

Appendix 5 – Subsidence Predictions Report (Seedsman Geotechnics, 2017)

Centennial Coal Company Limited
P O Box 1000
Toronto NSW 2283
www.centennialcoal.com.au





SEEDSMAN GEOTECHNICS PTY LTD

ACN 082 109 082
Telephone 0417279556
Facsimile 0242712220

CENTENNIAL MANDALONG PTY LTD

PREDICTION OF SUBSIDENCE IMPACTS FOR LW24 and LW24A

MAND17-03

MARCH 2017



SEEDSMAN GEOTECHNICS PTY LTD

ACN 082 109 082
Telephone 0417279556
Facsimile 0242712220

Thursday, 16 March 2017
REF: MAND17-03

Mr P Enright
Mining Approvals Coordinator
Centennial Coal Company Limited | Mandalong
12 Kerry Anderson Drive
Mandalong NSW 2264

Dear Phil,

RE: Subsidence predictions for LW24 – LW24A

Drawing on our experience with subsidence predictions at Mandalong Mine since longwall extraction began we are pleased to submit this report on the likely outcomes for LW24 and LW24A.

Please contact the undersigned if you require further details.

Yours truly,

Ross Seedsman
FAusIMM(CP)



EXECUTIVE SUMMARY

Since 2003, Mandalong Mine has been specifically designed to benefit from the presence of a very thick and strong conglomerate layer in the overburden in order to minimise subsidence impacts. The mine layout is designed so that this layer can span across the longwall extraction panel and deform elastically. This has resulted in vertical subsidence of less than about 1 m (compared to a maximum subsidence of 2.98 m in the original consent) and has protected surface and subsurface features from significant impact. The mine layout has been successfully employed for 21 panels mined to date and the same approach to mine design has been adopted for LW24 and LW24A.

In this report, the subsidence over 20 panels is reviewed. Subsidence above the chain pillars at Mandalong has ranged between less than 100 mm to about 1 m depending on the depth of cover. There is no evidence that there has been any pillar collapse. Relative deflection of the surface between adjacent chain pillars has been consistent with the predictions. There has been no measurable subsidence above the Main Heading pillars. The measured tilts and strains have been consistent with the predictions.

For LW24 and LW24A similar geotechnical conditions are predicted: the igneous sill in the coal seam will not have a material impact of the subsidence outcomes. Compared to the 46 m wide chain pillars used previously, the recently adopted 37 m pillar width may result in an additional 10-15 % vertical subsidence above the pillars. This is well within the variability in outcomes recorded to date and will result in negligible changes in the risk of exceeding the predicted deformations. The similar geology and mine layout will result in a continuation of the range of impacts and consequences experienced to date. Deformation applied to dwellings will be within the safe, serviceable, and repairable range. There will be no tensile cracking of the soil or any exposed rock. There may be some minor compression humps detected on sealed roads. The movements likely to be imposed onto the TransGrid towers are very low with less than 3mm/m tilt and 1 mm/m strain. Given the gentle topography above LW24 and LW24A and the low subsidence deformations no rock falls or cliff instability is predicted.

The spanning of the massive conglomerate ensures that there is no hydrogeological connection between the surface and the underground workings. Others should use the subsidence predictions to assess impacts on other natural or built features within the area, including floods and changes in surface hydrology.



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1 INTRODUCTION AND BACKGROUND

Mandalong Mine is an existing underground longwall coal mining operation producing thermal coal that is supplied to domestic and export markets. The mine is located approximately 35 km south-west of Newcastle near Morisset in New South Wales. Mandalong Mine is 100 percent owned and operated by Centennial Mandalong Pty. Limited (Centennial Mandalong), a subsidiary of Centennial Coal Company Limited. Centennial Coal Company Limited is a wholly owned subsidiary of Banpu Public Company Limited.

Mandalong Mine operates under Development Consent SSD-5144 which was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4, Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act), and provided for extension of the mining area with a production limit of 6 million tonnes per annum of thermal coal from the West Wallarah and Wallarah-Great Northern Seams.

The currently approved Mandalong Mine comprises the underground workings and surface infrastructure of the following:

- The Mandalong Mine Access Site, encompassing underground workings and associated surface infrastructure near Morisset.
- Delivery of run-of-mine coal from the underground workings to the Cooranbong Entry Site. The Cooranbong Entry Site coal handling and processing facilities are approved under the Northern Coal Logistic Project (SSD-5145).
- Delivery of run-of-mine coal from the underground workings to the Delta Entry Site, located near Wyee at the Vales Point Rail Unloader Facility. The coal handling facility is approved under DA35-2-2004.
- Mandalong South Surface Site (MSSS), which is yet to be constructed, encompassing ventilation shafts, ventilation fans and underground delivery boreholes located approximately 6 km south-west of the Mandalong Mine Access Site.

An igneous sill exists to the west of approved longwall panels 22 to 24. Due to historic uncertainty associated with the extent of the igneous sill, longwall panels 22 to 24 were shortened as a conservative measure to mitigate the sill's impact on the mine's production. In recent times through ongoing geological exploration and the successful extraction of adjacent longwall panels below the igneous sill its extent and condition has become better understood. This has resulted in the proposed extension of longwall panel 24 and the addition of longwall panel 24A within the Project Application Area of SSD-5144. Figure 1 illustrates the proposed extension of chain pillars and longwall mining regarding these two panels.

Centennial Mandalong has prepared a Statement of Environmental Effects (SEE) to support an application seeking to modify Development Consent SSD-5144 under Part 4 of the EP&A Act. The modification is seeking to undertake the extended development of Maingate 24 and extended secondary extraction of longwall panel 24 in addition to the development of Maingate 24A and extraction of longwall panel 24A within the Project Application Area of SSD-5144 as illustrated on Figure 1.

Outlined below are the primary components of the Mandalong Longwall Panel 24 to 24A Modification:



- Extension of Longwall 24 from 1,631 m to 2,570 m. This yields 1,030,813 additional tonnes beyond 1,766,912 tonnes already approved.
- Addition of Longwall 24A. Longwall 24A is proposed to be 2,470 m in length which yields an additional 2,679,560 tonnes.

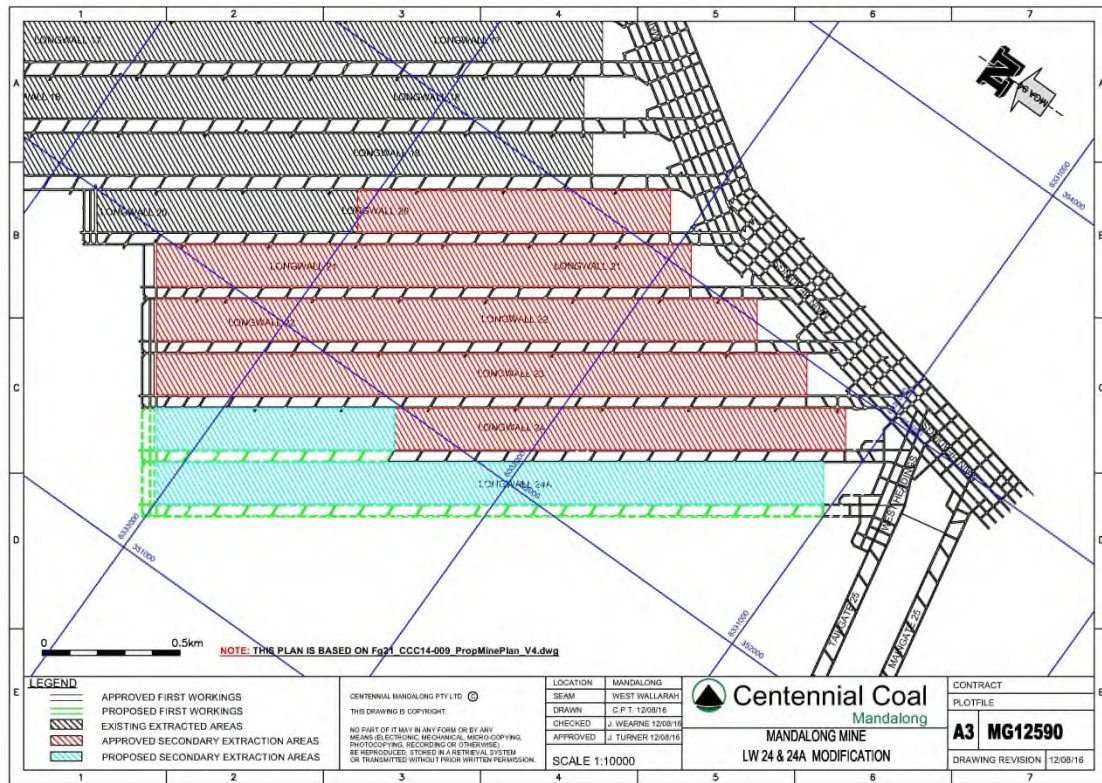


Figure 1 Detail of the proposed modification for LW24 and LW24A (shown in blue and green) outside the Mandalong South approved plan.

1.1 LEGISLATIVE FRAMEWORK

State Significant Development (SSD) Consent SSD-5144 was granted on 12 October 2015 by the NSW Planning Assessment Commission under Part 4 Division 4.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). Centennial Mandalong is now proposing to modify its Development Consent SSD 5144 for the Mandalong Longwall Panel 24 to 24A Modification. SSD consents may be modified under Section 96 of the EP&A Act provided that the development as modified will be substantially the same development as the development for which consent was originally granted.

It is considered the proposed modifications to the Mandalong Southern Extension Project SSD-5144 development consent are substantially the same development as the development for which consent was originally granted being an underground longwall coal mine. The proposed modification will provide additional coal resources given the improved understanding regarding the extent and condition associated with the igneous sill. As such, it is considered the modification can be modified pursuant to Section 96(2) of the EP&A Act.



1.2 MINE GEOMETRY

The location of LW24 and LW24A with respect to surface features is shown in Figure 2. Close inspection of this figure will reveal that there has been no change in the dimension of the Main Heading pillars (27.8 m solids and 5.2 m roadways). From MG20 onwards the chain pillar width has decreased from 46 m to 37 m. The longwall extraction voids are 160 m wide. The development roadway height is 3.4 m and the depth of cover ranges between 250 m and 330 m, with the surface topography lying between 20 m and 80 m above sea level.

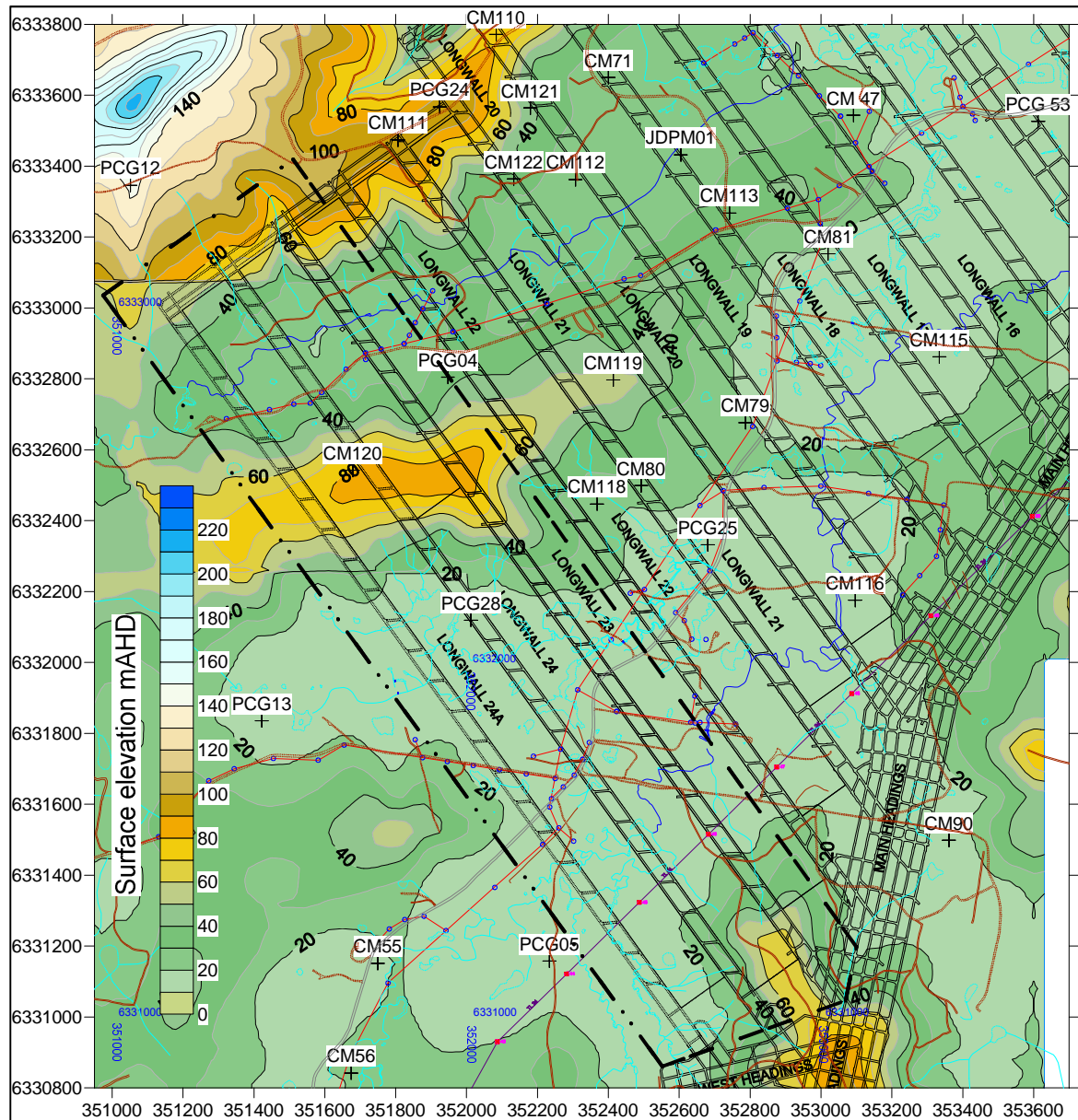


Figure 2 Mine plan, surface topography, drainage lines, boreholes used in determining conglomerate thickness and the location of surface infrastructure – study area shown with dash/double dot line. Detailed plans of infrastructure included in an appendix.



