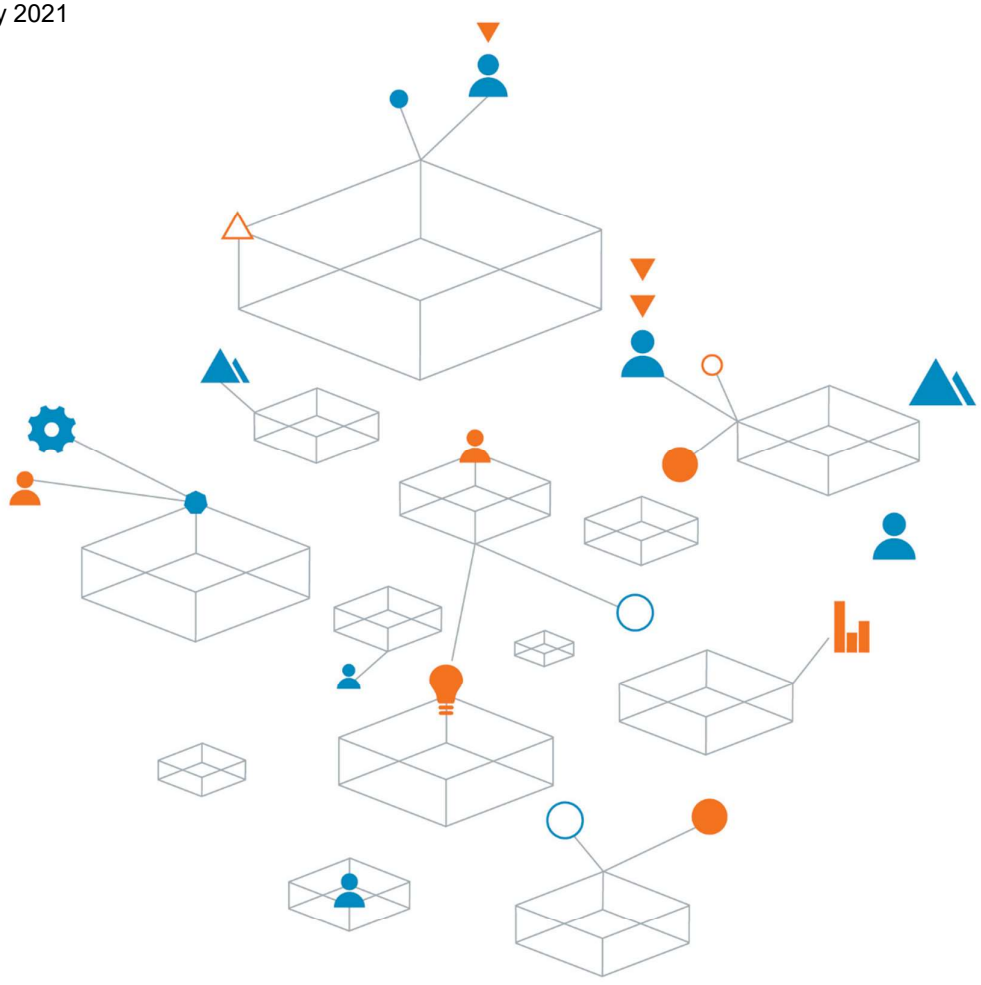
Newcastle Grammar School LTD
Proposed Stage 1 Additions - Newcastle Grammar School Park Campus - 127 Union Street, Cooks Hill
754-NTLGE282007-AB
Mine Subsidence Desktop Assessment

2 February 2021



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Proposed Additions - Newcastle Grammar School Park Campus

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Quality information

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1. Introduction

Erica Thomas, Head of School for Newcastle Grammar School, commissioned Coffey Australia Pty Ltd (Coffey) to carry out a mine subsidence desktop assessment for the proposed Stage 1 additions for the Newcastle Grammar School - Park Campus located at 127 Union Street, Cooks Hill.

This report addresses the scope outlined in Section 3.6.1 Coffey proposal 754-NTLGE282007-AA.Rev1 dated 10 December 2020.

It is proposed to demolish several buildings on the site and to construct two large buildings between two to three storeys in height.

The site is known to be located over abandoned mine workings within the Borehole Seam completed by the Australian Agricultural Company (AACo) from their New Winning Pit at a depth of 58m to 63.5m below the ground surface.

2. Scope of work undertaken

This mine subsidence assessment was based on a desk study of the following:

- Review of previous Coffey job files in the area particularly:
  - Proposed Ten Storey Development 291 King Street Newcastle (GEOTWARA21991AA-AD dated 19 July 2013.
  - Proposed Icon Central Development GEOTWARA22349AB-AC dated 24 February 2016.
  - Lingard Hospital Additions GEOTWARA20316AD-AH dated 27 June 2017.
  - 118 Parry Street (N8878-01-AH dated July 2004)
- Record Tracings (mine plans) RT566 Sheets 4 and 8 of the AACo combined New Winnings Pit within the Borehole Seam supplied by Department of Primary Industries – Mineral Resources
- 1:100,000 Scale Newcastle Coalfield Regional Geology Sheet.
- SANSW Merit Policy document

The coal pillars stability assessment was completed using rectangular pillar theories, incorporated in the Modified UNSW Power Law strength equation as presented in (Galvin & University of New South Wales. School of Mining En, 1998).

3. Geotechnical model

3.1. Surface conditions summary

The site is located at 102 DP 861562, 127 Union Street, Cooks Hill as shown on Drawing 2. The site is bounded by Union Street to the north east, Parkway Avenue to the south west, and Corlette Street to the south east.

Topographically the site is located within a former estuarine floodplain in the historical location of Cottage Creek. Historical maps (including Plan of Port of Newcastle 1887, Map of the Newcastle District showing the Colliery Holdings 1932) have the area as a “swamp”. Since the 1900 the area has been raised with fill creating a near level plain with Cottage Creek realigned to Parkway Avenue south of the site. Newcastle Harbour is located 1km to the north.

The site falls to the north at approximately 1V:70H, with site elevations (RLs) ranged from 2.02m AHD at the northern corner and up to 3.02m AHD at the southern corner.

The surrounding area generally consists of residential developments and parkland.

3.2. Regional geology

Based on the 1:100,000 scale Newcastle Coalfield Geology map, the site is underlain by Quaternary deposits comprising gravel, sand, silt and clay. Underling this unit is the late Permian aged Lambton Subgroup of the Newcastle Coal Measures comprising interbedded and interlaminated siltstone, sandstone and coal.

The mined Borehole Seam forms the floor of the Lambton Subgroup, which also contains the Yard Seam not present at the site. (The Yard Seam was mined beneath The Hill, approximately 500m to the east of the site.)

3.3. Subsurface conditions

The nearest historical borehole to the site is located 100m to the south east of the site (No. 5 Borehole drilled by AACo). A second is located 320m to the west of the site (No. 2 Borehole). These boreholes were sourced from NSW Department of Planning Industry and Environment website 'DiGS'.

The interpreted geotechnical units at the site based on shallow boreholes drilled onsite and the historical boreholes noted above are shown in Table 1.

Table 1: Summary of ground model stratigraphy

Unit number	Unit	Description	Approximate Base Depth (m)
1	Fill	Sandy CLAY\CLAY/ SAND/Sandy GRAVEL	3 to 4
2	Estuarine clay	Clay soft to firm consistency	9 to 10
3	Estuarine sand	Interbedded sand and clay, firm consistency and medium dense sands	16 to 19
4	Residual clay	Clay stiff to very stiff consistency	22 to 25
5	Interbedded siltstone and sandstone	Highly weathered to moderately weathered, very low strength to at least 30m	58*
6	Borehole Seam	Mined Seam. Lower 16' 5.25" (5m) to 17' (5.2m) being grouped together with the upper 1' 4.5" (0.4m) to 20" (0.5m) of poor quality unsuitable for mining.	63.5*
7	Waratah Sandstone	High to very high strength sandstone	From 63.5*
*Note * Depths estimated from historical drilling in the area.*			

Stationary water level is expected about 1.5m to 2m below the ground surface.

Using information including the *BHP Coal Geology Section - Borehole Seam C538,* the Borehole Seam in this location dips to the north east at 1V in 70H increasing to the south of the site to approximately 1V in 30H to the north east.

RT566 has two 2' (0.6m) faults shown in the area, one through the site and a second 35m to the north east of the site.

4. Factual information on workings

4.1. History

The Borehole Seam was discovered in 1848. Mining was originally carried out by the AACo in the Hamilton area from the 'D Pit' shaft which was sunk at Denison Street (2km north west of the site) and became operational in 1852 and later converted to an air shaft in 1877 for the No. 2 Pit. A nearby 'E Pit' was sunk in 1854 on Everton Street, 382m south west of D Pit and was primarily used for ventilation.

In 1861, the Australian Agricultural Company sank its No. 2 (169ft / 51.5 m deep) shaft near the intersection of Beaumont and Kemp Street, 1.6km north-west of the site. Later the 'Hamilton Pit' was sunk in 1872 near Lawson Street and Thomas St 1.3km to the west of the site. These shafts were later combined for the mine generally known as the No. 2 Pit /Hamilton Pit workings.

In 1888, the AACo sunk its New Winning Pit in the Cooks Hill Area (the pit utilised to mine the area beneath the site) 680m to the east of the site. According to (Power, 1912), the seam was worked by the bord and pillar method with pillar extraction in some areas. The nearest secondary workings are located 120m to the south-east of the subject site.

The workings of these two pits were separated by barrier coal which was originally 5 chains in width (RT566 Sheet 4 from 1905) located from the western side of Union Street, with this barrier later generally mined out (RT566 Sheet 8) with only a 5m to 20m barrier remaining (Refer to Drawing 3).

Danvers Power (1912) provides a description of the workings within the New Winnings Pit which indicates that headings were driven parallel and 70 yards (64m) apart, bords were 6 yards wide (5.4m) and 33 yards long (30m) and pillars were 12 yards wide (11m). This is a general representation of what was nominally aimed for in the pit, though allowing for ±3m. Within 150m of the site, based on scaling of pillar widths from the RT, the pillars range from 8.1m wide to 15.5m wide with an average width of 10.8m. Pillar lengths are scaled to range from 10.1m up to 64.3m with an average of 29.7m.

The method of mining in bords is described by (Power, 1912) to be as follows:

1. Middle Coal taken 7'7" (2.3m) with the Morgan band left in the mine;
2. Bottom Coal lifted 4'4" (1.3m) with the Jerry band being put to one side;
3. Top Coal dropped 4'1" (1.2m) with the aid of drums or ladders to stand on.

It is noted that the top coal stood up (did not collapse) better than the roof rock and so delamination and caving of the roof is expected, (this has been observed within numerous boreholes drilled in the area).

A passage from the 1908 Royal Commission (Robertson, Sulman, & James, 1908) below provides further information on the mined section. The sketch referred to is shown below in Figure 1.

> "The top lift (A) on the sketch is of an exceptionally tender nature and has little cohesive strength. The coal immediately above (B) is also of a very friable character. Following upon the third operation (dropping the top coal) the splint coal above, and frequently the shale roof, falls in the bords, and together with the dirt bands fill up more or less the space from which the coal has been excavated often to within about 3 feet of the top of the seam, thus, to some extent automatically supporting the pillars. The roof over the seam proper consists of splint coal and bands 4 feet, and overlying shale and sandstone."

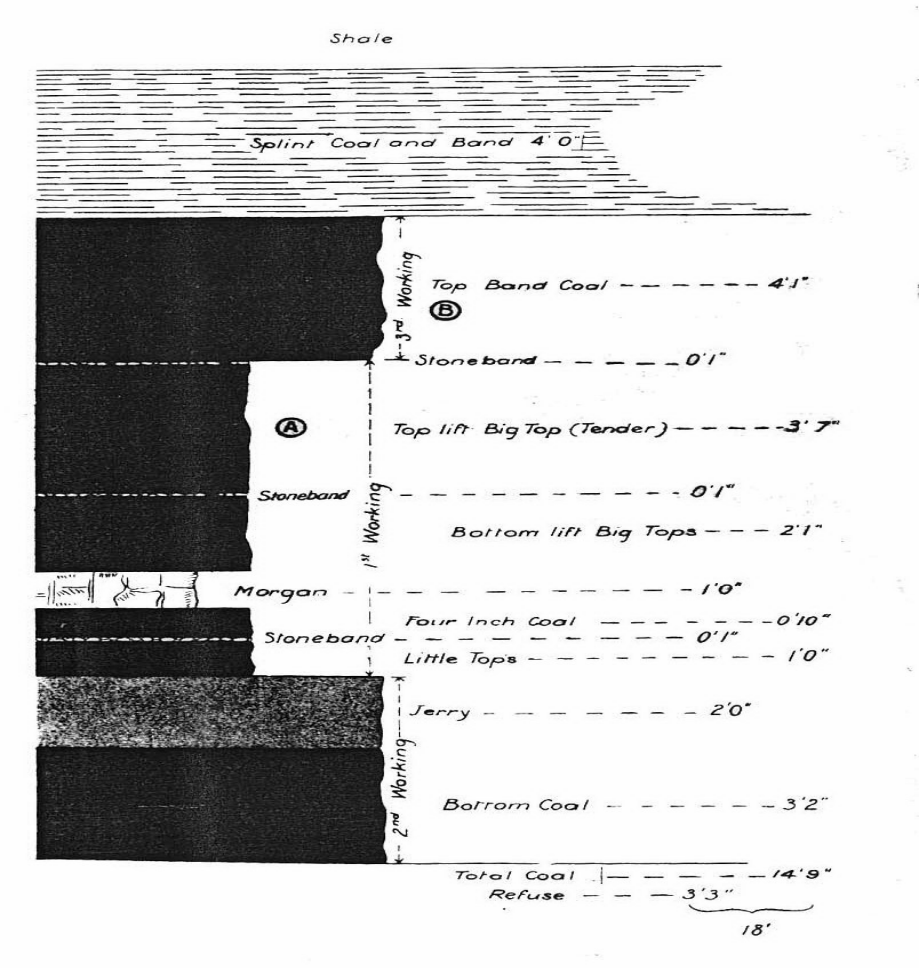

Figure 1: Borehole Seam section from 1908 Royal Commission (Robertson, Sulman, & James, 1908)

The above section is considered to be representative of the Borehole Seam in the area.

Crush events have occurred in both of the mines.

- On 22 June 1889 a crush event occurred within the Hamilton Pit.
- Within the New Winning Pit, mine the creep occurred on three phases Creep 1 on 15 May 1906, Creep 2 on 17 October 1907 and Creep 3 on 17 January 1908. The extent of these were shown on RT566 Sheet 4.

The extent of the crush event within the Hamilton Pit is not recorded and/or readily available as others in the Newcastle area (1896 and 1897 crush events within the Wickham and Bullock Island Colliery (W&BIC) or the 1906 to 1908 Creeps 1 to 3 events in the New Winnings Pit). However, during previous drilling works for 118 Parry Street (Coffey report N8878-01-AH 5 July 2004), crushing was evident within the area of secondary mining south west of Parry Street. The magnitude of crushing is not available as the borehole was not continued to the floor of the Borehole Seam.

For the New Winning Pit mine, as reported in the 1908 Royal Commission and summarised in a report by (To, 1988) large scale subsidence events have occurred in the Borehole Seam workings beneath Newcastle. This started at Wilsons Heading, and followed a number of faults (including Oliver's Fault) through headings. The consequences of these 'creeps' was cracks of up to 75mm width and surface depressions up to 825mm deep resulting in damage to buildings and infrastructure. Creep 1 was temporarily halted by the North East Narrow heading. Creep 2 continued Creep 1 beneath The Hill to

Church Street partially halted by the barrier beneath the Christ Church Cathedral. The larger surface subsidence values appeared to be where two layers of mining were present.

Creep 3 is bounded by Perkin Street to the west and the limit of mining in the east.

The mine workings of the No. 2 and Hamilton pits were abandoned in 1901 (RT566), while the New Wining Pit workings were abandoned in 1916.

