Douglas Partners
Geotechnics / Environment / Groundwater

Report on
Mine Subsidence Investigation

Proposed Rezoning Lot 42, DP 846326
Corner Wilton Drive and Mount Vincent Road,
East Maitland

Prepared for
Mr D.Wilton

Project 81674
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Integrated Practical Solutions

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The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		10 September 2015
Reviewer		10 September 2015

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Executive Summary

It is understood that rezoning of the site is proposed for development of roads and houses as part of the residential subdivision.

Records indicate that the site has been subject to underground coal mining during several periods from the 1920's to the early 1960's. The approximate inferred location of the workings is shown on Drawing 2, attached.

Subsurface investigation by drilling was undertaken in the western part of the site where shallow workings (to about 30 m depth) were encountered. Generally the conditions encountered comprised shallow soil overlying medium and high strength sandstone overburden, further overlying coal and or mine workings. Groundwater was encountered in most bores. Assessment on the eastern part of the site where the workings are expected to be at greater depth was limited to desktop assessment of mine records.

The results of this geotechnical assessment have identified the following mine subsidence issues that require consideration prior to development:

- There is a risk of pothole subsidence (typically at depths of cover less than 20 m to 25 m). Remedial measures will be required to manage this risk prior to development;
- For the deeper working on the eastern parts of the site, on the basis of mine records, there is typically low risk of pillar instability, except for a mapped scattering of "small, slender or triangular/trapezoidal shaped" pillars which are likely to require at least localised remedial works;
- The potential was identified for a weak mudstone to be present in the floor of the workings, potentially reducing the bearing stability of the pillars and increasing the extent of remedial works required.

Furthermore, this report provides preliminary comments on remediation options for mitigation of the risk issues identified above. These include removal / backfilling, grouting, and engineered design measures, all of which should be undertaken in consultation with and subject to the approval by the MSB (Mine Subsidence Board).

Additional detailed geotechnical investigation should be undertaken during the design stage of the project in order to quantify the required extent of any remediation of the workings, and should include further investigation and assessment as outlined in Section 8.6 of this report.

On the basis of the investigations detailed in this report it is considered that the site would be suitable, from a mine subsidence perspective, for future urban development subject to the above considerations being addressed by engineering design and adoption of appropriate remedial risk mitigation measures.

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Report on Mine Subsidence Investigation
Proposed Rezoning
Lot 42, DP 846326 Corner Wilton Drive and Mount Vincent Road East Maitland

1. Introduction

This report presents the results of a mine subsidence investigation undertaken for a proposed residential development at the above mentioned site. The investigation was undertaken with reference to Douglas Partners Pty Ltd (DP) proposal NCL150067-01 dated 13 February 2015 and acceptance received by Mr Dennis Wilton dated 16 February 2015.

It is understood that rezoning of the site is proposed. Development of the site is proposed to comprise roads and houses as part of the residential subdivision.

The aim of the investigation was to assess surface and subsurface conditions at the site and provide information and comments on the following:

- Data review: Geology, Mine identification, Seam Identification, Seam thickness and working height;
- Subsurface conditions;
- Location of workings;
- Condition of workings;
- Depth of cover relative to proposed development;
- Overburden materials and strength;
- Risk of Pothole Subsidence;
- Preliminary Pillar stability assessment (for selected pillars greater than 30 m depth of cover) and associated risks; and
- Remediation options including earthworks and or grouting.

The investigation comprised the drilling of one cored bore and 34 non-cored boreholes, Sonar and CCTV inspection of voids and survey of test locations. The details of the field work are presented in this report, together with comments and recommendations on the issues listed above. The investigation was tailored to the western part of the site where shallow workings were identified. At this stage assessment of the deeper workings on the eastern parts of the site was limited to desktop assessment.

2. Site Description

The site is located at the corner of Wilton Drive and Mount Vincent Road, East Maitland NSW. The site is shown on the plan provided by the client titled Conceptual Road & Urban Precincts, dated 13.12.12, attached in Appendix B.

The site is approximately rectangular in shape and ranged in plan dimensions from approximately 190 m to 350 m in width and approximately 950 m in length. Based on survey data supplied by the client the site surface levels range from RL 48 AHD in the north east corner to RL 3 AHD in the west, toward Wallis Creek.

The western part of the site was covered with grass and sparse trees. The eastern part of the site was covered with trees. Natural drainage gullies drain toward the south west.

The site is shown in photographs in Figures 1 to 4 below.

Figure 1: Site facing north-west from south east corner of site

Figure 2: Site facing east from central part of site

Figure 3: Site facing south east from near adjacent Lot 8

Figure 4: Site Facing south west from near the adjacent Lot 8

3. Background Data

3.1 Regional Geology

Reference to the Hunter Coalfields Regional Geology 1:100,000 sheet published by the Department of Mineral Resources, indicates that the site lies within the area of outcrop of the Tomago Coal Measures (TCM). This unit is of Permian Age and typically comprises sandstone, siltstone, laminate and coal. The site is underlain by the Wallis Creek formation of the TCM, and the Rathluba seam is the basal seam within the formation.

The conditions encountered in bores drilled on this site are consistent with the Tomago Coal Measures Rathluba Seam.

3.2 Reports By Others

The client supplied DP with a report by Brunskill Pty Limited (Ref 1) for the adjacent site, Lot 8 Wilton Drive to the north of this study site.

Ref 1 indicates the following relevant data in relation to this study site:

- Record Traces (RT) 535, 603, 603A and 238 may be relevant to the site;
- Part of Lot 42 has been undermined by first workings in the Rathluba Seam; and

- Rathluba (No.1) workings were completed in several periods, with the first in the 1920's, abandonment in the 1935, reopening in 1945 and final abandonment in 1963. Rathluba No. 2 was opened in 1952 and was abandoned in 1954.

Ref 1 indicates the shaft shown in RT603 has a depth of 12.2 m and the fan shaft shown in RT603 has a depth of 18 m.

3.3 Record Trace (RT) Information

RT 238

RT238 is titled "Plan of Maitlayar Colliery", note Rathluba has been strike out of the heading and replaced with Maitlayar. RT 238 shows the following:

- The western most workings located below the site were in the Rathluba Seam and were bord and pillar workings, which are understood to have been worked and surveyed in several stages from 1927 to 1935;
- Pillar widths and lengths range from about 3 m to 18 m with occasional narrower and wider pillars;
- Bord widths are generally in the range 3 m to 5 m with occasional slightly narrower and wider bords;
- Pillar lengths are generally in the range 8 m to 36 m;
- A seam section is provided, which indicates a total seam thickness of 11'0" (3.35 m), with an upper inferior coal 4'10" (1.47 m), and a dip direction to the south east at 1 to 8; and
- Two shafts located just south of the study site labelled as 40 ft (12.19 m) and 60 ft (18.28 m) shafts.