2 REVIEW OF SUBSIDENCE IMPACTS TO DATE

The longwall panel width at Mandalong Mine (initially 125 m and now 160 m) has been specifically designed to exploit the presence of a very thick and strong conglomerate layer in the overburden in order to minimise subsidence impacts. The mine layout is designed so that this layer can span across the longwall extraction panel and deform elastically. This has resulted in vertical subsidence of less than about 1 m (compared to a maximum subsidence of 2.98 m in the original consent) and has protected surface and subsurface features from significant impact.

In developing the mine layout in 2003 the approach was to have surface deformations that would be below SSR (safe serviceable and repairable) and would not result in a significant change in the flood hazard. In 2003, this was translated to specific design constraints of less than 7 mm/m tilt, less than 4 mm/m strain, and less than 500 mm subsidence under the flood plains – more than 500 mm was acceptable in the high ground where the depth of cover is deeper. These constraints have relaxed slightly as more experience has been gained. An appendix to this report provides more details.

The mine layout has been successfully employed for the 21 panels mined to date and the same approach has been adopted for LW24 and LW24A. Since longwall extraction began at Mandalong it is understood that there has been no breach of consent and no unacceptable consequences.

Cumulative frequency plots of the subsidence deformations over the just completed panel are shown in Figure 3 for LW16 to LW20; maximum values are tabulated in Table 1. The strain and tilt data are consistent with the interpretation of the SSR criterion; the vertical subsidence data includes data from the high ground away from the flood plains and hence does not show how well the subsidence constraint for the flood plain areas has been achieved.

3 CONTINUATION OF GEOTECHNICAL CONDITIONS

3.1 WEST WALLARAH SEAM

Based on the available drilling, the West Wallarah Seam dips gently to the west (about 0.5°) so the depth of cover reflects the surface topography to some degree (Figure 4). The seam thickness is between 4.25 m and 5.25 m. At the north east end of the LW24 and LW24A the seam is partially intruded by igneous material – this will have no material impact on the predicted deformation of the pillars or the deflection of the conglomerate.

Minor dykes, small faults, and more closely jointed zones have been encountered during mining. These have been of such a scale that they were not detected during borehole-based surface exploration prior to mining. From a subsidence perspective only the joint zones appear to have modified the surface subsidence outcomes.

Based on the knowledge of the geological conditions, it is anticipated that similar geological conditions and similar subsidence outcomes will be encountered during LW24 and LW24A and on this basis the impacts and consequences will be similar.

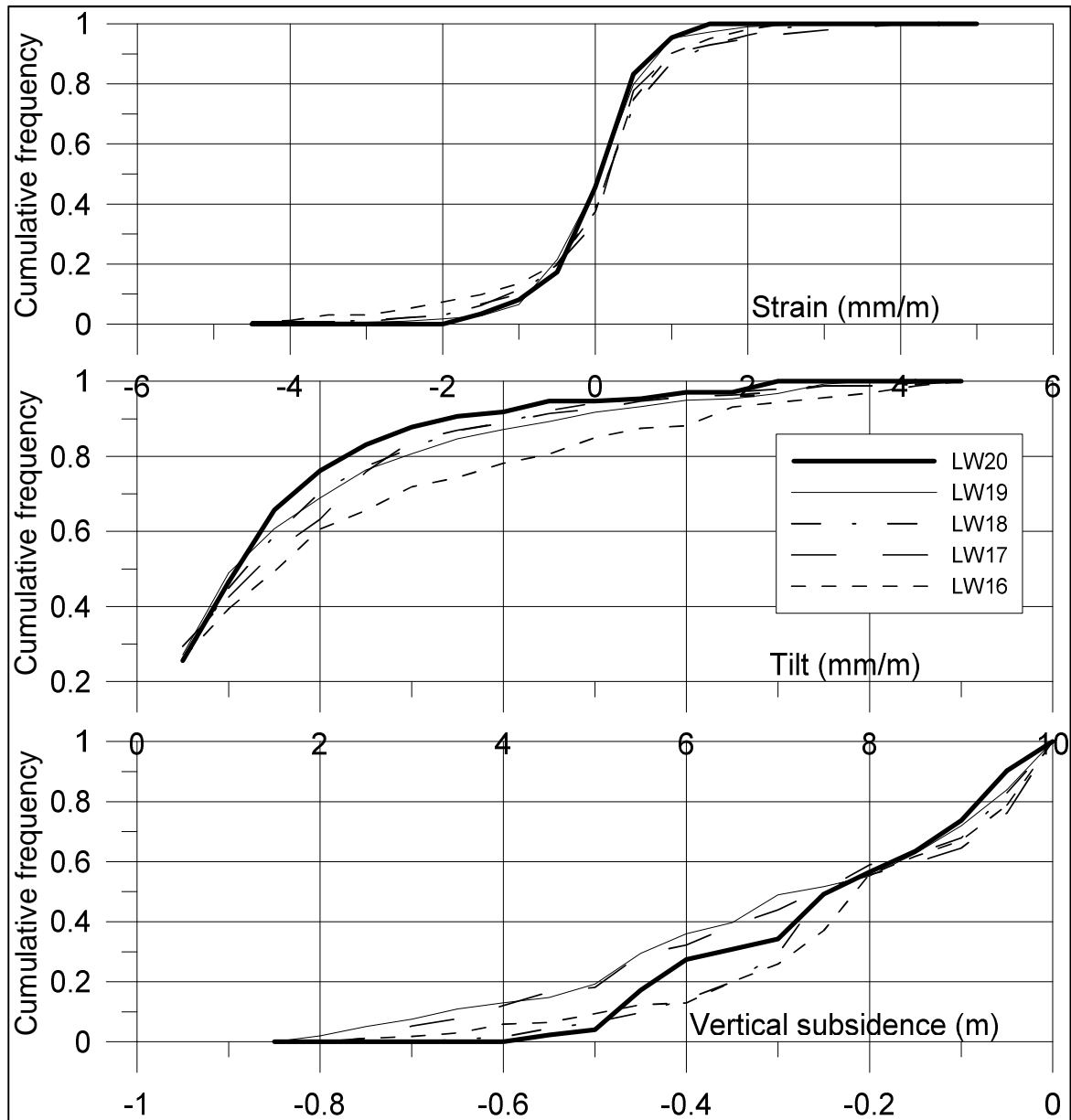


Figure 3 Histograms of vertical tilts and strain data

Table 1 Maximum values of the subsidence parameter surveyed for each longwall

	Maximum vertical (mm)	Maximum tilt (mm/m)	Maximum tensile strain (mm/m)	Maximum compressive strain (mm/m)
LW16	782	13.0	2.3	-5.6
LW17	767	9.9	3.8	-7.5
LW18	655	8.9	2.9	-10.9
LW19	807	11.8	3.6	-4.4
LW20	570	7.0	1.4	-1.8

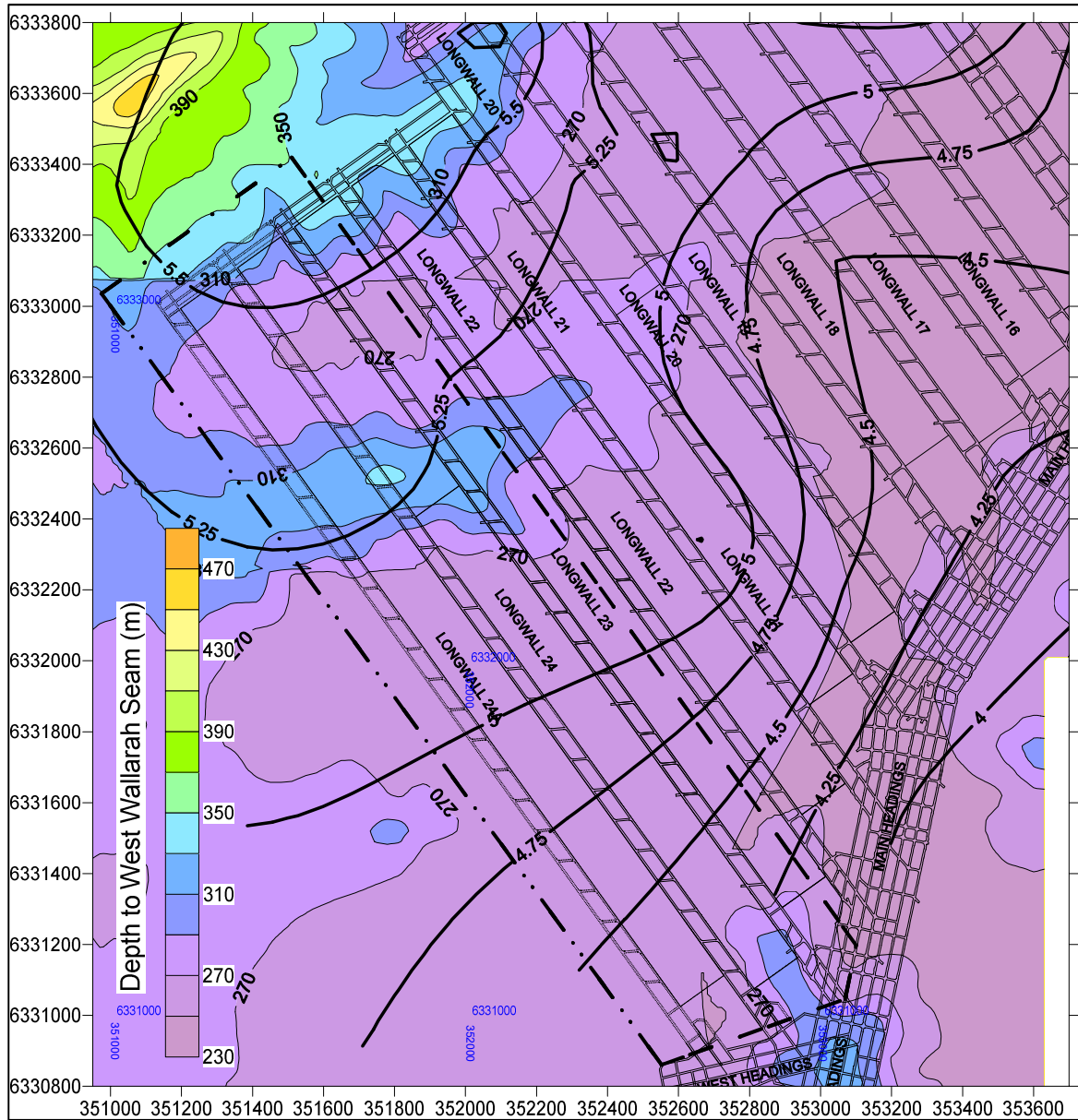


Figure 4 Depth of cover and West Wallarah Seam thickness (both expressed in metres)

3.2 MANDALONG CONGLOMERATE

In common with the earlier longwalls at Mandalong, there is a thick conglomerate layer in the overburden about 100 m above the coal seam. Using a combination of the core logs and the geophysical logs, the top and bottom of the thickest/shallowest monolithic beam in each hole have been identified. Using borehole CM 80 above Maingate 20 as an example (Figure 5), the top and bottom are marked by siltstones (non-orange colour in lithology log) and peaks in the natural gamma and neutron logs (red in the GRDE/SSN cross plot). Figure 5 also includes the natural gamma and neutron logs from CM 120 above maingate 24 to highlight the similarity in the overburden strata.

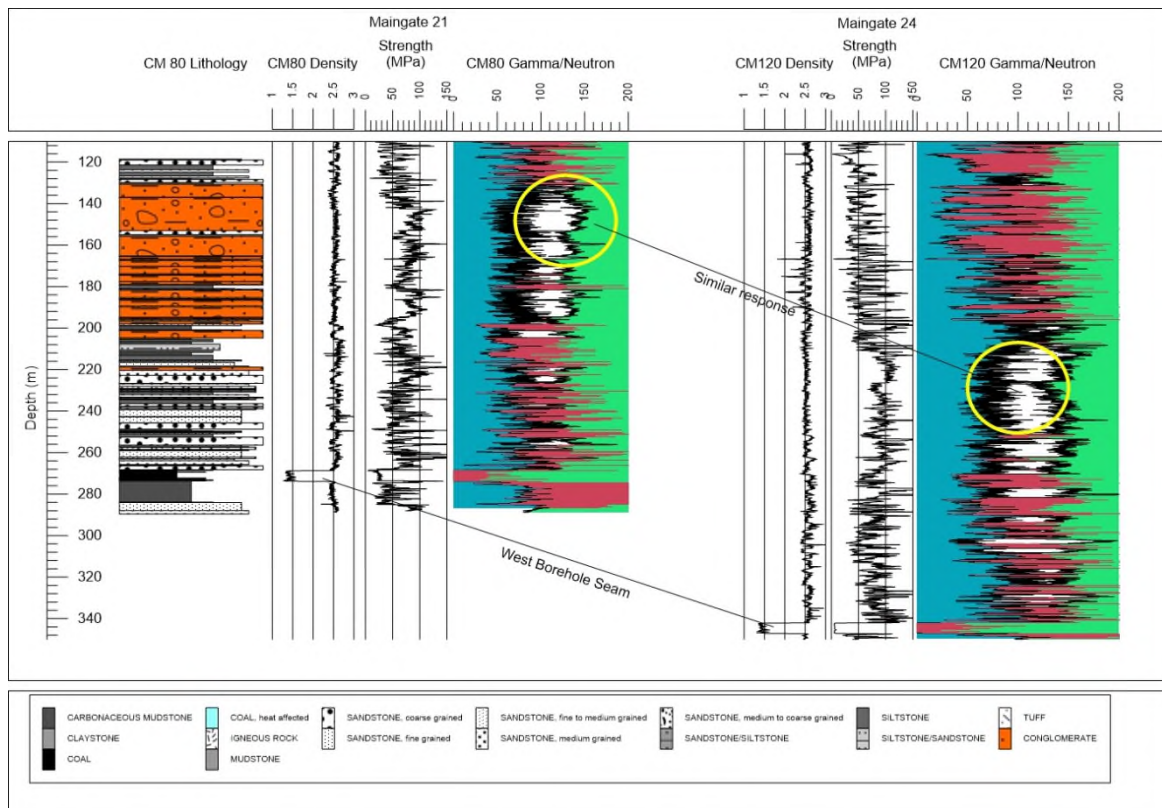


Figure 5 Geology and geophysical logs for borehole CM 80 (massive conglomerate layer between 131 m and 167m) and similar log traces for borehole CM 120

A contour plan of the thickness of this massive unit (Figure 6) indicates the thickness varies between 25 m to 35 m in the area of interest. The massive unit lies approximately 100 m above the West Wallarah Seam. As discussed in earlier reports the contours indicate general trends – it is possible that there are variations in thickness between the points of observation in the boreholes. The subsidence measurements from LW17 and LW18 do not indicate that the conglomerate layer failed despite the concern highlight by the hatching in Figure 6, so failure in the vicinity of CM 119 above LW21 is not anticipated.

