

Ditton Geotechnical Services Pty Ltd  
80 Roslyn Avenue Charlestown NSW 2290  
PO Box 5100 Kahibah NSW 2290



24 June 2021

Mr Phil Enright  
Mining Approvals Coordinator  
Centennial Mandalong  
12 Kerry Anderson Drive  
MANDALONG NSW 2264

Report No. MAN-005/8

Dear Phil,

**Subject: Subsidence Assessment for the Proposed Shortening of LW30 as a Variation to the LW30 & 31 Extraction Plan**

## **1.0 Introduction**

This letter provides a mine subsidence assessment of the surface features above the proposed shortening of Longwall (LW) 30 in the Extraction Plan area for LW30 & 31 at the Centennial Mandalong Mine, Mandalong.

The assessment of the mining layout approved under SSD-5144 Mod 9 for LW30 to 31 is presented in **DgS, 2021** and has been referred to in this study.

## **2.0 Proposed Modification to LW30**

The length of LW30 will now be 436 m shorter than the approved length to avoid mining through a north west striking dyke below Mannering Creek. Longwall 31 remains unchanged.

The proposed variation to the approved mine plan is shown in **Figure 1a**.

### 3.0 Surface Features above the Proposed Mining Layout Variation

The effects of the proposed variation to LW30 have been assessed for the following surface features:

- A first order tributary of Mannering Creek
- Steep slope No. 1a
- Kiar Ridge & Toepfers Roads (unsealed tracks)
- Private Lot with a Dwelling (No. 55)
- Aboriginal Heritage Sites

The location of the above surface features relative to the proposed variation to LW30 are shown in **Figures 1a to 1b** and **2a to 2b**.

The Aboriginal Heritage Sites were inspected over four days in April/May 2021 by a principal geotechnical engineer to photograph and record their current condition and determine if there were any mitigating features such as isolating joints, bedding partings or favourable geometry that could reduce the likelihood of impact due to mine subsidence.

Details of the heritage sites are presented in **Umwelt, 2021**.

### 4.0 Subsidence Contour Effect Predictions for LW30 and 31

The proposed shortening of LW30 will reduce the extent of the subsidence effects around the starting location of LW30. The magnitudes of the maximum panel subsidence effects remain unchanged for the longwalls as shown in **Table 1**.

Based on the subsidence prediction methodology presented in **DgS, 2021** the Upper 95% Confidence Limit (U95%CL) subsidence effect contours for the shortened LW30 and approved LW31 are presented in **Figures 3a-c** together with the built features. The mean contours are presented in **Figures 3d-f**.

The U95%CL contours are also shown with the Aboriginal Heritage sites in **Figures 4a-c**.

**Table 1 - Predicted Maximum Subsidence Effects for LW 30 to 31**

LW Panel #	Panel Width W (m)	Cover Depth H (m)	W/H Ratio	Mining Height^ (T)	Chain Pillar Width w (m)	Massive Strata Unit Thickness t (m)	Unit y (m)	SRP	First S <sub>max</sub> (m)		Final S <sub>max</sub> <sup>\$</sup> (m)		Final Chain Pillar Stress (MPa) & FoS		Final Chain Pillar S <sub>p</sub> (m)		Maximum Tilt T <sub>max</sub> (mm/m)		Maximum Horizontal Tensile Strain* (mm/m)		Maximum Horizontal Compressive Strain* (mm/m)	
									m	U95	m	U95	Stress	FoS	m	U95	m	U95	m	U95	m	U95
Crossline XL 3 (see Figure 1a)																						
31	200	420	0.48	3.60	53	25	104	Low	0.69	0.89	1.11	1.31	41.0	1.50	0.92	1.07	7	10	3	4	3	5
Crossline XL 4 (see Figure 1a)																						
30	200	380	0.53	3.60	51	22	98	Low	0.57	0.77	1.01	1.21	40.0	1.44	0.90	1.05	12	18	4	6	5	8
31	200	450	0.44	3.60	53	19	97	Low	0.64	0.84	1.07	1.27	46.2	1.33	0.96	1.12	6	9	3	4	3	5
Crossline XL 4a (see Figure 1a)																						
30	200	310	0.65	3.80	51	11	98	Low	0.89	1.04	1.19	1.33	27.9	2.06	0.59	0.69	15	22	5	7	6	9
31	200	335	0.60	3.60	53	19	97	Low	0.78	0.91	1.08	1.22	29.6	2.08	0.62	0.72	8	12	3	5	5	8

<sup>^</sup> - Roadway height = 3.5 m & pillar length (solid) l = 99 m. Unit y = distance to base of massive strata unit above the mine workings; SRP = refers to Subsidence Reduction Potential of the assumed strata unit for the purposes of subsidence prediction ( Low, Moderate, High). \* - Predicted strains are for a surface with deep soil cover and a 'smooth' profile. Near surface rock may cause strain concentrations which are 2 x 'smooth' profile strains. mean = average or mean prediction; U95 = Upper 95% Confidence Limit or Credible-Worst Case prediction for smooth profiles. Tensile strains may also concentrate on the crests of steep slopes with compressive strains along the toe. underlined - single side abutment load effects only.

**Bold** - It is noted that the measured maximum tilt and tensile strains above LW 1-26a,b have been generally closer to the predicted mean values, whilst the compressive strains have generally matched the U95%CL predictions.

## 5.0 Impact Assessment to Surface Features

### 5.1 General

The proposed variation will reduce the extent of the previous subsidence effect predictions for the steep slope 1a and several rock-face features, Mannering Creek tributary and Kiar Ridge Road; see **Figures 3a to 3c** (U95%CL) and **Figures 3d to 3f** (mean values).

It is assessed that only the modification to the Aboriginal Heritage site predictions require review in this report. The sites assessed are those included within the 26.5° angle of draw limits from the modified LW30 and 31.

### 5.2 Aboriginal Heritage Site Impacts

#### 5.2.1 Potential Impact Assessment Criteria

The likelihood of damage occurring at the heritage sites has been assessed based on the following impact parameter criteria (see **Table 2A**). The criteria consider the theoretical cracking limits of rock of 0.3 to 0.5 mm/m and the ‘system’ slackness or strain ‘absorbing’ properties of a jointed, thinly bedded and highly weathered rock mass during subsidence deformation. The lack of measured observed impact (surface cracking) due to measured strains of up to 3 mm/m above the Mandalong Mine is an example of the difference between theoretical and in-situ rock mass cracking behaviour.

The condition of the rock mass (strength/jointing and bedding) and the dimensions / orientation of the grinding groove sites and rock shelters have now been factored into the potential impact assessment for individual sites, based on the methodology presented in **Shepherd and Sefton, 2001**.

**Table 2A – Impact Potential Criteria for Aboriginal Heritage Sites**

Cracking Damage Potential - Indicative Probabilities of Occurrence	Predicted ‘smooth profile’ Horizontal Strain (mm/m)	
	Tensile <sup>^</sup>	Compressive <sup>^</sup>
Very Unlikely (<5%)	< 0.5	< 2
Unlikely (5 - 10%)	0.5 - 1.5	2 - 3
Possible (10 - 50%)	1.5 - 2.5	3 - 5
Likely (>50%)	> 2.5	> 5
Erosion Damage Potential - Indicative Probabilities of Occurrence	Predicted Surface Gradient Change or Tilt Increase	
	<0.3% (< 3 mm/m)	
	0.3-1% (3 - 10 mm/m)	
	1-3% (10 - 30 mm/m)	
	>3% (>30 mm/m)	

<sup>^</sup> - transient strains originally not included in the assessment of cracking likelihood due to the apparent lack of cracking impact to natural features above LW 1-24a for tensile strains up to 3 mm/m and compressive strains of up to 6 mm/m. However, cracking has developed on ridges during subsidence development above LW25b that suggests cracking may have developed where strains exceeded 1.5 mm/m.

The ‘Cracking Damage Potential’ is considered the primary damage potential indicator and the ‘Erosion Damage Potential’ is an additional, secondary criterion that is relevant to features



exposed to concentrated water flows along creeks or sites that have been damaged by cracking. Therefore, for the cases where cracking is deemed ‘likely’ at a site, the potential for erosion damage will also be considered ‘likely’. The same logic also applies to ‘possible’ cracking impact sites.

### 5.2.2 Predicted Impacts

The predicted subsidence impacts at each feature are based on U95%CL tilts and strains and summarised in **Table 2B** and taken from contours shown in **Figures 4a to 4c**.

Three rock shelters (45-3-4546, 45-3-1228 and 45-3-4544) are now considered to be rock shelters with PAD and have been shown as such in **Table 2B**. One previously named rock shelter (MS9-OH1) is now not considered to be a heritage site but is shown in **Table 2B** for completeness.

Several strain mitigating (reducing) effects have also been identified during the site inspections and noted where relevant below the potential impact assessment. Where these conditions are present the predicted impact potential has been decreased by one category (i.e. a likely strain impact is decreased to a ‘possible’ impact).

The mitigating features for grinding groove sites in order of strain isolating effectiveness are:

- the grooves are located on a loose boulder.
- the grooves are located on an elevated sandstone ledge within the creek bed and ‘open’ on one side sub-parallel to the creek centreline.
- the grooves are located between persistent orientated joints that are likely to open or shear before buckling or fresh cracking occurs.

Where jointing or open-ledge ends are not present the groove sites are considered to be “locked” into the rock mass and vulnerable to ground strains.

Based on thirteen subsided rock shelter cases presented in **Shepherd and Sefton, 2000**, it is assessed that the mitigating features for rock shelter sites at Mandalong of strain isolating effectiveness (in descending order) are:

- the shelters have been formed in large boulders and have soil foundations.
- the shelter overhangs are supported on three sides (i.e. cavernous) and less likely to collapse than single-sided shelters (i.e. blocky overhangs).
- the shelters are not directly located above longwall ribs.
- the longwall retreat directions are face-on or end-on with the long-axis of the shelter, so the shear strains are minimised relative to half-on longwall directions.
- rock shelters are typically ‘dry’.

**Shepherd and Sefton, 2000** indicate that ‘rock shelters with art’ on the back walls are vulnerable to damage where compressive strains may concentrate and cause spalling damage. Shearing may develop in the weaker sandstone beds at the back of a shelter where stress notches are likely to occur from both natural weathering processes as well as mine subsidence deformation.