RT 603

RT603 is titled "Plan of Abandonment Rathluba No. 1 and No. 2 Colliers".. RT 603 shows the following:

- All workings below the site were bord and pillar (rectangular, trapezoidal and triangular in shape);
- The eastern most workings located the below the site had been surveyed in several stages from 1952 to 1953;
- Pillar widths range from about 3.5 m to 20 m with occasional narrower and wider pillars;
- Bord widths are generally in the range 3 m to 5.5 m with occasional narrower and wider bords;
- Pillar lengths are generally in the range 5 m to 36 m;
- A seam section is shown, which indicates a total seam thickness of 11'0" (3.35 m), with an upper inferior coal 4'10" (1.47 m);
- Dip rate of 1 in 12, and a direction of dip S 30° E;
- Three shafts located just south of the study site labelled as Shaft, Tunnel Mouth and Fan Shaft;

- A borehole located in south east corner of the site; and
- RT603 incudes workings shown on RT 238 (i.e. western most part of workings) and indicates that these were inaccessible parts of the workings in the 1950's and were positioned at the time based on the RT 238 and surface features such as tunnel and shafts.

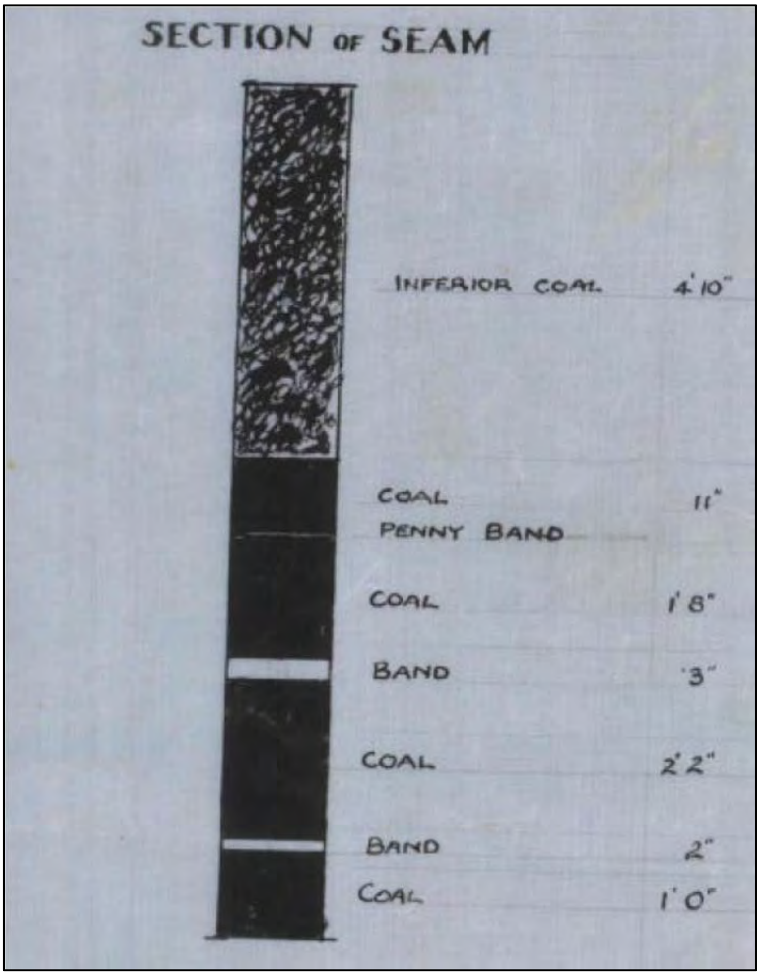

Figure 5: Rathluba Seam Section from RT 603

3.3.1 Location of Site Relative to RT

The relevant parts of the record trace have been geo-referenced, as shown on Drawing 2, relative to the following:

- "Old" borehole location in the south eastern part of the site;
- Observed hole to south of the site which is likely to be Tunnel shaft position; and
- Bores L106 and L207 based on the results of this investigation (sonar results).

It is noted that the record trace was prepared using now outdated survey methods and the plans can also be subject to distortion over time. It is also possible that workings were undertaken that were not surveyed, for example stripping of pillars may have occurred post survey and or additional unchartered workings may be present. Therefore the record trace can only be expected to provide an approximate representation of the actual layout of the workings.

Given the record of survey in the 1950's and 1960's, the workings in the far east of the site along Mount Vincent Road are considered to have a higher level of confidence in their recorded location due to more modern survey methods then previous workings in the 1920's and 1930's. Furthermore, RT603 indicated that the workings in the western part of the site have been positioned based on surface features.

3.3.2 Pothole Subsidence

McNally (Ref 5) suggests that the term 'shallow' mine workings at depths less than 30 m. This was based on UK, US and South Africa experience that caving rarely exceeds ten times the "seam's working thickness, which is generally less than 3 m". McNally further noted that, in the Northern Coalfields, (i.e. the Newcastle and lower Hunter areas) caving (of bord and pillar workings) rarely exceeds three to four times the working section and is often less below thick sandstone roofs. Experience in the Cessnock area relating the Greta and Homesville Seams indicated that caving will extend to a significantly higher elevation in areas of pillar extraction or mine fires.

It is DP's experience that potholes in the Tomago Coal Measures and the Newcastle Coal Measures rarely occur where there is more than about 20 m depth of cover, where working heights are less than 3.5 m and for relatively flat dipping seams.

Pothole subsidence occurs due to ravelling and spalling of the roof of mine workings, leading to progression of a void towards the surface. Where sufficient depth of cover is present the void will normally choke off due to bulking (expansion) of the collapsed soil and rock compared to the original in-situ volume. Where there is insufficient cover the void will progress to the surface and manifest typically as hole of similar or lesser diameter than the width of the mine void. A depth of cover of about 3 to 5 times the mining height is generally sufficient to choke off the pothole before it propagates to the surface, however potholes can occur with greater depths of cover especially when water is able to seep into the potholes, such as occurs in gullies or creeks.

The depth of the hole which forms at the surface is usually significantly less than the depth to the mine workings as the base of the hole is filled with collapsed material. Exceptions to this can occur, particularly where running water can enter the void and wash the collapsed material into the mine workings, and or steeply dipping workings are present.

4. Field Work Methods

4.1 General

Field work was confined to the western parts of the site for the purpose of providing information on the shallower workings associated with RT 238. No investigation has been undertaken on the deeper workings under eastern parts of the site.

Field work was undertaken in the period 26 February 2015 to 11 March 2015 and comprised the following:

- Site inspection and walkover by senior geotechnical engineer;
- One cored bore (Bore 1);
- 34 non-cored bores;
- CCTV inspection of selected voids;
- Sonar inspection of selected voids; and
- Survey of bores.

4.2 Boreholes

Bores L101 to L112, L21 to L212, and L301 to L310 (34 in total) were drilled by non-core methods to depths of up to 25 m. These bores were drilled using a track mounted Terex R20 top hole hammer compressed air hammer rig during the period of the 9 March 2015 to 11 March 2015. These bores were drilled along three selected lines (Lines 1 to 3) for the purpose of indicating the depth of cover in the western part of the site, and where undertaken were access allowed. The bores were logged based on chip samples returned to the surface, observed air return to the surface and drill resistance. The depth record on the logs is considered accurate to within ± 0.2 m, given such drill methods.

Bore 1 was drilled using NMLC coring methods to provide information on rock strata, such as strength, weathering and jointing. Bore 1 was drilled using a truck mounted scout drill rig. The bore was advanced by auger, rotary within soil/weathered rock and NMLC coring was undertaken within rock. The subsurface conditions encountered in Bore 1 were logged by a geotechnical engineer, who also retrieved regular samples for identification and laboratory testing purposes. The rock core was logged for rock type, weathering, strength and discontinuities. Photographs of core within the core box were undertaken prior to point load testing. Point load testing is discussed in Section 6 of this report.