3.3 COAL SEAM FLOOR

The floor of the West Wallarah Seam is the geological formation known as the Awaba Tuff. In shallow mines around Lake Macquarie this unit has sometimes been associated with floor and pillar instability. At Mandalong this unit is of adequate strength and has not been observed to impact on pillar or floor stability or settlement/subsidence.

The distance to the underlying Fassifern Seam (Figure 7) decreases to the northwest generally coincident with the increase in depth of cover. Importantly for LW24 and LW24A, the interburden thickness is similar to that in the previous longwalls at Mandalong such that the empirical prediction tool can continue to be used.

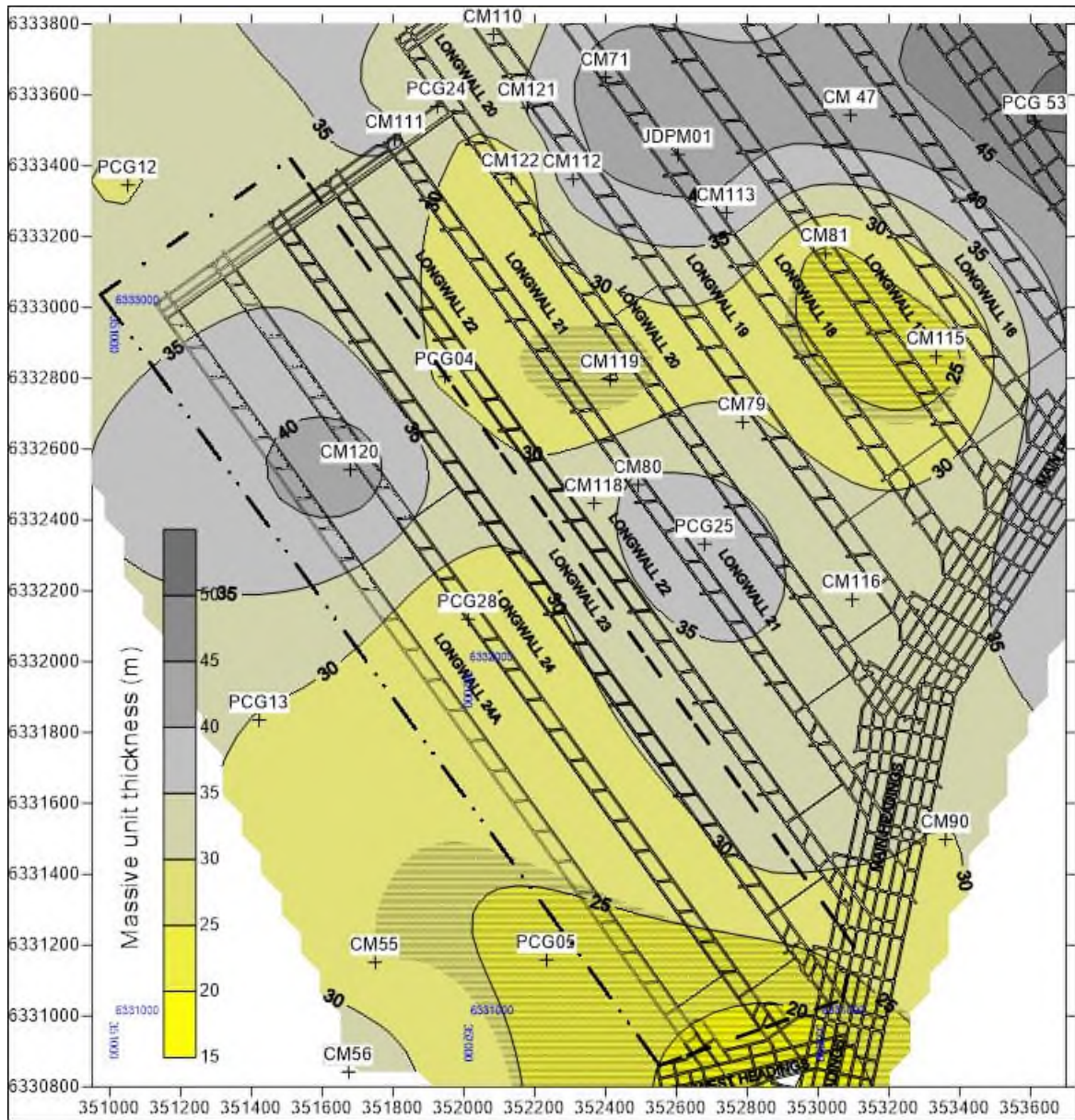


Figure 6 Massive unit thickness (in metres) – hatching shows areas where there may be a greater risk of failure of the beam

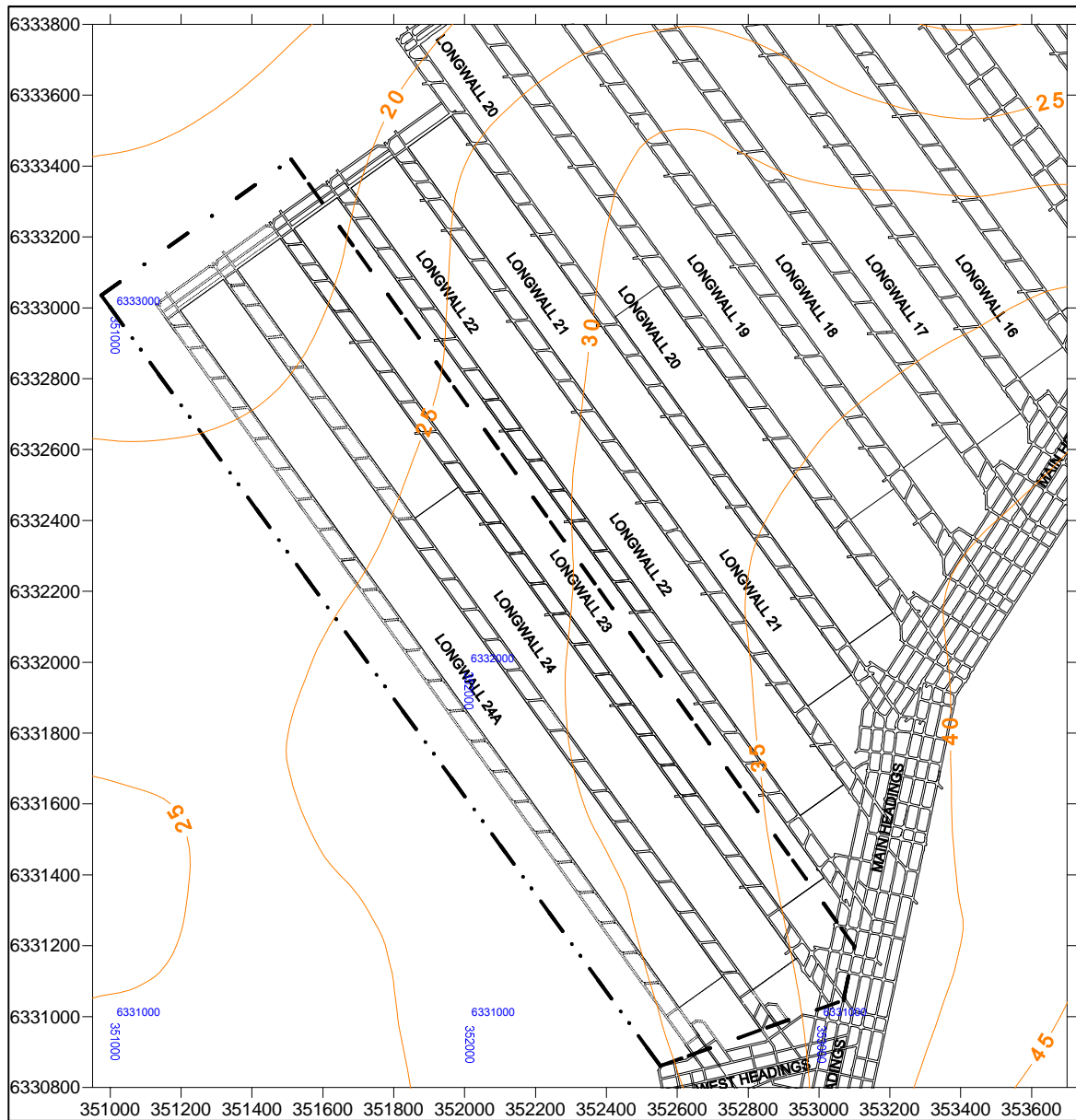


Figure 7 Separation of West Wallarah and Fassifern Seam (m)

3.4 SURFACE FEATURES

The location of dwellings and public roads and tracks are shown in Figure 8 and the location of major power infrastructure is shown in Figure 2 which also presents contours of the surface elevation. More detailed plans are included in an appendix. Above LW24 and LW24a the maximum terrain slope is in the range of 18° to 27° (Figure 8) and there are no cliff-lines.

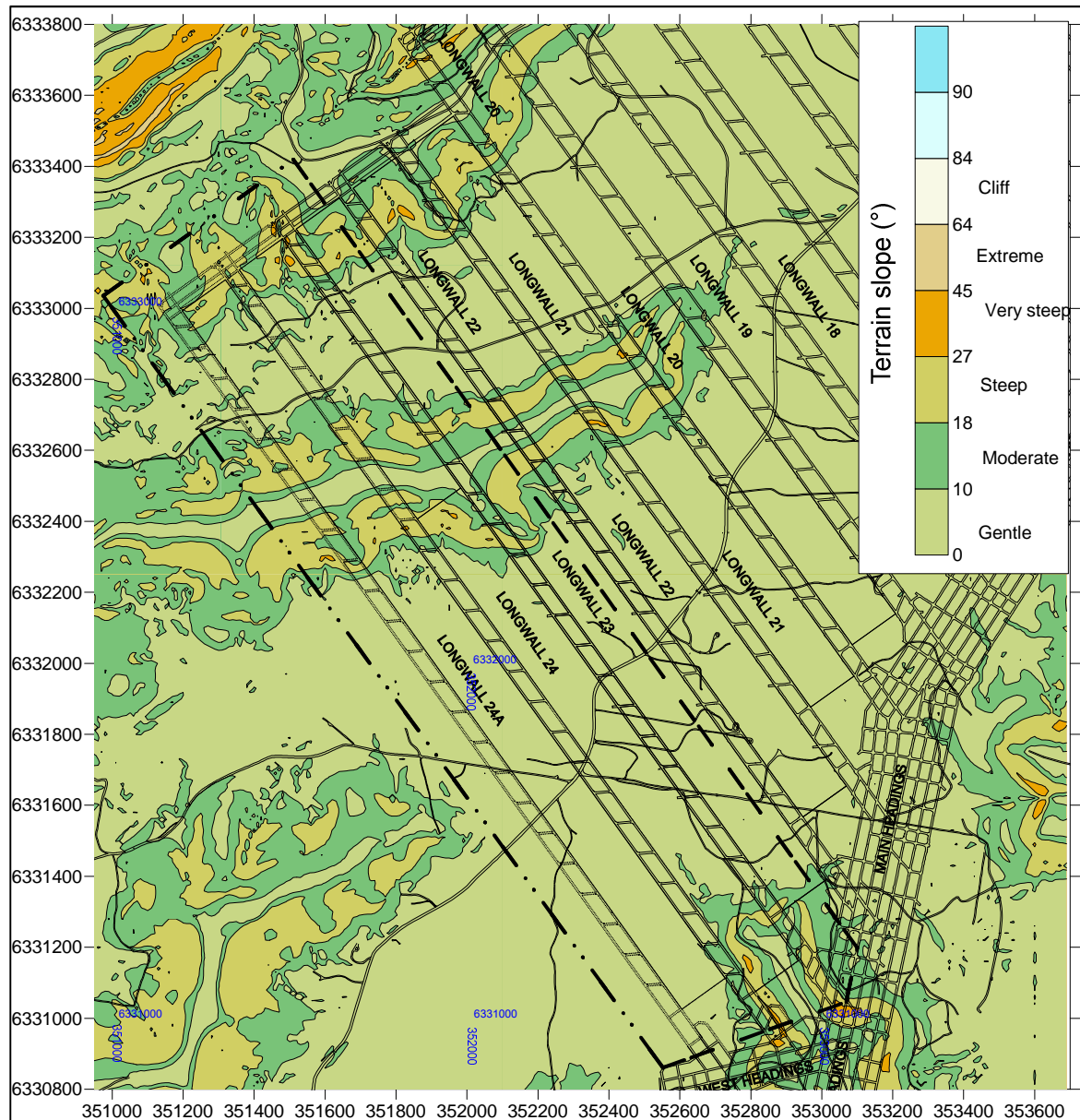


Figure 8 Terrain slope above LW21 to LW24A (°)

4 PREDICTION FOR LW24 AND LW24A

As discussed above, the geological evidence suggests that similar geotechnical conditions will be encountered in LW24 and LW24A. It is assessed that the presence of the sill in parts of the seam will not have a material impact on the subsidence behaviour recorded to date.

The width of the chain pillars for MG24 and MG24A is 37 m as implemented in LW20 compared to the 46 m used previously. As yet, there has been no longwall extraction on both sides of 37 m wide chain pillars. An appendix to this report outlines the design methods adopted to make predictions on the future behaviour of the chain pillars.

The same prediction methodology and visualisation procedures as adopted to date have been used to make the predictions for LW24 and LW24A. The subsidence outcomes have been



reviewed at the end of each longwall panel and there has been continuous improvement in the selection of some of the key input parameters.