4.2. Working dimensions

Using historical No. 5 Borehole located 100m to the south east of the site, the maximum mined section was 16' 5 ¼" (5m). Similarly, from No. 2 Borehole located 320m the coal and bands section totalled 17' 0.5" (5.2m).

Other mined heights from historical sources include:

- 8' 2" (2.5m) (Pittman, 1912) for Dyetts Heading 1.8km east of the site
- 11' 10" (3.6m) (Pittman, 1912) for Wilsons District 1.1km east of the site

Both of these sections indicate the Jerry Stone and below was not mined.

Without any further information specific to the site, the mined section would be a maximum of 5.2m with the full coal seam thickness being 5.7m.

Within 150m of the site, based on scaling of pillar widths from the RT566, the pillars range from 8.1m wide to 15.5m wide with an average width of 10.8m. Pillar lengths are scaled to range from 10.1m up to 64.3m with an average of 29.7m.

For the Hamilton Pit workings, the pillars are slenderer (5m rather than 11m) with evidence of failure (118 Parry Street located 450m north of the site per Coffey Report N8878-01-AH dated July 2004). Close to the site, the pillar width is scaled to be less than 5m within areas of secondary mining.

The residual void height encountered at 291 King Street, 830m to the north east of the site (Coffey report GEOTWARA21991AA-AD dated 19 July 2013) into the New Winning Pit was 3.0m on one side of the borehole and 3.5m on the other. The 118 Parry Street investigation, (see above) although different mine (i.e. the Hamilton Pit Workings) 450m north of the site, encountered void heights away from failure of 1.53m, 3.55m and 2.9m.

4.3. Roof and floor of the mine workings

The immediate roof of the workings is comprised of a combination of silty coal overlain by siltstone and shale. Experience obtained from drilling numerous boreholes in the Borehole Seam workings in the Newcastle area shows that although prone to spalling and cave-in, the compressive strength of the immediate roof of the workings remains much greater than that of the underlying clean coal.

At 118 Parry Street (Coffey report N8878-01-AH dated July 2004) the immediate roof had point load I_{s50} values ranging from 0.3 to 2.2MPa which is estimated to correlate to a UCS value of 5.5MPa to 40MPa using a ratio of I_{s50} to UCS of 18, as previously obtained from lab testing in the area (GEOTWARA20878AA-AF dated 3 April 2009). Additionally, boreholes which have intersected mining bords show this material to 'arch' increasing the width of the pillar in this area. Therefore, punching failure of the workings into the roof is considered to be a non-credible case for these workings.

The Waratah Sandstone forms the floor of the Borehole Seam.

A good knowledge base regarding the characteristics of the Waratah Sandstone beneath Newcastle is now available from numerous recent boreholes, carried out by Coffey in the area and records of old boreholes and mining conditions. Based on this, the Waratah Sandstone is considered:

- Free from tuffaceous clays, weaker rock beds or fractured zones
- At least 5 m thick

- Not prone to significant softening
- Not known to cause floor heave or pillar bearing capacity problems
- Very high to extremely high strength sandstone encountered in BH03

For the Waratah Sandstone, at 118 Parry Street (Coffey report N8878-01-AH dated July 2004) the immediate floor had I_{s50} values ranging from 1.3MPa to 3.4MPa (UCS ~23MPa to 61MPa using the above I_{s50} to UCS ratio of 18). Therefore, punching failure of the workings into the floor is considered to be a non-credible case for these workings.

4.4. Position of mine workings

The location of the workings relative to the site is shown on Drawings 3 and 4. Borehole/ grout boreholes verification work from more than sixty boreholes from 13 sites drilled into bords within the New Winning Pit mine workings have verified that record tracing RT566 Sheet 8 is a close representation of the mine workings. Slight discrepancies exist between Sheet 4 and Sheet 8 however some of this may be due to scaling issues, plan damage (folding) and issues arising from stitching the separate images that make up the mine plans. For the New Winning Pit, the nearest boreholes to the Site, into the Borehole Seam were from grouting beneath Gibbson Street (GEOTWARA22349AB-AC dated 24 February 2016) 820m to the north east of the site.

Similarly, the combined Sheets 1 and 10 for the combined Hamilton and No. 2 pit workings have also been shown to be a close representation of the mine workings, with drilling from more than eight developments, the nearest being 450m north of the site (118 Parry Street). An alternative version of the layout is shown on Sheet 5, with similar light discrepancies between the two versions for the combined Hamilton Pit and No.2 Pit workings as was observed for the New Winning Pit workings.

5. Discussion

5.1. State of mine workings

The mine workings in the area consists of four areas:

- A small area of secondary mining within the New Winning Pit Mine located 150m south east of the site which is anticipated to have been mined to failure. This secondary mining is likely to be adding abutment loading to the nearby pillars. As such pillar stability calculations should consider abutment loading.
- An area of first workings within the New Winning Pit Mine with a pillar width to height ratio just under 2. These workings are anticipated to be still standing with the bords expected to have residual void heights less than 3m due to roof fall and poor quality coal left in the mine.
- An area of secondary mining and slender pillars within the combined D Pit, E Pit, No.2 Pit and Hamilton Pit. These workings have previously been shown to have failed. The failure is likely to extend to the barrier between the mines and as such no longer of risk to the proposed development.
- A barrier between the two mines ranging from 10m to 40m wide with locally thinner and wider zones particularly near headings.

5.2. Pillar stability assessment

5.2.1. Pillar factor of safety methodology

In order to quantify pillar stability, a factor of safety (FOS) is used. The factor of safety of an individual pillar is the ratio of pillar strength to pillar load. There are many published methods in practice around the world to estimate pillar strength. All are simplifications and, thus have limitations. In Australia, the

UNSW Pillar Design method (Galvin et al 1998) is commonly used. This approach is based on semi-empirical relationships, derived from a database of failed and un-failed pillars. It is only valid where roof and floor conditions are good and where full pillar yield does not exist. In general, as discussed above based on core drilling of the seam, this appears to be the case in this area.

An angle of draw defines a zone around a mined area or 'panel' that would be affected, should pillar failure occur. Due to the mainly fine grained and low strength nature of the overburden, an angle of draw of approximately 26.5° (2V:1H) has been adopted in this report.

The strength of the pillars with a width to height ratio ≤5 (S_p in MPa) can be estimated using Equation 1.

$$S_p = \frac{8.6(Q.w)^{0.51}}{h^{0.84}} \quad (1)$$

Where: w = width of pillar (m), h = height of pillar (m).

Where the width to height ratio is >5, the equation is modified to Equation 2.

$$S_p = \frac{27.63(Q)^{0.51}}{w^{0.22}h^{0.11}}\left\{0.29\left[\left(\frac{w}{5h}\right)^{2.5} - 1\right] + 1\right\} \quad (2)$$

Where: Q = shape factor:

- For width greater than 6: $Q = \frac{2L}{L+w}$ (3)
- For width less than 6: $Q = \left(\frac{2L}{L+w}\right)^{\frac{R-3}{3}}$ (4)

Where R = width/height

The assessed load applied to the coal pillars is obtained by the weight of all the overburden layers within the tributary area, expressed as a vertical pressure on the top of the pillar. The tributary area is typically taken the midway along bords and cut throughs surrounding a pillar, as shown in Figure 2.

Where: 'TW' is the tributary width and 'TL' is the tributary length.

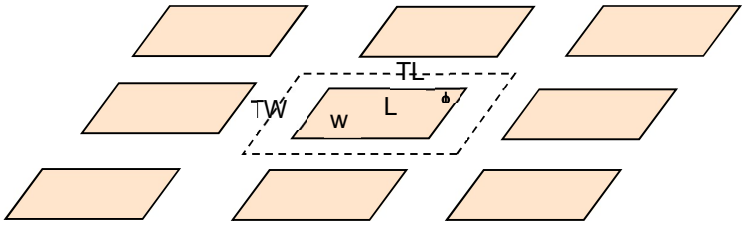

Figure 2: Tributary model

Transfer of load from secondary worked or crushed areas to adjacent pillars was assessed using the procedures in the Australian Coal Association Research program (ACARP) Final Report – Chain Pillar Design (Calibration of ALPS) C6036 Oct 1998 (Colwell, Frith, & Mark, 1998). In this approach, the load transferred from the retreat mined area is distributed over a zone of adjacent pillars based on empirical equations developed from longwall mining. In this case the abutment angle of 21° was adopted as per the report.

$$Therefore\ new\ pillar\ stress = \sigma_p = \frac{(Tributary\ load \quad A)}{w} \quad (5)$$

Using the following

$$Abutment\ load\ A = \rho g\left(\frac{1}{2}H\,W - \frac{1}{8}W^2 tan\emptyset\right) < \rho g\left(\frac{1}{2}H^2\,tan\emptyset\right) \quad (6)$$

and

$$Proportion\ ratio\ R = 1 - [(D - w - w_e)/D]^3 \quad (7)$$

5.2.2. Pillar stability calculations

For the pillar stability assessment, Coffey has adopted two heights:

1. The upper limit mined height of 5.2m
2. The full seam thickness of 5.7m.

For the pillar plan dimensions, we have adopted two widths:

1. Actually drawn plan dimensions
2. Less 0.5m to the drawn plan widths to model potential robbing of the pillars and/or spalling in accordance with SA NSW merit assessment policy.

For the overburden stress we have adopted two states:

1. Total overburden stress ('Dry state') equivalent to during mining under the site assuming 58m cover
2. Total overburden stress ('Dry state') equivalent to during mining under the site assuming 58m cover plus abutment loading to assess the likelihood of the pillar creep event

Pillar stability calculations are summarised in Table 2.

Table 2: Summary of pillar stability calculations

Pillar	Width (m)	Length (m)	Scaled Tributary Width (m)	Tributary Length (m)	Abutment Loading	Factor Of Safety	
Height (m)						5.2	5.7
Pillar 1	10.4	12.0	17.1	15.6	No Abutment	2.6	2.4
					With Abutment	1.7	1.6
	9.9				No Abutment	2.4	2.2
					With Abutment	1.6	1.5
Pillar 2	9.0	25.2	16.1	30.0	No Abutment	2.4	2.3
					With Abutment	1.6	1.5
	8.5				No Abutment	2.2	2.1
					With Abutment	1.4	1.3
Pillar 3	9.9	21.0	15.9	24.3	No Abutment	2.9	2.7
					With Abutment	1.9	1.8
	9.4				No Abutment	2.7	2.5
					With Abutment	1.7	1.6
Pillar 4	12.1	28.5	17.6	33	No Abutment	3.5	3.3
					With Abutment	2.3	2.2
	11.6				No Abutment	3.3	3.1
					With Abutment	2.2	2.0
Pillar 5	11.0	64.5	17.7	68.1	No Abutment	3.3	3.1
					With Abutment	2.2	2.1
	10.5				No Abutment	3.1	2.9
					With Abutment	2.1	1.9
Pillar 6	29.0	32.5	40.0	39.6	No Abutment	5.7	5.2
					With Two Way Abutment	3.9	3.6
	28.5				No Abutment	5.5	5.2
					With Two Way Abutment	3.8	3.5

The above assessment indicates the area had a high factor of safety at the time of mining, away from the secondary mining with the factor of safety generally greater than 2.5, meaning isolated pillar failures are barely credible. However, as secondary mining has been completed in the vicinity of the site (150m away or nine pillars away) then the factor of safety of the panel is much lower.

Allowing for the abutment loading to come from both sides and being conservative with the pillar dimensions, the barrier has a factor of safety greater than 3.8 and is assessed to be long term stable with a width to height ratio greater than 4.

Reviewing a large portion of the workings around the site with a total of 221 pillars within the New Winning Pit, the average factor of safety is 2.6 for full seam thickness of 5.7m. Allowing for abutment loading, this reduces the factor of safety to 1.9 assuming full seam thickness. Figures to show the factor of safety distribution are shown below. Taking 0.5m off the width of each and every pillar the

average factors of safety for without and with abutment loading becomes 2.4 and 1.8 for without and with abutment loading respectively.

Figures to show the factor of safety distribution are shown below.

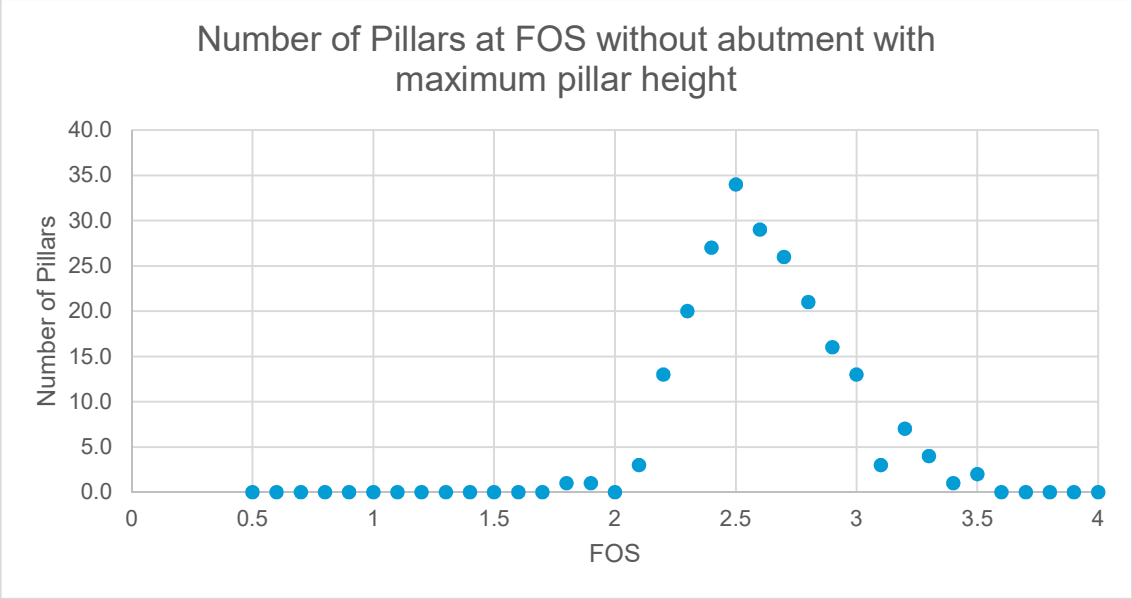

Figure 3: Number of pillars at each factor of safety without abutment loading at full seam thickness and scaled pillar widths

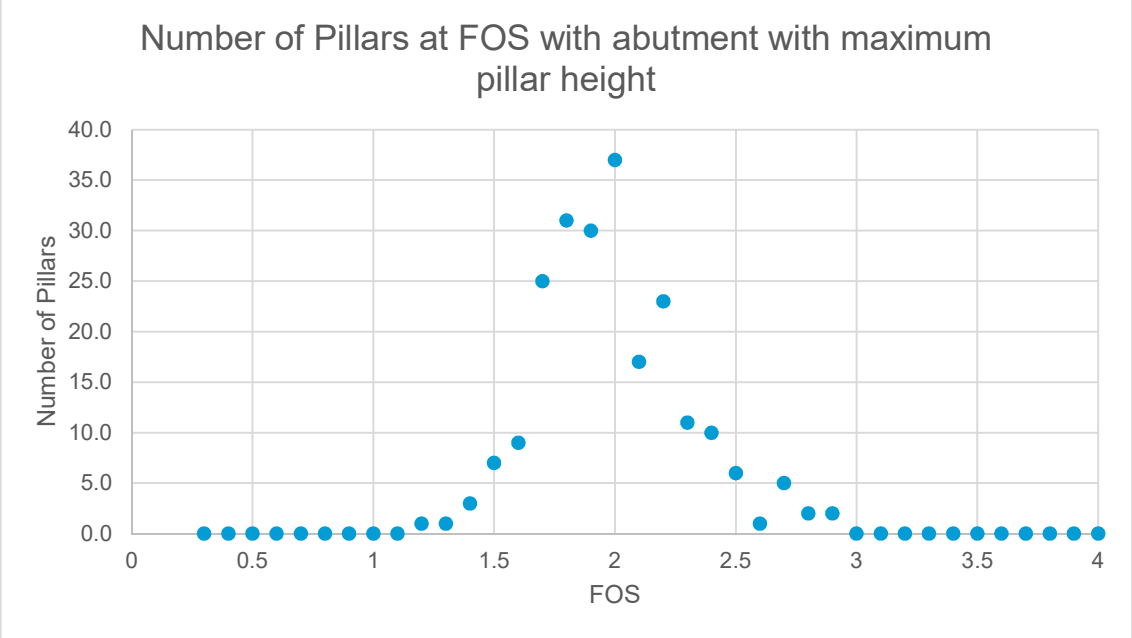

Figure 4: Number of pillars at each factor of safety with abutment loading at full seam thickness and scaled pillar widths