**Table 2B - Predicted Subsidence Impacts due to LW30 - 31 at Aboriginal Heritage Sites**

Site Name	AHIMS No.	Site Type	Groove Site Plan Dimensions or Shelter Span (m)	Final Subsidence (m)	Final Horizontal Strain (mm/m)^	Cracking Damage Potential	Final Tilt (mm/m)	Erosion Damage Potential
RPS PS25	45-3-3511	Artefact Scatter	<0.05	0.93	-3.4 (1.5)	<u>Unlikely</u> [isolated objects]	0.6	<u>V. Unlikely</u>
RPS TBM29	45-3-3536		<0.05	0.01	0.2	V. Unlikely	0.4	V. Unlikely
Morans Ck	45-3-1223		N/A	0.01	0.7	Unlikely	0.4	V. Unlikely
Buttonderry Creek	45-3-1226	Grinding Groove	Not found	0.58 (?)	1.2 (?)	<u>Unlikely</u>	10.0 (?)	Unlikely
MS10-GG-1	45-3-4548		3 x 7	0.03	0.0	<u>V. Unlikely</u>	0.3	<u>V. Unlikely</u>
MS10-GG-2	45-3-4549		1 x 1	0.03	0.0	<u>V. Unlikely</u> [open sided]	0.3	<u>V. Unlikely</u>
MS10-GG-3	45-3-4550		0.4 x 0.4	0.02	0.0	<u>V. Unlikely</u> [loose boulder]	0.3	V. Unlikely
MS9-GG-1	45-3-4551		1 x 1	0.24	1.1	<u>Unlikely</u> [open sided]	13.0	Possible
MS9-GG-2	45-3-4552		3 x 5	0.82	-1.0 (1.5)	Possible	6.7	Unlikely
MS9-GG-3	45-3-4545		1 x 3	0.38	4.6	<u>Possible</u> [open sided]	14.5	Possible
RPS CYL05	45-3-3492		3 x 5	0.05	1.3	<u>Unlikely</u>	2.4	Unlikely
RPS PS26	45-3-3512		2 x 3	0.03	0.7	<u>Unlikely</u> [between joints]	1.0	Unlikely
MS9-OH-1	<b>Not a site</b>	Rock Shelter	3	0.67	-2.0 (1.5)	Possible	4.5	Unlikely
RPS PS01	45-3-3586		2	0.53	0.1 (1.5)	<u>V. Unlikely</u> [loose boulder]	11.6	Possible [l. boulder]
RPS PS02	45-3-3639		3	0.20	2.3	Unlikely [between joints]	9.0	Unlikely
RPS PS03	45-3-3640		5	0.08	0.6	<u>V. Unlikely</u>	2.0	<u>V. Unlikely</u>
RPS PS04	45-3-3641		2.5	0.07	0.4	<u>V. Unlikely</u>	1.5	<u>V. Unlikely</u>
RPS PS05	45-3-3642		two caves 1.5 & 2	0.17	2.4	<u>Unlikely</u> [between joints]	8.5	Unlikely
RPS PS27	45-3-3594		5	0.01	0.05	<u>V. Unlikely</u>	0.1	V. Unlikely
RPS PS29	45-3-3595		5	0.61	-0.9 (1.0)	Unlikely	10.5	Possible
Morans Creek	45-3-1228	Rock Shelter with Art	5	0.04	0.0	V. Unlikely [loose boulder]	0.5	V. Unlikely
RPS PS28	45-3-3513	Rock Shelter with PAD	7	0.00	0.05	<u>V. Unlikely</u>	0.1	<u>V. Unlikely</u>
RPS PS32	45-3-3514		25	0.03	0.1	<u>V. Unlikely</u>	0.4	<u>V. Unlikely</u>
MS9-RS-1	45-3-4547		4	0.60	-1.5 (1.5)	Possible	5.6	Unlikely
MS9-RS-2	45-3-4546		5	0.04	0.0	<u>V. Unlikely</u> [loose boulder]	0.4	V. Unlikely
MS9-RS-3	45-3-4544		5	0.03	0.0	<u>V. Unlikely</u> [loose boulder]	0.4	V. Unlikely

^ - Tensile strain is positive; (brackets) - transient or dynamic strains; V. Unlikely - Very Unlikely; [square brackets] - mitigating circumstances that are likely to isolate the feature from ground strains. **bold** - cracking and/or erosion impact assessed as ‘likely’. **Shaded** - risk of impact has increased since the Mod 9 assessment; Underlined - the risk of impact has decreased since the Mod 9 Assessment; *italics* - erosion potential based on tilt may be increased to match cracking potential likelihood of ‘likely’ or ‘possible’.

**Shepherd and Sefton, 2000** also indicates that none of the shelters with spans up to 7 m or 8 m have collapsed after subsidence of 1.0 ~ 1.24 m, tilts of 2 to 8 mm/m and strains of +/- 1.6 to 1.75 mm/m (tensile & compressive).

It is assessed that the majority of the rock shelters at Mandalong have spans of < 8 m and could be subject to subsidence effects that are likely to be similar to the above cases. The likelihood that these rock shelters will collapse is assessed as 'unlikely'. There is only one shelter (with PAD) that has a span of 25 m (45-3-3514) and is outside the angle of draw to LW31. The magnitude of predicted tilt (<0.5 mm/m) and strain (<0.1 mm/m) is very low and unlikely to impact the site.

The results for the proposed variation to LW30 and 31 in **Table 2B** have also been compared to the Approved Mod 9 (LW30 to 33) predictions presented in **Table 2C**.

**Table 2C - Predicted Mod 9 Subsidence Impacts due to U95 % CL Values at Aboriginal Heritage Sites**

Site Name	AHIMS No.	Site Type	Final Subsidence (m)	Final Horizontal Strain (mm/m) <sup>^</sup>	Cracking Damage Potential*	Final Tilt (mm/m)	Erosion Damage Potential*
<b>Proposed Mining Layout for LW30-33 (Mod 9)</b>							
RPS PS25	45-3-3511	Artefact Scatter	1.15	-1.2 (1.5)	Possible	4.3	<i>Unlikely</i>
RPS TBM29	45-3-3536		0.01	0.2	V. Unlikely	0.3	V. Unlikely
Morans Ck	45-3-1223		0.01	0.7	Unlikely	0.4	V. Unlikely
Buttonderry Creek	45-3-1226	Grinding Groove	1.14	0.2 (2)	Possible	2.8	<i>V. Unlikely</i>
MS10-GG-1	45-3-4548		0.88	1.7	Possible	3.9	<i>Unlikely</i>
MS10-GG-2	45-3-4549		0.84	2.1	Possible	3.2	<i>Unlikely</i>
MS10-GG-3	45-3-4550		0.76	3.6	<i>V. Unlikely (loose boulder)</i>	1.6	V. Unlikely
MS9-GG-1	45-3-4551		0.85	3.3	<b>Likely</b>	3.1	<i>Unlikely</i>
MS9-GG-2	45-3-4552		1.09	-0.4 (1.5)	Possible	6.0	<i>Unlikely</i>
MS9-GG-3	45-3-4545		0.29	5.1	<b>Likely</b>	12.1	<i>Possible</i>
RPS CYL05	45-3-3492		0.24	3.2	<b>Likely</b>	8.2	<i>Unlikely</i>
RPS PS26	45-3-3512		0.09	1.7	Possible	2.2	<i>V. Unlikely</i>
MS9-OH-1	not a site	Rock Shelter	0.93	-1.0 (1.5)	Possible	5.4	<i>Unlikely</i>
RPS PS01	45-3-3586		1.0	-1.2 (1.5)	Possible	5.0	<i>Unlikely</i>
RPS PS02	45-3-3639		0.9	0.6	Unlikely	4.5	Unlikely
RPS PS03	45-3-3640		1.0	-0.1 (1.5)	Possible	3.0	<i>Unlikely</i>
RPS PS04	45-3-3641		1.0	-0.5 (1.5)	Possible	3.0	<i>Unlikely</i>
RPS PS05	45-3-3642		1.0	0.5	V. Unlikely	3.7	Unlikely
RPS PS27	45-3-3594		0.1	1.1	Unlikely	1.3	V. Unlikely
RPS PS29	45-3-3595		1.0	1.1	Unlikely	3.7	Unlikely
Morans Creek	45-3-1228	Rock Shelter with Art	0.06	-0.1	V. Unlikely	0.3	V. Unlikely
RPS PS28	45-3-3513	Rock Shelter with PAD	0.54	1.5	Possible	13.4	Possible
RPS PS32	45-3-3514		0.88	1.5	Possible	4.0	<i>Unlikely</i>
MS9-RS-1	45-3-4547		0.83	-0.8 (1.5)	Possible	6.2	<i>Unlikely</i>
MS9-RS-2	45-3-4546		0.05	0.5	Unlikely	0.3	V. Unlikely
MS9-RS-3	45-3-4544		0.04	0.5	Unlikely	0.6	V. Unlikely

<sup>^</sup> - Tensile strain is positive; (brackets) - transient or dynamic strains; V. Unlikely - Very Unlikely;

\* - see **Table 2A** for Impact Potential definitions. **bold** - cracking and/or erosion impact assessed as 'likely'.

*italics* - erosion potential based on tilt may be increased to match cracking potential likelihood of 'likely' or 'possible'. Mitigating circumstances due to natural jointing and bedding due to recent inspections of the sites are not included in this table.

The assessed risk of cracking impact to twenty-five (25) AHIMS registered sites and one non-registered rock shelter site within the 20 mm angle of draw due to the proposed LW30 to 31 are summarised below (in highest to lowest risk ranking order):

- Two Grinding Groove Sites (45-3-4552 & 45-3-4545) may ‘possibly’ be impacted (10% - 50% probability).
- One Rock shelter with PAD (45-3-4547) and one non-registered Rock Shelter (MS9-OH-1) may ‘possibly’ be impacted (10% - 50% probability).
- Three Rock Shelters (45-3-3639, 45-3-3595 & 45-3-3642) are ‘unlikely’ to be impacted (5% - 10% probability) due to favourable geometry/geology.
- Four Grinding Groove Sites (45-3-1226, 45-3-4551, 45-3-3492 & 45-3-3512) are ‘unlikely’ to be impacted (5% to 10% probability).
- Two Artefact Scatter sites (45-3-3511 & 45-3-1223) are ‘unlikely’ to be impacted (5% - 10% probability).
- One Rock Shelter with Art (45-3-1228) and four with PAD (45-3-4546, 45-3-4544, 45-3-3513 & 45-3-3514) are ‘very unlikely’ to be impacted (<5 % probability).
- Three Grinding Groove Sites (45-3-4548, 45-3-4549 & 45-3-4550) are ‘very unlikely’ to be impacted (<5% probability).
- Four Rock Shelters (45-3-3586, 45-3-3594, 45-3-3640, 45-3-3641) are ‘very unlikely’ to be impacted (< 5% probability).
- One Artefact Scatter (45-3-3536) is ‘very unlikely’ to be impacted (<5% probability).