4.1 PREDICTION OF PILLAR SUBSIDENCE AND PANEL SAG

The mine plan was subdivided into subpanels based on consideration of depth of cover, thickness of the massive conglomerate unit and whether there is to be subsequent extraction to the south west (Figure 9). The vertical subsidence above the chain pillar is a function of depth of cover, with a correction applied if the panel is the last one mined. Figure 10 presents a contour plan of the predicted deflection of the massive conglomerate unit which was used for future panels. The following figures present visualisations over previously mined panels and in some cases the survey data has been used to override the deflection prediction. Table 2 provides a listing for each of the subpanels.

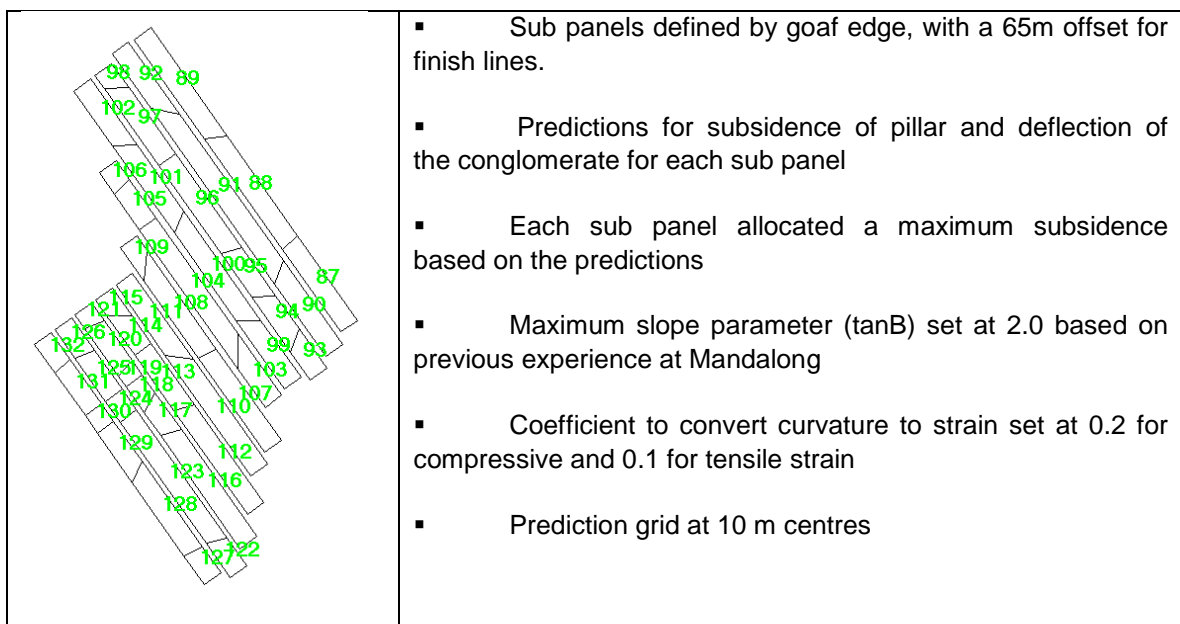


Figure 9 Visualisation of vertical subsidence, tilt and strains

Table 2 Predictions of vertical subsidence as input to the influence function program SDPS

SDPS	LW	Depth	Pillar (mm)	Sag (mm)	SDPS input (mm)	SDPS	LW	Depth	Pillar (mm)	Sag (mm)	SDPS input (mm)
87	15.1	240	373	200	251	110	21.1	275	531	275	806
88	15.2	275	531	500	498	111	21.2	275	531	500	1031
89	15.3	250	413	350	362	112	22.1	255	434	200	634
90	16.1	240	373	500	873	113	22.2	290	618	450	1068
91	16.2	275	531	200	731	114	22.3	280	559	350	909
92	16.3	250	413	400	813	115	22.4	320	837	300	1137
93	17.1	230	337	600	937	116	23.1	255	434	300	734
94	17.2	250	413	400	813	117	23.2	270	505	300	805
95	17.3	260	457	200	657	118	23.3	290	618	350	968
96	17.4	275	531	200	731	119	23.4	300	684	350	1034
97	17.5	275	531	200	731	120	23.5	280	559	300	859
98	17.6	250	413	250	663	121	23.6	300	684	250	934
99	18.1	250	413	300	713	122	24.1	265	480	500	980
100	18.2	275	531	200	731	123	24.2	255	434	350	784
101	18.3	300	684	200	884	124	24.3	320	837	250	1087
102	18.4	275	531	200	303	125	24.4	300	684	250	934
103	19.1	250	413	500	913	126	24.5	280	559	250	809
104	19.2	250	413	200	613	127	25.1	260	457	600	538
105	19.3	250	413	250	297	128	25.2	260	457	400	408
106	19.4	300	684	250	385	129	25.3	260	457	375	392
107	20.1	200	249	300	549	130	25.4	300	684	250	385
108	20.2	275	531	300	831	131	25.5	320	837	200	402
109	20.3	300	684	250	385	132	25.6	280	559	250	344

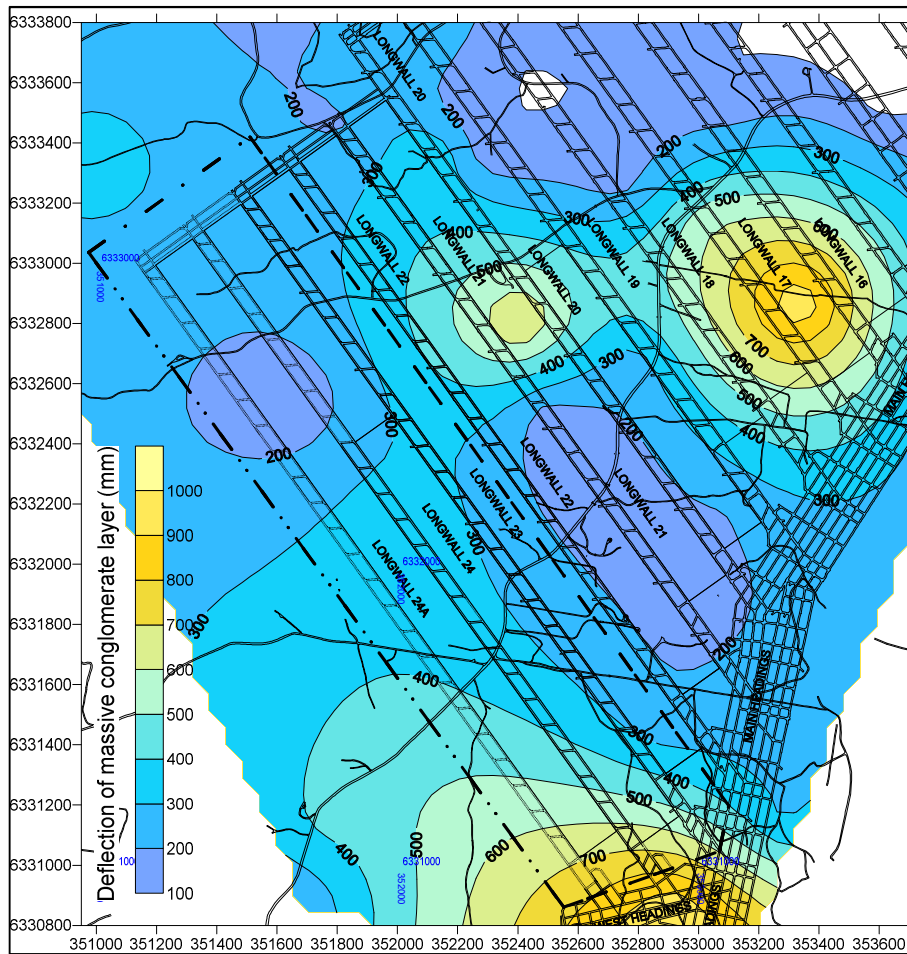


Figure 10 Prediction of conglomerate deflection (panel sag)

4.2 SUBSIDENCE PARAMETERS

Figure 11, Figure 12, and Figure 13 present contour plans of the prediction of vertical subsidence, tilt, and strains at the end of LW24A. DXF and grid files have been forwarded separately.

Histograms of the predicted movements within a footprint defined by 20 mm of vertical subsidence are presented in Figure 14 for the panels from LW15 to LW24A. The maximum values are:

- Vertical – 884 mm
- Tilt – 6.3 mm/m
- Tensile strain 1.2 mm/m
- Compressive strain 3.0 mm/m

Plots of how the subsidence will progressive develop along Mandalong and Tobins Roads compared to subsidence since LW 15 extraction are presented in Figure 15 and Figure 16.

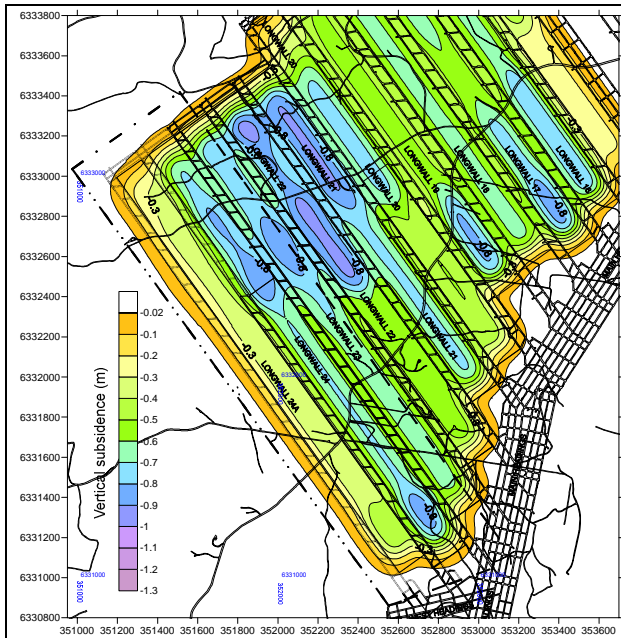


Figure 11 Vertical subsidence at end of LW24A

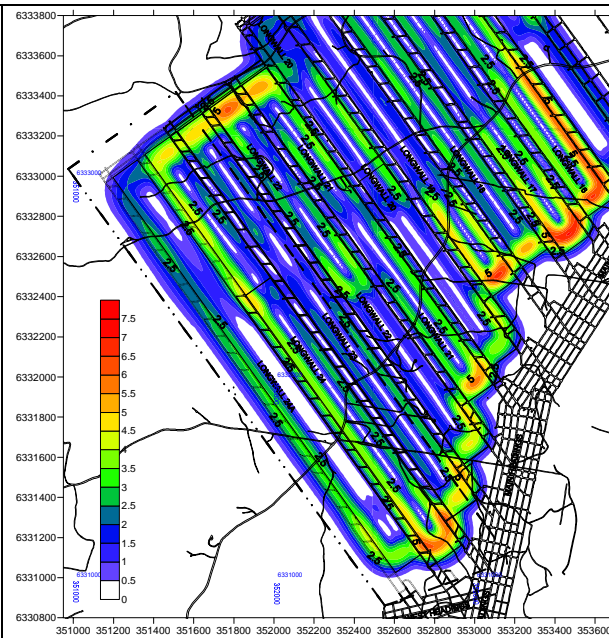


Figure 12 Tilt at end of LW24A

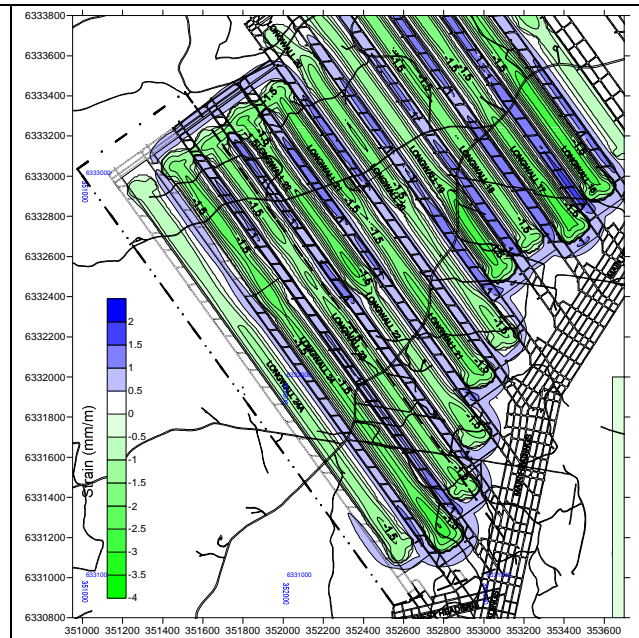


Figure 13 Strain at end of LW24A

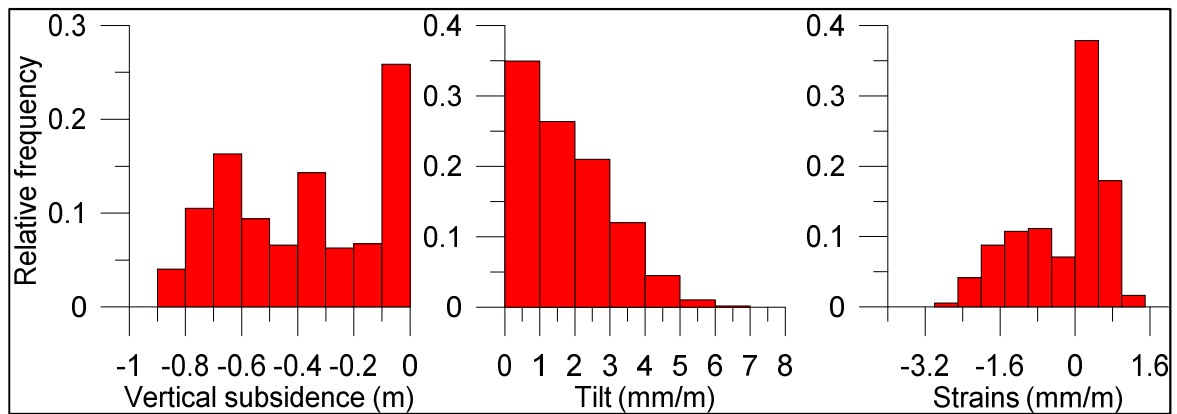


Figure 14 Histograms of predicted subsidence parameters at the end of LW24A.