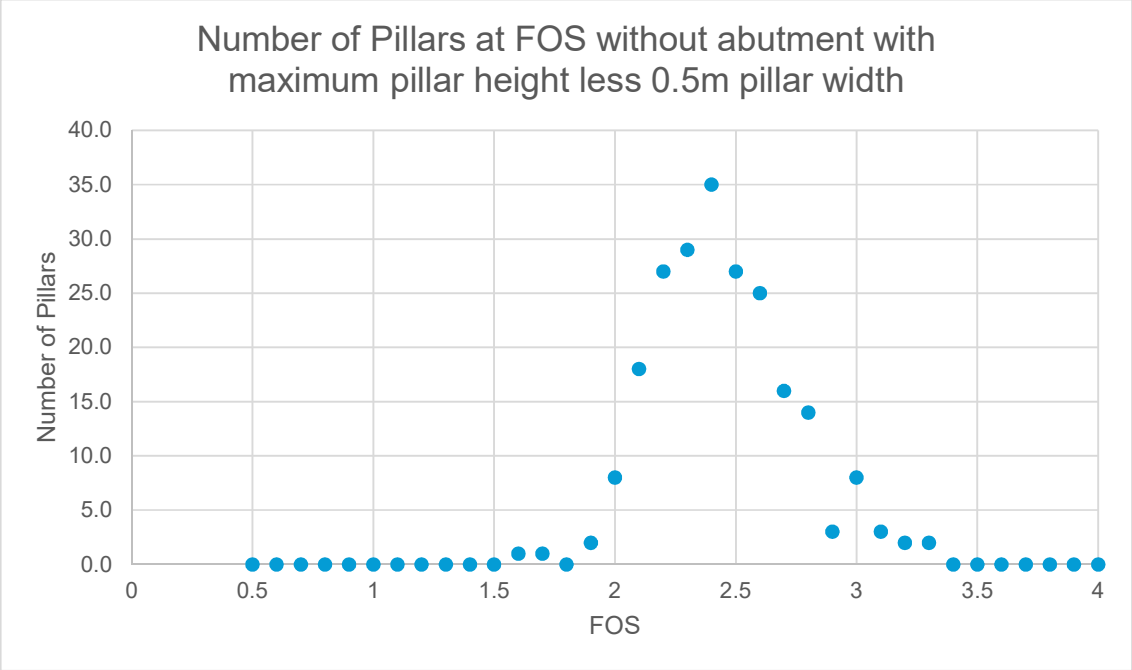

Figure 5: Number of pillars at each factor of safety without abutment loading at full seam thickness and less 0.5m from scaled pillar widths

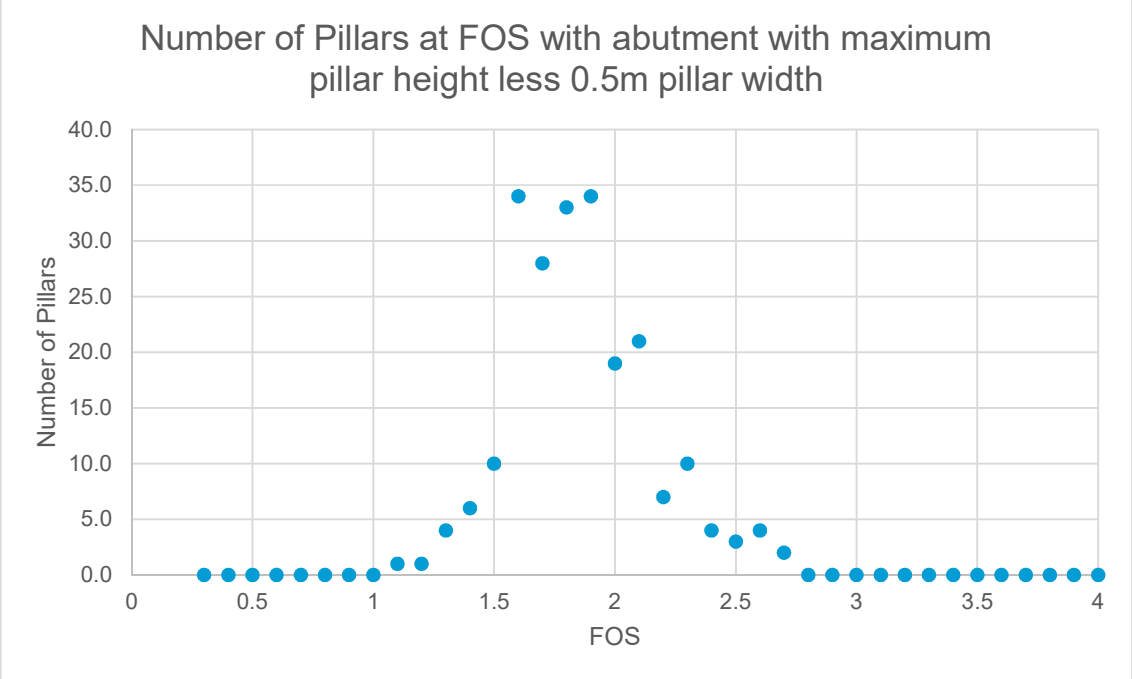

Figure 6: Number of pillars at each factor of safety with abutment loading at full seam thickness and less 0.5m from scaled pillar widths.

The above analysis ignores buoyancy effects from pore pressure within the mine workings and overburden which is likely to have a positive effect.

5.3. Estimated subsidence

5.3.1. Estimating crush from volume exchange method

Should an event occur within the area it is important to estimate the amount of potential crush at mine level. For the first method, volume exchange (i.e. volume in pillar required to fill the void), Coffey has adopted the following formula.

$$Crush = \frac{\left[\left(H_v \times W_{(B+P)}\right) - W_P \times H_{Crus} \times BF_P\right]}{W_{(B+P)}} \quad (8)$$

Where:

- H_v = height of void remaining (assumed to be between 1.5m and 3.6m based on CCTV inspections from Coffey reports GEOTWARA21991AA-AD dated 19 July 2013 and N8878-01-AH dated July 2004
- $W_{(B+P)}$ = width of bord and pillar (taken as 17.6m based on Pillar 4 nominated on Drawing 3)
- W_P = width of pillar (taken as 12.1 based on Pillar 4 nominated on Drawing 3)
- H_{Crush} = Height of pillar being mobilised by the crush (taken as the void height of 1.5m to 3.6m)
- BF_P = bulking factor of pillar crushing (assumed to be 1.2)

Using this information, it is estimated that the maximum convergence (crush) of the seam at the base of the trough may be between 0.25m (for 1.5m residual void height) and 0.65m for the upper void height of 3.6m.

The resultant surface subsidence is expected to be approximately 60% to 65% of these values due to opening of beddings within the rock, unit but higher than the ratio of 55% observed over long wall panels in the Newcastle region (Holla, 1987). i.e. this means that the surface subsidence is anticipated to be between 0.15m and 0.45m.

5.3.2. Estimated crush based on historical crush values

As an alternative method to assess the likely magnitude of crushing, Coffey developed a database of crush (seam convergence) magnitude encountered in boreholes drilled into collapsed first workings in the Newcastle Area.

Generally, the surface subsidence is reported over longwall mining as s_{max}/t versus W/H (Holla, 1987)

Where:

s_{max} = maximum surface subsidence at centre of trough

t = thickness of seam extracted

W = Width of longwall panel

H = Height of overburden

To account for extraction ratio, the height of extraction typically adopted for s_{max}/t in references (Holla, 1987) was multiplied by the extraction ratio of the pillars at the borehole location scaled from the RT at the borehole location.

$$\frac{Crush}{h.e} \; refers \; to \; \frac{crush\,(m)}{mined\; height\; x\; extractio\; ratio} \quad (9)$$

The results for five different areas are provided in Figure 6.

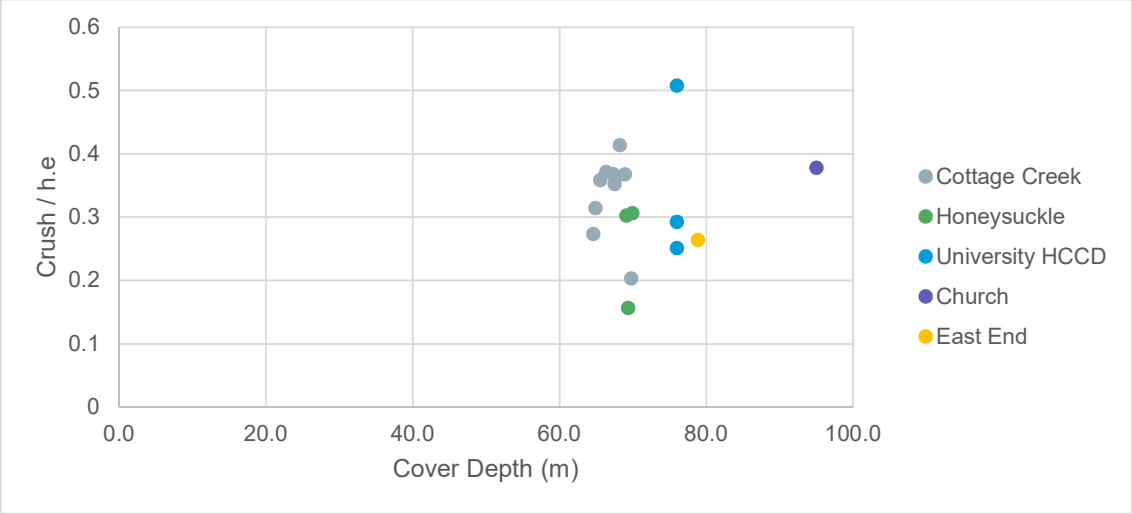

Figure 7: Summary of crush at mine level data over mined height multiplied by extraction ratio relative to overburden depth encountered in Boreholes completed beneath the Newcastle Area

Based on the above, it may be estimated the amount of crush at seam level would be in the order of 30% to 40% (with an upper bound value of 50%) of the mined height multiplied by the extraction ratio. This low ratio (Figure 7) was evident in historical mine workings following crush events where the collapse did not fill the entire void space.

Using Figure 7 data and the scaled extraction ratio of 40% shown on the RT566, the amount of crush at mine level would be between

- 5.2 (mined height) x 0.4 x 0.3 (lower bound value Figure 7) = 0.6m
- 5.2 (mined height) x 0.4 x 0.5 (upper bound value Figure 7) = 1.0m

The above values are crush at seam level with the resultant surface subsidence likely to be in the order of 60% to 65% of this value (i.e. 0.35m to 0.65m) due to bedding separations (allowing for some additional settlement relative to the measured values over long wall panels reported in the Newcastle (Holla, 1987). It is noted these values may be reduced were evidence of lower mined height can be obtained.

5.3.3. Proposed subsidence values

Using subsidence curves developed for subsidence over long wall panels (Holla, 1987), the subsidence profile, using the depth of 58m that may develop in the area includes:

- The surface subsidence of 350mm to 650mm allowing for 600mm to 1000mm of crush at mine level.
- The maximum tilt for the building is expected to be in the range of 10mm/m to 20mm/m.
- The maximum tensile strains are assessed to be in the range of 2.5mm/m to 5mm/m with a radius of curvature of 4km to 2km.
- The maximum compressive strains are assessed to be in the range of 3.5mm/m to 6.5mm/m with a radius of curvature of 2.5km to 1.5km.
- The point of inflection 18m from limit of support which is the barrier beneath Union Street.

With the limit of mining being more than 18m from the site, should an event occur, it would likely occur fully through the site. This means that first tensile strains, then tilts followed by compressive strains would affect the site at surface level.

5.4. Reference to SA NSW Merit Assessment Policy

For buildings over standard guidelines, the SA NSW assesses projects based on merit as set out in a document entitled *Development Application - Merit Assessment Policy* (Version 1, 25 May 2018). Attachment C to the Policy outlines the procedure used to assess surface development on merit. The purpose of the procedure is to:

- Provide a consistent approach when assessing development applications
- Provide guidance on the type of engineering mitigation measures and geotechnical reporting that may be required to facilitate assessment of a development application

With reference to Table 2 of the SANSW Merit Assessment Policy, due to the proposed development being used for school classrooms and halls the structures would be classified as B3 (public building with high trafficability.

The uncertainty factor is used by SANSW to determine the levels of conservatism and allowed assumptions required when assessing the likelihood of a trough subsidence event. The level of geotechnical uncertainty is categorised as low, medium or high based on the level of confidence and understanding of the:

- Geological environment (R1)
- Level of geotechnical investigation (R2)
- Type of coal mine plans and records (R3)
- Method used to assess stability and impact (R4)

The weighting applied to each factor is:

- R1 = 2
- R2 = 2
- R3 = 3
- R4 = 3

An uncertainty value of either ranging from 1 to 3 is assigned for each category (R1 to R4) based on the descriptions in Table C2 of Appendix C of the SANSW Merit Assessment Policy (attached in Appendix B of this report). The uncertainty values (U) are:

- Low uncertainty = 1
- Moderate uncertainty = 2
- High uncertainty = 3

Once these have been determined, the Uncertainty Factor can be determined by applying the following formula:

Uncertainty Factor (UF) = (R1xU)+(R2xU)+(R3xU)+(R4xU) -10

The Uncertainty Factor is used to rate project uncertainty for a project is rated as low, medium or high uncertainty based on the following values:

- Low uncertainty – UF <= 5
- Moderate uncertainty – UF > 5 and <=10
- High uncertainty – UF >10

The SANSW Assessment Policy is attached to this report for reference in Appendix A.

A summary of uncertainty factors for the subject site is provided below in Table 3.

Table 3: Summary of uncertainty factors

Item	Weighting	Uncertainty Value	Uncertainty Factor	Comments
Geological Environment (R1)	2	3	6	Mining records show a number of faults in area including beneath the site
Level of geotechnical Investigation (R2)	2	3	6	No site specific borehole data, or inferences made from boreholes located more than 50m from site
Coal Mine Plans and Records (R3)	3	2	6	Hand worked, single layer with a number of boreholes confirming accuracy of mine workings generally more than 500m from the site
Method used to assess stability and impact (R4)	3	1	3	Single method used, looking at whole coal pillars all values clearly outlined, less 0.5m with various heights assessed. Increased pillar heights
Total			21	
Uncertainty Factor (UF)			11	

Based on the above and the SANSW Merit Policy, the site may be considered to have a 'Uncertainty Factor' of high uncertainty.

In accordance Attachment C-Table C3, for B3 structures the workings cannot have a high uncertainty. It is noted the area does not meet moderate uncertainty either with a factor of safety less than 2.1 (allowing for the abutment loading due to the proximity of secondary workings and the width to height ratio less than '4' (currently in the order of 1.9).

As a minimum, with reference to Attachment C-Table C3 of the SANSW Merit Policy, the building should be designed to be safe serviceable and any damage limited to "very slight" in accordance with AS2870's damage classification for the following parameters:

- Tilt up to 20mm/m.
- Tensile and compressive strains of 6.5mm/m
- Radius of curvature of 1.5km.

It is noted these parameters are quite large may not be appropriate for the proposed structures.

An example of the settlement curve is provided below in Figure 8.