The approximate location of Lines 1 to 3 and the bores are shown on the attached Drawing 1, Test Location Plans.

The bores were collared at the near surface with PVC to allow further inspection and or grouting by others at the completion of drilling. The bores were terminated at the limit of investigation.

The test locations were selected by DP where access allowed at the time of investigation.

The surface levels at the test locations were measured by the DP engineer with a differential GPS, and are considered to be typically ± 0.1 m accuracy. Bores L208 and L210 were undertaken in areas with tree canopy, thus accuracy of the survey at these locations is considered to be about ± 1.0 m. The bore location co-ordinates (MGA) and surface levels (AHD) are shown on the attached logs and within Tables 1 to 3 below.

4.3 CCTV Inspections

Inspection of Boreholes 1, L302, L301, L305, L23, L205, L207, L101 and L106 was undertaken using the DP's specialised CCTV borehole camera on the 11 March 2015.

Collapsing conditions within rubble occurred within some bores, preventing full bore depth inspection.

The accuracy of depths recorded during CCTV inspections down the boreholes, as presented in the CCTV Camera Record Sheets, are considered to be typically within ± 0.4 m, based on calibrations with hand tape.

4.4 Sonar Scanning

Sonar scanning was undertaken within voids encountered in Bores 1, L106 and L207 collapsing conditions.

The sonar rotates around a vertical axis and maps the distance to the surrounding surfaces by measuring the reflected response of sound waves emitted from the unit.

5. Field Work Results

5.1 Walkover Observation Results

No potholes were observed on the site surface during inspection walkover.

A hole was observed on the neighbouring property to the south of the site. The location of the hole is shown on the attached Test Location Plan and is shown in Figure 6 below.

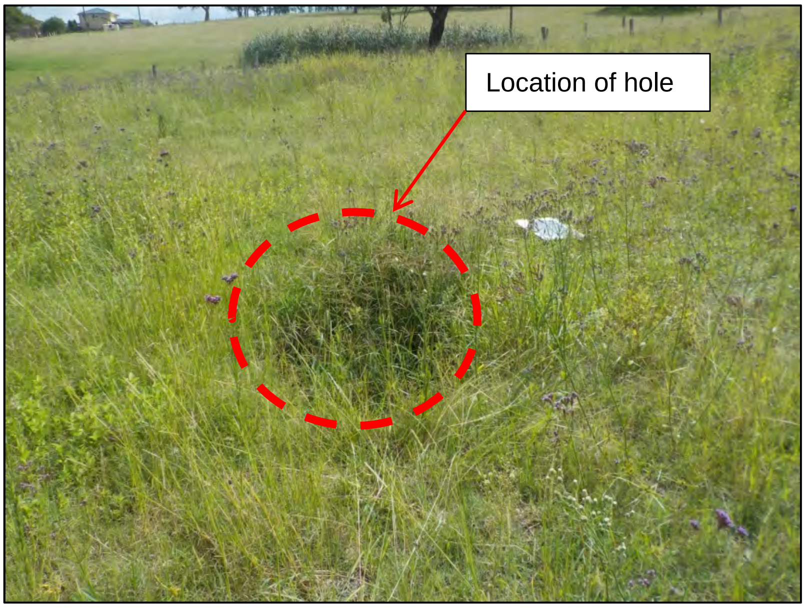

Figure 6: Hole observed at surface of neighbouring property. The hole diameter was approximately 2 m. The location of the hole coincides with the approximate location of the "Tunnel Mouth" as shown on RT603

Two drainage gullies were observed at the site. One is located in the eastern part of the site and one was located on the western part of the site.

Sandstone outcropping was exposed within both gullies. The sandstone appeared to be high strength. Two main orthogonal joint sets were observed with the following dip and dip directions:

- Joint Set 1 75°/270°M at 0.5-2 m spacings; and
- Joint Set 2 75°-80°/180°M at 2 m spacings.

The drainage gullies appear to have been formed by natural erosional process, and possibly disturbance due to quarrying of sandstone. Large blocks of sandstone were observed near the site entry gate along Mount Vincent Road.

Steel casing and a clamp were observed in the south east corner of the site and has been annoted "old borehole" on Drawing 2. RT603 indicated the presence of a "borehole" in this area of the site. These features appear to approximately correlate with the position shown on the RT.

5.2 Bores

The subsurface conditions encountered in Bore 1 are presented in detail in the attached borehole logs in Appendix A. The results of the 34 non-cored bores are shown in Tables 1 to 3 below. These should be read in conjunction with the accompanying notes in Appendix A, which explain the classification methods and define descriptive terms used on the logs and in this report. Photoplates of rock core from Borehole 1 are attached in Appendix A.

The subsurface conditions encountered in the Bore 1 have been broadly divided into the following geotechnical units summarised as follows and are further summarised in Table 3 below:

- **Soil** – A thin veneer of topsoil (clayey silt) was encountered overlying silty clay soil to 0.8 m depth;
- **Weathered Rock** – Extremely low to low strength sandstone and siltstone to 6.2 m depth;
- **Upper Coal Layers** – Thin coal layers in upper bedrock profile;
- **Overburden** – Overlying the worked coal seam, the overburden comprised typically, medium and high strength sandstone and siltstone to 20.57 m depth. Joint spacing was typically 1 m to 3 m;
- **Void** – Opening in rock mass greater than 50 mm, caused or created by previous mine workings;
- **Rubble** – Immediately overlying mine floor (within previously worked bords). The term “rubble” is commonly associated with rock materials altered during mining or potential roof collapse and can be similar in particle size to gravel/cobble/boulders;
- **Coal (Rathluba seam)** – Very low strength, coal. Also a layer 0.3 m thick of extremely low strength mudstone toward base of the seam (Bore 1); and
- **Siltstone and Sandstone** (basal unit) – Low, medium and high strength fresh and or slightly weathered siltstone and sandstone, from 24.54 m to 25.5 m in depth.

Table 1: Results of Bores along Line 1 (Bores L101 to LI12)