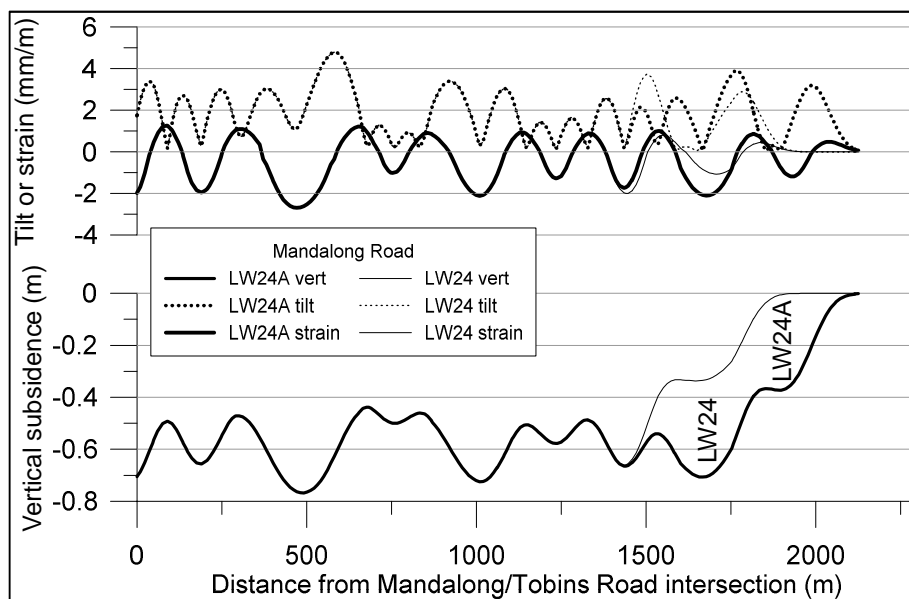


Figure 15 Progressive subsidence along Mandalong Road

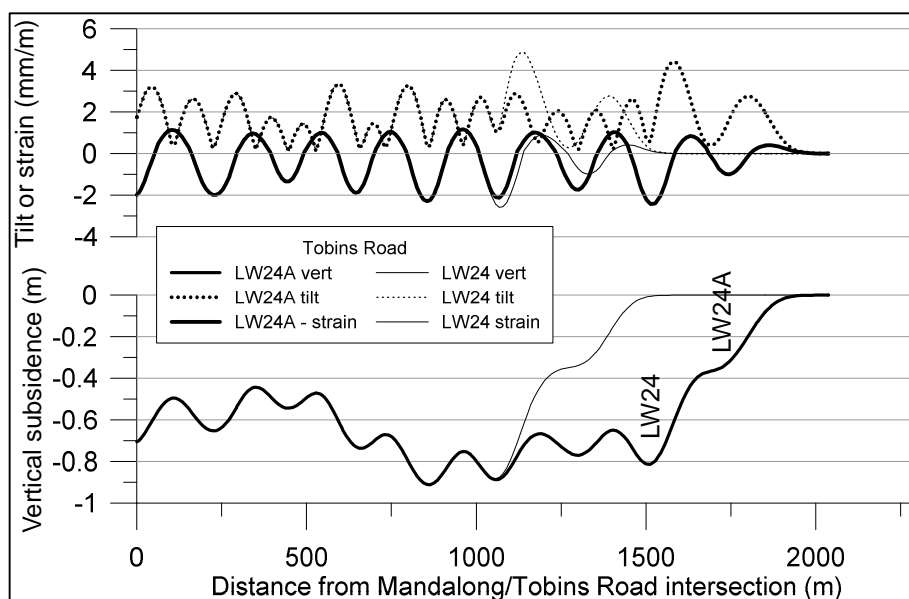


Figure 16 Progressive subsidence along Tobins Road



4.3 SUBSIDENCE AT SELECTED ELECTRICAL INFRASTRUCTURE

As shown in Figure 2, Towers 45 to 47 on Line TL24 could possibly be impacted by the proposed longwall mining. The progressive onset of vertical subsidence as predicted along surface under TL24 is shown in Figure 17. Depending on its location with respect to the longwall extraction and the chain pillars a tower may see the impact of the sag of the conglomerate separately from the compression of the chain pillar; two longwalls may need to be extracted before the subsidence movements are complete. Table 3 presents the predicted movements at each tower at the end of LW24 and LW24A – if using this in a risk assessment process, the comments about reliability should be considered.

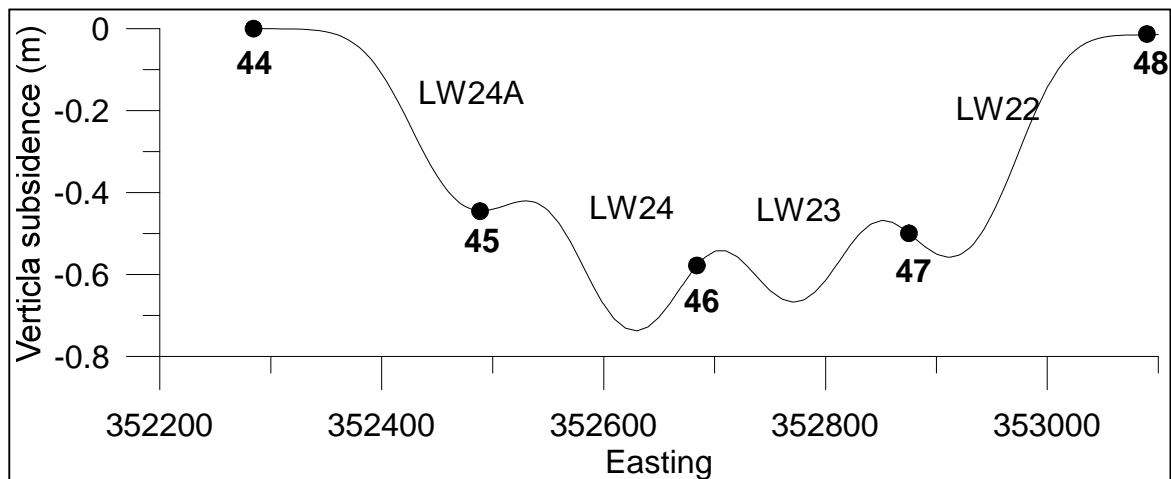


Figure 17 Vertical subsidence along the TransGrid power line at the completion of LW24A

Table 3 Predicted movements at each tower at the end of each longwall

Tower	End LW24 as currently approved			End LW24A		
	47	46	45	47	46	45
Easting	352876.2	352682.2	352489.5	352876.2	352682.2	352489.5
Northing	6331704	6331514	6331321	6331704	6331514	6331321
Vertical (m)	-0.51	-0.35	0.00	-0.50	-0.58	-0.45
Horizontal (m)	0.04	0.05	0.02	0.04	0.03	0.01
Tilt (mm/m)	1.7	1.1	0.2	1.7	2.1	0.9
Strain (mm/m)	-0.4	0.8	0.1	-0.3	0.7	-1.2

There are powerlines (on poles) along Tobins Road and Mandalong Road. Tabulations of the vertical movement and tilt at each location are presented in Table 4 and Table 5.

Table 4 Movements on poles – Tobins Road

Easting	Northing	End LW24 vertical (m)	End LW24 tilt (mm/m)	End LW24A vertical (m)	End LW24A tilt (mm/m)
351839.8	6332921	-0.35	0.4	-0.77	0.6
351825.9	6332895	-0.33	1.0	-0.76	0.9
351761.5	6332882	-0.20	2.8	-0.66	1.1
351714.8	6332872	-0.10	2.2	-0.67	1.7
351661.7	6332826	-0.01	0.3	-0.81	0.7
351593.5	6332758	0.00	0.0	-0.53	4.1
351560.7	6332729	0.00	0.0	-0.41	1.8
351515.2	6332727	0.00	0.0	-0.37	0.4
351447	6332712	0.00	0.0	-0.30	2.0
351324.5	6332682	0.00	0.0	-0.04	1.3



Table 5 Movements on poles Mandalong Road

Easting	Northing	End LW24 vertical (m)	End LW24 tilt (mm/m)	End LW24A vertical (m)	End LW24A tilt (mm/m)
352409.4	6332064	-0.63	2.1	-0.65	1.6
352317.3	6331921	-0.34	0.1	-0.70	0.9
352265.6	6331754	-0.07	1.9	-0.38	1.1
352251.7	6331670	-0.01	0.3	-0.37	0.1
352239.1	6331616	0.00	0.0	-0.34	1.9
352234.5	6331591	0.00	0.0	-0.30	2.5
352262.1	6331533	0.00	0.0	-0.27	2.8
352214.9	6331484	0.00	0.0	-0.08	2.2
352082.6	6331364	0.00	0.0	0.00	0.0
352274.8	6331644	-0.01	0.4	-0.37	0.1
352304.7	6331682	-0.05	1.7	-0.37	0.4
352330	6331728	-0.16	2.9	-0.46	3.3
352353	6331774	-0.28	2.0	-0.63	3.2
352174.7	6331684	0.00	0.0	-0.31	2.4
352091.8	6331698	0.00	0.0	-0.14	2.9
352020.5	6331710	0.00	0.0	-0.03	1.2
351948	6331719	0.00	0.0	0.00	0.1

4.4 SUBSIDENCE AT RESIDENTIAL IMPROVEMENTS

Centennial Mandalong has provided a compilation of dwellings and building in the study area for LW24 and LW24A (Table 6). This table is included in this report with the predicted subsidence parameters included. It is noted that previous property management plans have been based on the maximum values within a 20m radius.



4.5 RELIABILITY

The same prediction methodology as used since 2003 has been applied to LW24 and LW24A. The reliability of the prediction should be assessed in the context of the accumulated experiences over the last decade. The mine layout is formulated so that the chance of unacceptable consequences is very low and that has certainly been the case so far. Where there have been localised movements above prediction they have not resulted in unacceptable consequences and explanations have been found in geotechnical conditions that could not have been anticipated from the information provided prior to the mining of the relevant longwall panel.

When using the results of the visualisation process in a risk assessment process it is recommended that the impacts and consequences of deformations 1.5 and 2.0 times the predicted value be considered. In addition, the base prediction for a specific location on the surface should be the maximum predicted values within a 20 m radius.






Table 6 Location of Dwellings and Building for Subsidence Predictions for LW24-24A

Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
206	LW24	Dwelling Single storey timber frame and clad on bearers and joists.	351450	6332967	-0.47	3.7	0.2	0	0	0	
	LW24	Steel and timber frame shed	351462	6332984	-0.54	3.8	-0.7	0	0	0	






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24	Garden shed	351440	6332996	-0.48	3.8	-0.9	0	0	0	
	LW24	Timber and corrugated iron	351456	6332997	-0.54	3.8	-1.0	0	0	0	
207	LW24	Dwelling Single storey timber frame and weatherboard on bearers and joists.	351703	6332811	-0.79	2.1	-1.2	-0.02	0.8	0.3	
	LW24	Open steel frame shed and garden sheds.	351729	6332806	-0.75	2.6	-0.3	-0.04	1.4	0.4	






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
73	LW23	Dwelling Single storey timber frame and clad on bearers and joists.	351905	6332930	-0.67	1.6	0.6	-0.39	1.7	0.8	
	LW23	Steel garages	351898	6332914	-0.70	2.0	0.1	-0.37	0.9	0.6	
	LW23	Horse shelters	351924	6332891	-0.69	1.8	0.4	-0.38	1.5	0.7	






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
88	LW23	Dwelling Converted steel frame shed	352444	6332224	-0.50	0.9	0.9	-0.49	0.9	0.9	
212	LW24	Dwelling Timber frame and clad, on bearers and joists.	352360	6332087	-0.60	2.1	0.0	-0.55	3.5	-0.8	
	LW24	Concrete in ground pool and steel sheds.	352333	6332095	-0.56	1.6	0.6	-0.49	3.7	0.0	





Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24	Steel barn, weathertex and colorbond on concrete slab.	352024	6332138	-0.42	3.0	0.7	-0.13	2.7	0.2	
90	LW23	Dwelling Brick veneer on bearers and joists. (located outside EP area)	352636	6331936	-0.51	1.7	0.8	-0.51	1.7	0.8	
	LW23	Steel frame shed on concrete slab (located outside EP area)	352679	6331928	-0.49	0.4	0.8	-0.49	0.5	0.8	






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
219	LW24	Single storey, steel frame, brick veneer on bears and joists. Colorbond roof.	352518	6331718	-0.61	2.6	0.2	-0.33	0.4	0.5	
	LW24	Colorbond shed on concrete slab.	352489	6331754	-0.61	2.6	0.1	-0.33	0.3	0.5	
213	LW24A	Single storey steel granny flat (converted shed)	352096	6331729	-0.21	3.2	-0.1	0	0	0	 <p> <small> Date: 8 June 2016 Time: 10:50:51 AEST Position: 35.252518, 150.831718 Altitude: 13m Datum: AUSTRALIAN GEODETIC (GDA 1984) UTM Zone: 56Q UTM UTM Easting: 6331729 UTM Northing: 3525180 UTM Zone: 56Q UTM </small> </p>






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24A	Horse stables with colorbond roof.	352113	6331788	-0.34	1.9	-1.2	0	0	0	
	LW24A	Machinery shed	352149	6331712	-0.30	2.5	-1.0	0	0	0	
211	LW24A	Dwelling Single storey log and shingle. (located outside EP Area)	351816	6331794	0.00	0.0	0.0	0	0	0	
	LW24A	In ground concrete pool (located outside EP Area)	351806	6331823	0.00	0.0	0.0	0	0	0	






Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24A	Timber chicken sheds	351827	6331853	0.00	0.1	0.0	0	0	0	<p>Date: 3/16/2016 15:27:00 (UTC+10:00) Position: 35.1827 151.8531853 Altitude: 27m Datum: AUSTRALIAN GEODETIC 1984 (GDA94) Azimuth Bearing: 151.7021 173.8000 (true) Roll/Pitch/Angle: 0/0/0 Horizontal Angle: 0/0/0 Zoom: 1X</p> 
	LW24A	Granny flat and garage	351836	6331826	0.00	0.0	0.0	0	0	0	<p>Date: 3/16/2016 15:30:07 (UTC+10:00) Position: 35.1836 151.81826 Altitude: 27m Datum: AUSTRALIAN GEODETIC 1984 (GDA94) Azimuth Bearing: 151.7021 173.8000 (true) Roll/Pitch/Angle: 0/0/0 Horizontal Angle: 0/0/0 Zoom: 1X</p> 
218	LW24A	Single storey timber dwelling on bears and joists, colorbond roof	352316	6331492	-0.32	2.2	-1.1	0	0	0	<p>Date: 3/16/2016 15:32:07 (UTC+10:00) Position: 35.2316 151.492 Altitude: 27m Datum: AUSTRALIAN GEODETIC 1984 (GDA94) Azimuth Bearing: 151.7021 173.8000 (true) Roll/Pitch/Angle: 0/0/0 Horizontal Angle: 0/0/0 Zoom: 1X</p> 



Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24A	Colourbond shed, carport and horse shelter	352342	6331540	-0.37	0.1	-0.7	0	0	0	
214	LW24A	Two storey, rendered dwelling on concrete slab (located outside EP Area)	351947	6331672	0.00	0.0	0.0	0	0	0	
	LW24A	In ground concrete pool (located outside EP Area)	351956	6331653	0.00	0.0	0.0	0	0	0	



Centennial Property Ref.	LW	Structure	E	N	End LW24A			End LW24 as current approved			Photo
					Vertical (m)	Tilt (mm/m)	Strain (mm/m)	Vertical (m)	Tilt (mm/m)	Strain (mm/m)	
	LW24A	Car port (located outside EP Area)	351957	6331642	0.00	0.0	0.0	0	0	0	
	LW24A	Cabin, weatherboard on bearers and joists	352001	6331630	0.00	0.1	0.1	0	0	0	
	LW24A	Steel workshop (located outside EP Area)	351993	6331593	0.00	0.0	0.0	0	0	0	



5 PREDICTED IMPACTS AND CONSEQUENCES

Given the predicted strains and experiences to date at Mandalong, it is unlikely that there will be any tensile cracking or compressive buckling developed in soil or rock. The compressive strains may be sufficient to cause bulging of sealed roads.

