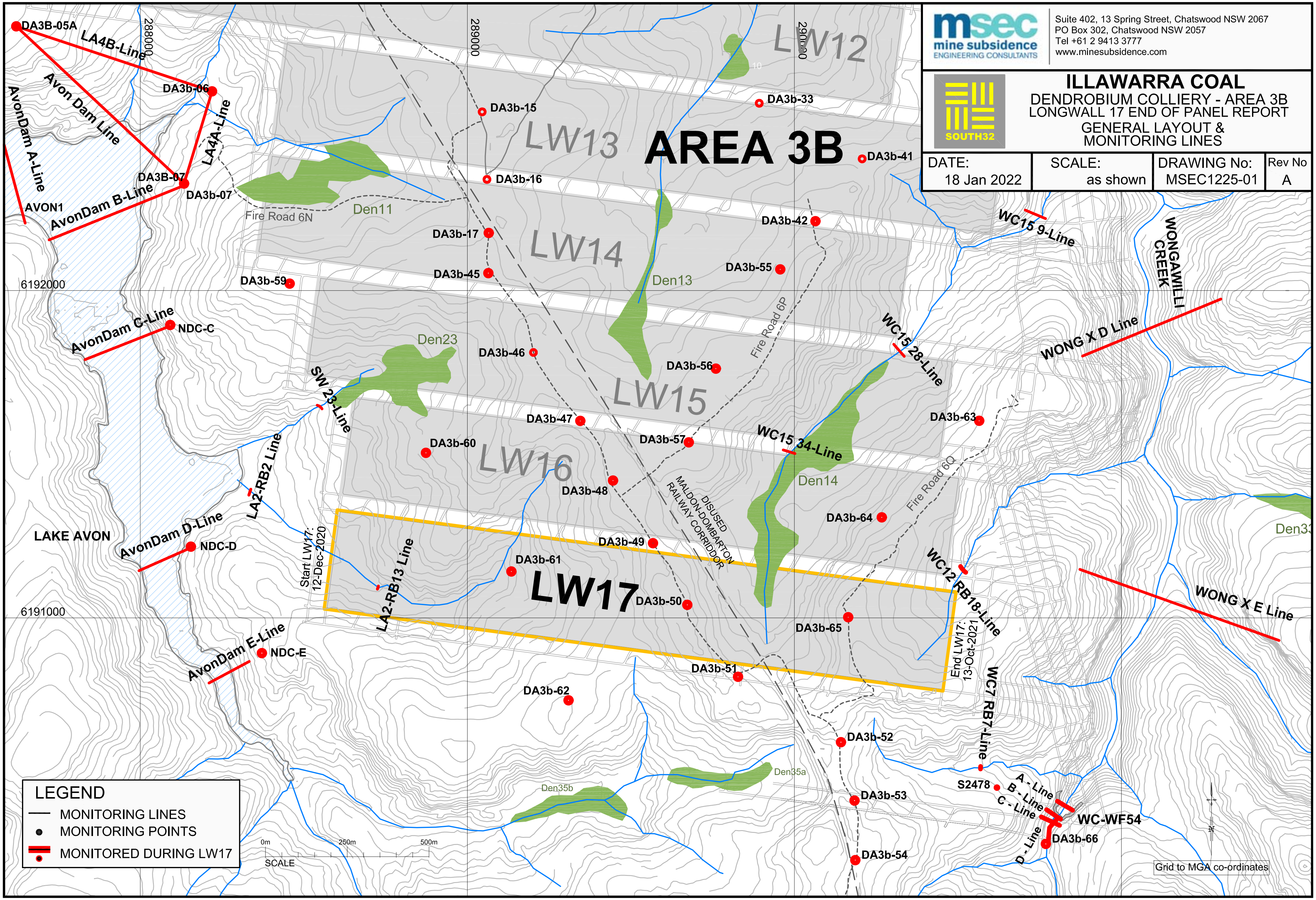
DENDROBIUM COLLIERY - AREA 3B LONGWALL 17 END OF PANEL REPORT

GENERAL LAYOUT & MONITORING LINES