Bore	L101	L102	L103	L104	L105	L106	L107	L108	L109	L110	L111	L112
Surface Level (AHD)	**20.28**	**21.75**	**15.82**	**15.86**	**15.33**	**14.76**	**13.01**	**15.76**	**19.69**	**18.62**	**15.54**	**15.89**
Soil (Silty Clay), Depth (m)	0.0-2.0	0.0-0.3	0.0-1.2	0.0-1.4	0.0-2.1	0.0-1.3	0.0-3.4	0.0-1.1	0.0-1.1	0.0-0.8	0.0-1.1	0.0-1.0
Weathered Rock, Depth (m)	2.0-2.5	0.3-0.9	1.2-3.5	1.4-2.3	2.1-3.8	1.3-4.0	3.4-7.1	1.1-2.0	1.1-2.0	0.8-2.0	1.1-3.0	1.0-3.0
Overburden Sandstone, Depth (m)	2.5-15.7	0.9-21.5	NE	2.3-6.3	3.8-7.4	4.0-4.2	7.1-7.6	2.0-12.7	2.0-14.6	2.0-18.7	3.0-6.2	3.0-6.1
Upper Coal, Depth (m)	15.7-15.8	NE	NE	NE	NE	4.2-4.3	NE	NE	14.6-14.8	NE	NE	NE
Overburden Sandstone, Depth (m)	15.8-19.4	NE	NE	NE	NE	4.3-8.1	NE	NE	14.8-18.9	NE	NE	NE
Top of Coal Seam (m) (No Void)	NE	NE	3.5	6.3	7.4	NE	7.6	12.7	18.9	18.7	NE	6.1
Bottom of Coal Seam, Depth (m), (No Void)	NE	NE	6.7	9.5	10.7	NE	10.9	15.7	22.4	22.0	NE	NEDCC
Thickness of Coal Seam (m)	NA	NA	3.2	3.2	3.3	NA	3.3	3.0	3.5	3.3	NA	NEDCC
Top of Void, Depth (m)	19.4	21.5	NE	NE	NE	8.1	NE	NE	NE	NE	6.2	NE
Bottom of Void, Depth (m)	19.9	22.0	NE	NE	NE	8.9	NE	NE	NE	NE	6.6	NE
Total Thickness of Void (m)	0.5	0.5	NA	NA	NA	0.8	NA	NA	NA	NA	0.4	NA
Top of Rubble, Depth (m)	19.9	22.0	NE	NE	NE	8.9	NE	NE	NE	NE	6.6	NE
Bottom of Rubble, Depth (m)	22.6	24.9	NE	NE	NE	11.1	NE	NE	NE	NE	10.0	NE
Thickness of Rubble (m)	2.7	2.9	NA	NA	NA	2.2	NA	NA	NA	NA	3.4	NA
Total Thickness of Void and Rubble (m)	3.2	3.4	NE	NE	NE	3.0	NE	NE	NE	NE	3.8	NE
Floor Depth (m)	22.6	24.9	6.7	9.5	10.7	11.1	10.9	15.7	22.4	22.0	10.0	NEDCC
Bore Termination Depth (m)	22.7	25.0	12.4	12.4	12.4	11.2	11.0	15.9	23.0	23.0	12.1	7.5
Depth of Cover (m)	19.4	21.5	3.5	6.3	7.4	8.1	7.6	12.7	18.9	18.7	6.2	6.1
Roof Level of Coal Seam or Void (AHD)	0.9	0.3	12.3	9.6	7.9	6.7	5.4	3.1	0.8	-0.1	9.3	9.8
Depth to Groundwater based on CCTV (m)	9.8	NE	NE	NE	NE	4.4	NE	NE	NE	NE	NE	NE
Groundwater Level (AHD)	10.5	NE	NE	NE	NE	10.4	NE	NE	NE	NE	NE	NE

Notes for Tables 1 to 3:
NA = Not Applicable
NE = Not Encountered
NEDCC = Not encountered due to collapsing conditions, preventing further drilling
NT = Not Tested

Table 2: Results of Bores along Line 2 (Bores L201 to L212)

Bore	L201	L202	L203	L204	L205	L206	L207	L208	L209	L210	L211	L212
Surface Level (AHD)	**20.69**	**21.47**	**21.61**	**21.23**	**20.20**	**19.16**	**15.80**	**22.5***	**24.31**	**26.5***	**21.39**	**21.36**
Soil (Silty Clay), Depth (m)	0.0-2.1	0.0-1.9	0.0-1.3	0.0-1.9	0.0-0.5	0.0-1.0	0.0-1.3	0.0-2.2	0.0-1.4	0.0-0.9	0.0-0.6	0.0-1.6
Weathered Rock, Depth (m)	2.1-4.0	1.9-6.4	1.3-5.0	1.9-5.6	0.5-1.3	1.0-1.5	1.3-1.8	2.2-3.0	1.4-2.0	0.9-2.0	0.6-2.0	1.6-2.5
Overburden Sandstone, Depth (m)	NE	NE	NE	NE	1.3-7.8	1.5-7.6	1.8-10.1	3.0-12.8	2.0-16.9	2.0-20.5	2.0-6.9	2.5-5.8
Upper Coal, Depth (m)	NE	NE	5.0-5.1	5.6-5.8	7.8-7.9	7.6-7.8	NE	12.8-13.0	16.9-17.1	20.5-20.7	NE	NE
Overburden Sandstone, Depth (m)	NE	NE	5.1-8.6	5.8-10.4	7.9-11.0	7.8-10.9	NE	13.0-16.3	17.1-20.5	20.7-24.4	NE	NE
Top of Coal Seam (m) (No Void)	4.1	6.4	NE	10.4	NE	10.9	10.1	16.3	NE	24.4	NE	5.8
Bottom of Coal Seam, Depth (m), (No Void)	7.1	8.9	NE	NEDCC	NE	14.6	10.7	19.1	NE	27.8	NE	9.0
Thickness of Coal Seam (m)	3.0	2.5	NA	NEDCC	NA	3.7	0.6	2.8	NA	3.4	NA	3.2
Top of Void, Depth (m)	NE	NE	8.6	NE	11.0	NE	10.7	NE	20.5	NE	6.9	NE
Bottom of Void, Depth (m)	NE	NE	9.6	NE	13.1	NE	12.8	NE	22.0	NE	8.1	NE
Total Thickness of Void (m)	NA	NA	1.0	NA	2.1	NA	2.1	NA	1.5	NA	1.2	NA
Top of Rubble, Depth (m)	NE	NE	9.6	NE	13.1	NE	12.8	NE	22.0	NE	8.1	NE
Bottom of Rubble, Depth (m)	NE	NE	12.0	NE	14.4	NE	13.3	NE	23.2	NE	10.1	NE
Thickness of Rubble (m)	NA	NA	2.4	NA	1.3	NA	0.5	NA	1.2	NA	2.0	NA
Total Thickness of Void and Rubble (m)	NE	NE	3.4	NE	3.4	NE	2.6	NE	2.7	NE	3.2	NE
Floor Depth (m)	7.1	8.9	12.0	NEDCC	14.4	14.6	13.3	19.1	23.2	27.8	10.1	9.0
Bore Termination Depth (m)	9.9	9.4	12.1	10.9	14.5	16.5	13.4	19.4	23.3	30.2	10.2	9.2
Depth of Cover (m)	4.1	6.4	8.6	10.4	11.0	10.9	10.1	16.3	20.5	24.4	6.9	5.8
Roof Level of Coal Seam or Void (AHD)	16.6	15.1	13.0	10.8	9.2	8.3	5.7	6.2	3.8	2.1	14.5	15.6
Depth to Groundwater based on CCTV (m)	NT	NT	NT	NE	9.8	NT	NE	NT	NT	NT	NT	NT
Groundwater Level (AHD)	NT	NT	NT	Dry	9.4	NT	Dry	NT	NT	NT	NT	NT

Notes for Tables 1 to 3:

NA = Not Applicable

NE = Not Encountered

NEDCC = Not encountered due to collapsing conditions, preventing further drilling

NT = Not Tested

Table 3: Results of Bores along Line 3 (Bores L301 to L310)