With the low values of tilt and strain combined with the relatively gentle topography, there will be no far-field movements (defined as measurable horizontal movements without vertical movements in excess of 20 mm) and there will be no ‘upsidence’ in the water courses.

There are no cliffs in the area so there can be no cliff falls induced. The mining-induced changes in the slope of the terrain will not be sufficient to generate rock falls or rock rolls.

The mine layout was selected so that any impact to dwelling would be less than safe, serviceable, and repairable and this has been demonstrated to date.

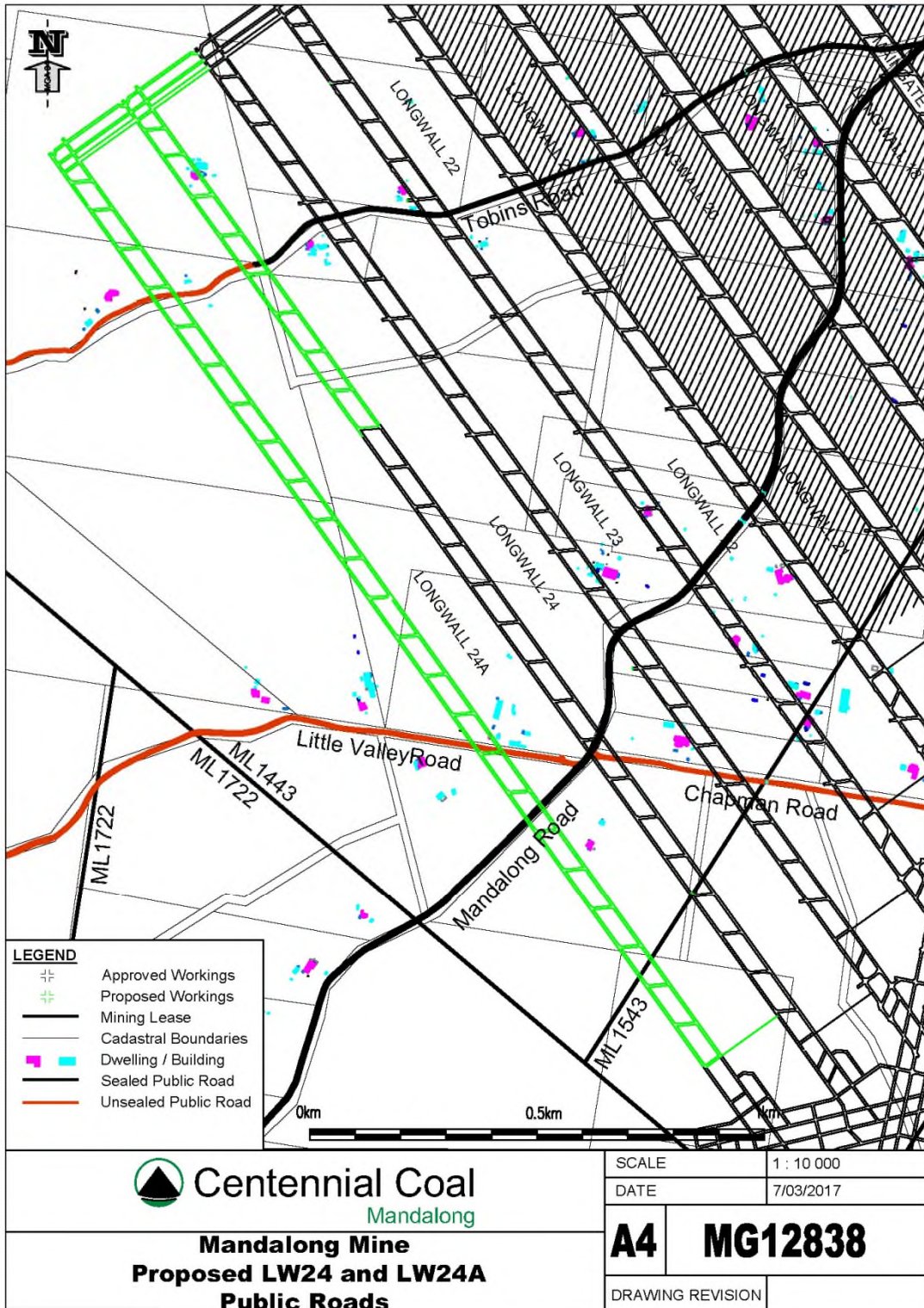
The strains predicted to be imposed on Mandalong Road and Tobins Road are similar to those previously so similar impacts are likely. There may be some minor compression bumps develop in the bitumen seals.

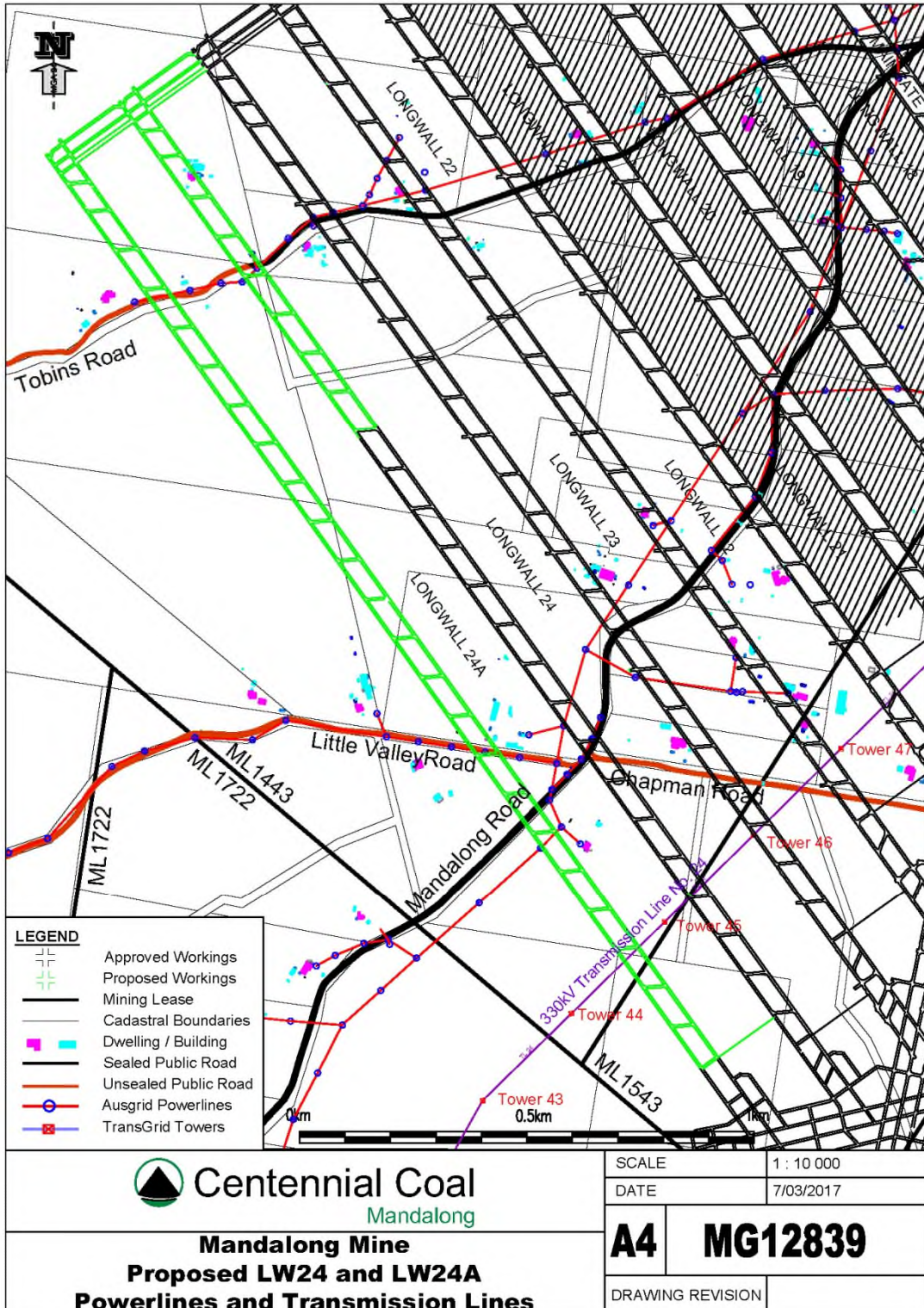
The predicted subsidence should not adversely impact the functionality of power/telecommunication poles. The predicted strains will adversely impact the transmission towers and they will need specific attention.

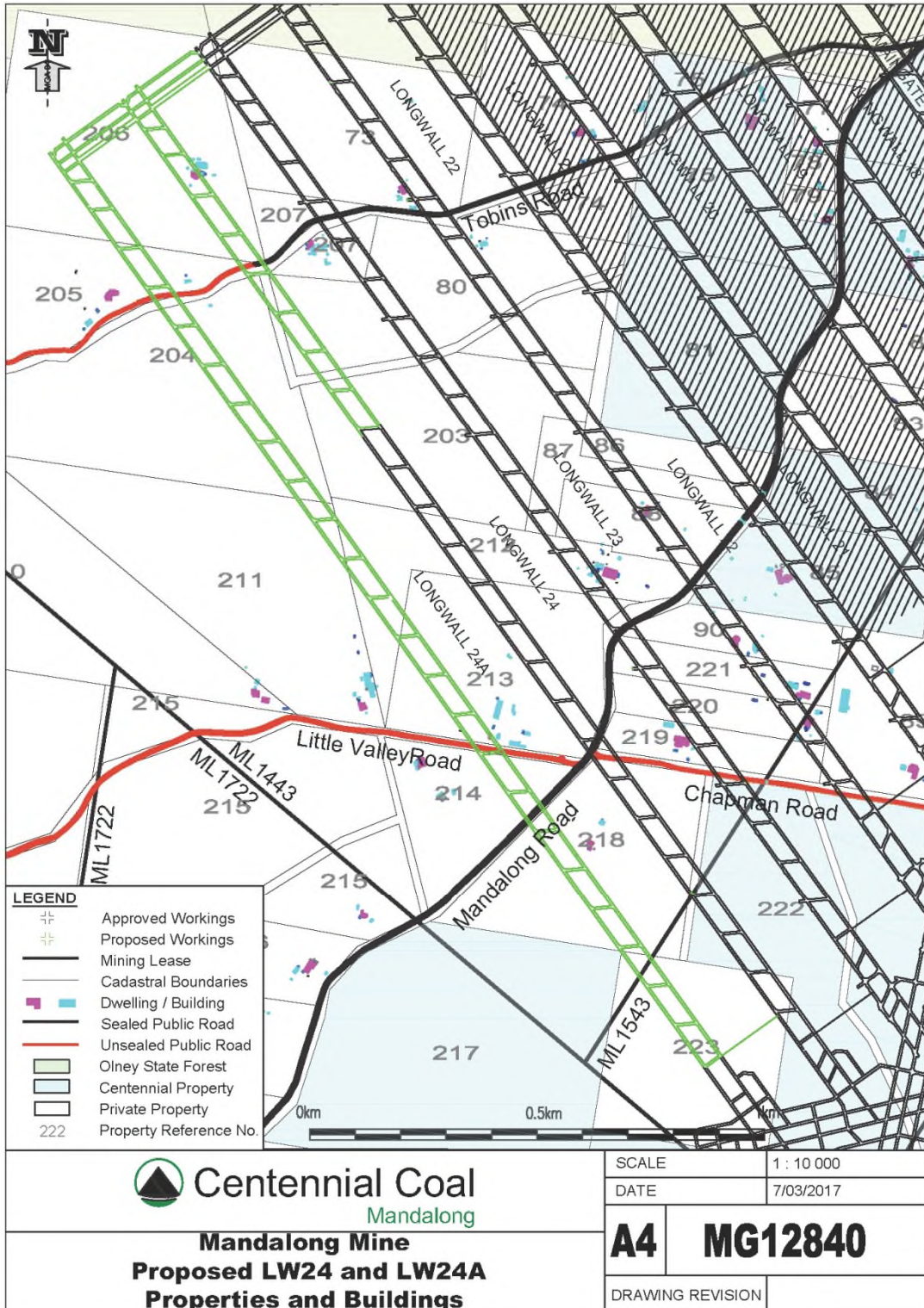
The impact of the subsidence on other surface and subsurface natural and built features (including shallow groundwater) should be assessed by relevant experts. It is noted that the deflection of the massive conglomerate units without the onset of failure implies that longwall caving and fracturing will not extend more than about 100 m above the coal seam.