In terms of erosion damage potential due to high tilts (> 10 mm/m), there are two grinding grooves (45-3-4551 & 45-3-4545) that may ‘possibly’ be damaged. There are also two rock shelter sites (45-3-3595 & 45-3-3586) that may ‘possibly’ be impacted by erosion due to high tilt (> 10 mm/m).

Compared to the previous impact assessment in the Mod 9 Report (**Table 2C**), the results for the Proposed LW30 to 31 in **Table 2B** indicate the risk of potential cracking impact will increase for one site, decrease for sixteen sites and remain unchanged for eight sites as follows:

- One Grinding Groove site (45-3-4545) will have the risk of cracking **decreased** from ‘likely’ to ‘possible’ (from > 50% to between 10% & 50% probability) due to favourable geometry/geology.
- Two Grinding Groove sites (45-3-3492 & 45-3-4551) will have the risk of cracking **decreased** from ‘likely’ to ‘unlikely’ (from > 50% to between 5% & 10% probability).
- Four Grinding Groove sites (45-3-4548, 45-3-4549, 45-3-3512 & 45-3-1226) & one Artefact Scatter (45-3-3511) will have their risk of cracking **decreased** from

‘possible’ to ‘unlikely’ or ‘very unlikely’ (from between 10% & 50% to < 10% probability).

- One Rock Shelter site (45-3-3642) will have the risk of cracking **increased** slightly from ‘very unlikely’ to ‘unlikely’ (from <5% probability to between 5% & 10%). The increase is due to the single panel effects are higher than the multiple panel case with chain pillar compression effects.
- Three Rock Shelter sites (45-3-3640, 45-3-3586 & 45-3-3641) and two with PAD (45-3-3513 & 45-3-3514) will have the risk of cracking **decreased** from ‘possible’ to ‘very unlikely’ (from between 10% & 50% to <5% probability).
- One Rock Shelter site (45-3-3594) and two with PAD (45-3-4546 & 45-3-4544) will have the risk of cracking **decreased** from ‘unlikely’ to ‘very unlikely’ (from 5% to 10% to <5% probability).
- Two grinding groove sites (45-3-4552 & 45-3-4550), four rock shelters (MS9-OH-1, 45-3-3639, 45-3-3595 & 45-3-3596), one rock shelter with PAD (45-3-4547) and one rock shelter with Art (45-3-1228) and two artefact site (45-3-3536 & 45-3-1223) will remain **unchanged** compared to the Mod 9 Report.

The erosion potential is assessed to increase from ‘unlikely’ to ‘possible’ at one grinding groove site (45-3-4551) with one grinding groove site (45-3-1226) increasing slightly from ‘very unlikely’ to ‘unlikely’. Erosion damage potential has also increased for two rock shelters (45-3-3595 & 45-3-3586) from ‘unlikely’ to ‘possible’.

Overall, it is assessed that the proposed LW30 to 31 Extraction Plan will have a **lower** risk of impact to the aboriginal heritage sites than the Mod 9 mining layout for LW30 to 33.

### 5.2.3 Observed v. Predicted Impacts of Heritage Sites

Only two grinding groove sites and one rock shelter site have been directly undermined by LW28b at Mandalong Mine to-date. There have also been three grinding grooves outside of the extraction limits of LW25a but within the angle of draw; see **Figure 1b**.

A summary of the predicted v. measured strains and impacts at each site is summarised in **Table 3**.

**Table 3 - Predicted v. Measured Subsidence Impacts at Heritage Sites To-date**

Site	Type	LW#	Predicted Strain (mm/m)	Predicted Cracking Impact	Measured Strain (mm/m)	Observed Impacts	Comment
RPS DF03	GG	25a	1.0	Unlikely	<1	Nil	Observed outcome consistent with predictions
RPS PS11	GG	25a	1.0	Unlikely	<1	Nil	
RPS CYL07	GG	25a	1.0	Unlikely	<1	Nil	
RPS TBM31	GG	28b	-3.5 (1.5)	Possible	-3.5 to 1.5	Nil	
RPS TBM32	RS	28b	2.2	Possible	-3.5 to 1.5	Nil	
RPS TBM34	GG	28b	-3.0 (1.5)	Possible	-3.5 to 1.5	1 mm vertical crack sub-parallel to creek bed alignment (NE/SW) at existing NE/SW joint (pre-mining).	As above. Crack width tapers indicates buckling of rock ledge due to compressive valley closure strains. Grooves not damaged directly by crack.

GG = grinding groove site; RS = Rock Shelter

The results of the impact review after mining indicates the assessment methodology for the heritage sites is reliable and does not require adjustment of cracking threshold strains at this stage.

#### 5.2.4 Impact Management Strategies

Impact management strategies for the above AHIMS sites have been developed as part of the Heritage Management Plan completed as part of the LW30-31 Extraction Plan. Based on the outcomes of this variation, no changes are required to these impact management strategies.

For and on behalf of

**Ditton Geotechnical Services Pty Ltd**



Steven Ditton  
Principal Engineer and Director  
BE(Civil/Hons) C.P.Eng(Civil), M.I.E.(Aust); MAusIMM  
NPER 342140 RPEQ (Civil)

#### Attachments:

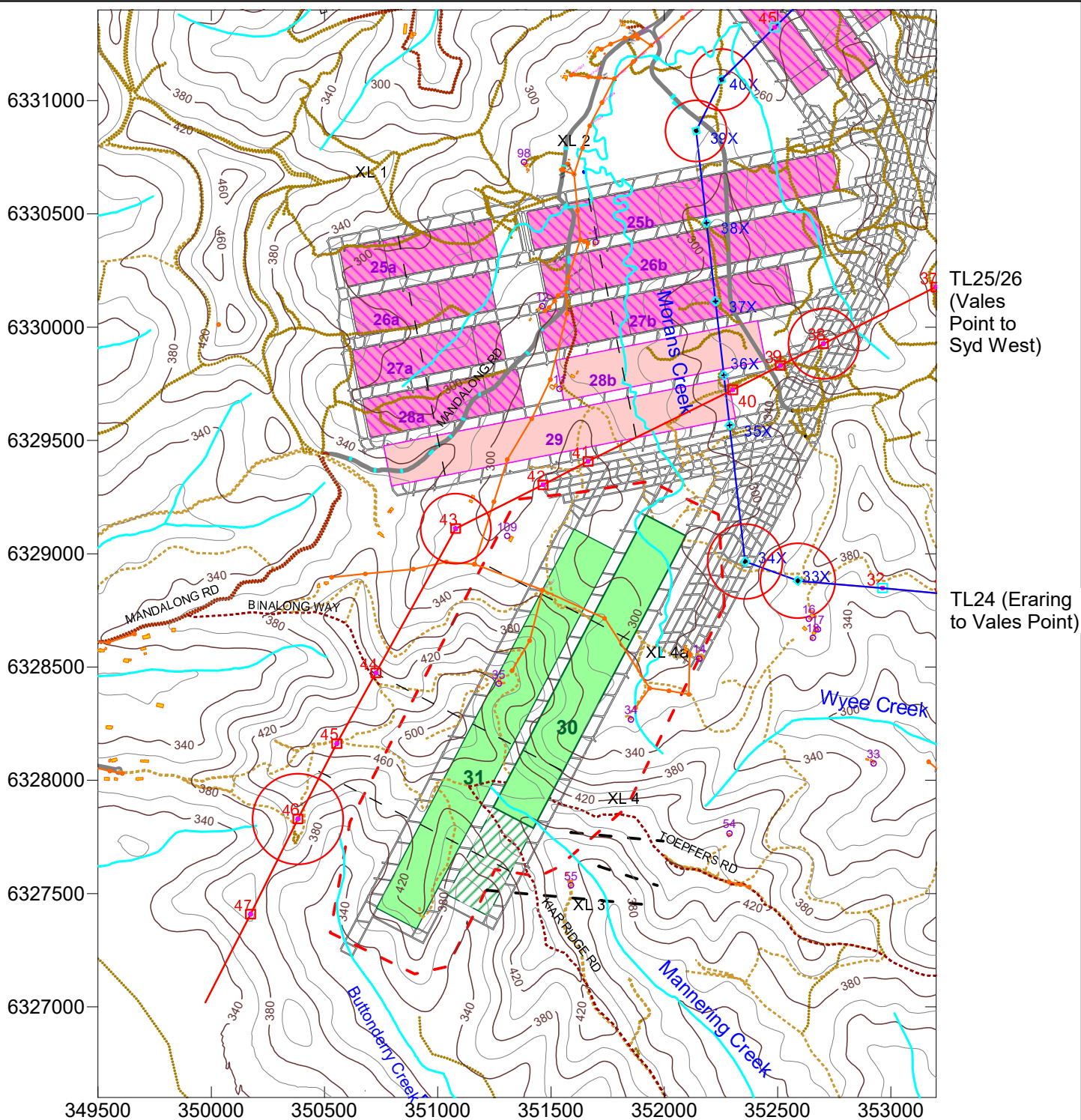
Figures 1a to 4c

**References:**

DgS, 2021. **Subsidence Predictions and General Impact Assessment for LW30 to 31 Extraction Plan at the Mandalong Mine.** DGS Report No. MAN-005/2 (15 April)

Shepherd and Sefton, 2001. **Subsidence Impact on Sandstone Cliff RockShelters in the Southern Coalfield, New South.** Proceedings of 5<sup>th</sup> Triennial Conference of Mine Subsidence Technological Society.