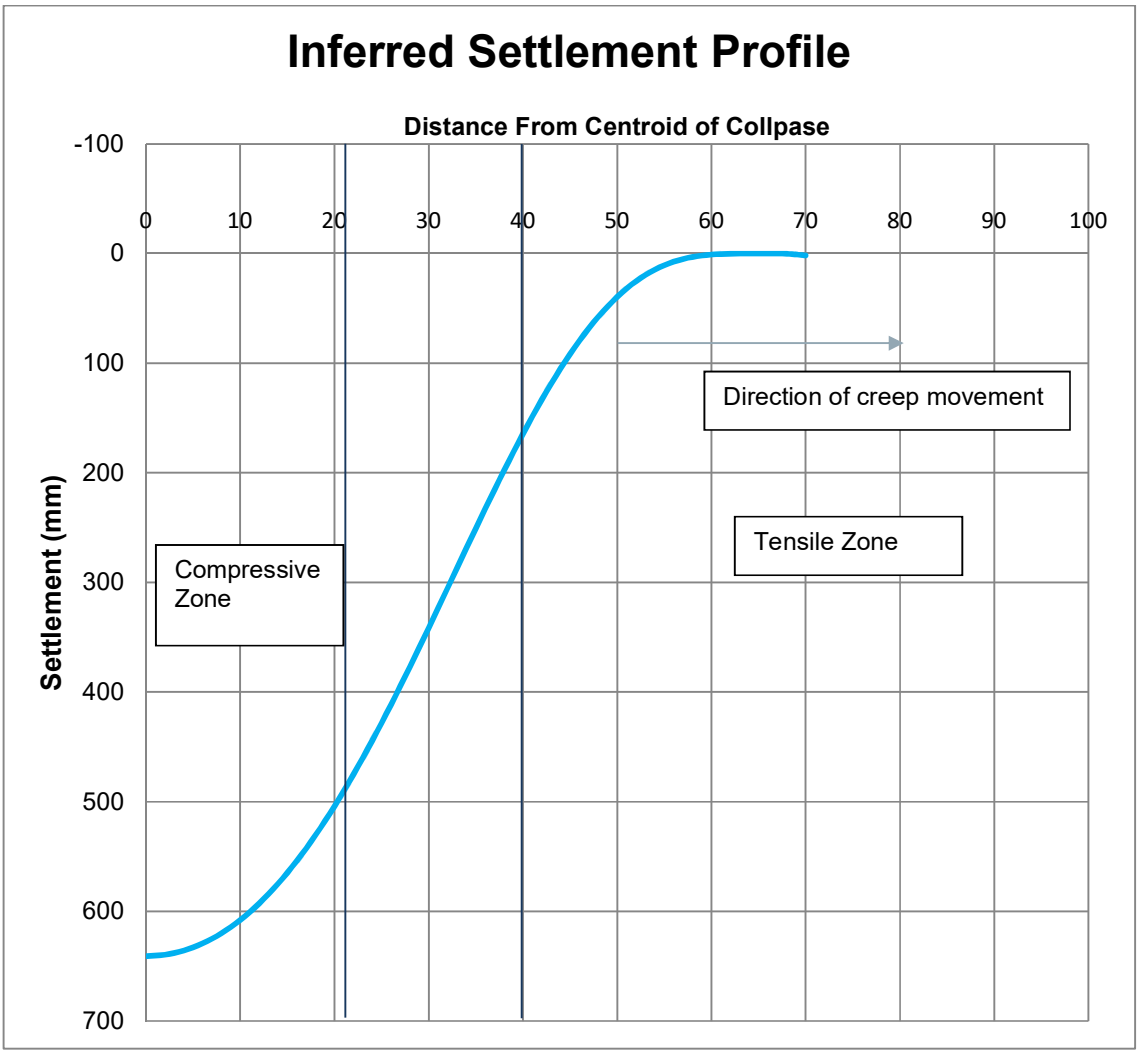

Figure 8: Idealised settlement profile.

This profile, should an event occur, would originate from the south east.

6. Risk reduction measures

The mine subsidence risk is a product of likelihood of occurring and consequence of occurring. This risk may be reduced by:

- Structural design to accommodate the above subsidence parameters.
- Drilling boreholes into the mine workings including two boreholes one either side of a pillar to verify the exiting void height, bord widths and pillar heights.
- Grouting of the mine workings. To assess appropriate locations of grout, numerical modelling may beneficial/ be required including to the nearby secondary mining.
- Combination of the above options

7. Closing remarks

The Newcastle Grammar School site at 127 Union Street Cooks Hill is positioned over relatively uniform pillars with a moderate to low factor of safety when allowing for roof fall to the full seam thickness and abutment loading due to secondary mining.

The project structural engineer should review the above subsidence parameters from Section 5.3.3 to assess if these parameters can be economically accommodated to assess the best method to move forward.

Further advice on the uses and limitations of this report is presented in the attached document, 'Important Information about your Coffey Report'.

Signature:	
Full name:	Simon Baker
Title:	Senior Geotechnical Engineer
Date:	2 February 2021

References

Colwell, M., Frith, R., & Mark, C. (1998). *Chain Pillar Design:(Calibration of ALPS).* ACARP Research Project No.C6036.

Galvin, J. M., & University of New South Wales. School of Mining En. (1998). *Establishing the strength of rectangular and irregular pillars ACARP Research Project No. C5024.* Sydney: University of New South Wales Mining Research Centre.

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Pittman, E. F. (1912). *Coal Resources of New South Wales.* Sydney: William Applegate Gullick Government Printer.

Power, F. D. (1912). *Coalfields & Collieries of Australia.* Sydney: Critchley Parker.

Robertson, D. A., Sulman, J., & James, A. H. (1908). *Report of the Royal Commisson on Earth Subsidences at Newcastle.* Sydney: William Applegate Gullick.

To, E. M. (1988). 1908 Royal Commission Revisited. *Proceedings of the Conference on Buildings and Structures subject to Mine Subsidence*, (pp. 26-35). Maitland.

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment. Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Drawings

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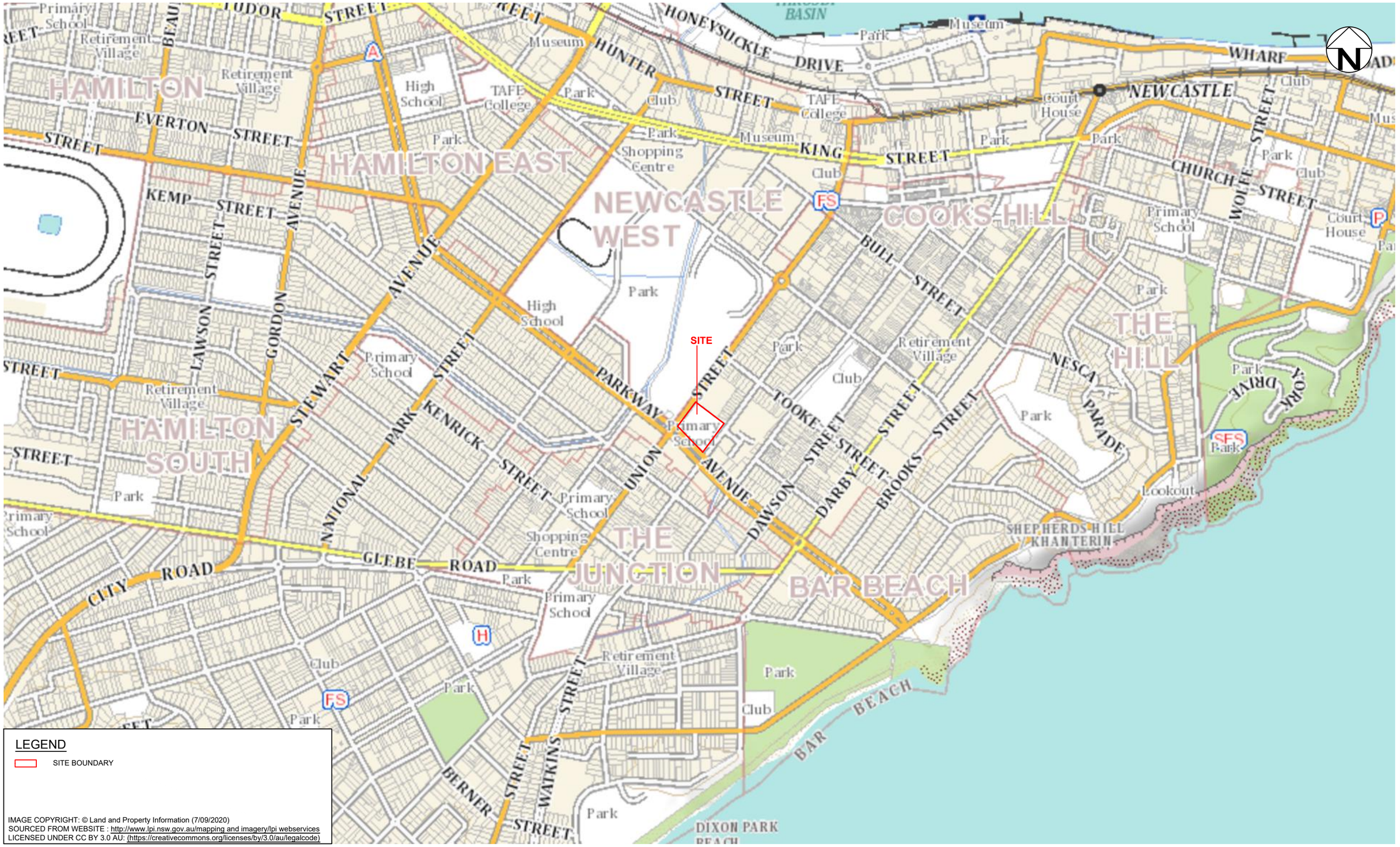

LEGEND

SITE BOUNDARY

revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE			

100 0 100 300 500

Scale (metres) 1:10,000

drawn	SJB
approved	JD
date	28/01/2021
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client: NEWCASTLE GRAMMAR SCHOOL LTD

project: PROPOSED STAGE 1 ADDITIONS - NEWCASTLE GRAMMAR SCHOOL
127 UNION STREET COOKS HILL
MINE SUBSIDENCE ASSESSMENT

title: SITE LOCATION PLAN

project no: 754-NTLGE282007 | drawing no: DRAWING 1 | rev: A

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LEGEND

- SITE BOUNDARY
- SURROUNDING LOT BOUNDARIES

revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE			

20 0 20 40 60 80 100

Scale (metres) 1:2000

drawn	SJB
approved	JD
date	28/01/2021
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client: NEWCASTLE GRAMMAR SCHOOL LTD

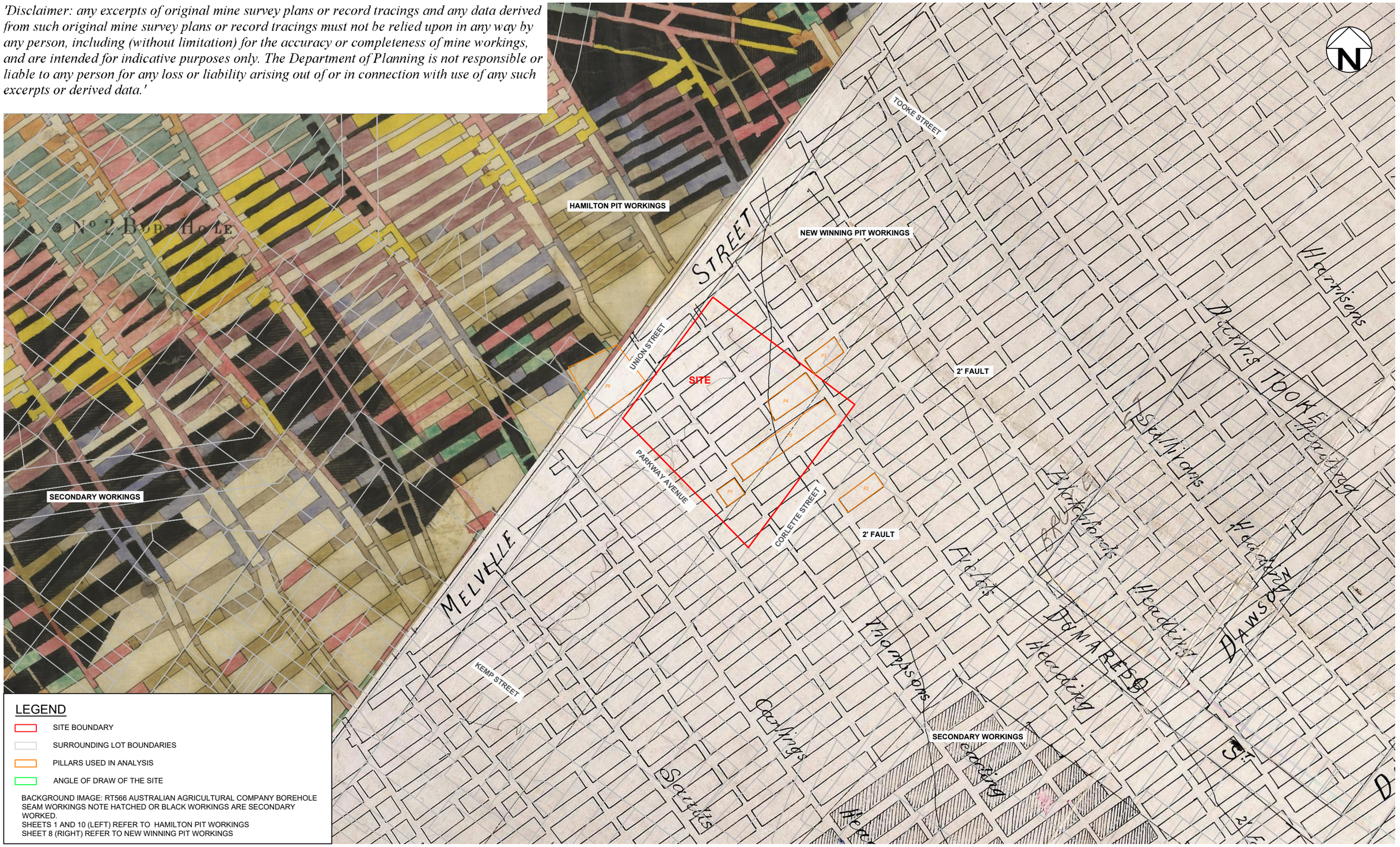
project: PROPOSED STAGE 1 ADDITIONS - NEWCASTLE GRAMMAR SCHOOL
127 UNION STREET COOKS HILL
MINE SUBSIDENCE ASSESSMENT

title: SITE CONDITIONS

project no: 754-NTLGE282007 | drawing no: DRAWING 2 | rev: A

PLOT DATE: 28/01/2021 12:11:00 PM DWG FILE: F:\GEOTECH\NIC\S1\ JOB FILES\NEWCASTLE PROJECTS\NTLGE280000\754-NTLGE282007 - NEWCASTLE GRAMMAR SCHOOL PARK CAMPUS STAGE 1\DRAWINGS\AB - MINE DRAWING.DWG

'Disclaimer: any excerpts of original mine survey plans or record tracings and any data derived from such original mine survey plans or record tracings must not be relied upon in any way by any person, including (without limitation) for the accuracy or completeness of mine workings, and are intended for indicative purposes only. The Department of Planning is not responsible or liable to any person for any loss or liability arising out of or in connection with use of any such excerpts or derived data.'



revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE			

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Scale (metres) 1:2000

drawn	SJB
approved	JD
date	28/01/2021
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client: NEWCASTLE GRAMMAR SCHOOL LTD

project: PROPOSED STAGE 1 ADDITIONS - NEWCASTLE GRAMMAR SCHOOL
127 UNION STREET COOKS HILL
MINE SUBSIDENCE ASSESSMENT

title: SITE RELATIVE TO RT566 SHEETS 1, 8 AND 10

project no: 754-NTLGE282007 | drawing no: DRAWING 3 | rev: A

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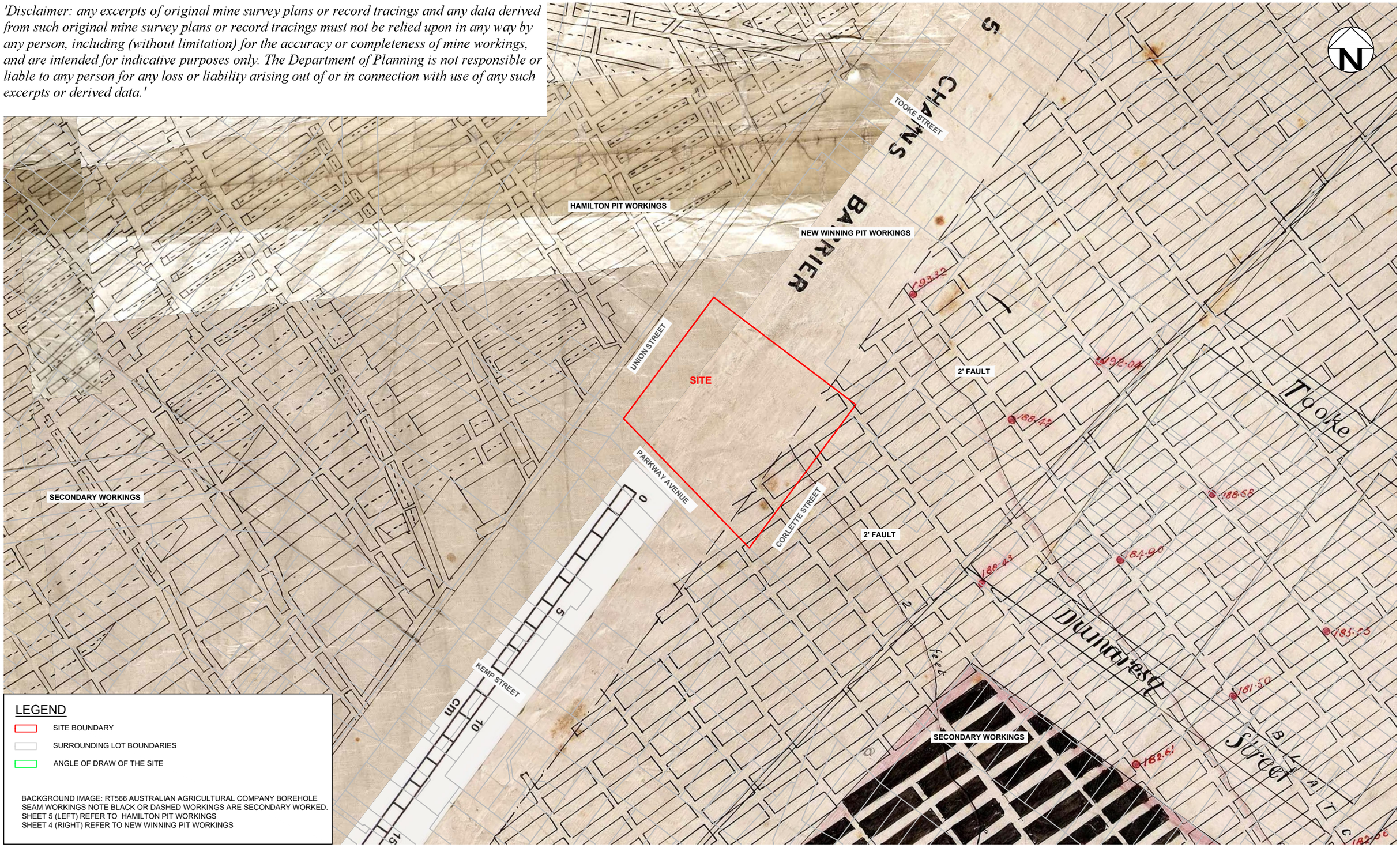

LEGEND

- SITE BOUNDARY
- SURROUNDING LOT BOUNDARIES
- ANGLE OF DRAW OF THE SITE

BACKGROUND IMAGE: RT566 AUSTRALIAN AGRICULTURAL COMPANY BOREHOLE SEAM WORKINGS NOTE BLACK OR DASHED WORKINGS ARE SECONDARY WORKED.
SHEET 5 (LEFT) REFER TO HAMILTON PIT WORKINGS
SHEET 4 (RIGHT) REFER TO NEW WINNING PIT WORKINGS

revision	no.	description	drawn	approved	date
	A	ORIGINAL ISSUE			

20 0 20 40 60 80 100
Scale (metres) 1:2000

drawn	SJB
approved	JD
date	28/01/2021
scale	AS SHOWN
original size	A3

coffey
A TETRA TECH COMPANY

client: NEWCASTLE GRAMMAR SCHOOL LTD

project: PROPOSED STAGE 1 ADDITIONS - NEWCASTLE GRAMMAR SCHOOL
127 UNION STREET COOKS HILL
MINE SUBSIDENCE ASSESSMENT

title: SITE RELATIVE TO RT566 SHEETS 4 AND 5

project no: 754-NTLGE282007 | drawing no: DRAWING 4 | rev: A

PLOT DATE: 28/01/2021 12:11:20 PM DWG FILE: F:\GEOTECH\NICS\1 JOB FILES\NEWCASTLE PROJECTS\NTLGE280000\754-NTLGE282007 - NEWCASTLE GRAMMAR SCHOOL PARK CAMPUS STAGE 1\DRAWINGS\AB - MINE DRAWING.DWG

Appendix A - Historical Boreholes

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Parish: NEWCASTLE
County: Northumberland No. 2
Portion:
Name: A.A. Co's. No.2 Borehole Height a.s.l.: 13·9'
Map: LJJ 10-7 Reference: Roy. Comm. 1886 p.171
Location: See LJJ Map
Sunk by: Date: For:

Strata	Thickness Ft.	in.	Depth Ft.	in.	Remarks
Sand	28	0			
Slate coloured clay	2	6			
Sand	10	0			
Clay	11	6			
Clay	28	6			
Coal smut, with blue clay shale forming with coal pipes	15	0	80	6	
Blue shale	10	3			
Chert bed	0	1½			
Blue shale & post girdles	5	6			
Post and shale girdles	14	0			
Grey post	0	5			
Post and shale girdles	6	3			
Grey post	0	9½			
Post and shale girdles	5	3½			
Grey post	1	9½			
Post and shale girdles	1	6			
Grey post	6	6			
Blue shale	1	4			
Grey post (shelly)	2	9			
Ironston e	0	5¾			
Grey post (shelly)	4	3			
Crusted grey post	1	1½			
Blue shale	2	0¾			
Crusted grey post	2	7½			
Post and shale girdles	1	4			
Post ribbed ironstone	1	9½			
Post and shale girdles	2	3			
Conglomerate sand and pebbles	3	10			
Blue shale with several small beds of ironstone, post, and chert rock	6	1¾			
Shale ironstone	4	4¾			
Coal smut	0	6¾			
Shale	0	5			
Coal smut	0	8½			
Coal and bands	17	0½			
Total			201	0½	

Parish: NEWCASTLE
County: Northumberland
Portion:
Name: A.A. Co's. No. 5 Borehole
Map: LJJ 106
Location: See LJJ Map. Near Bellingham
Sunk by:

No. 5
Height a.s.l.: 15-2'
Reference: Roy. Comm. 1886 /p.172
Date:
For:

Strata	Thickness Ft.	Thickness in.	Depth Ft.	Depth in.	Remarks
Surface sand & several gravel beds	30	6			
Black clay mixed with pebbles	10	5			
Clay of various colours	28	1			
Soft Coal	1	8	70	8	
Blue slate	2	6			
Soft post	1	5			
Blue slate	3	6			
Grey post	1	10			
Blue slate	4	6			
Grey post	2	7½			
Blue slate	3	7½			
Post & slate girdles	2	4½			
Grey post	2	6½			
Blue slate	2	8½			
Grey post	4	4½			
Grey post & slate girdles	7	10½			
Ironstone band	-	0½			
Grey post	-	5			
Ironstone band	-	1½			
Grey post	3	4½			
Ironstone band	-	1½			
Post & threads of ironstone	3	2½			
Post	2	1½			
Post & slate girdles	4	7			
Slate	1	3½			
Post & slate girdles	5	6½			
Slate	1	5½			
Grey post	0	9			
Slate & post girdles	10	8			
Grey post	1	8			
Ironstone	0	2			
Post & slate girdles	8	5½			
Ironstone	0	6			
Blue slate	7	3½			
Ironstone	-	1			
Slate & post girdles	1	3			
Ironstone	-	1½			
Post & slate girdles	3	10½			
Dark slate	1	0			
Grey post	4	10½			
Slate & post girdles	1	8½			
Blue slate	3	0			
Slate & post girdles	3	3½			
Ironstone	-	1½			
Blue slate	3	1½			
Ironstone band	-	2			
Blue slate	2	1½			
Ironstone	0	6			
Slate crown	1	0½			
Smut and clay	-	10½			
Fireclay	1	0			
Coarse COAL	-	6	190	7½	
Coarse coal clay partings	-	5			Borehole Sea
Fireclay	-	5½			
COAL & bands	16	5½	208	5½	
Post	-	5	0	5	
Total			208	10½	

Appendix B - SA NSW Merit Assessment Policy

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Development Application – Merit Assessment Policy

Document number:	Version number: 1
Date: Friday, May 25, 2018	

Contact details

Name: Kieran Black	Position: Technical Manager
Business Unit: Risk Engineering	Division: Subsidence Advisory NSW
Phone: (02) 4908 4391	Email: kieran.black@finance.nsw.gov.au

Table of Contents

1. Introduction

1.1 Subsidence Advisory NSW

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

1. To manage claims for compensation where surface developments are damaged by mine subsidence following extraction of coal or shale in NSW.

2. To regulate surface development within mine subsidence districts (districts) to minimise liabilities arising from mine subsidence.

3. To manage risk associated with mine subsidence including public awareness of mine subsidence.

1.2 Regulation of surface development

Districts are proclaimed in areas where there is potential for mine subsidence to impact surface development. This may be a result of potential ground instability in previously mined areas or ground movement due to planned future mining activity.

SA NSW has set surface development guidelines (guidelines) which specify the type of construction permitted on each property in districts. SA NSW has assigned one of eight guidelines to each property located in a district. The type of guideline that is applied depends on subsidence hazards at the property. Each guideline includes restrictions on building footprints, height, foundation type, superstructure material and occupation density.

Applications that comply with certain guidelines can be assessed by an Accredited Certifier, including councils, and do not require SA NSW approval. Table 1 summarises each development guideline and the relevant certifying authority for compliant applications. All applications for proposed development on a property that does not comply with the property's guideline must be considered by SA NSW on merit.

Applicants can find out the guideline assigned to a property through the NSW Planning Portal at www.planningportal.nsw.gov.au/find-a-property.

Table 1 - Summary of SA NSW's development guidelines

SA NSW surface development guideline	Brief description*	Assessment authority
Guideline 1. Non-active mine workings at risk of pothole subsidence	Single storey brick veneer or two storey clad frame on engineer designed footings to span a 5m pothole	SA NSW
Guideline 2. Non-active mine workings possible subsidence risk	Single or two storey brick veneer on AS 2870 footings/slabs. Maximum length of 24m and maximum footprint of 400m².	Councils and certifying authorities*
Guideline 3. Non-active mine workings remote subsidence risk	Up to four storey residential structures in accordance with all standards and codes.	Councils and certifying authorities*
Guideline 4. Active mining areas - high predicted subsidence impact	Single storey clad frame on strip footings or waffle slab to minimum H2 AS2870 site classification. Maximum length 18m and maximum footprint of 250m².	SA NSW
Guideline 5. Active mining areas – moderate predicted subsidence impact	Single or two-storey clad frame or brick veneer on footings/slabs to minimum H2 AS 2870 site classification. Maximum length of 24m and maximum footprint of 400m².	Councils and certifying authorities*
Guideline 6. Active mining areas – minimal predicted subsidence impact	Single or two-storey clad frame or brick veneer on AS 2870 slabs/footings Maximum length of 30m and maximum footprint of 500m².	Councils and certifying authorities*
Guideline 7. On Application	The complexity of the geotechnical environment or lack of information regarding subsidence risk requires that all surface development be assessed by SA NSW	SA NSW
Guideline 8. No Restrictions	SA NSW has assessed, based on available records the subsidence hazard to be negligible	Councils and certifying authorities*

*A full copy of each SA NSW surface development guideline is available at www.subsidenceadvisory.nsw.gov.au/development-guidelines.

** Councils and Certifying Authorities, can approve compliant applications on properties assigned these guidelines. All applications that do not comply with the guideline assigned to the property must be assessed by SA NSW on merit.

2. Policy Statement

This policy provides a framework for the assessment and determination of development applications within districts that do not comply with the SA NSW development guideline assigned to the property.

2.1 Objectives

The key objectives of the policy are to:

- ensure compliance with all relevant statutory requirements
- ensure public safety
- establish a comprehensive, transparent and consistent process for assessing development applications that do not comply with SA NSW's development guidelines
- clearly define roles and responsibilities
- provide guidance on the type of conditions that SA NSW may impose as part of a conditional approval of a development application prior to construction in order to gain final approval following construction
- establish a consultation process
- establish a dispute resolution process
- prevent unnecessary delays in SA NSW's assessment of development applications.

2.2 Scope

This policy applies to all officers, consultants, contractors and outsourced service providers performing work for SA NSW. It also applies to all SA NSW activities that involve assessment of applications for proposed surface development that do not comply with SA NSW's guidelines and the preparation of associated guidelines and procedures.

2.3 Ethical Conduct

All activities must be conducted in an ethical and transparent manner and comply with the values, principles and articles in the Code of Conduct.

Staff will ensure they are not, or are not perceived to be, in a conflict of interest with any stakeholders. Those staff who have, or may be perceived to have, a perceived conflict of interest in the outcome of a development application or related decision should disclose

any perceived conflict to their manager and discuss whether they should exclude themselves from any role in the consideration of the application.

2.4 Roles and Responsibilities

Each of the following has specific assigned responsibilities under this policy:

- Chief Executive Officer (CEO)
- Technical Manager
- Senior Risk Engineer & Senior Advisor Residential Subsidence Regulation
- SA NSW officers

2.4.1 Chief Executive Officer

The CEO is responsible for:

- establishing a policy for the assessment of development proposals within a district
- ensuring the delegations set out in the Instrument of Delegation are appropriate to the development assessment process
- reviewing any determination of an application that is subject to an appeal by a stakeholder.

2.4.2 Technical Manager

The Technical Manager is responsible for:

- ensuring that their staff, including consultants, contractors and outsourced service providers, comply with this policy and associated procedures
- reviewing and updating this policy and the associated procedures and guidelines
- approving or refusing applications for proposed development of land in line with SA NSW's Instrument of Delegations.

2.4.3 Senior Risk Engineer & Senior Advisor, Residential Subsidence Regulation

The Senior Risk Engineer and Senior Advisor, Residential Subsidence Regulation are responsible for:

- complying with this policy, the associated procedure and Instrument of Delegations.

2.4.4 SA NSW officers

SA NSW officers undertaking the assessment of Integrated Development referrals and applications are responsible for:

- complying with this policy, the associated procedure and Instrument of Delegations.
- referring any suggestions for improvement or queries to their respective Manager.

3. Development applications

This policy applies to the assessment and determination of development applications:

- made under section 22 of the Act
- referred to SA NSW as integrated development under section 91A of the *Environmental Planning and Assessment Act 1979.*

3.1 Application lodgement

Applications for development within a district may be submitted directly through SA NSW's online portal at www.subsidenceadvisory.nsw.gov.au or as an Integrated Development application through the relevant local council.

Applications should include detailed plans of the proposed structure, including the location and details of articulation / control joints in brickwork to confirm compliance with the requirements of the Building Code of Australia.

3.1.1 Referral of Integrated Development

Integrated Development is development that requires consent under the *Environmental Planning and Assessment Act 1979* and one or more approvals under other Acts.