DATE:	SCALE:	DRAWING No:	Rev No
18 Jan 2022	as shown	MSEC1225-01	A



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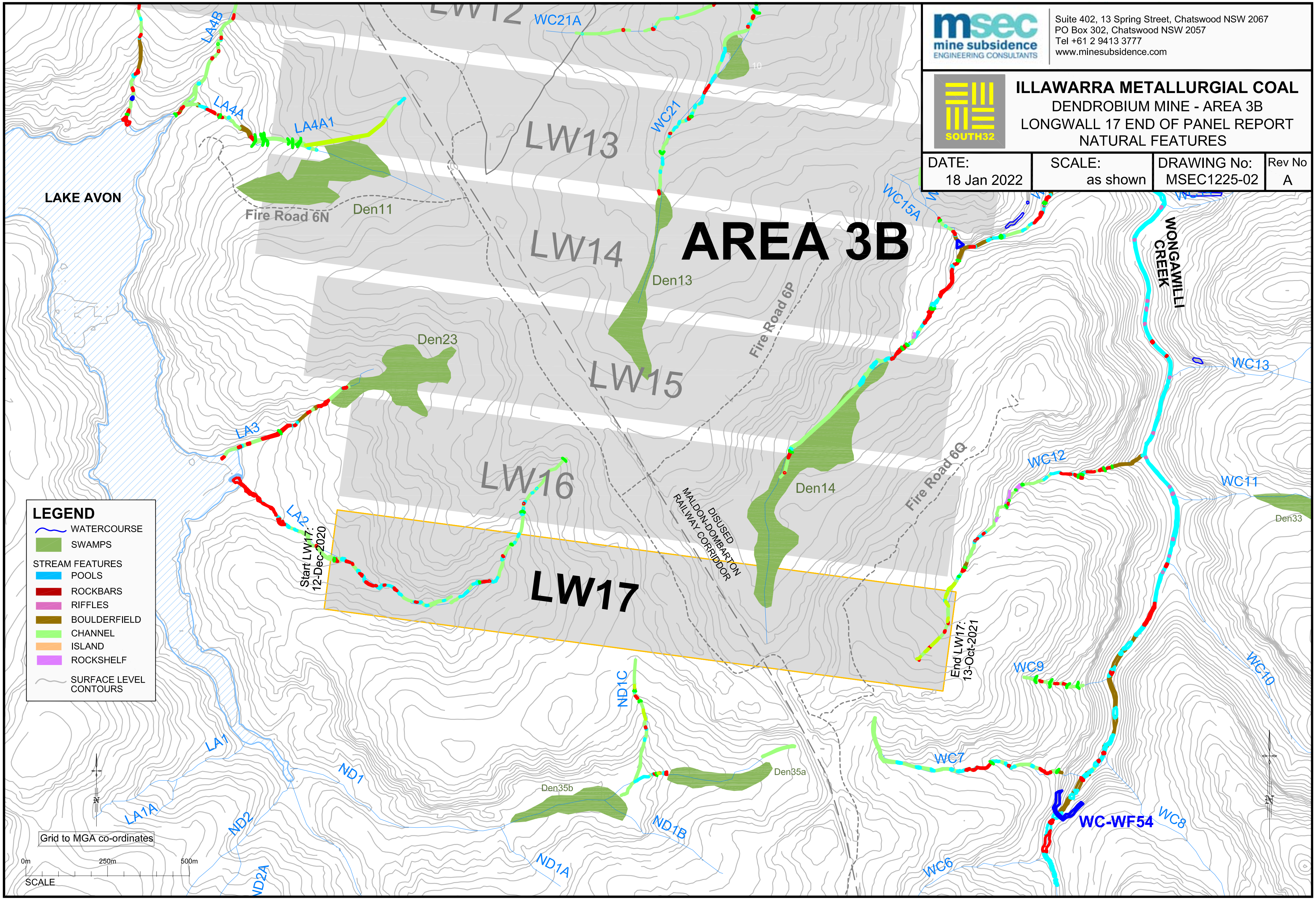