Bore	L301	L302	L303	L304	L305	L306	L307	L308	L309	L310	Bore 1
Surface Level (AHD)	**27.65**	**28.82**	**24.97**	**26.53**	**28.04**	**29.59**	**30.17**	**28.18**	**27.38**	**26.91**	**26.35**
Soil (Silty Clay), Depth (m)	0-1.0	0.0-3.0	0.0-0.5	0.0-0.6	0.0-0.3	0.0-0.8	0.0-0.8	0.0-1.8	0.0-1.8	0.0-1.2	0.0-0.8
Weathered Rock, Depth (m)	1.0-3.0	3.0-4.0	0.5-1.0	0.6-1.0	0.3-0.5	0.8-2.0	0.8-2.0	1.8-3.0	1.8-3.0	1.2-3.0	0.8-6.2
Overburden Sandstone, Depth (m)	3.0-17.5	4.0-19.1	1.0-11.8	1.0-10.6	0.5-8.8	2.0-20.7	2.0-21.6	3.0-7.3	3.0-6.5	3.0-6.6	6.2-17.1
Upper Coal, Depth (m)	17.5-18.8	19.1-19.4	11.8-12.1	10.6-10.8	8.8-9.0	20.7-21.0	21.6-21.8	7.3-7.4	6.5-6.7	6.6-6.9	17.1-17.3
Overburden Sandstone, Depth (m)	18.8-20.9	19.4-22.2	12.1-15.2	10.8-14.0	9.0-12.0	23.9	21.8-24.8	7.4-10.6	6.7-9.9	6.9-9.9	17.3-20.57
Top of Coal Seam (m) (No Void)	NE	NE	NE	NE	NE	23.9	NE	NE	NE	NE	23.5
Bottom of Coal Seam, Depth (m), (No Void)	NE	NE	NE	NE	NE	27.6	NE	NE	NE	NE	24.5
Thickness of Coal Seam (m)	NA	NA	NA	NA	NA	3.7	NA	NA	NA	NA	0.7
Top of Void, Depth (m)	20.9	22.2	15.2	14.0	12.0	NE	24.8	10.6	9.9	9.9	20.57
Bottom of Void, Depth (m)	23.2	23.3	16.0	14.4	12.9	NE	26.8	11.1	10.4	10.4	21.07
Total Thickness of Void (m)	2.3	1.1	0.8	0.4	0.9	NA	2.0	0.5	0.5	0.5	0.50
Top of Rubble, Depth (m)	23.2	23.3	16.0	14.4	12.9	NE	26.8	11.1	10.4	10.4	20.6
Bottom of Rubble, Depth (m)	24.3	24.9	18.3	17.4	15.2	NE	28.4	13.9	13.1	13.1	23.8
Thickness of Rubble (m)	1.1	1.6	2.3	3.0	2.3	NA	1.6	2.8	2.7	2.7	3.2
Total Thickness of Void and Rubble (m)	3.4	2.7	3.1	3.4	3.2	NE	3.6	3.3	3.2	3.2	3.7
Floor Depth (m)	24.3	24.9	18.3	17.4	15.2	27.6	28.4	13.9	13.1	13.1	23.8
Bore Termination Depth (m)	24.5	30.1	18.4	17.5	15.3	27.9	28.5	14.0	13.2	13.2	25.5
Depth of Cover (m)	20.9	22.2	15.2	14.0	12.0	23.9	24.8	10.6	9.9	9.9	20.6
Roof Level of Coal Seam or Void (AHD)	6.8	6.6	9.8	12.5	16.0	5.7	5.4	17.6	17.5	17.0	5.8
Depth to Groundwater based on CCTV (m)	17.1	18.3	NT	NT	NE	NT	NT	NT	NE	NE	16.0
Groundwater Level (AHD)	10.6	10.5	NE	NE	DRY	NE	NE	NE	NE	NE	10.4

Notes for Tables 1 to 3:

NA = Not Applicable

NE = Not Encountered

NEDCC = Not encountered due to collapsing conditions, preventing further drilling

NT = Not Tested

Bore L112 and L204 encountered collapsing conditions and bores were terminated prior to reaching target depths of below the Rathluba Seam. This indicates the likely presence of mine workings.

The results of the non-cored bore are further summarised as follows:

- Coal Seam ranging from 2.5 m to 3.7 m thickness (typically 3.3 m to 3.5 m);
- Void thickness ranging from 0.4 m to 2.2 m;
- Rubble thickness ranging from 0.5 m to 3.4 m; and
- Total Void and rubble thickness ranging from 2.6 m to 3.8 m.

5.2.1 Groundwater Observations

Free groundwater was observed at depths of 16 m, 18.3 m, 17.1 m, 9.8 m, 9.8 m, 4.4 m within Bores 1, L302, L301, L205, L101 and L106, respectively during CCTV inspection on 11 March 2015. The observed free groundwater levels range from RL 9.4 AHD to RL 10.6 AHD. CCTV inspection of bores generally indicated that groundwater levels at the time of investigation were within the depth of the Rathluba Seam or just above the seam (i.e. at top of workings).

It should be noted that no free groundwater was observed in Bore L305 (top of coal RL 16 AHD), L204 (top of coal RL 10.8 AHD) and L207 (top of coal 5.7 AHD) indicating dry workings.

It should be noted that groundwater levels are transient as they are affected by features such as climatic conditions, soil permeability and groundwater extraction and, therefore, will vary with time.

5.3 CCTV Inspections

CCTV inspection results are presented on the attached CCTV camera record sheet, within Appendix A.

The CCTV generally indicates the following:

- Limited jointing/fractures in sandstone overburden;
- A thin veneer of coal remaining in the Roof zone, indicating likely collapse of the upper coal layers into the workings;
- Rubble covers the majority of the floor of the workings; and
- Most areas of the workings are flooded, but some in the far north and western part of the site are dry.

5.4 Sonar Scanning

The pertinent sonar inspection results (possible roadway walls) are presented on the attached Drawing 2 – Inferred RT603 Layout and Depth of Cover Plan.

The Sonar results generally indicate the following:

- Roadway width of between 3.6 m and 4.2 m at Bore 1;

- Possible wall trending east north east to west south west at Bore L207;
- Partial plot of intersections with the roadway north of Bore L106. Roadway about 3.5 m in width at Bore L106; and
- Rubble in the voids partially obstructed the plots at each sonar location.

The roadway widths inferred from sonar results were consistent with the RTs.

The inferred workings layout near Bore 1 and L106 appears similar to that shown on the RT and within a few metres of the position shown on the RT.

6. Laboratory Testing

Laboratory testing included Point load index tests on selected rock core samples and results are recorded on the attached borehole logs. Point load index tests were undertaken to assess rock strength.

7. Proposed Development

Development of the site is proposed to comprise roads, houses and associated services as part of the residential subdivision. A concept plan by the client is shown in Appendix B, attached.

8. Comments

8.1 Location of Workings

The inferred location of the workings represented by RT603 is shown in Drawing 2, attached.

As outlined in Section 3.3.1 of this report, it is considered that the inferred layout of the RT should be considered approximate. Although some bores encountered a coal seam where a void was mapped and vice versa, the results of drilling and sonar indicate a scatter of results broadly consistent with the inferred layout. Taking into account potential inaccuracies in the RT, which experience on other sites has shown can vary by up to about ± 10 m.

Given that Bores L310, L307, L303 intersected voids and bore L112 encountered collapsing conditions (likely workings), outside of the general area which have been recorded on RT’s, it is considered that unchartered workings are likely to be present in locations including the north west and north east corners of the workings represented by RT 238 (western parts of site) near these bores. Further investigation would be required to assess potential uncharted working locations and conditions, and to assess potential impacts on pothole subsidence and pillar stability.