Integrated Development is referred to SA NSW by a local council. Referrals may occur through SA NSW's portal.

Integrated Development is referred when an applicant has indicated on a development application (DA) form submitted to council that the DA is to be assessed as Integrated Development.

3.2 Application process

After receiving a development application, SA NSW will:

- register the application and determine whether it requires assessment on merit.

  Note applicants may refer to the NSW Planning Portal to find out the surface development guideline applied to a property in order to determine whether the proposed application complies with the guideline or will require a merit assessment.

- undertake a preliminary review and if necessary either (1) request more information from the applicant or (2) consult the relevant coal mine operator or the Division of Resources and Geoscience (DRG).

- Refer to Attachment A for an overview of the merit assessment process based on building type, and whether the application is inside a current mining title. If additional information is required, SA NSW will notify the applicant within **14 calendar days** of receipt of the application.

- make a determination based on its records and any other available information.

- issue written notification advising the applicant of the outcome of the application.

SA NSW is to provide the applicant with a determination within **40 calendar days** of receipt of the application, excluding any time lost due to requests for additional information or consultation with external parties.

3.3 Advisory services

SA NSW offers expert advice on matters relating to mine subsidence or proposed development of land that may be subject to mine subsidence, whether or not the land is within a district.

Any interested party, including councils, can approach SA NSW for advice on mine subsidence matters, including requests for comment on development proposals that are not Integrated Development.

4. Assessment process

4.1 Assessment overview

SA NSW's assessment process aims to generate appropriate controls to eliminate or reduce risks associated with mine subsidence in districts.

As part of the assessment process for development applications that do not comply with SA NSW's guidelines, SA NSW will consider the:

- likelihood that mine subsidence events will occur
- consequence of mine subsidence events on surface infrastructure and public safety
- reliability of information used to determine the above, including mine plans, assumed pillar and extraction dimensions, and assumptions regarding geotechnical modelling
- risks arising from the proposed engineering controls.

The assessment process will vary depending on the type, size, potential repair cost of the proposed development, and whether it is in an area affected by operational, historical or future mining (refer to **Attachment A)**.

The guideline assigned to a property includes information about whether the property is located in an operational (active) or non-active mining area. Applicants can find out the SA NSW guideline assigned to a property through the NSW Planning Portal. A full copy of all SA NSW development guidelines is available at www.subsidenceadvisory.nsw.gov.au/development-guidelines.

4.2 Applications within a current mining title

4.2.1 Assessing mine subsidence risks within current mining titles

In assessing risks associated with mine subsidence for development applications within a current mining title, SA NSW will consider the available information at the time including:

- the current development approval or mining lease to extract coal under the site
- any plans to extract coal under the site, including the likely timeframe and predicted ground surface subsidence impact
- the potential consequences of predicted subsidence on proposed development and the appropriate engineering controls required to mitigate against subsidence damage.

SA NSW will request information from the relevant mine operator or the Division of Resources & Geoscience within **5 calendar days** of receipt of the application. If no response is received from the mine operator within **14 calendar days**, SA NSW may make its own reasonable determination on the development application based on available information.

SA NSW does not require geotechnical desktop assessments to support development applications in operational or future mining areas. However, SA NSW may require a geotechnical investigation or desktop study to support large infrastructure projects or developments in active mining areas as part of its conditions of approval.

4.2.2 Consultation with the title holder

SA NSW is to consult the relevant title holder during the assessment of development applications within a current mining title.

SA NSW is to consider the title holders advice when making a determination. The title holder will be notified of any determination of a development application in a current mining title that varies from the relevant advice. On request, SA NSW shall provide the title holder with an explanation for the decision.

There may be situations where a mine operator objects to a proposed development in a current mining title. In these situations, SA NSW may request the mine operator and applicant to reach a co-existence agreement before making a determination.

4.2.3 Co-existence agreements

Co-existence agreements between the mine operator and applicant may include a subsidence liability and cost prediction assessment based on the likely mining plans and development of land.

There may be some instances, such as in areas where there is a high degree of certainty for coal extraction within a well constrained timeframe, where it is more appropriate for co-existence agreements to require mining to precede development.

4.2.4 Request for further information to facilitate assessment

SA NSW is able to encourage discussions on co-existence agreements between applicants, mine operators and the Department of Planning including the Division of Resources and Geoscience as necessary.

4.2.5 Previous mine workings within a current mining title

In areas where there are previous mine workings in a current mining title, SA NSW will also assess the mine subsidence risk in accordance with section 4.3 of this policy in addition to section 4.2 of this policy.

4.2.6 Areas of potential future mining

SA NSW may consult the Division of Resources and Energy (DRG) on applications for B3 category structures as identified in **Table 2**.

SA NSW is to provide DRG with at least **14 calendar days** to provide advice on the application. SA NSW will consider DRG's advice when making a determination on such applications. If DRG does not provide a response within the specified timeframe, SA NSW may make its own assessment and determination.

4.3 Mine workings outside a current mining title

Some districts cover mine workings outside a current mining title, these include known or suspected historical underground mine workings, shafts and tunnel entries.

4.3.1 Assessing mine subsidence outside a current mining title

In assessing the risk associated with mine subsidence for development applications near mine workings outside a current mining title, SA NSW will consider the:

- nature of the proposed surface development
- type and condition of the mine workings beneath the site
- depth of the mine workings beneath the site
- history of subsidence at the site
- estimated likelihood of subsidence occurring in the future
- geotechnical characteristics of the site
- potential consequences of subsidence
- reliability of the information available to assess the above.

4.3.2 Requests for further information to facilitate assessment

SA NSW may require additional information to facilitate assessment of an application, including geotechnical studies or investigations into potential subsidence risk. SA NSW's standards for geotechnical analysis and reporting for mine subsidence are outlined at **Attachment B**.

Applicants planning to build in areas where there are mine workings outside a current mining title are encouraged to contact SA NSW in the preliminary stages to ascertain

whether geotechnical studies will be required. SA NSW's building type classifications and requirements for geotechnical desktop studies are outlined at **Table 2**.

SA NSW is to notify applicants when further information is required to progress the assessment of a development application within **14 calendar days** of receipt. In instances where geotechnical investigations are deemed necessary, SA NSW is to outline the necessary scope and objectives of the investigations.

In instances where SA NSW has requested further information from the applicant, the development application will be placed on hold until the information has been received. If SA NSW has not received a response from the applicant within **two months** of the request, SA NSW is to issue a reminder email to the applicant. If no response is received within **one month** of the reminder, SA NSW may close the application and notify the applicant by email. The applicant can re-submit the application at any time.

Refer to **Attachment C** for guidance on how SA NSW assesses subsidence risk and the type of engineering controls that may be applied based on geotechnical uncertainty, the estimated level of subsidence risk and the type of proposed surface development.

4.3.3 Geotechnical investigations

The types of geotechnical investigations SA NSW may require to facilitate assessment of a development application include, but are not limited to:

- desktop studies of mining history, geological/geotechnical conditions, subsidence history
- ground surface observation and geotechnical mapping
- subsurface investigation
- stability and subsidence analysis
- risk assessment and development of risk mitigation measures.

The extent of investigations required will depend on anticipated subsidence hazards as well as the nature of the proposed development. In areas with minimal well-defined subsidence hazards, SA NSW may deem a simple desktop study to be sufficient. Development applications in areas with a history of subsidence and complex ground conditions are more likely to require extensive desktop studies followed by further mapping, subsurface investigation, analysis, assessment and reporting.

The selection of investigation techniques and the evaluation of pillar stability and subsidence impact should be made by competent professionals. SA NSW's minimum requirements for geotechnical reports accompanying development applications are outlined at **Attachment B.**

All geotechnical studies and investigations must be undertaken by suitably qualified and experienced geotechnical, mining or engineering geology professionals. SA NSW can provide details of suitably qualified professionals upon request.

A list of key technical papers that SA NSW recognises as providing acceptable methodologies for estimating subsidence risk are set out at **Attachment D**. SA NSW may also accept other technical papers on request.

Table 2 – SA NSW classification of building type used to indicate requirement for desktop geotechnical study

Building Structure Description		
SA NSW category	**General Classification of Building type**	**SA NSW requirement for Geotechnical Assessment**
B1	• up to and including 3 storeys (including rooftop access) • < 50m maximum plan footprint dimension • no basement • no load bearing masonry construction • up to and equal to $3 M construction cost	Desktop assessment not required with submission. *SA NSW may request further geotechnical work following submission if site undermined by historical workings.*
B2	• up to and including 4 Storeys (including basements and rooftop access); or • Between $3 M to $5 M construction cost; or • > 50m in maximum plan footprint dimension	Desktop assessment not required with submission. *SA NSW may request further geotechnical work following submission if site undermined by historical workings.*
B3	• greater than 4 storeys (including basements and rooftop access) or • > 100m maximum plan footprint dimension • Greater than $5 M construction cost; or • Use - Hospital Wards, Operating theaters, critical public infrastructure Public Buildings with high trafficability (i.e. school halls etc.)	Desktop assessment required with submission if site undermined by historical workings. *SA NSW may request further geotechnical work following submission if site undermined by historical workings.*

5. Determinations and Approvals

Certifying Authorities, including local councils, can approve some applications that comply with development guidelines that SA NSW has assigned to a property. Details of surface development guidelines that do not require SA NSW approval is available at **Table 1**. All applications that do not comply with a property's development guideline are to be considered by SA NSW on merit.

5.1 Section 22 Approval

For all applications lodged directly to SA NSW by the applicant, approval is granted by SA NSW under Section 22 (3) of the Act. Copies of this approval can be used to accompany a Development Application with the relevant local council.

5.2 General Terms of Approval

For development applications lodged through council as an 'integrated development', council is to lodge the application with SA NSW on behalf of the applicant under Section 91 of the *Environmental Planning and Assessment Act 1979* in order to obtain General Terms of Approval (GTAs).

SA NSW is to issue GTAs within **21 calendar days** of receiving the development application from council. If an integrated referral cannot be returned within **21 calendar days,** SA NSW is to notify council of the delay within the **21 calendar day** timeframe.

In instances where SA NSW requires further information to assess a development application referred through council, SA NSW is to request the additional information from council within **21 calendar days** of receiving the application.

SA NSW is to specify whether approval or conditional approval has been granted under section 22 of the Act when issuing GTAs. In instances where SA NSW grants conditional approval, the applicant is required to meet any applicable conditions before building works can be carried out.

In the event that SA NSW does not grant approval, council is required to refuse the application.

5.3 Refusals

SA NSW may refuse a development application where mine subsidence risks are considered too high. Examples of development applications that SA NSW may refuse include:

- Development applications that SA NSW has determined present an unacceptable financial or safety risk and the potential subsidence impact cannot be effectively mitigated through engineering design.

- Areas where the subsidence hazard has been assessed by SA NSW to present a credible and unacceptable public safety risk and an effective mitigation strategy is not feasible.

In such cases, SA NSW officers are available to meet with the applicant to attempt to find a mutually agreeable solution. If the applicant is not satisfied with the proposed pathway forward, they may request a meeting with the CEO or dispute the determination in accordance with Section 6 of this policy.

6. Reviews and Dispute resolution

SA NSW offers applicants the option to formally request a review if they are not satisfied with the determination of a development application. The CEO is to be notified of all requests for review and make the final determination on the outcome of reviews.

Prior to initiating the formal review process, SA NSW may suggest meeting with the applicant to attempt to reach a mutually agreeable solution.

6.1 Review process

To initiate a review, applicants are to submit a written request to SA NSW for a review of a determination on a development application. The submission needs to outline the reasons for the request including justifying why there should be a review and what the applicant considers would be a reasonable determination. If applicable, details of the applicant's preferred review type should be included.

SA NSW is to acknowledge requests for reviews within **7 calendar days** and advise the applicant of timing and next steps, depending on the review type, within **14 calendar days**.

The findings and recommendations from external reviews are to be provided to the CEO for consideration. The CEO is to make the final determination on the outcome of the review. Once finalised, SA NSW is to advise the applicant of the outcome of the review with an explanation for the determination. SA NSW is to finalise reviews within **40 calendar days** of the request.

6.1.1 Reviews of applications with mine workings outside a current mining title

Applicants disputing SA NSW's determination of applications within historical (non-active) mine areas have the option for an internal review by a different SA NSW officer or a review by an external consultant. The CEO may use these subsequent reports to inform the final decision.

6.1.2 Reviews of applications within a current mining title

Applicants disputing SA NSW's determination of an application within a current mining title have the option for an internal review by an SA NSW Risk Engineer who was not involved in the original determination.

Note: There is no option for external reviews of applications within a current mining title as subsidence impacts in these locations have generally been previously agreed upon by coal mine operators and the Division of Resources & Geoscience.

6.2 Review of determination

6.2.1 Internal reviews

SA NSW offers applicants the option of an internal review of a determination on a development application at no cost. Internal reviews are carried out by a SA NSW Risk Engineer with no involvement in the original determination.

6.2.2 External reviews

External reviews of development applications in areas with existing mine workings outside a current mining title are to be carried out by an independent consultant with extensive experience in mine subsidence studies and acceptable to SA NSW. SA NSW will use the report to reconsider the determination.

If the review results in SA NSW's original determination on the application being overturned, SA NSW may re-imbursement the applicant for the cost of the review.

7. Key Performance Indicators

Key Performance Indicators are an important part of the strategic planning process and play a role in the measurement of SA NSW's progress towards achieving its planned goals. The following table lists the key performance indicators.

- If the application is made under section 22 of the Act, SA NSW will advise the applicant if additional information is required to progress their application within **14 calendar days** of receipt.
- If the application is made as an integrated development under section 91 of the *Environmental Planning and Assessment Act* 1979, SA NSW will advise council if it requires additional information to progress the application within **21 calendar days** of receipt unless additional information is requested by SA NSW in order to progress the application.
- All merit based approvals under section 22 of the Act will be determined within **40 calendar days** of receipt unless additional information is requested by SA NSW to progress the application.
- 90% of integrated development applications made under section 91 of the *Environmental Planning and Assessment Act* 1979 will be determined within **21 calendar days** of receipt unless additional information is requested by SA NSW in order to progress the application.
- 10% of integrated development applications made under section 91 of the *Environmental Planning and Assessment Act* 1979 will be determined within **40 calendar days.** SA NSW will notify council that additional time is required within **21 calendar days.**

***Note:** assessment durations exclude "stop the clock" periods where SA NSW is waiting for additional information from the applicant or a third party to enable an assessment.