Umwelt, 2021. **Heritage Management Plan for LWs 30-31.**



TL25/26  
(Vales  
Point to  
Syd West)

TL24 (Eraring  
to Vales Point)

- |  |                                   |  |                                             |  |                                    |
|--|-----------------------------------|--|---------------------------------------------|--|------------------------------------|
|  | Deleted Section of LW30           |  | Creeks                                      |  | Culvert                            |
|  | Proposed LW30 - 31 Variation      |  | Cover Depth Contours (40m & 20m)            |  | Sealed & Unsealed Public Roads     |
|  | Approved LW25 - 29                |  | Unsealed Private Access Roads / Fire Trails |  | Transgrid TL & Towers              |
|  | Extracted Longwalls               |  | Tension Tower 26.5° AoD Buffer Zones        |  | Domestic Powerlines & Timber Poles |
|  | First Workings Roadways (Tunnels) |  | -26.5° Angle of Draw                        |  |                                    |
|  | House Locations                   |  | Structures                                  |  |                                    |
|  | Prediction Lines                  |  |                                             |  |                                    |

DgS

Engineer: S.Ditton  
Drawn: S.Ditton  
Date: 18.06.21

Ditton Geotechnical  
Services Pty Ltd

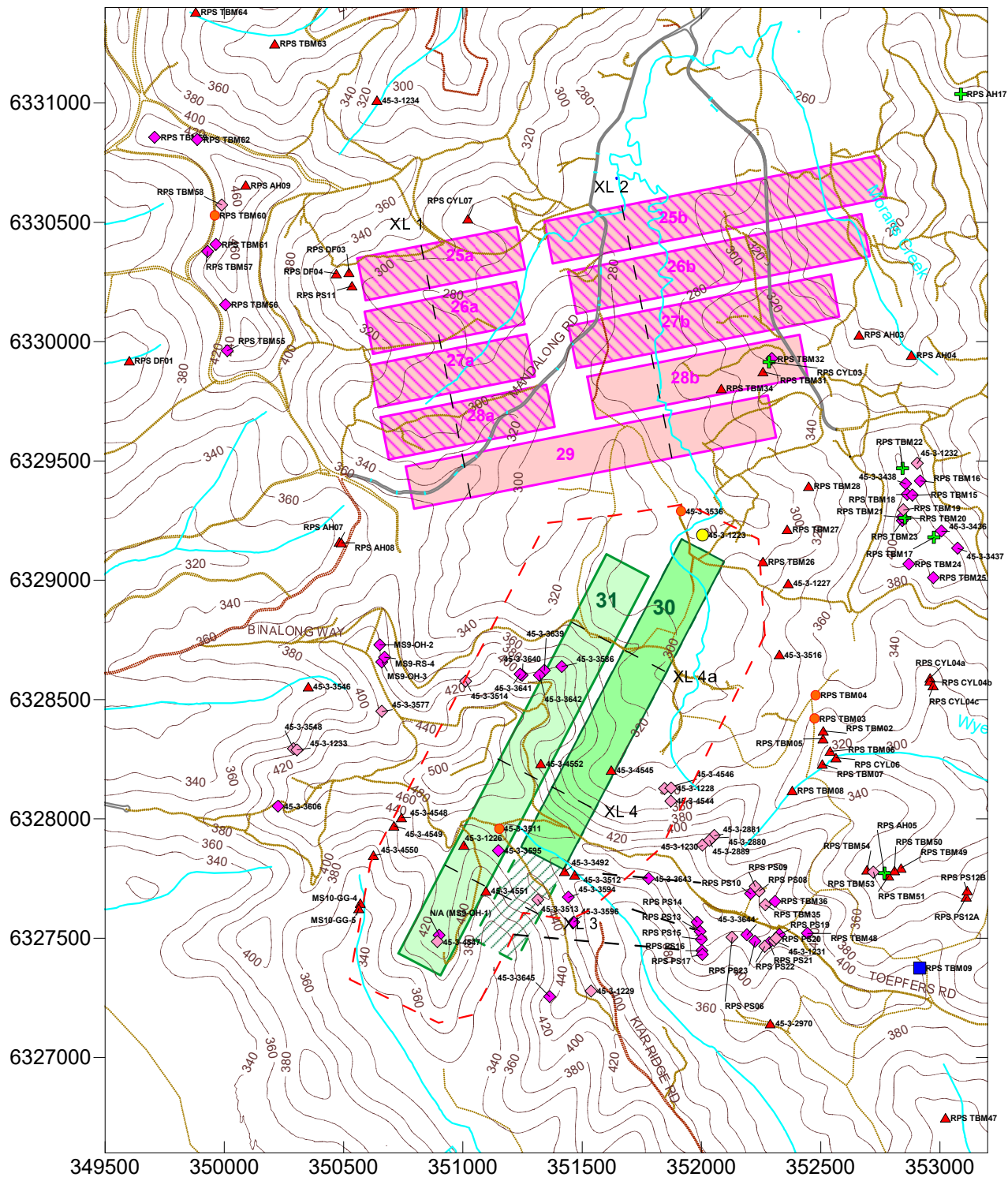
Client: Centennial Mandalong  
MAN-005/8

Title: Cover Depth Contours & Built Features above the Proposed  
Variation to LW30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 1a





- |  |                                     |  |                                     |  |                     |
|--|-------------------------------------|--|-------------------------------------|--|---------------------|
|  | Deleted Section of LW30             |  | Scarred Tree                        |  | Creeks (Ephemeral)  |
|  | Proposed Variation to LW30 - 31     |  | Grinding grooves                    |  | Sealed Roads        |
|  | Approved LW25 - 29                  |  | Water supply                        |  | Unsealed Tracks     |
|  | Extracted LW Panels                 |  | Rock Shelters or Stone Arrangements |  | 26.5° Angle of Draw |
|  | Artefact Scatter or Individual Find |  | Rock Shelters with Art or PADs      |  |                     |
|  | Open Camp Site                      |  |                                     |  |                     |

**DgS**

Engineer: S.Ditton  
 Drawn: S.Ditton  
 Date: 15.06.21

Ditton Geotechnical  
 Services Pty Ltd

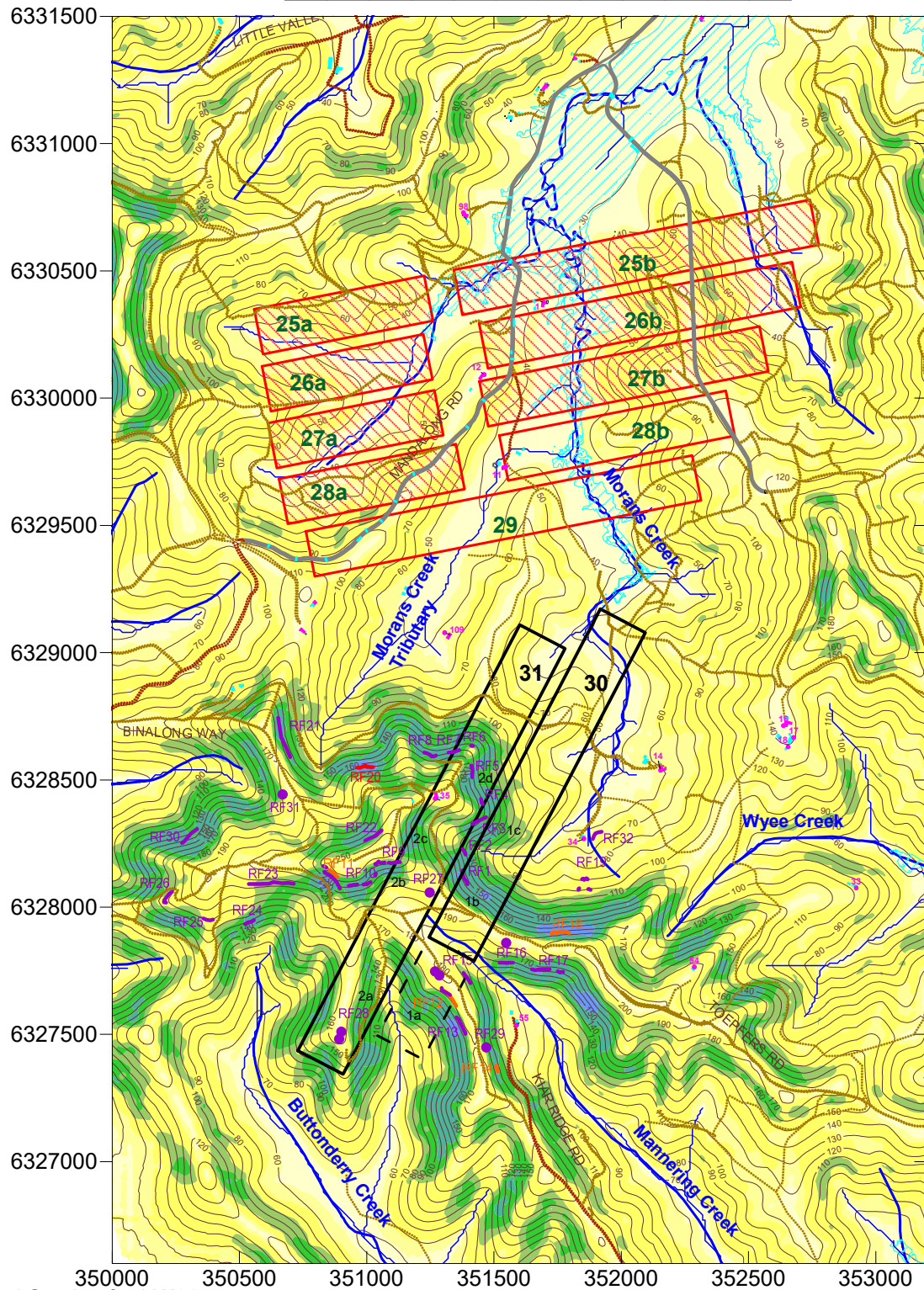
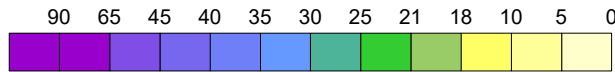
Client: Centennial Mandalong  
 MAN-005/8

Title: Cover Depth and Aboriginal Artefact Sites above Proposed  
 Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 1b

Slope (degrees):



Deleted Section for LW30

Proposed Variation to LW30 - 31

Approved LW25 - 29

Extracted Longwalls

Sealed Roads Culverts

Pre-mining Levels (AHD)

Creeks & Tributaries

1 in 100 Year Flood Limit

Unsealed Roads/Tracks

House No.

RF20 Rock Faces 10 m to 20 m high

RF11 Rock Faces 5 m to 10 m high

RF1 Rock Faces < 5m high

Boulders < 5 m high

1a - 2c Steep Slope No.