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LONGWALL 17 END OF PANEL REPORT
BUILT FEATURES

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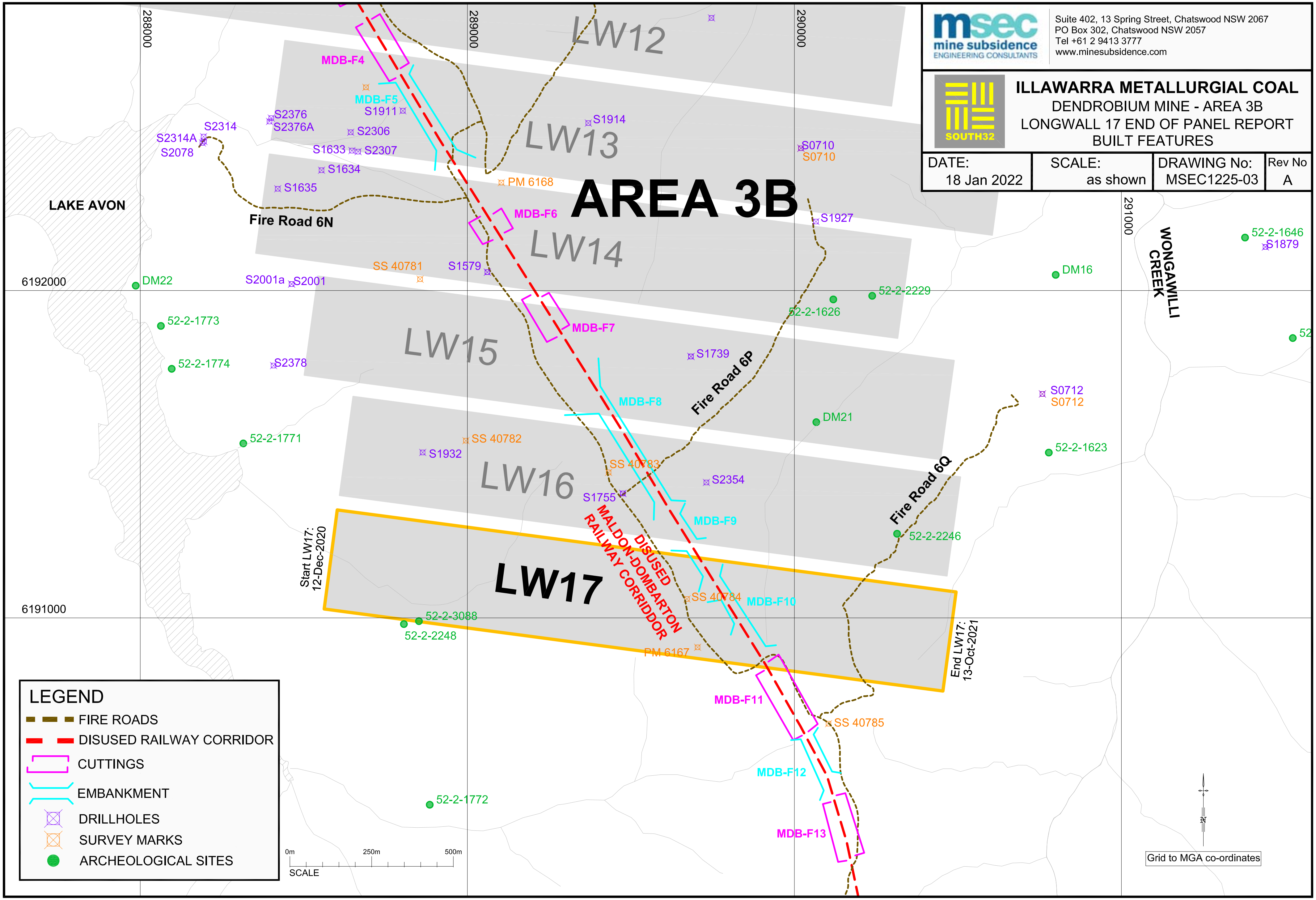

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LONGWALL 17 END OF PANEL REPORT
MEASURED INCREMENTAL HORIZONTAL MOVEMENT VECTORS DUE TO LW17

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