8.2 Summary of Condition of Workings

Pertinent data from the desktop review is further summarised as:

- The RT’s do not indicate pillar extractions at this site;
- Depth of cover ranging up to 70 m in the north east corner of the site;
- Bord and pillar dimensions are variable;
- Seam heights of 3.3 m with upper 1.4 m an inferior quality coal; and
- No working height given but as potential maximum working height of up to 3.3 m (or full seam thickness) may be inferred.

The pertinent features encountered in the bores include:

- Rathlaba Seam unmined thickness ranging from approximately 2.5 m to 3.7 m and more typically about 3.3 m to 3.5 m;
- Void thickness ranging from approximately 0.4 m to 2.2 m;
- Void and rubble within mine working ranging from approximately 2.6 m to 3.8 m thick;
- Workings appear flooded except in the far north-west part of the site. Contours outlining the depth of cover are shown on Drawing 3 attached; and
- Depth of cover ranging from 4.1 m to 24.8 m at bore locations across the western part of the site. Contours of depth of cover, from the results of drilling are presented on Drawing 3.

The thickness of the unmined coal typically indicates a potential maximum working height of 3.3 m to 3.5 m, which is consistent with RT’s.

Where voids were interested the immediate roof strata appears intact with limited fracturing and only a thin veneer of coal is present (based on CCTV inspection) and the voids are partially filled with a layer of rubble on the floor which is likely to comprise fallen unmined top coal. It is likely that the working height, was less than the full seam height, and probably about 1.9 m.

8.3 Risk of Pothole Subsidence

DP’s experience with pothole formation as outlined in Section 3.2.2 indicates that generally potholes rarely occur in the Maitland and surrounding areas where depth of cover is more than 20 m. No potholes were observed at the site, and the sandstone overburden from Bore 1 was typically medium to high strength with limited jointing/fractures. Furthermore, it appears coal tops have most likely fallen to the floor and are present as rubble. This indicates a potential working height of about 1.9 m, rather than a working height equivalent to the full seam height of 3.5 m.

Given the general guide of a 1:5 ratio for pothole bulking factor, and a conservative worst case working height of 3.5 m, potholes would be considered to choke off at a depth of about 20 m (i.e. 5 times 3.5 m is ~20 m). This depth is considered conservative, but reasonable based on the results of this investigation and comments with Ref 5.

Based on the above comments it is considered that the formation of potholes at the site may generally:

- Could potentially occur at depths less than 20 m of cover, however unlikely at depths between 20 m to 30 m depth of cover;
- In the location of the natural gully in the central western part of the site, if regular surface water flows can occur there may be an increased risk of pothole formation; and
- Potholes are not being expected to occur at depths of cover greater than 30 m.

8.4 Potential Remediation Strategies

It is DPs experience that the Mine Subsidence Board will require remedial measures to prevent the risk of pothole subsidence for depths of cover of less than about 20 m to 25 m.

Potential remedial measure can include bulk earthworks comprising cutting to the base of seam level and replacement with engineered filling or alternatively, grouting of the remnant voids. Design of the development to be sympathetic to the pothole risk may reduce the extent of remediation required, however management strategies may still be required to maintain public safety in areas of open space.

The choice of options for remedial measures will likely depend on economic feasibility with bulk earthworks generally viable at relatively shallow depths of cover and grouting generally becoming more viable at greater depths. The depth at which each option is viable will depend on a range of factors including market rates at the time of construction, rock excavatability, consideration of potential creep settlement of deep fill on site classifications as well as estimates of the residual voids requiring grouting and the associated uncertainty of these estimates.

The proposed concept remediation options require further geotechnical assessment, and civil/structural design input, and are discussed below in the following sections of the report.

8.4.1 Cut and Fill Earthworks Replacement

A possible option to remediate the workings includes bulk earthworks cut and fill replacement. This option is generally most viable at shallower depths of cover and in the past on other sites has generally been undertaken at less than about 10 m depth of cover. The viability in terms of cost is likely to be governed by excavatability.

For this option the overburden should be excavated to the base of voids and/or rubble. Backfill should be undertaken in accordance with AS 3798 (Ref 2) and should be undertaken under Level 1 earthworks monitoring and testing by DP or similar accredited earthwork testing company.

The presence of water in the workings may complicate this option, as dewatering is likely to be required during construction. At a minimum the dewatering will need to remove water from the existing flooded voids associated with the workings. There is also likely to be ongoing flow to the excavation, possibly from associated upslope workings as well as seepage from the soil and rock. Dewatering may require a combination of targeted extraction wells, sump and pump methods as well as damming off flows from adjacent workings, however this should be subject to more detailed design. Consideration will also need to be given to management of extracted water; options will depend on various factors including water quality and may include re-injection of the water to adjacent workings, surface or off-site disposal.

Closing of any open voids exposed in the walls of excavation may be required by suitable means, such as using course fill or concrete, prior to placing controlled filling.

Compacted fills of greater than about 5 m depth have been observed to undergo creep settlement over time and therefore this will need to be taken into account in the design of earthworks. It may be necessary to align the extent of site cut with lot boundaries and reduce cut batter slopes in order to limit differential settlements across house lots. The amount of differential settlement will depend on the fill material characteristics, the compaction specification, the depth of cut and the cut batter slope. On other sites, for 10 m cuts, houses sites over the batter slope have been assigned more onerous site classifications than would be required for reactive soil moments to account for the differential movement.

For preliminary purposes it is suggested that batter slopes are limited to 1V:1H or shallower and include regular benching to allow the fill layers to “key in”.

8.4.2 Grout Injection

An alternative option to remediate workings includes grout injection via bores drilled to remnant voids associated with the workings. The grout used for such applications is typically a fly-ash cement blend with a minimum UCS of about 1 MPa.

It should be noted that the workings are flooded and the placement of grout may displace this water to the surface during grouting. Consideration will need to be given to management of displaced water as discussed in the section above.

Further detailed geotechnical investigation and design is recommended to confirm location of workings, grout volumes, mix design, construction/installation and verification methods.

8.4.3 Other Measures

Alternatives options to the remedial measures described may be available, subject to consultation and agreement with the MSB. These measures are generally more suitable at the upper end of the depth of cover range for pothole risk and can include:

- Structures designed as per MSB design for pothole subsidence guidelines (Ref 3); and
- Roads constructed using plastic geo-grid reinforcement for spanning of potholes, or concrete slabs designed to span potholes.

Other measures that might need to be considered in additional to the above include the following:

- Surface drainage designed to reduce risk of infiltration; and
- Appropriate fencing and signage to restrict public access may be considered, if and where required.

8.5 Pillar Stability Assessment

8.5.1 Pillar Stability Analysis

As the depth of cover increases to the east the site, the load that the overburden imposes on the coal pillars increase. Thus, a preliminary assessment has been undertaken to assess risk of pillar crush/failure.