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 15.05.21

Ditton Geotechnical Services Pty Ltd

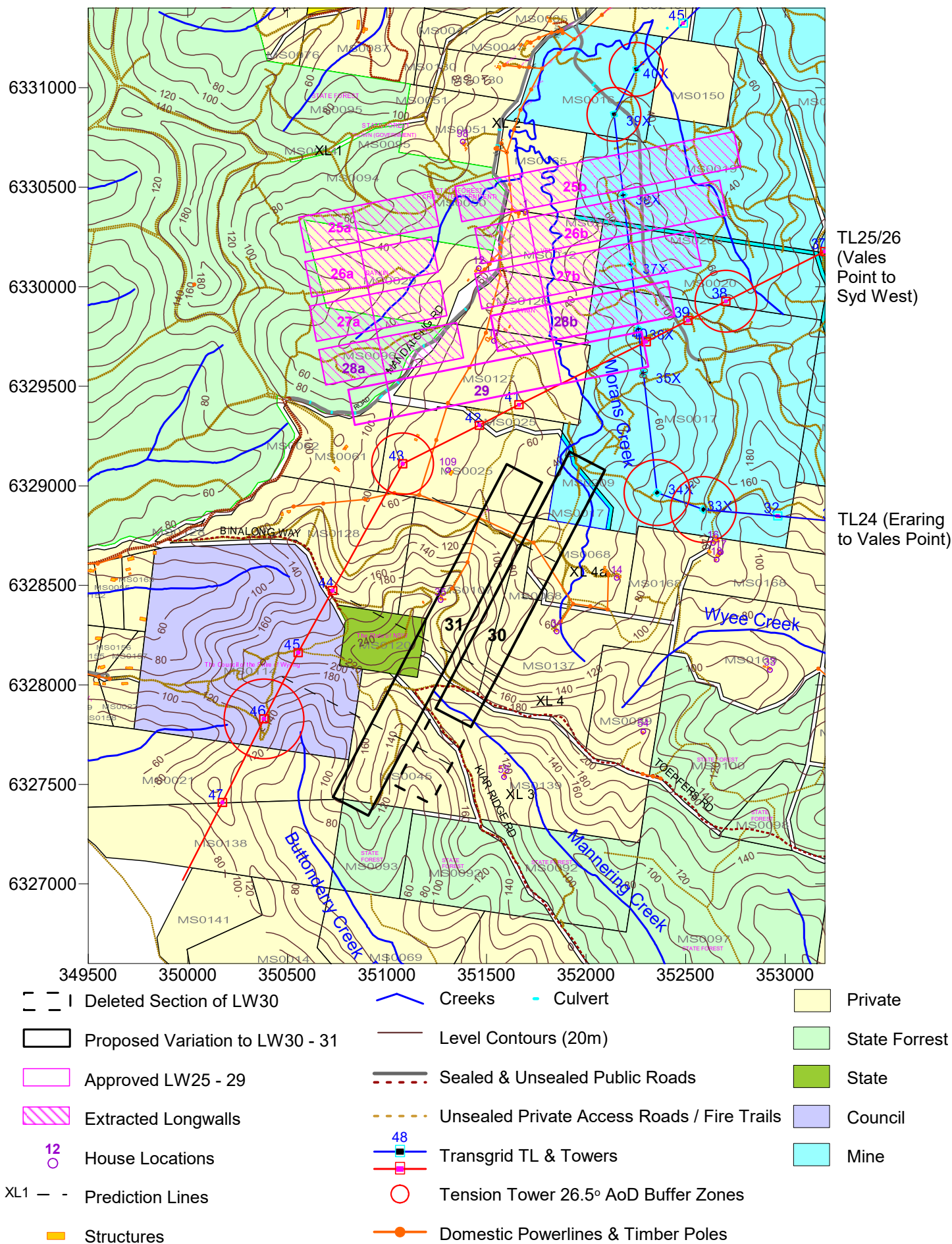
Client: Centennial Mandalong  
MAN-005/8

Title: Pre-mining Surface Levels & Natural Features above the Proposed Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 2a





TL25/26  
(Vales  
Point to  
Syd West)

TL24 (Eraring  
to Vales Point)

DgS

Engineer: S.Ditton  
Drawn: S.Ditton

Date: 15.06.21

Ditton Geotechnical  
Services Pty Ltd

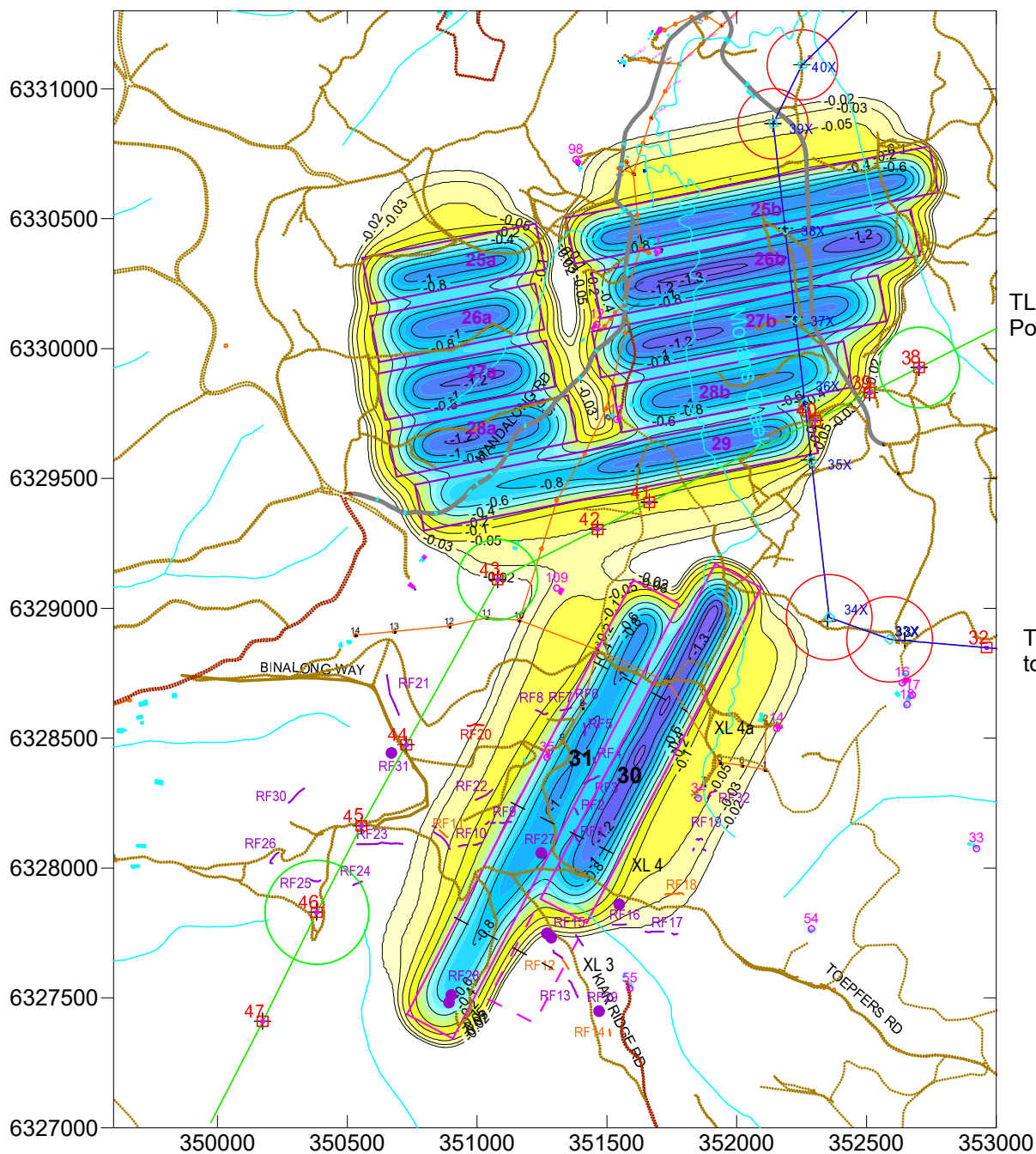
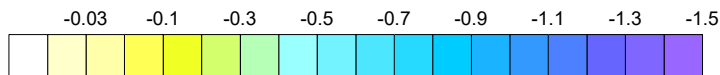
Client: Centennial Mandalong  
MAN-005/8

Title: Pre-mining Surface Levels, Landholdings & Built Features above the  
Proposed Variation to LW30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 2b

Subsidence (m):



TL25/26 (Vales Point to Syd West)

TL24 (Eraring to Vales Point)

Key:

- Deleted section for LW30
- Proposed Longwall 30 & 31 Variation
- Approved Longwalls in Extraction Plan
- Creeks
- Roads
- 10 Houses
- TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