8. Related Policies and Documents

Issuer	Reference	Document Name
NSW Government	No 23	*Coal Mine Subsidence Compensation Act 2017*
NSW Government		*Coal Mine Subsidence Compensation Regulation 2017*
NSW Government	No 203	*Environmental Planning and Assessment Act 1979*
NSW Government		*Environmental Planning and Assessment Regulation 2000*
NSW Government		*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*
NSW Government	No 17	*State Records Act 1998* (regarding the creation, management and protection of records and public access to those records)
NSW Government	No 52	*Government Information (Public Access) Act 2009* (regarding public access arrangements to agency information)
NSW Government	No 133	*Privacy and Personal Information Protection Act 1998* (regarding the collection and protection of personal information)
NSW Government	No 35	*Independent Commission Against Corruption Act 1988* (regarding reporting of any matter suspected on reasonable grounds to involve corrupt conduct)
NSW Government	October 2015	NSW Integrated Mining Policy - *Indicative Secretary's Environmental Assessment Requirements for State Significant Development - Mining (Hotlink)*
NSW Public Service Commission	Direction No 1 of 2015	The Code of Ethics and Conduct for NSW government sector employees
Department of Finance, Services and Innovation	Hotlink	Code of Ethics and Conduct

9. Document Control

9.1 Document Approval

Name & Position	Signature	Date
Kieran Black Technical Manager		25 May 2018
Brendan Killen A/Chief Executive Officer		25 May 2018

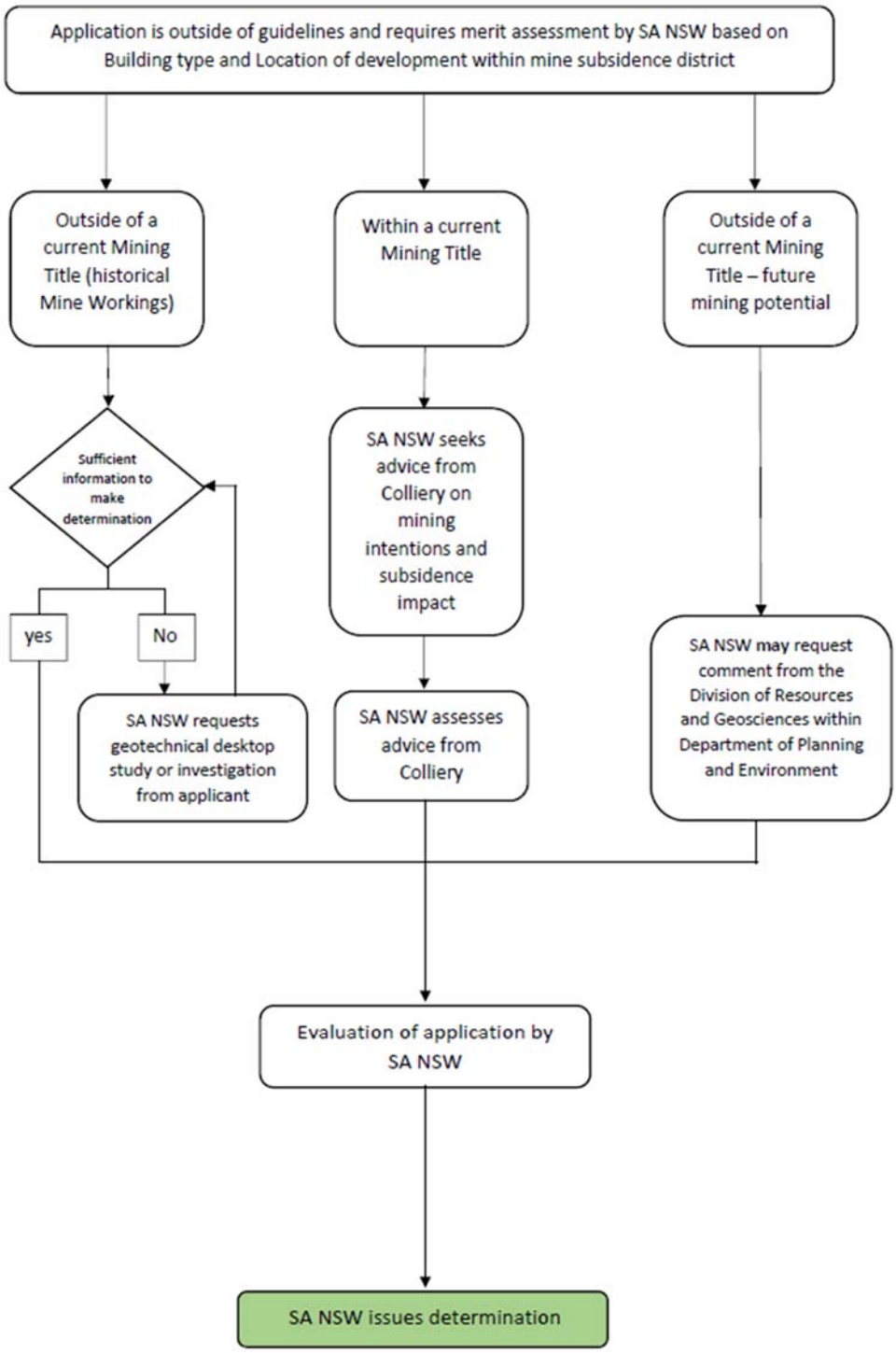
9.2 Document Version Control

Version	Status	Date	Prepared By	Comments
1.0	Draft	23 March 2018	Kieran Black	

9.3 Review Date

The attachments to this policy will be reviewed and updated as required. A formal review will be undertaken every two years. Feedback from applicants and other stakeholders will be considered during the review process.

Attachment A: Merit based development application assessment flowchart



Attachment B: SA NSW's minimum requirements for geotechnical reports

Geotechnical desktop study or geotechnical investigation reports provided to SA NSW as part of a development application should clearly address the following.

The likelihood of mine subsidence affecting the site. An assessment of this should be clearly stated in the report. Include if applicable an assessment of:

- Pillar failure – (The UNSW pillar strength formula should not be used without providing a thorough assessment of the inputs used and the level of confidence in them. The formulae should not be used on selected isolated pillars, but rather averaged over an entire panel. An assessment should then be made if the panel is susceptible to a pillar run. Clear recommendations should be made on what further work the applicant could undertake to reduce the uncertainty.)
- Surface pothole formation.
- Migration of overlying soil into subsidence cracks or mine voids.
- Poorly or un-remediated mine openings such as drifts and shafts.
- Residual subsidence due to ongoing goaf consolidation and settlement of the overburden (superincumbent strata).
- The potential for variability in any assumptions used in the assessment (as described above) including:
    - Parametric Analysis: Identify the primary variables and provide their adopted values and expected variability.
    - Sensitivity Analysis: Assessment of how outcomes or risks are affected by variations in input values for a parameter.
    - Sources of information and their reliability, including discussion of perceived gaps in information with specific reference to a geotechnical model as defined in Australian Standard AS 1726-2017 Geotechnical site investigations.
- Recommendation on whether further geotechnical studies or investigations should occur in order to make a more accurate assessment.

The consequence of subsidence. Including, if applicable, predictions of:

- Surface deformations including;

        - Vertical subsidence (mm)
        - Horizontal displacement both tensile and compressive (mm/m)
        - Tilt (mm/m)
        - Radius of curvature (km)
    - Anticipated nature and extent of damage to the proposed development

Additionally, SA NSW may request that the applicant provide;

- An estimate of repair costs (including cost of re-housing of inhabitants during repair) of proposed development should a subsidence event occur
- An assessment of whether a credible safety risk exists should a subsidence event occur. This should include both structural failure and formation of subsidence features.

Recommendation on appropriate engineering controls (if applicable). All engineering controls should be accompanied by clear justification as to how and why the adopted methods are appropriate. The likelihood and consequence of a subsidence event with the controls in place should be assessed.

- Each report should, if applicable, include the following in assessing subsidence risk:
    - Seams worked (single or multi-seam, seam thickness and structure)
    - The class of mine workings (i.e. Historical, Operational or Future)
    - The characteristics of mine workings (e.g. depth, extraction height, percentage of extraction, geotechnical conditions).
    - Mine workings type, age and level of confidence in accuracy (bord and pillar, pillar extraction, longwall/miniwall, mining height, 1st workings, 2nd workings)
    - Regional geology (Stratigraphy/dip/faults/dykes)
    - Overburden properties (soil cover, rock strength, discontinuities, moisture sensitivity, water table, potential for time dependent strength and stiffness changes (i.e. creep)
    - Mine workings roof, seam and floor properties (as per overburden properties plus peak and residual strength and stiffness of coal pillars, strain hardening goaf)
    - Propensity for pillar geometry change (rib spall, roof collapse)
    - Standing pillars factor of safety (FoS), goaf, bearing capacity of roof and floor, pothole development potential

- Justification for adopted parameters
- Mine subsidence parameters for systematic behavior (vertical subsidence, horizontal strain, tilt, curvature).
- Likelihood and allowance for non-systematic mine subsidence behavior (e.g. dependent on geological structure: faults, dykes, slip planes and / or topography, cuttings).

- **Clear recommendations** – The geotechnical consultant should clearly put forward their conclusions and recommendations and avoid the use of ambiguous language.

Attachment C: Procedure used by SA NSW Risk Engineers to assess surface development on merit

The purpose of this procedure is to:

1. provide a consistent approach when assessing development applications

2. provide guidance on the type of engineering mitigation measures and geotechnical reporting that may be required to facilitate assessment of a development application.

SA NSW will apply different conditions of approval based on building category. SA NSW classification of building category is described in Table C1.

Table C1 – Classification of Building type

SA NSW category	General Classification of Building type
B1	• up to and including 3 storeys (including rooftop access) • < 50m maximum plan footprint dimension • no basement • no load bearing masonry construction • up to and equal to $3 M construction cost
B2	• up to and including 4 storeys (including basements and rooftop access); or • Between $3 M to $5 M construction cost; or • > 50m in maximum plan footprint dimension
B3	• greater than 4 storeys (including basements and rooftop access) or • > 100m maximum plan footprint dimension • Greater than $5 M construction cost; or • Use - Hospital Wards, Operating theaters, critical public infrastructure Public Buildings with high trafficability (ie school halls)

Trough Subsidence Risk

SA NSW will apply our conditions of approval based on;

- the assessed level of geotechnical uncertainty (uncertainty factor),

- the assessed stability of remnant coal pillars based on estimated factors of safety and slenderness of remnant coal pillars, and

- the type of structure (building category).

It should be noted that this is intended as a guide, and the conditions of approval may vary in areas that have a high level of geotechnical complexity. SA NSW will provide justification on request should the applicant dispute the outcome.

The uncertainty factor is used by SA NSW to determine the levels of conservatism and allowed assumptions required when assessing the likelihood of a trough subsidence event.

The level of geotechnical uncertainty is categorised as low, medium or high based on the level of confidence and understanding of the;

- Geological environment (R1)
- Level of geotechnical investigation (R2)
- Type of coal mine plans and records (R3)
- Method used to assess stability and impact (R4).

The weighting applied to each factor is outlined below;

- R1 = 2
- R2 = 2
- R3 = 3
- R4 = 3

Refer to **Table C2** to determine the uncertainty value (U) that should be applied for each of the above. The uncertainty value (U) that can be applied to each of the above are as follows;

- Low uncertainty = 1
- Moderate uncertainty = 2
- High uncertainty = 3

Once these have been determined, the Uncertainty Factor can be determined by applying the following formulae;

Uncertainty Factor (UF) = $(\boldsymbol{R1} \times \boldsymbol{U}) + (\boldsymbol{R2} \times \boldsymbol{U}) + (\boldsymbol{R3} \times \boldsymbol{U}) + (\boldsymbol{R4} \times \boldsymbol{U}) - \mathbf{10}$

Table C2 – Factors used to determine the Uncertainty factor

	(Low Uncertainty)	Medium Uncertainty	High Uncertainty (U)
	U value = 1	U value = 2	U value = 3
Geological Environment (R1) value =2	· A review of available mine plans and records indicate that faults, dykes or other adverse geological structures are likely not present. (i.e. should be regular layout - no evidence of limiting intersection spans, no significant patterns of truncated or miss-aligned roadways) · If borehole information is available, a review of geotechnical and geophysical logs indicate no anomalous geological structures or stratigraphy being present. · Records indicate seam dip is less than 10 degrees	· A review of available mine plans and records, indicate that Faults dykes or other geological structures may be present. (i.e. evidence of limiting intersection spans, no significant patterns of truncated or miss-aligned roadways) · If borehole information is available, a review of geotechnical and geophysical logs indicate an anomalous high density of joints and/or small faults (i.e. less than 200mm throw) · Records indicate seam is dipping at between 10 and 20 degrees	· An analysis of record tracings, indicates faults / dykes are present. Structures are either clearly marked on plan or immediately obvious from analysis of mine plan layout. · If borehole information is available, an analysis of core samples and geophysical logs indicates an anomalous high density and orientation of faults / dykes or other rock types that may contribute to magnitude of subsidence impact. · Borehole information indicates potential for soft floor or roof conditions resulting in foundation or roof punching failure. · Records indicate seam is dipping at greater than 20 degrees
Level of geotechnical Investigation (R2) Value =2	· Geotechnical investigation sufficient to adequately assess; - depth of workings, - geo reference mine plans - void heights and widths - pillar plan dimension under site - material properties and slaking potential of overburden and roof and floor - state of workings (failed or standing) Note: this will likely require a minimum of two fully cored and geotechnically logged boreholes	· Geotechnical investigation sufficient to confirm; - mine void dimensions - depth to seam - state of workings (failed or standing) roof and floor properties. Note: this will require a minimum of one borehole	· No site specific borehole data, or inferences made from boreholes located more than 50m from site

	(Low Uncertainty)	Medium Uncertainty	High Uncertainty (U)
	U value = 1	U value = 2	U value = 3
Coal Mine Plans and Records (R3) Value = 3	· Mechanised mining showing 1st workings only · Mine workings record tracing based on post mining survey results with regular layout · Sufficient post mining geotechnical boreholes in area to confirm record tracings accuracy · Mine workings show previously extracted longwall panels · Multi-seam mining is a minimum of 100m between seams	· Hand worked mines (welsh bords) with regular layout and sufficient borehole data to confirm dimensional accuracy. · Mechanised workings showing partial or full pillar extraction Mechanised workings showing single gate road mini-wall panels.	· Irregular mechanised or hand worked mining
Method used to assess stability and impact (R4) Value = 3	· Method used to assess stability of pillars and subsidence impact has been validated by use of another method – i.e. numerical modelling validated by empirical method OR peer review by relevant professional accepted by SA NSW · Pillar stability calculations are based on the average pillar FoS for panel. · Other potential pillar loading scenarios considered if applicable. · All variables and assumptions used in estimating both pillar stability and subsidence impact clearly outlined - in the absence of borehole data, credible worst-case assumptions have been made (ie assume 0.5m off plan dimensions, full seam extraction + 0.5m to allow for roof fall). · Pillar stability and subsidence impact assessment capable of being replicated from data published in report	· single method used to assess stability of pillars and subsidence impact (note that in assessing pillar stability the average panel FoS should be used rather than assessment on isolated pillars) · Other potential pillar loading scenarios considered if applicable. · All variables and assumptions used in estimating both pillar stability and subsidence impact clearly outlined	· No geotechnical report or analysis · Geotechnical analysis does not meet specified criteria · Internal estimation of subsidence risk based on available records carried out by SA NSW Risk Engineers.

The application of these can be divided up into low, medium and high uncertainty based on the following values;

- Low uncertainty - <= 5
- Moderate uncertainty > 5 and <=10

- High uncertainty >10

Refer to **Table C1** in order to determine the building type.

Apply the Building Type classification (B1, B2 or B3) in conjunction with the uncertainty **C3** for a guide as to the conditions of approval and design requirements based on building category, the uncertainty factor and calculated FoS and slenderness ratio (W/h) of the remnant coal pillars.

Sinkhole (pothole) Risk

The attached table (**Table C2)** provides a broad outline on the conditions that SA NSW may apply for areas that have been identified as having a sinkhole (or pothole) risk.

This is based on (1) cover depth, (2) borehole information, (3) the nature of the workings and (4) seam dip and (5) previous history of pothole formation.

The assessment of pothole risk outlined below is intended as a guide. The proponent may engage a geotechnical consultant to provide a more detailed analysis of the risk of sinkhole (pothole) formation for a particular site. However, it should be noted that if a credible pothole risk is identified, SA NSW will generally require that the risk of sinkhole formation be effectively eliminated as far as is practicable.

Refer to **Table C4** for a guide as to the type of conditions that SA NSW may apply based SA NSW classification of building category and sinkhole risk.

Internal refit

If a proposal is for an internal re-fit of an existing building, and the existing building will remain structurally unaltered, SA NSW will not require any design mitigation measures unless (1) site is subject to medium or high sinkhole risk and (2) existing structure is inadequate to cater for the assessed maximum pothole diameter and (3) cost of refit is greater than $3 M ($3,000,000.00).