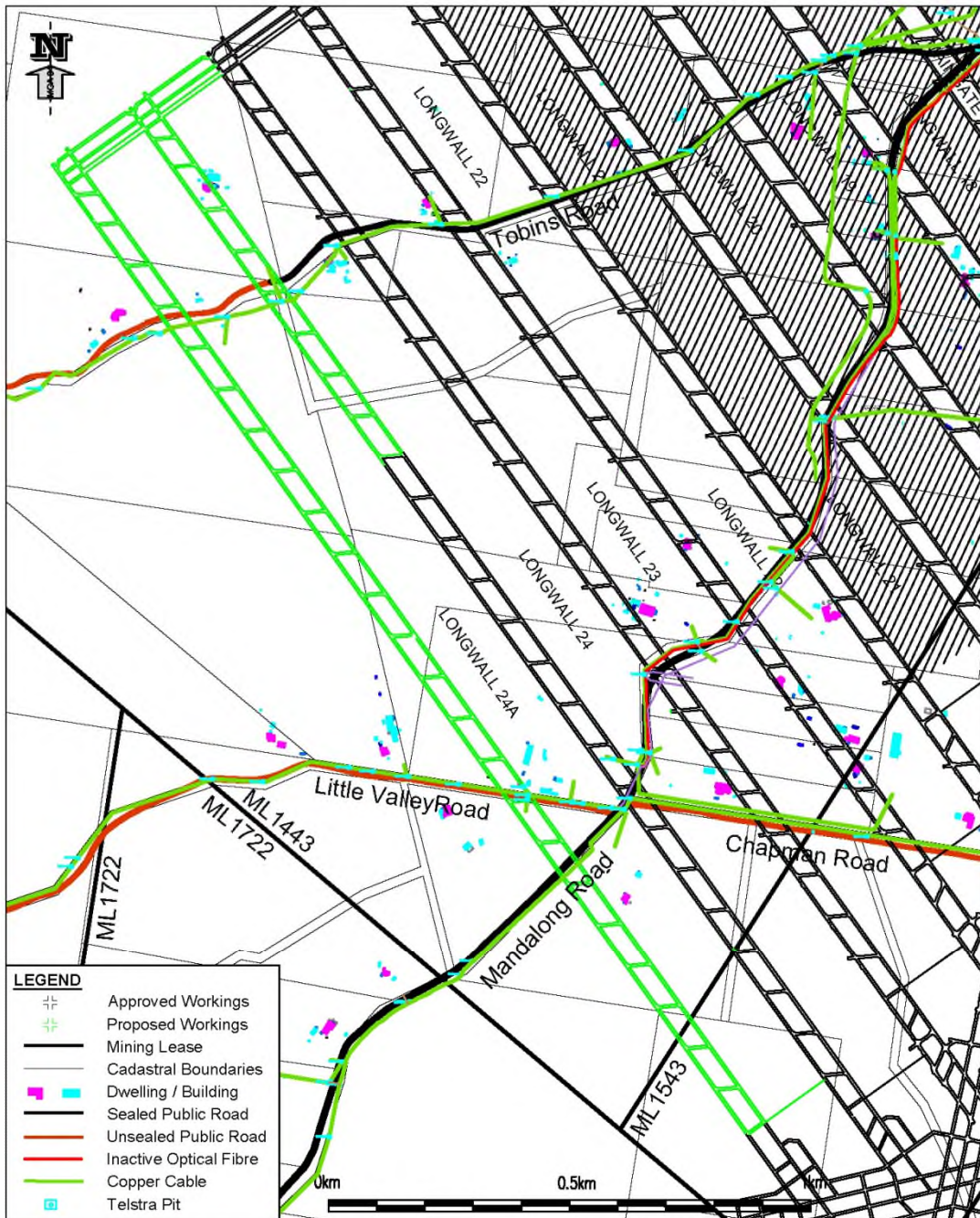


APPENDIX – PLANS OF SURFACE INFRASTRUCTURE









 Centennial Coal Mandalong	SCALE	1 : 10 000
	DATE	7/03/2017
Mandalong Mine Proposed LW24 and LW24A Telstra Communications	A4	MG12841
	DRAWING REVISION	



APPENDIX – REVIEW OF PREDICTION MODEL

In 2003 Mandalong Mine identified improvements to the original approved mine design to reduce subsidence impact risks, particularly in low-lying areas. Whereas the consent had allowed up to 2.98 m of vertical subsidence, it was identified that vertical subsidence would need to be limited to less than about 500 mm in the low lying areas. A new subsidence prediction methodology was required if an economically viable mine was to be designed.

Compared with existing empirical methods, the new prediction method is based on geotechnical engineering principles and as a consequence all predictions are exposed to the inherent variability of the geotechnical properties of the rock mass.

The prediction methodology is based on predicting the vertical subsidence above chain pillars using geotechnical engineering principles as applied in foundation engineering, and adding this to the deflection of a thick conglomerate beam that has been identified in the overburden¹. These predictions are then used in an influence function program to produce contour plans of the deformations.

There has been extensive monitoring of surface subsidence at Mandalong Mine since the beginning of operations in 2003. The following discussion is based on a review of data to the end of LW18. The surface deformations above the Main Headings and chain pillars are within the anticipated range of elastic deformation of the roof/pillar/floor system and do not indicate the onset of unstable conditions. This is consistent with underground observations in the longwall tailgates and long-term ventilation roadways. The sag of the surface between the chain pillars is consistent with geotechnical predictions of the deflection of a massive conglomerate layer that has been identified to be present about 100 m above the coal seam.

AI PREDICTION OF MAXIMUM VALUES

Table 7 summarises a comparison between the predictions of subsidence above the chain pillars and sag between pillars with recent surveyed results for a number of cross lines. Figure 18 presents histograms of the deviation between prediction and measured values of vertical subsidence, tilts, and strain.

Table 7 Comparison of predicted and actual subsidence – maximum values along crosslines

	CS2			CS3EX			CS8			CS18			CS19			CS20		
	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference
Vertical																		
Pillar																		
LW 15 CL																		
Pillar	309	252	-57	405	270	-135												
LW16 CL	659	925	266	659	575	-84	780	553	-227	800	782	-18						
Pillar	483	271	-212	478	281	-197	547	505	-42	571	402	-169						
LW 17 CL	642	688	46	652	599	-53	798	809	11	849	905	56						
Pillar	538	282	-256	491	294	-197	556	477	-79	639	294	-345	524	512	-12	529	259	-270
LW 18 CL	718	462	-256	646	674	28	879	774	-105	1013	905	-108	652	641	-11	693	516	-177
Pillar	323			240	484	244	293	430	137	321	394	73	243	445	202	258	330	72
LW 19 CL	276			228	540	312	293	805	512	272	807	535	235	462	227	215	335	120
Tilt																		
LW 15					6.9			4.6										
					3.9			2.2										
LW 16				3.6	5.5	1.9	5.7	3.5	-2.2	5.2	10.3	5.1						
	2.7	13	10.3	2.8	4.4	1.6	3.8	2.5	-1.3	3.5	6.3	2.8						
LW 17	2.4	8.8	6.4	2.68	7.4	4.72	3.7	5.5	1.8	4.1	9.7	5.6						
	1.9	7.5	5.6	2.44	5.3	2.86	3.8	6.5	2.7	3.5	10	6.5						
LW18	2.6	3.5	0.9	2.44	6.8	4.36	4.7	5.8	1.1	5.3	11.2	5.9	2.5	2.9	0.4	2.6	5.33	2.73

¹ Seedsman, R.W. 2010. Calibrated parameters for the prediction of subsidence at Mandalong Mine. Coal 2010 - 10th Australasian Coal Operators' Conference, Wollongong.



	CS2			CS3EX			CS8			CS18			CS19			CS20		
	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference	Visualised	Measured	Difference
	3.5	4	0.5	4.06	3.6	-0.46	7.2	5.8	-1.4	7.3	8.3	1	4.1	2.8	-1.3	4.2	2.99	-1.21
LW19				1.8	5.3	3.5	2.6	7.8	5.2	2.52	11.8	9.28	1.9	4.8	2.9	1.56	2.56	1
Strain																		
	1.9	0.6	-1.3	1.9	0.8	-1.1	0.9	0.2	-0.7									
LW 16 CL	-2.15	-3	-0.85	-2.1	-3.5	-1.4	-2.7	-1.8	0.9	-2.6	-6.9	-4.3						
	2.17	2	-0.17	2.3	0.7	-1.6	2.9	0.2	-2.7	3.15	2.4	-0.75						
	2.17	0.9		2.3	1	-1.3	2.9	1	-1.9	3.15	4.5	1.35						
LW17 CL	-1.73	-3.1	-1.37	-1.97	-2.6	-0.63	-2.47	-1.7	0.77	-2.4	-8.1	-5.7						
	2	1.2	-0.8	2.04	0.8	-1.24	3.14	1.5	-1.64	3.6	3	-0.6						
	2	1.3	-0.7	2.04	0.9	-1.14	3.14	0.7	-2.44	3.6	3.6	0	2.5	0.3	-2.2	2	1.7	-0.3
LW18 CL	-2.26	-3	-0.74	-2.16	-1.4	0.76	-3.34	-2.1	1.24	-3.35	-6.7	-3.35	-2.18	-1.2	0.98	-2.35	-1.39	0.956
	1.28	1.8	0.52	1.59	0.7	-0.89	2.6	0.3	-2.3	2.7	2.4	-0.3	1.6	0.2	-1.4	1.46	0.48	-0.98
	1.28			1.59	0.2	-1.39	2.6	0.7	-1.9	2.8	1.9	-0.9	1.6	0	-1.6	1.46	0.078	-1.382
LW19 CL	-0.65			-0.67	-1.2	-0.53	-0.9	-1.4	-0.5	-0.86	-4.4	-3.54	-0.74	-0.9	-0.16	-0.5	-1	-0.5
	0.6			0.55	0.9	0.35	0.78	1	0.22	0.722	2	1.278	0.587	0.5	-0.087	0.48	1.258	0.778

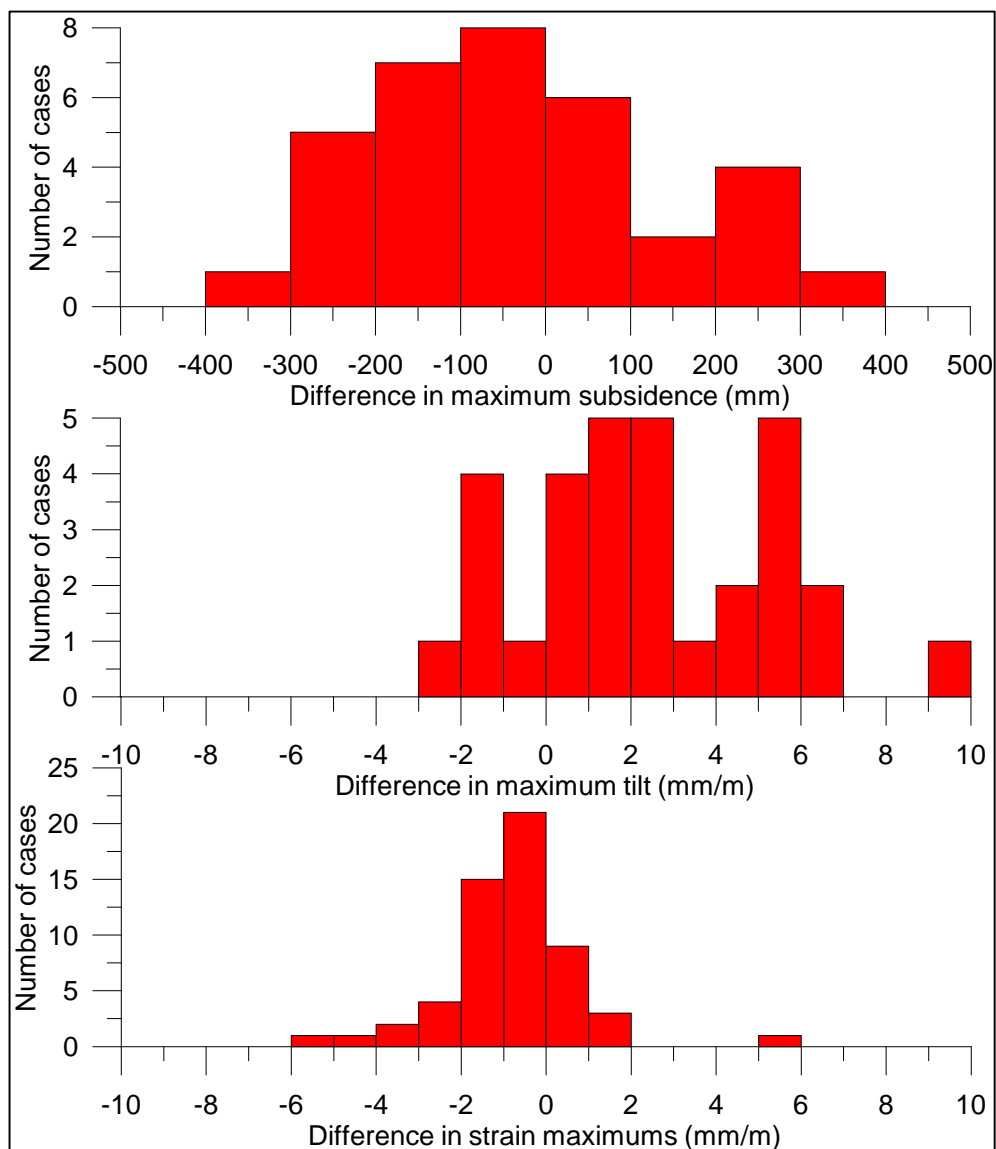


Figure 18 Histograms of the deviation between survey results and the prediction along 6 cross lines (data is measured less prediction).



A 2 Main Headings

The subsidence survey along the centreline of LW17 (Figure 19) in early 2016 indicates that there has been typically less than 10 mm of recorded movement above the Main Headings (Figure 20), noting that the reproducibility of the survey method is in the order of +/-20 mm as controlled by soil shrink and swell.