**DgS**

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical  
Services Pty Ltd

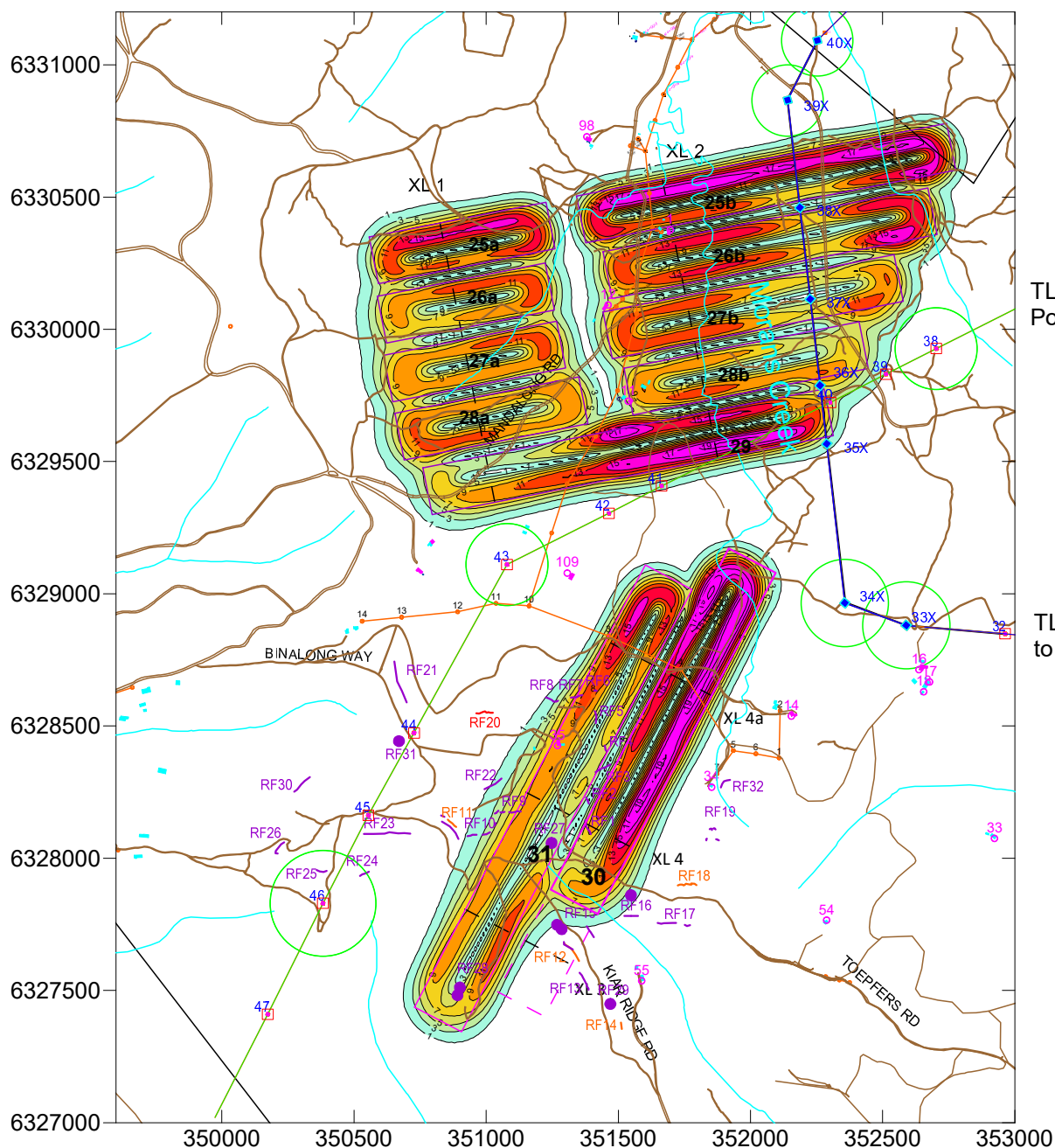
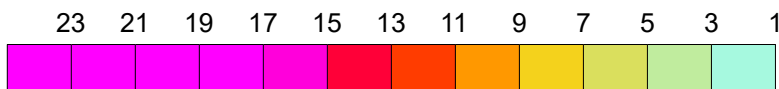
Client: Centennial Mandalong  
MAN-005/8

Title: Predicted Final Subsidence Contours (U95%CL) for the Proposed  
Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3a

Tilt (mm/m):



TL25/26 (Vales  
Point to Syd West)

TL24 (Eraring  
to Vales Point)

Key:

Deleted section for LW30

Proposed Longwall 30 & 31 Variation

Approved Longwalls in Extraction Plan

Creeks

Roads

Houses

32

TransGrid Transmission Lines  
& Towers

26.5 degree AoD "buffer zones"  
for Tension Towers

Domestic Powerlines & Poles

XL4 -- Prediction Lines

RF20

RF11

RF1

Rock Faces 10 m to 20 m high

Rock Faces 5 m to 10 m high

Rock Faces < 5m high

Boulders < 5 m high

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical  
Services Pty Ltd

Client: Centennial Mandalong  
MAN-005/8

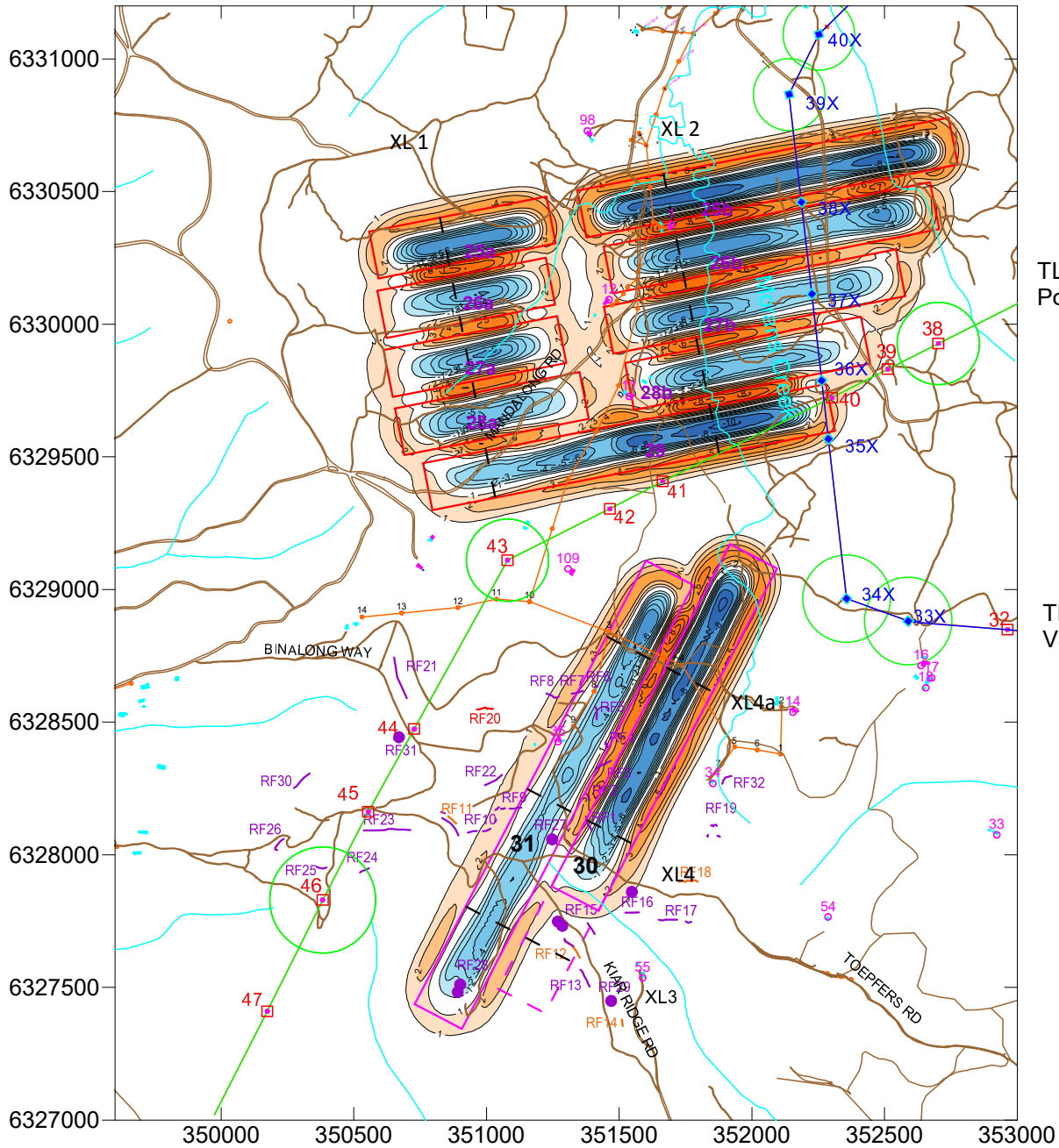
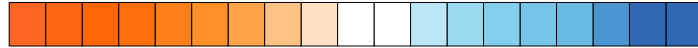
Title: Predicted Final Tilt Contours (U95%CL) for the Proposed Variation  
to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3b



Strain (mm/m):



TL25/26 (Vales Point to Syd West)

TL24 (Eraring to Vales Point)

Key:

- Deleted section for LW30
- Proposed Longwall 30 & 31 Variation
- Approved Longwalls in Extraction Plan
- Creeks
- Roads
- 10 Houses
- 32 TransGrid Transmission Lines & Towers
- 33 TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical Services Pty Ltd

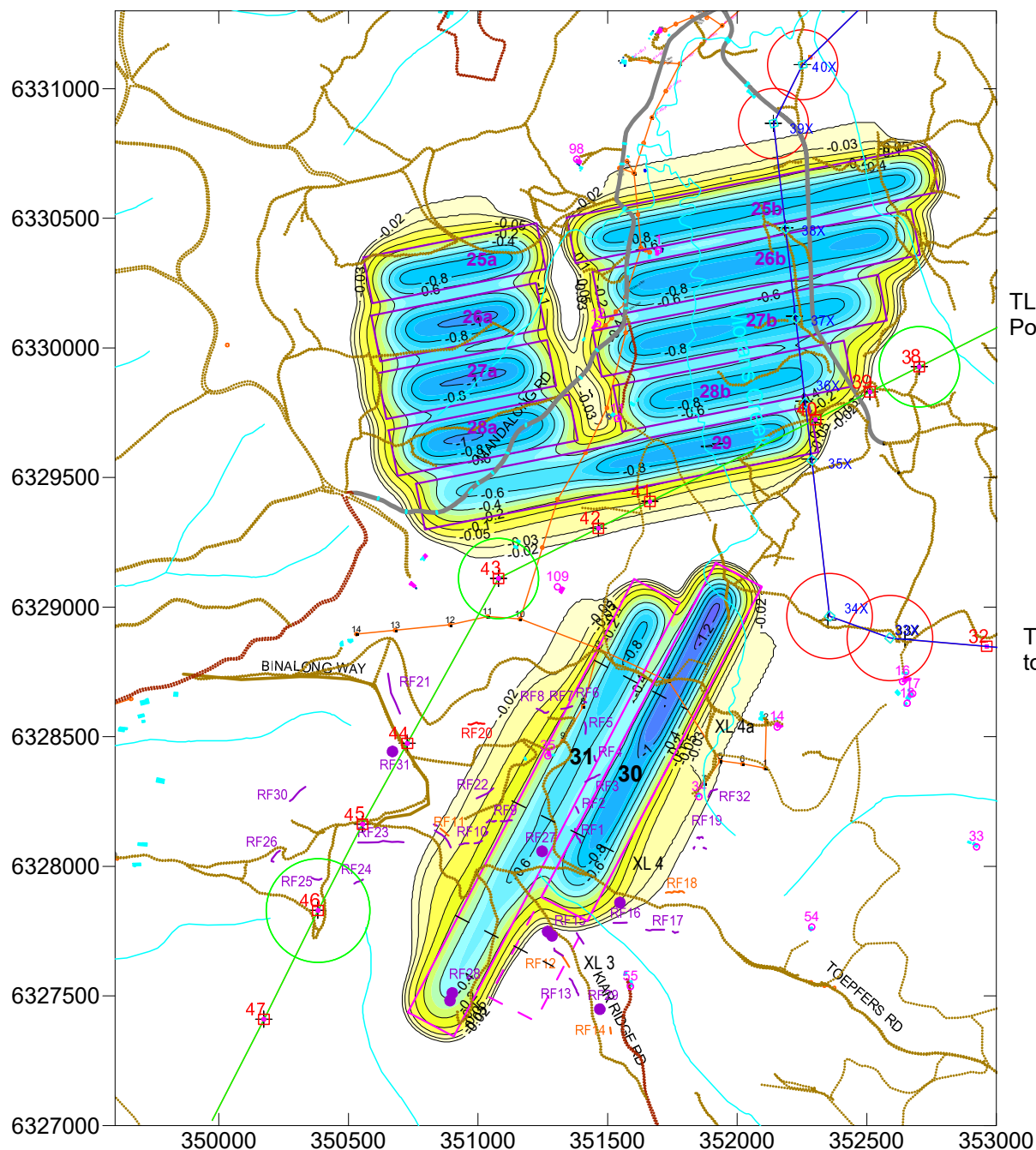
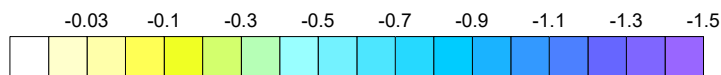
Client: Centennial Mandalong  
MAN-005/8