Attachment C - Table C3. SA NSW Estimated Conditions of Approval for Trough Subsidence Risk

SA NSW category (refer to table C1)	Uncertainty Factor	General Summary of likely approval conditions for sites where the pillar FoS (and W/h ratio's) greater than nominated values				General Summary of likely approval conditions for sites where the pillar FoS less than nominated values	
		FoS	W/h Ratio	Allowed assumptions for assessment of pillar stability	General Summary of approval conditions	Summary of design requirements	General summary of likely approval conditions (these may vary in accordance with the geotechnical environment and subsidence risk)
B1	Low uncertainty (≤ 5)	>1.6	>2	Unless informed by borehole data; 1) Pillars are full seam height 2) Plan pillar dimensions are as shown on record tracings.	(1) Submit Site Classification report (to AS2870 standard) to SA NSW for our records (2) Following construction, provide sign-off from qualified engineer that improvements have been constructed in accordance with plans and foundations have been constructed accordance with AS2870. Note: Nominal subsidence parameters up to 2mm/m +/- horizontal strain, 2mm/m tilt and 7km radius of curvature may be applied by Risk Engineer dependant upon type of structure	If the estimated subsidence impact is less than or equal to; (1) 3mm/m horizontal strain (+/-), (2) 4mm/m Tilt and (3) 5km radius of curvature. Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable". If estimated subsidence impact is greater than above, then structure must both satisfy the above and in addition remain structurally safe to occupants taking into account additional estimated subsidence impact.	(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable". The subsidence impact parameters should be clearly stated. (2) If the parameters exceed (+/-) 3mm/m horizontal strain, 4mm/m Tilt and 5km radius of curvature, then signoff from a structural engineer that the point (1) above is met and (2) that structure will remain structurally safe given the estimated additional subsidence impact. (3) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	Moderate uncertainty (> 5 to ≤ 10)	>1.8	>2				
	High uncertainty (> 10)	>2.1	>4				
B2	Low uncertainty (≤ 5)	>1.8	>2	Unless informed by an adequate level of borehole data; 1) Pillars are full seam height 2) take 0.5m off pillar dimensions as shown on available mine plan records to allow for error 3) Absolute worst-case subsidence impact parameters should be determined regardless of apparent pillar stability (this assumes that all pillars with W/H rations of less than 8 fail)	(1) Submit Site Classification report (to AS2870 standard) to SA NSW for our records (2) If not already submitted, a geotechnical desktop study or investigation for SA NSW acceptance confirming that the pillars under the site meet the nominated pillar Factors of Safety for the appropriate uncertainty factor. (3) Provide signoff by a Structural Engineer experienced in mine subsidence design that the proposed improvement will remain structurally sound and safe in the event that it is subject to absolute worst case subsidence impact. (4) Following construction, provide sign-off from a suitably qualified engineer that improvements have been constructed in accordance with plans and foundations have been constructed in accordance with AS2870. Note: Nominal subsidence parameters up to 2mm/m +/- horizontal strain, 2mm/m tilt and 7km radius of curvature may be applied by Risk Engineer dependant upon type of structure	If the estimated subsidence impact is less than or equal to; (1) 5 mm/m horizontal strain (+/-), (2) 7 mm/m Tilt and (3) 2 km radius of curvature. Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable". If estimated subsidence impact is greater than above, structure must remain safe to occupants taking into account additional estimated subsidence impact. Note: potential exists for refusal or requirement to grout if the risk of pillar failure and subsidence impact has been assessed by Risk Engineers as being unacceptable.	(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable". The subsidence impact parameters should be clearly stated. (2) If the parameters are within (+/-) 5mm/m horizontal strain, 7mm/m Tilt and 2km radius of curvature, then signoff from a structural engineer that the structure will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 up to and including the above. In addition, the structure must be designed to remain safe under absolute worst-case subsidence impact. (3) Submit a "Subsidence Impact Statement" prior to commencement of detailed design for acceptance by SANSW, which shall identify the: a. Mine subsidence parameters used for the design. b. Main building elements and materials. c. Risk of damage due to mine subsidence d. Design measures proposed to control the risks. e. Comment on the likely building damage in the event of mine subsidence and sensitivity of the design to greater levels of mine subsidence. (4) Submit detailed design drawings prior to the commencement construction with design measures proposed to control the mine subsidence risk clearly highlighted. (5) Following construction, sign-off from a suitably qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	Moderate uncertainty (> 5 to ≤ 10)	>2.1	>3				
	High uncertainty (> 10)	>2.1	>5				
B3	Low uncertainty (≤ 5)	2.1	>2	Unless informed by borehole data; 1) Assumed pillar height should take into account potential for roof failure 2) take 0.5m off pillar dimensions as shown on record tracings to allow for error 3) Potential for pillar foundation failure should be considered 4) Absolute worst case subsidence impact parameters should be determined regardless of apparent pillar stability (this assumes that all pillars with W/H ratios of less than 8 fail)	(1) Provide a peer review of the initial geotechnical report by a consultant acceptable to SA NSW with confirmation and signoff that the pillars are long-term stable. (2) Provide signoff by a Structural Engineer experienced in mine subsidence design that the proposed improvement will remain structurally sound and safe in the event that it is subject to absolute worst case subsidence impact (ie that all pillars with W/H ratios of less than 8 fail). (3) A number of permanent survey marks to AHD will be required so that building movement can be monitored should mine subsidence occur. survey marks need to be initially surveyed and all details are to be forwarded to Subsidence Advisory NSW. (4) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans and in accordance with all relevant building codes and standards.	Structure must be designed to be "safe, serviceable and readily repairable" under the predicted subsidence impact parameters. If estimated subsidence impact greater than specified, subsidence impact must be either eliminated or mitigated by a suitable means such as the emplacement of grout into the mine workings, or another suitable engineered mitigation measure put forward for SA NSW acceptance. If estimated subsidence impact greater than specified, subsidence impact must be either eliminated or mitigated by a suitable means such as the emplacement of grout into the mine workings, or another suitable engineered mitigation measure put forward for SA NSW acceptance.	(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'very slight' in accordance with AS2870 (Damage Classification), and readily repairable". The subsidence impact parameters should be clearly stated. (2) Either (a) submit a proposal to remove the risk of mine subsidence by a suitable means, such as grouting or (b) demonstrate that the improvement can be designed to remain "safe, serviceable and any damage from mine subsidence shall be limited to 'very slight' damage in accordance with AS2870 (Damage Classification), and readily repairable". If grouting option chosen, submit for acceptance by Subsidence Advisory NSW prior to commencing work: a. Grout Design, including grout locations (dimensioned in plan and elevation), and design parameters for any residual mine subsidence. b. Grout Implementation Plan; including a site plan (showing property boundaries within 200m of the site), grout locations (dimensioned in plan and elevation), proposed bore locations, and grout designers endorsement. c. Grout Verification Plan; showing the location of verification holes and the grout designer's endorsement. Any assumptions applied to the numerical modelling shall be subject to verification (using empirical or analytical methods) and a sensitivity analysis. Arrange for an independent peer review of the grouting design and implementation plan by a suitably qualified engineer acceptable to the Subsidence Advisory NSW. On completion of grouting submit a Grout Verification Output Report endorsed by the grout designer and site verification engineers for compliance with the accepted Grouting Plan. (3) Submit an "Engineering Impact Statement" prior to commencement of detailed design for acceptance by SANSW, which shall identify the: a. Mine subsidence parameters used for the design. b. Main building elements and materials. c. Risk of damage due to mine subsidence d. Design measures proposed to control the risks. e. Comment on the likely building damage in the event of mine subsidence and sensitivity of the design to greater levels of mine subsidence. (4) Submit detailed design drawings prior to commencement construction with the design measures proposed to control the mine subsidence risk clearly highlighted and the design subsidence parameters clearly marked on the plan. (5) A number of permanent survey marks to AHD will be required so that building movement can be monitored should mine subsidence occur. survey marks need to be initially surveyed and all details are to be forwarded to Subsidence Advisory NSW. (6) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	Moderate uncertainty (> 5 to ≤ 10)	2.1	>4				
	High uncertainty (> 10)	High uncertainty not acceptable for B3 type surface developments					

Attachment C - Table C4. Estimated Sinkhole conditions of approval based on Building type and Subsidence Risk

SA NSW category	Pothole Risk	Summary of design requirements*	General summary of likely approval conditions*
B1	Low Risk • Cover depth is less than 10 times the seam thickness, however on-site borehole evidence has been provided that workings have completely failed and risk is limited to piping of soil into pre-existing tension cracks and consolidation of goaf. • SA NSW risk engineers have assessed the risk of pothole formation as being low	Additions (i.e. deck, additional storey, garage with slab): No additional design requirements Granny Flats (<60m2 internal floor area): No additional design requirements if constructed with lightweight materials. No cavity brick, brick veneer or other masonry allowed without being required to be designed for the parameters outlined below. For single residential dwellings In the absence of geotechnical advice accepted by SA NSW risk engineers. Waffle-pod slabs or slab on ground permitted. Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" given following subsidence parameters; (1) 3mm/m horizontal strain (+/-), (2) 7mm/m Tilt and (3) 2km radius of curvature.	(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" given the following subsidence parameters; (+/-) 3mm/m horizontal strain, 7mm/m Tilt and 2km radius of curvature. (2) Submit Site Classification report (to AS2870 standard) to SA NSW for our records (3) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	Moderate Risk • Borehole confirmation that cover depth is 5 to 10 times the Seam Thickness • No previous history of pothole formation on current block or neighbouring blocks with similar cover depths. • Records indicate the seam dip is less than 10 deg • SA NSW risk engineers have assessed the risk of pothole formation as being moderate	Additions (i.e. deck, additional storey, uninhabitable garage with slab): No additional design requirements Granny flats (<60m2 internal floor area) and single dwellings: Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" should a pothole with maximum diameter of 5m open up at any point underneath. Dual Occupancy or units: Removal of risk of mine subsidence by a suitable means such as grouting under building footprint commercial premises: Removal of risk of mine subsidence by a suitable means such as grouting under building footprint	(1) Submit plans prior to construction with a letter from a qualified structural engineer that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" given that a 5m pothole could open up at any point underneath the proposed structure. (2) Submit Site Classification report (to AS2870 standard) to SA NSW for our records (3) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	High Risk · No borehole confirmation of cover depth and available records indicate cover depth is less than or equal to 10 x the Seam Thickness · Borehole confirmation of cover depth is less than or equal to 5 x the Seam Thickness, or less than 10m · Records indicate the seam dip is greater than 10 deg · Previous history of pothole formation on current block or neighbouring blocks with similar cover depths. · Geotechnical environment allows for accelerated weathering and degradation of both pillars and overburden. · SA NSW risk engineers have assessed the risk of pothole formation as being high	Additions (i.e. deck, garage with slab on ground, retaining walls over 1m etc): Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" should a pothole with maximum diameter of 5m open up at any point underneath. Additional Storeys not allowed without removal of risk by suitable means such as grouting. Single Dwelling: Removal of the risk by a suitable means such as grouting under building footprint Dual Occupancy or units: Removal of risk of mine subsidence by a suitable means such as grouting under entire lot commercial premises: Removal of risk of mine subsidence by a suitable means such as grouting under entire lot	(1) Submit a plan for acceptance by SA NSW prior to construction to remove the risk by the emplacement of grout into any mine voids. (2) Submit a grout verification report following grouting works for SA NSW acceptance that the risk of pothole formation on the site has been effectively eliminated such that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" if constructed in accordance with all relevant building codes and standards. (3) Submit Site Classification report (to AS2870 standard) to SA NSW for our records (4) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant and applicable building codes and standards.
B2	Low Risk • Cover depth is less than 10 times the seam thickness, however on-site borehole evidence has been provided that workings have completely failed and risk is limited to piping of soil into pre-existing tension cracks and consolidation of goaf. • SA NSW risk engineers have assessed the risk of pothole formation as being low	Structure must be designed to be "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" given subsidence parameters provided by Geotechnical Engineer in report accepted by SA NSW.	(1) Submit a geotechnical report prior to construction that provides residual subsidence design parameters for SA SW acceptance. (2) Submit Signoff from a qualified structural engineer that improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" given the subsidence parameters accepted by SA NSW. (3) Submit an "Engineering Impact Statement" prior to commencement of detailed design for acceptance by SANSW, which shall identify the: a. Mine subsidence parameters used for the design. b. Main building elements and materials. c. Risk of damage due to mine subsidence d. Design measures proposed to control the risks. e. Comment on the likely building damage in the event of mine subsidence and sensitivity of the design to greater levels of mine subsidence. (4) Submit detailed design drawings prior to commencement construction with design measures proposed to control the mine subsidence risk clearly highlighted. (5) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant codes and standards.
	Moderate Risk • Borehole confirmation that cover depth is 5 to 10 times the Seam Thickness • No previous history of pothole formation on current block or neighbouring blocks with similar cover depths. • Records indicate the seam dip is less than 10 deg • SA NSW risk engineers have assessed the risk of pothole formation as being moderate	Residential Development (single residence, townhouses, units, duel occupancy): Removal of risk of mine subsidence by a suitable means such as grouting under building footprint. commercial premises: Removal of risk of mine subsidence by a suitable means such as grouting under all trafficable areas of property.	(1) Submit a plan for acceptance by SA NSW prior to construction to remove the risk by the emplacement of grout into any mine voids. (2) Submit a grout verification report following grouting works for SA NSW acceptance that the risk of pothole formation on the site has been effectively eliminated such that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" if constructed in accordance with all relevant building codes and standards. (3) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant and applicable building codes and standards.
	High Risk · No borehole confirmation of cover depth and available records indicate cover depth is less than or equal to 10 x the Seam Thickness · Borehole confirmation of cover depth is less than or equal to 5 x the Seam Thickness, or less than 10m · Records indicate the seam dip is greater than 10 deg · Previous history of pothole formation on current block or neighbouring blocks with similar cover depths. · Geotechnical environment allows for accelerated weathering and degradation of both pillars and overburden. · SA NSW risk engineers have assessed the risk of pothole formation as being high	Residential Development (single residence, townhouses, units, duel occupancy): Removal of risk of mine subsidence by a suitable means such as grouting under entire lot. commercial premises: Removal of risk of mine subsidence by a suitable means such as grouting under all trafficable areas of property	
B3	Low Risk • Cover depth is less than 10 times the seam thickness, however on-site borehole evidence has been provided that workings have completely failed and risk is limited to piping of soil into pre-existing tension cracks and consolidation of goaf. • SA NSW risk engineers have assessed the risk of pothole formation as being low	Residential and commercial development (single residence, townhouses, units, duel occupancy): Removal of risk of mine subsidence by a suitable means such as grouting under building footprint.	(1) Submit a plan for acceptance by SA NSW prior to construction to remove the risk by the emplacement of grout into any mine voids. (2) Submit a grout verification report following grouting works for SA NSW acceptance that the risk of pothole formation on the site has been effectively eliminated such that the improvement will remain "safe, serviceable and any damage from mine subsidence shall be limited to 'slight' in accordance with AS2870 (Damage Classification), and readily repairable" if constructed in accordance with all relevant building codes and standards. (3) Following construction, sign-off from qualified engineer that improvements have been constructed in accordance with plans submitted to SA NSW and in accordance with all relevant and applicable building codes and standards.
	Moderate Risk • Borehole confirmation that cover depth is 5 to 10 times the Seam Thickness • No previous history of pothole formation on current block or neighbouring blocks with similar cover depths. • Records indicate the seam dip is less than 10 deg • SA NSW risk engineers have assessed the risk of pothole formation as being moderate	Residential and commercial development (single residence, townhouses, units, duel occupancy): Removal of risk of mine subsidence by a suitable means such as grouting under all trafficable areas of property.	
	High Risk · No borehole confirmation of cover depth and available records indicate cover depth is less than or equal to 10 x the Seam Thickness · Borehole confirmation of cover depth is less than or equal to 5 x the Seam Thickness, or less than 10m · Records indicate the seam dip is greater than 10 deg · Previous history of pothole formation on current block or neighbouring blocks with similar cover depths. · Geotechnical environment allows for accelerated weathering and degradation of both pillars and overburden. · SA NSW risk engineers have assessed the risk of pothole formation as being high		

Attachment D: List of methods and papers recognised for assessing likelihood and consequence of mine subsidence

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