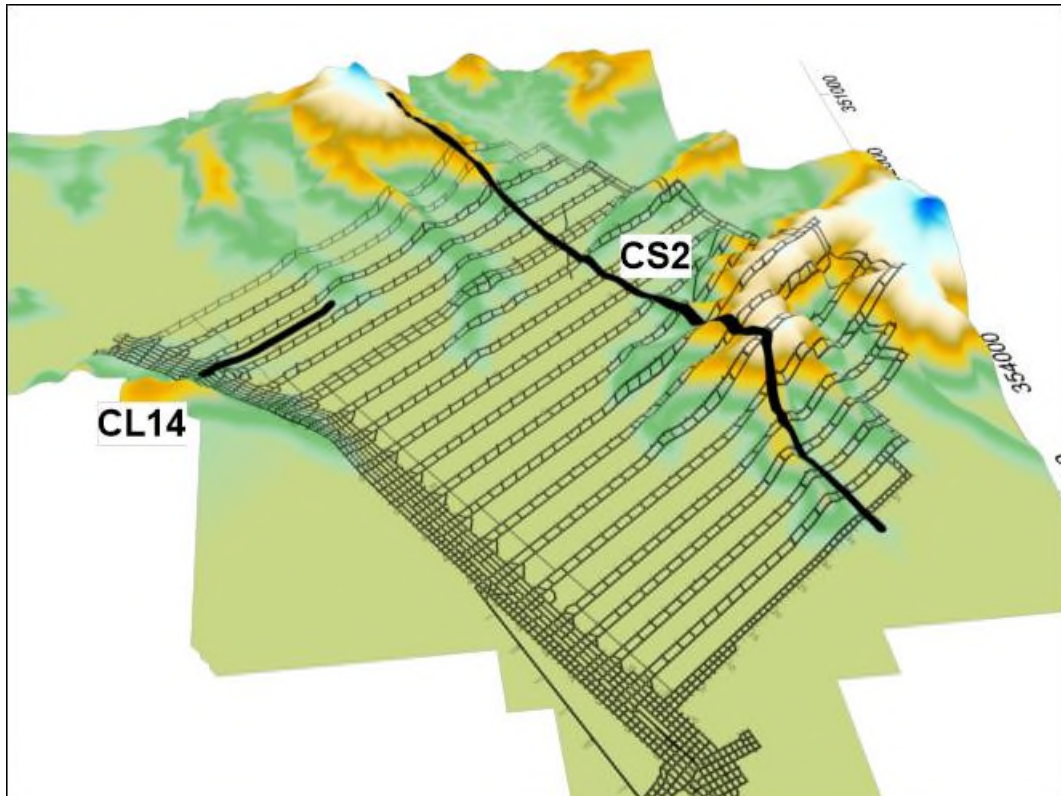


Figure 19 Location of CL14 and CS2 survey lines

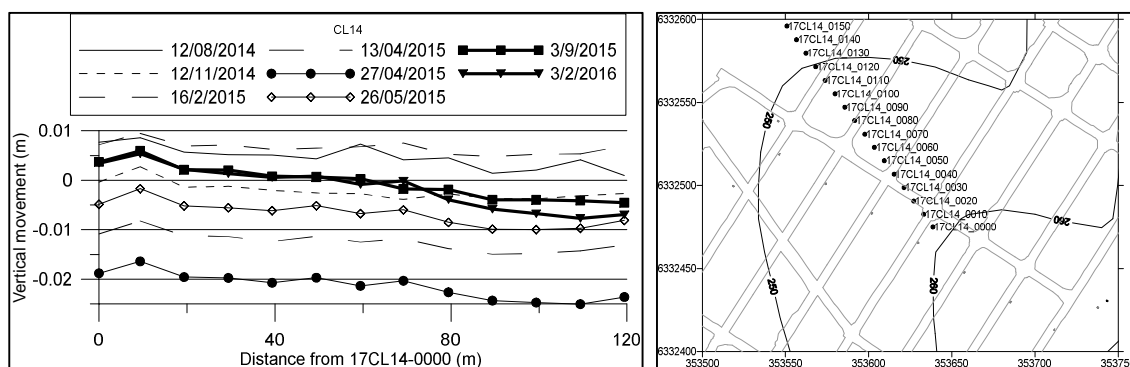


Figure 20 Survey data above the Main Headings along the centreline line down LW17

A3 Chain pillars

Since longwall extraction began in 2005 there has been no evidence that the chain pillars have collapsed. Certainly there is deformation of the surface above the chain pillars, for example along crossline line CS2 (Figure 21), which can be adequately explained by the compression of the roof and floor strata and the West Wallarah coal seam itself. A compilation of the tabulated and other



historical data relating the depth of cover and the minimum subsidence deformation above chain pillars (Figure 22) shows a strong relationship.

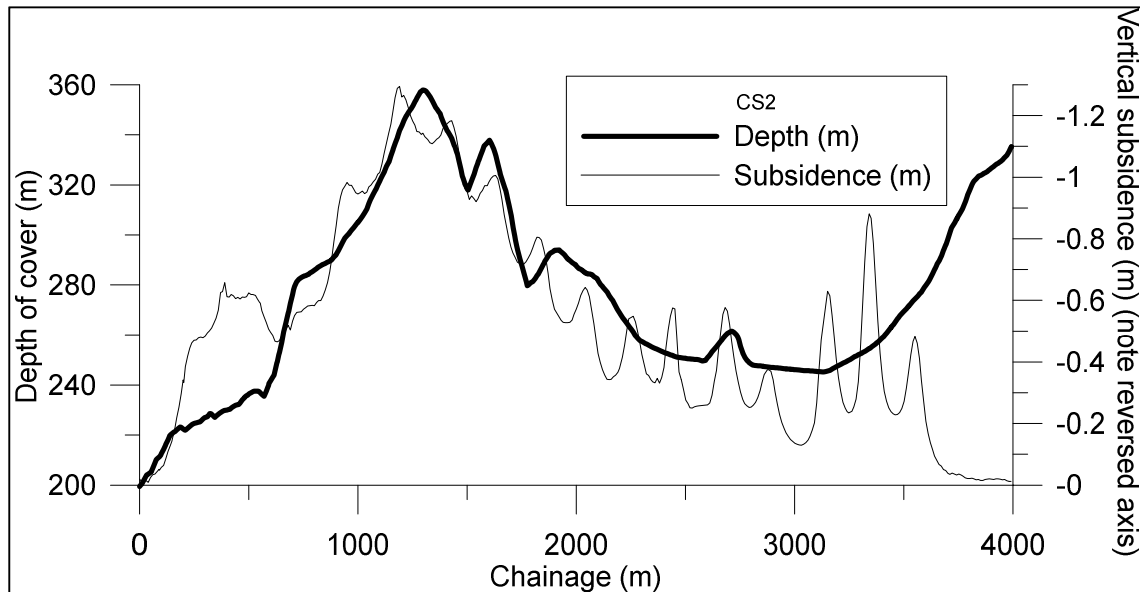


Figure 21 CS2 subsidence survey data from test 54 conducted in 2016 (n.b. subsidence axis inverted to emphasise relationship with depth of cover)

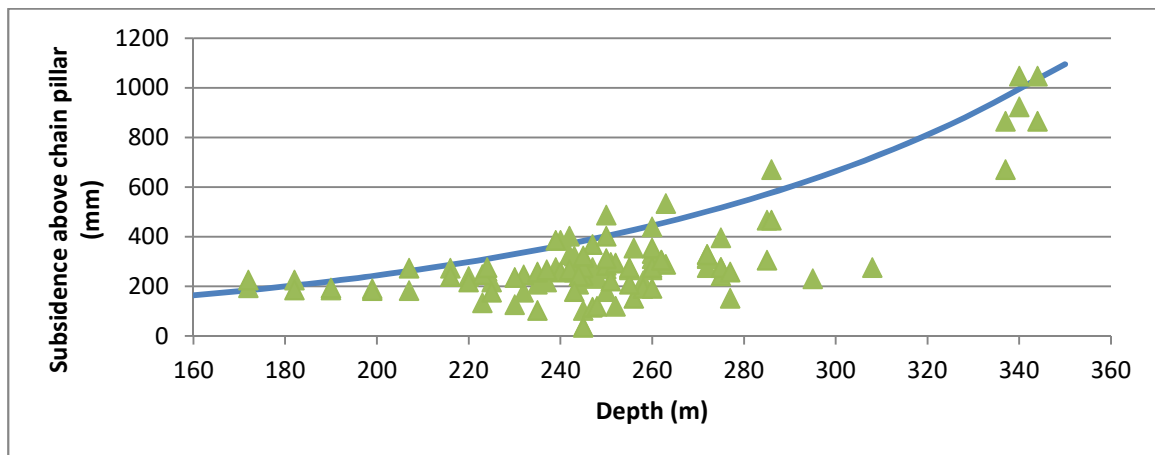


Figure 22 Vertical subsidence measured directly above chain pillars at Mandalong (data points and prediction line used in 2016)

A4 Conglomerate deflection - Panel sag

There was a revision of the technique to estimate sag of the conglomerate beam during the retreat of LW16, and the indications are encouraging for all but the CS2 line (Figure 23). It is assessed the geological conditions in the nearest borehole which is some 160 m distant do not accurately indicate the conditions under the CS2 survey line. This highlights the fact that the prediction of deflection requires a good knowledge of the beam thickness which, experience suggests, has been reasonable. It is assessed that the spacing of the exploration drill holes used to date has provided adequate information.

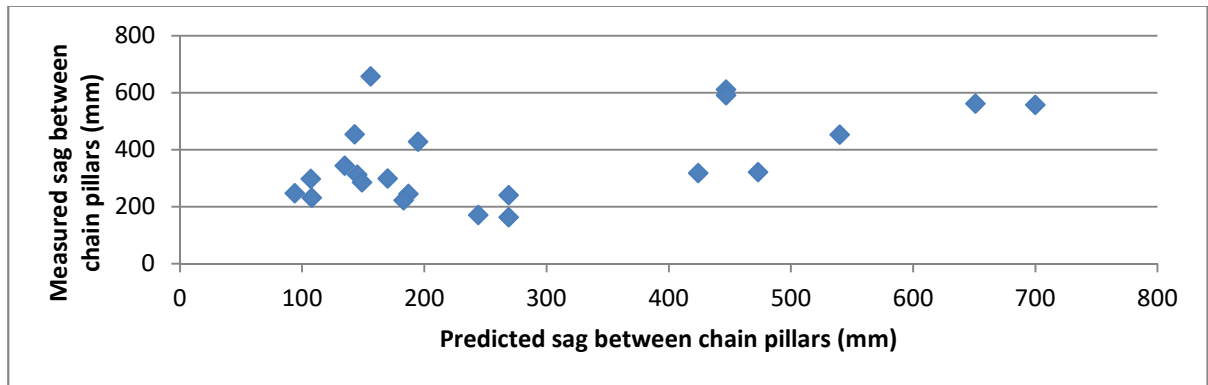


Figure 23 Centreline sag compared to prediction since LW16 revision (data in Table 1)

A5 Tilt and strain

The prediction of tilt and strain requires the prediction of vertical movements as discussed above plus two parameters used in the influence function method and that are/have been determined by back analysis. An implication of the prediction methodology is that maximum strains and tilts should be a linear function of the panel sag and this has been observed to date (Figure 24).

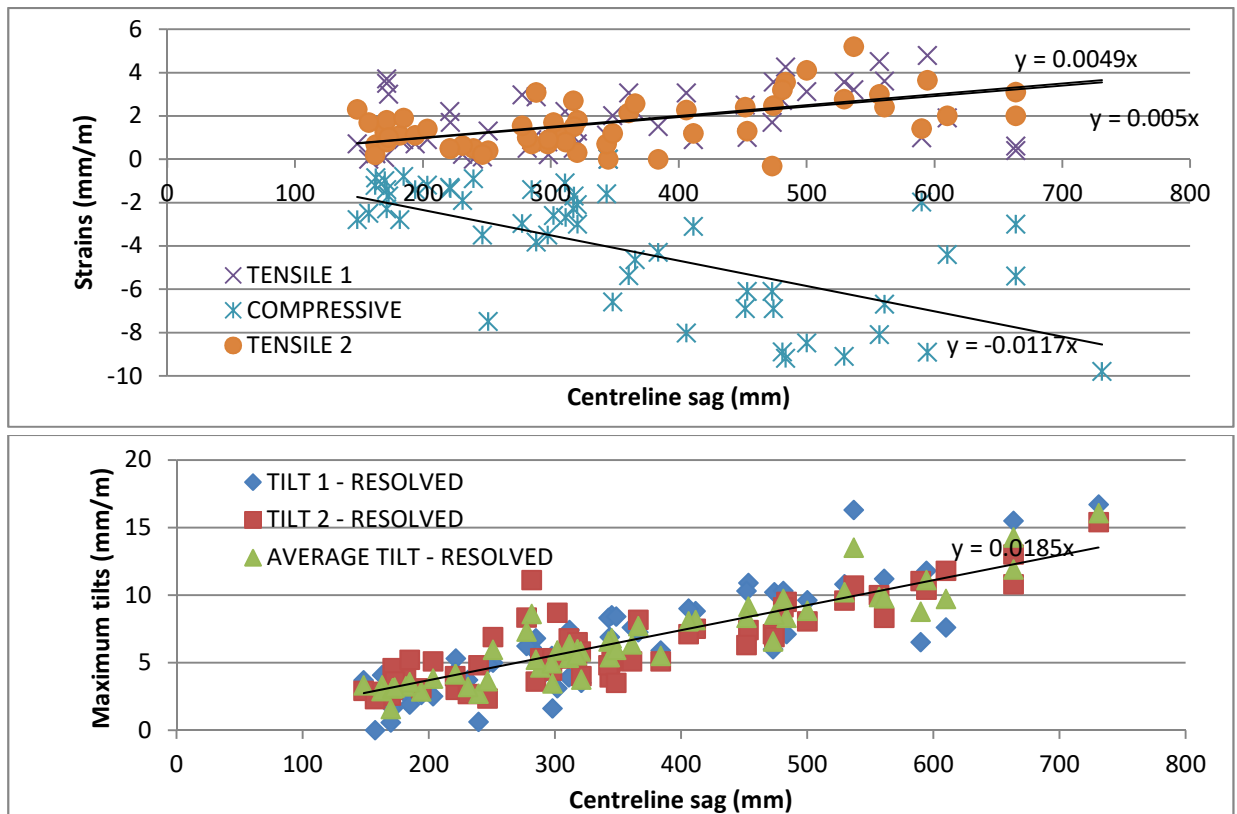


Figure 24 Maximum tilt and strain values related to the sag between chain pillars