Title: Predicted Final Horizontal Strain Contours (U95%CL) for the Proposed Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3c

Subsidence (m):



TL25/26 (Vales Point to Syd West)

TL24 (Eraring to Vales Point)

Key:

- Deleted section for LW30
- Proposed Longwall 30 & 31 Variation
- Approved Longwalls in Extraction Plan
- Creeks
- Roads
- 10 Houses
- TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5 m high
- Boulders < 5 m high

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical  
Services Pty Ltd

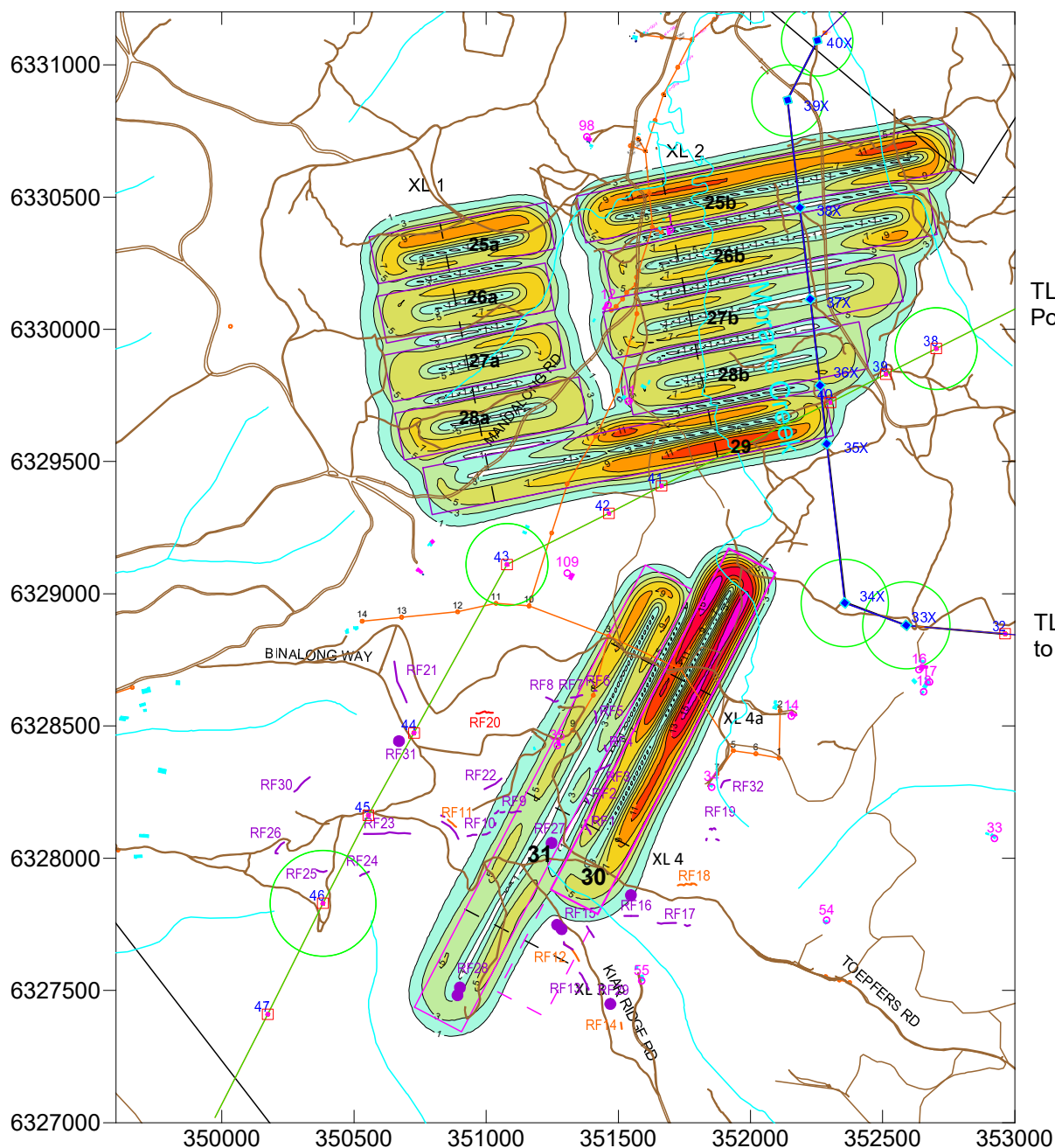
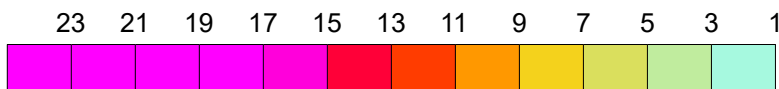
Client: Centennial Mandalong  
MAN-005/8

Title: Predicted Final Subsidence Contours (mean) for the Proposed  
Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3d

Tilt (mm/m):



TL25/26 (Vales Point to Syd West)

TL24 (Eraring to Vales Point)

Key:

- Deleted section for LW30
- Proposed Longwall 30 & 31 Variation
- Approved Longwalls in Extraction Plan
- ~ Creeks
- Roads
- 10 Houses
- 32 TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- - XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5m high
- Boulders < 5 m high

**DgS**

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical  
Services Pty Ltd

Client: Centennial Mandalong  
MAN-005/8

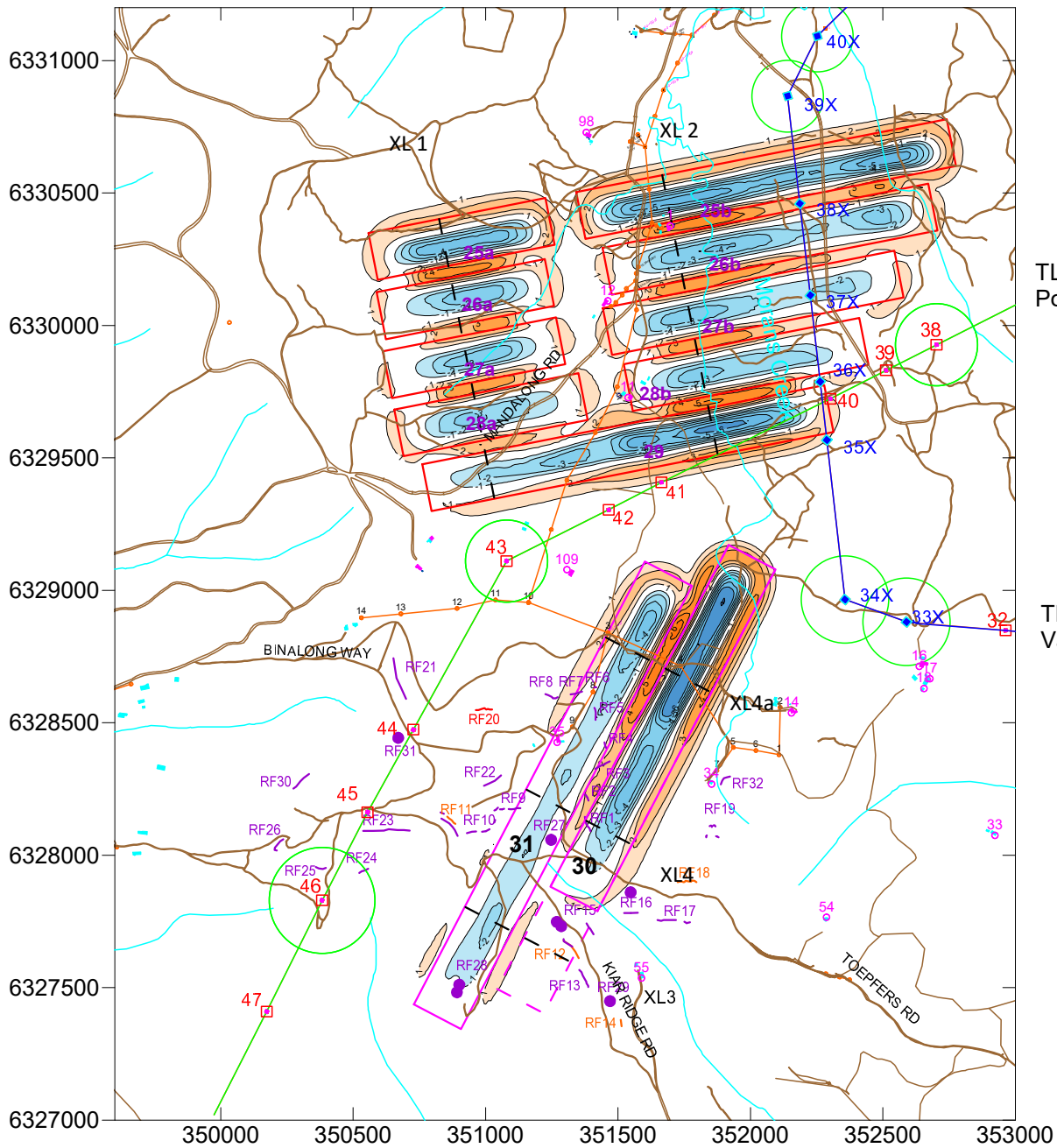
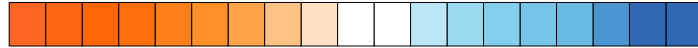
Title: Predicted Final Tilt Contours (mean) for the Proposed Variation  
to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3e



Strain (mm/m):



TL25/26 (Vales Point to Syd West)

TL24 (Eraring to Vales Point)

Key:

- Deleted section for LW30
- Proposed Longwall 30 & 31 Variation
- Approved Longwalls in Extraction Plan
- Creeks
- Roads
- 10 Houses
- TransGrid Transmission Lines & Towers
- 26.5 degree AoD "buffer zones" for Tension Towers
- Domestic Powerlines & Poles
- XL4 Prediction Lines
- RF20 Rock Faces 10 m to 20 m high
- RF11 Rock Faces 5 m to 10 m high
- RF1 Rock Faces < 5 m high
- Boulders < 5 m high

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical Services Pty Ltd

Client: Centennial Mandalong  
MAN-005/8

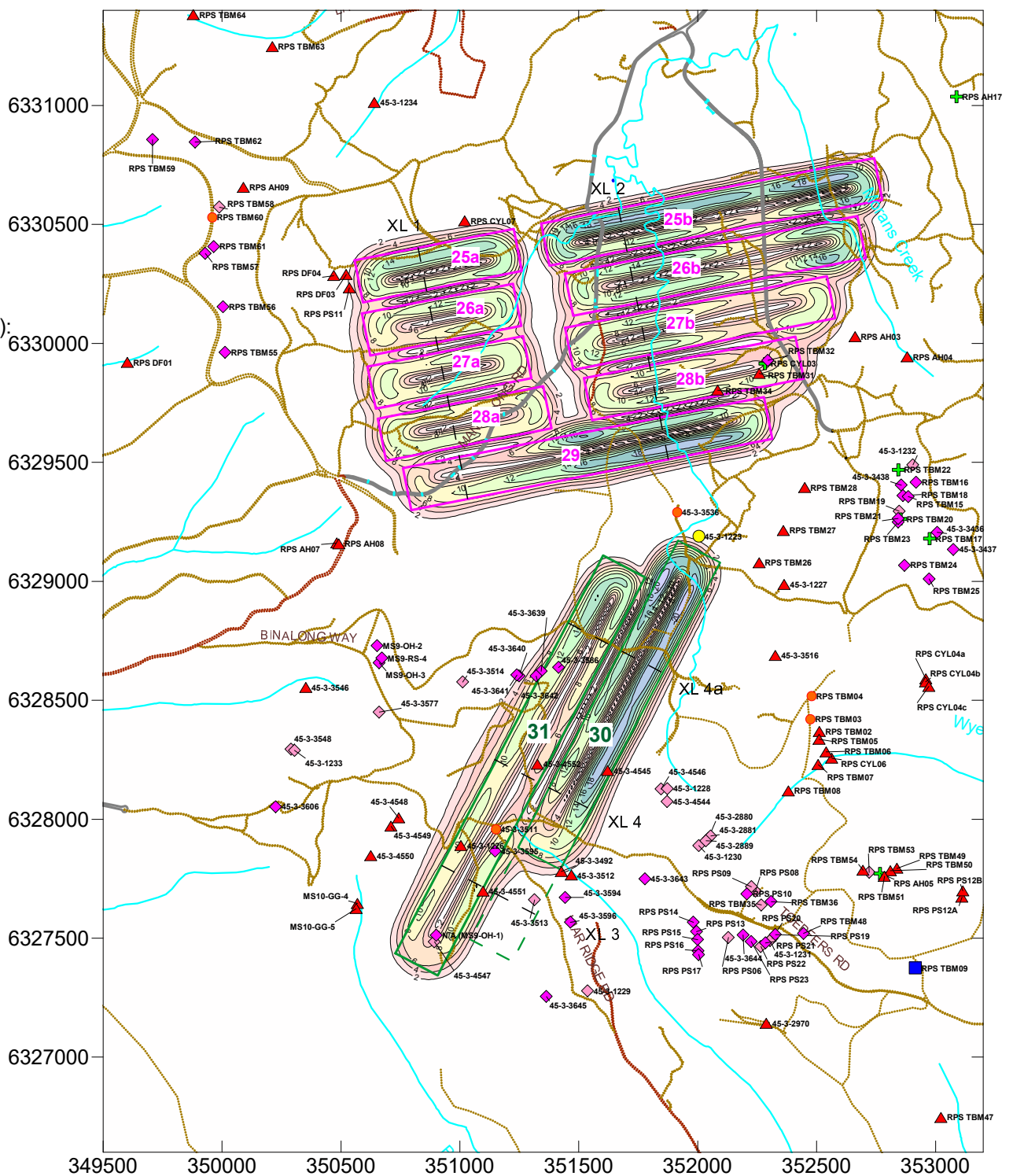
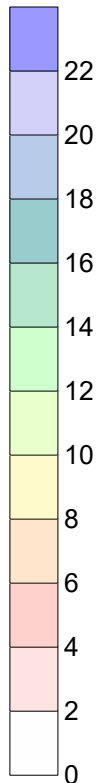
Title: Predicted Final Horizontal Strain Contours (mean) for the Proposed Variation to Longwalls 30 to 31 at the Mandalong Mine

Scale: 1:25,000 (A4)

Figure No: 3f



Tilt (mm/m):



Deleted Section of LW30

Proposed Variation to LW30 - 31

Approved LW25 - 29

Artefact Scatter or Individual Find

Open Camp Site

Scarred Tree

Grinding grooves

Rock Shelters

Rock Shelters with Art and/or PADs

Creeks

Roads & Tracks

DgS

Engineer: S.Ditton

Drawn: S.Ditton

Date: 20.06.21

Ditton Geotechnical  
Services Pty Ltd

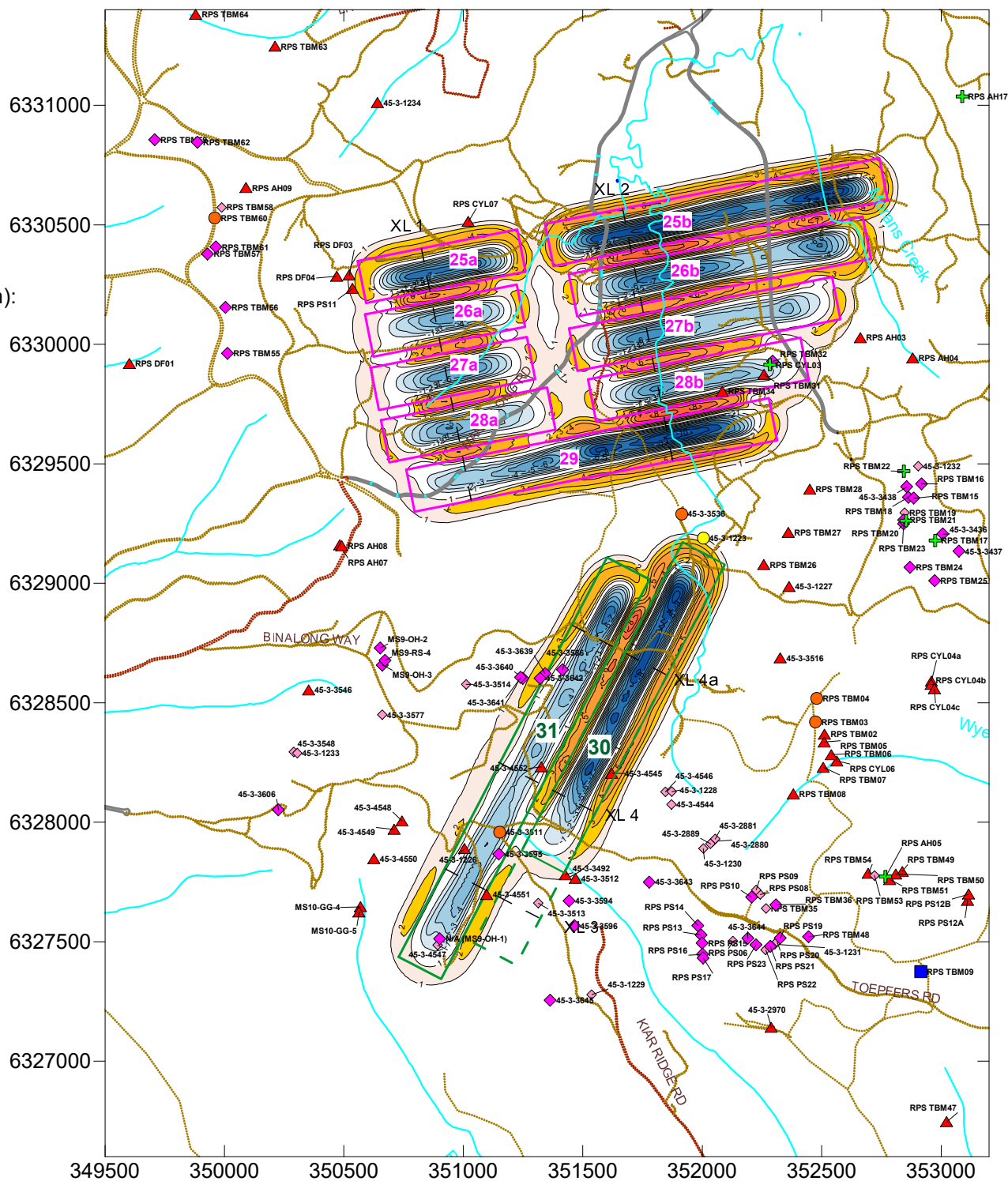
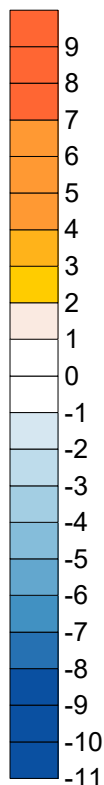
Client: Centennial Mandalong  
MAN-005/8







Title: Predicted U95%CL Tilt Contours & the Aboriginal Heritage  
Sites above the Proposed Variation to Longwalls 30 to 31  
at the Mandalong Mine






Scale: 1:25,000 (A4)

Figure No: 4b





-  Deleted Section from LW30
-  Proposed Variation to LW30 - 31
-  Approved LW25 - 29
-  Artefact Scatter or Individual Find
-  Open Camp Site
-  Scarred Tree

-  Grinding grooves
  Creeks
-  Rock Shelters
  Roads & Tracks
-  Rock Shelters with Art and/or PADs