Preliminary pillar stability calculations have been undertaken based on the following:

- UNSW methods (Ref 4). This method is for 'strong' floor and floor conditions;
- Thirty (30) pillars were selected to assess stability. These pillars were selected to represent a range of pillars and depths of cover, within the eastern part of the site. These 30 pillars (Pillars 1 to 30) are shown in Drawing 4 attached;
- Pillar dimensions as measured off RT 603 and a sensitivity analysis (reduction in pillar widths);
- Where pillars are triangular or trapezoidal in shape (such as Pillar 24 and 28) rather than rectangular, dimensions were estimated from about midway along the pillar sides;
- Depths of cover estimated from desktop review which indicates depth of cover is 70 m in the north east part of the site and 60 m in the south east part of the site;
- Bulk density of the overburden of 25 kN/m^3 (conservatively high);
- The calculations are based on full tributary loadings and do not account for loading from adjacent pillars or load shedding to abutments;
- As no investigation to confirm the dimensions of bords, pillars and or working height was undertaken in the eastern part of the site a sensitivity of the pillar stability was assessed for the following pillar dimensions (Cases termed 1 and 2):
    - Case 1 – Pillar dimensions as shown on the RT with a working height of 1.9 m; and
    - Case 2 - Pillar dimensions as shown on the RT with 1 m removed from the pillar widths and 1 m added to the bord widths, to represent possible inaccuracies in the RT, and a "worst case" working height equal to the estimated maximum seam thickness of 3.5 m.

The results of the analyses are presented in the detailed tables D1 and D2 in Appendix D, and are summarised in Table 4 below.

Table 4: Summary of Factors of Safety

Case	Description	Min FOS	Max FOS	Mean FOS
1	Pillar Height 1.9 m, pillars plan dimension as scaled from RT	2.7	18.7	8.7
2	Pillar Height 3.5 m, pillars plan dimension as scaled from RT- less 1 m	1.1	7.5	3.6

Note to Table 4
FOS – Factor of Safety

The results of the Case 1 analysis indicate FOS of individual pillars of greater than 2.7 which indicates a low risk of failure/instability.

The results of the Case 2 analysis indicate FOS of individual pillars of greater than 2.0 for Pillars 1 to 23, 25, 26, 29 and 30, which indicate a low risk of failure/instability. For Case 2 parameters, for Pillars 24 and 27 the FOSs drop to 1.7 and 1.8 resulting in a theoretical 0.1% chance of failure. For the Case 2 parameters Pillar 28's FOS drops to as low as 1.06, resulting in a theoretical chance of failure of about 50%.

For Case 1 the width to height ratio is generally greater than 3, however for Case 2 the ratio drops below 3 for 13 of the 30 pillars indicating that if the pillars are smaller than shown they may be strain softening and therefore is susceptible to a "pillar run". Pillars with low width to height ratios are generally interspersed with squatter pillars and pillars with higher factors of safety and therefore an extended pillar failure is less likely.

The results of the analyses for Case 1 indicate that for the pillar dimensions shown on the RT that there is a low risk of pillar failure occurring. The results also shown that pillar stability is highly sensitive to the pillar dimensions. Experience on other sites has shown that instability has occurred although the pillars shown on the RT are in theory stable, probably due to variations in the actual pillar dimensions compared to those mapped and therefore it is considered that the Case 2 results should be adopted for preliminary assessment purposes.

Based on Case 2 most mapped pillars in the eastern part of the site are considered to be at low risk of instability, except for "small, slender or triangular/trapezoidal shaped" pillars such as Pillar 28. It is noted that the RT shows a scattering of such smaller pillars.

It is recommend that further investigation be undertaken to assess actual pillar and mine working dimensions, strength of floor and potential weak zoning to confirm the results of this preliminary pillar stability analysis. This should be undertaken in conjunction with a more detailed pillar stability assessment considering the effects of tributary loading (i.e. load shedding to surrounding larger pillars).

Depending on the results of further assessment it may be necessary to undertake selected grouting of smaller pillars in conjunction with consideration of appropriate development guidelines/restriction. This process should be undertaken on consultation MSB, from which approval for the proposed development will be required.

8.5.2 Potential Bearing Failure

A layer of extremely low strength mudstone with interbedded weaker layers (consistency/strength to a stiff clay) was encountered in the lower sections of the Rathluba Seam and was approximately 0.3 m thick in Bore 1 (at 24 m depth). Bore 1 was located within workings which are flooded. The material below the floor of the seam comprised low, medium and high strength siltstone / sandstone for at least 1 m beyond the floor.

Bearing failure due to the weak mudstone layer at this site is considered a potential risk, however very limited information is available on the lateral extent of this layer. The mudstone layer was only recovered intact from Bore 1 and in this case the core sample was from the floor of the void of the workings and has been subject to removal of overburden pressures, disturbance during mining and exposure to water from flooding of the workings, all potentially leading to swelling and softening of the mudstone. The actual in-situ strength of the mudstone where it remains confined below pillars and forms the founding material is likely substantially higher than that observed in Bore 1, however core drilling through the pillars would be required to assess the actual strength and associated risk of bearing failure.

It is recommended that further core drilling and assessment is undertaken prior to Development Application approval to assess coal seam conditions in the pillars and further assessment of the risk of bearing failure be undertaken.

8.6 Further Geotechnical Investigation / Assessment

The site is constrained due to former coal mining and the associated risk of subsidence. Various potential options have been presented to manage these risks to allow development of the site, however there is insufficient data to allow detailed assessment and design of these options. Further geotechnical investigations / assessment are recommended and could include:

- Consultation with the MSB to confirm their requirements, which may inform the specific scope of additional works required;
- Core drilling through pillars to confirm the bearing strength;
- Additional core drilling or seismic refraction to assess excavatability;
- Hydraulic testing and water quality testing to assess dewatering requirements;
- Trial grouting to assess potential grout takes (this could include grouting of investigation bores);
- Detailed design of bulk earthworks and/or grouting; and
- Drilling and sonar/camera assessment of deeper workings to confirm pillar stability.

Such investigations could form part of the Development Application documentation for the urban development of the site.

8.7 Conclusion

The results of this geotechnical assessment have identified the following mine subsidence issues that require consideration prior to development:

- There is a risk of pothole subsidence (typically at depths of cover less than 20 m to 25 m). Remedial measures will be required to manage this risk prior to development;
- For the deeper working on the eastern parts of the site, on the basis of mine records, there is typically low risk of pillar instability, except for a mapped scattering of “small, slender or triangular/trapezoidal shaped” pillars which are likely to require at least localised remedial works;
- The potential was identified for a weak mudstone to be present in the floor of the workings, potentially reducing the bearing stability of the pillars and increasing the extent of remedial works required.

Furthermore, this report provides preliminary comments on remediation options for mitigation of the risk issues identified above. These include removal / backfilling, grouting, and engineered design measures, all of which should be undertaken in consultation with and subject to the approval by the MSB (Mine Subsidence Board).

Additional detailed geotechnical investigation should be undertaken during the design stage of the project in order to quantify the required extent of any remediation of the workings, and should include further investigation and assessment as outlined in Section 8.6 of this report.

On the basis of the investigations detailed in this report it is considered that the site would be suitable, from a mine subsidence perspective, for future urban development subject to the above considerations being addressed by engineering design and adoption of appropriate remedial risk mitigation measures.

9. References

1. Report by Brunskill Pty Limited (2014), titled 'Mine Workings Underlying and Adjacent to Lot 42 DP 846326 – Wilton Drive East Maitland – Updated Report', reference number BMPR 935A_070514, dated 7 May 2014.
2. Australian Standards AS 3798-2007, (2007), 'Guidelines on Earthworks for Commercial and Residential Developments', March 2007, Standards Australia.
3. Mine Subsidence Board Publication Designing For 'Pothole Subsidence', dated 2007.
4. Salamon, M D G, Galvin, (1998), J M, Hocking G and Anderson, I; Coal Pillar Strength from Back Calculation, UNSW Research Report RP/96 October 1998.
5. McNally G H (2000), Geology and mining practice in relation to shallow subsidence in the northern Coalfield, NSW. Australian Journal of earth Sciences, 2000, Vol 47, Issue 1, pp 21-34.

10. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for this project at Lot 42, DP 846326 Corner Wilton Drive and Mount Vincent Road, East Maitland. The work was carried out under DP's Conditions of engagement. This report is provided for the exclusive use of Mr D Wilton for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of DP, does so entirely at its own risk and without recourse to DP for any loss or damage. In preparing this report DP has necessarily relied upon information provided by the client and / or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and / or testing locations, and then only to the depths investigated and at the time the work was carried out. Sub-surface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after DP's field testing has been completed.

DP's advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by DP in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and / or testing locations. The advice may also be limited by budget constraints imposed by others or by site accessibility.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of DP. DP may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to DP. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by DP. This is because this report has been written as advice and opinion rather than instructions for construction.

Douglas Partners Pty Ltd

Appendix A

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

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Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Sampling Methods

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Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Soil Descriptions

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Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS 1726, Geotechnical Site Investigations Code. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	20 - 63
Medium gravel	6 - 20
Fine gravel	2.36 - 6
Coarse sand	0.6 - 2.36
Medium sand	0.2 - 0.6
Fine sand	0.075 - 0.2

The proportions of secondary constituents of soils are described as:

Term	Proportion	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	20 - 35%	Sandy Clay
Slightly	12 - 20%	Slightly Sandy Clay
With some	5 - 12%	Clay with some sand
With a trace of	0 - 5%	Clay with a trace of sand

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	vs	<12
Soft	s	12 - 25
Firm	f	25 - 50
Stiff	st	50 - 100
Very stiff	vst	100 - 200
Hard	h	>200

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	SPT N value	CPT qc value (MPa)
Very loose	vl	<4	<2
Loose	l	4 - 10	2 -5
Medium dense	md	10 - 30	5 - 15
Dense	d	30 - 50	15 - 25
Very dense	vd	>50	>25

Soil Descriptions

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Transported soils - formed somewhere else and transported by nature to the site; or
- Filling - moved by man.

Transported soils may be further subdivided into:

- Alluvium - river deposits
- Lacustrine - lake deposits
- Aeolian - wind deposits
- Littoral - beach deposits
- Estuarine - tidal river deposits
- Talus - scree or coarse colluvium
- Slopewash or Colluvium - transported downslope by gravity assisted by water. Often includes angular rock fragments and boulders.

Symbols & Abbreviations

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Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core Drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

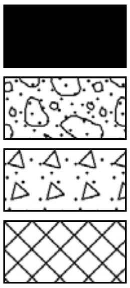
Other

fg	fragmented
bnd	band
qtz	quartz

Symbols & Abbreviations

Graphic Symbols for Soil and Rock

General



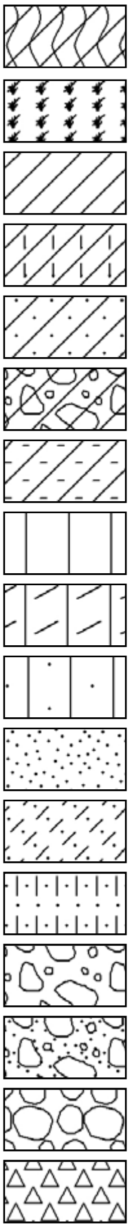
Asphalt

Road base

Concrete

Filling

Soils



Topsoil

Peat

Clay

Silty clay

Sandy clay

Gravelly clay

Shaly clay

Silt

Clayey silt

Sandy silt

Sand

Clayey sand

Silty sand

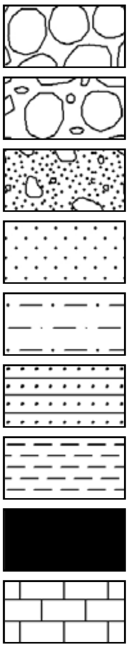
Gravel

Sandy gravel

Cobbles, boulders

Talus

Sedimentary Rocks



Boulder conglomerate

Conglomerate

Conglomeratic sandstone

Sandstone

Siltstone

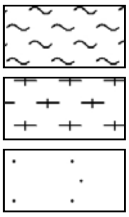
Laminite

Mudstone, claystone, shale

Coal

Limestone

Metamorphic Rocks

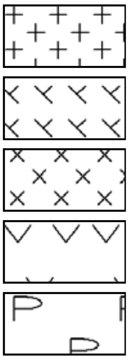


Slate, phyllite, schist

Gneiss

Quartzite

Igneous Rocks



Granite

Dolerite, basalt, andesite

Dacite, epidote

Tuff, breccia

Porphyry

Rock Strength

Rock strength is defined by the Point Load Strength Index ($Is_{(50)}$) and refers to the strength of the rock substance and not the strength of the overall rock mass, which may be considerably weaker due to defects. The test procedure is described by Australian Standard 4133.4.1 - 1993. The terms used to describe rock strength are as follows:

Term	Abbreviation	Point Load Index $Is_{(50)}$ MPa	Approx Unconfined Compressive Strength MPa*
Extremely low	EL	<0.03	<0.6
Very low	VL	0.03 - 0.1	0.6 - 2
Low	L	0.1 - 0.3	2 - 6
Medium	M	0.3 - 1.0	6 - 20
High	H	1 - 3	20 - 60
Very high	VH	3 - 10	60 - 200
Extremely high	EH	>10	>200

* Assumes a ratio of 20:1 for UCS to $Is_{(50)}$

Degree of Weathering

The degree of weathering of rock is classified as follows:

Term	Abbreviation	Description
Extremely weathered	EW	Rock substance has soil properties, i.e. it can be remoulded and classified as a soil but the texture of the original rock is still evident.
Highly weathered	HW	Limonite staining or bleaching affects whole of rock substance and other signs of decomposition are evident. Porosity and strength may be altered as a result of iron leaching or deposition. Colour and strength of original fresh rock is not recognisable
Moderately weathered	MW	Staining and discolouration of rock substance has taken place
Slightly weathered	SW	Rock substance is slightly discoloured but shows little or no change of strength from fresh rock
Fresh stained	Fs	Rock substance unaffected by weathering but staining visible along defects
Fresh	Fr	No signs of decomposition or staining

Degree of Fracturing

The following classification applies to the spacing of natural fractures in diamond drill cores. It includes bedding plane partings, joints and other defects, but excludes drilling breaks.

Term	Description
Fragmented	Fragments of <20 mm
Highly Fractured	Core lengths of 20-40 mm with some fragments
Fractured	Core lengths of 40-200 mm with some shorter and longer sections
Slightly Fractured	Core lengths of 200-1000 mm with some shorter and loner sections
Unbroken	Core lengths mostly > 1000 mm

Rock Descriptions

Rock Quality Designation

The quality of the cored rock can be measured using the Rock Quality Designation (RQD) index, defined as:

$$\text{RQD \%} = \frac{\text{cumulative length of 'sound' core sections} \geq 100\text{ mm long}}{\text{total drilled length of section being assessed}}$$

where 'sound' rock is assessed to be rock of low strength or better. The RQD applies only to natural fractures. If the core is broken by drilling or handling (i.e. drilling breaks) then the broken pieces are fitted back together and are not included in the calculation of RQD.

Stratification Spacing

For sedimentary rocks the following terms may be used to describe the spacing of bedding partings:

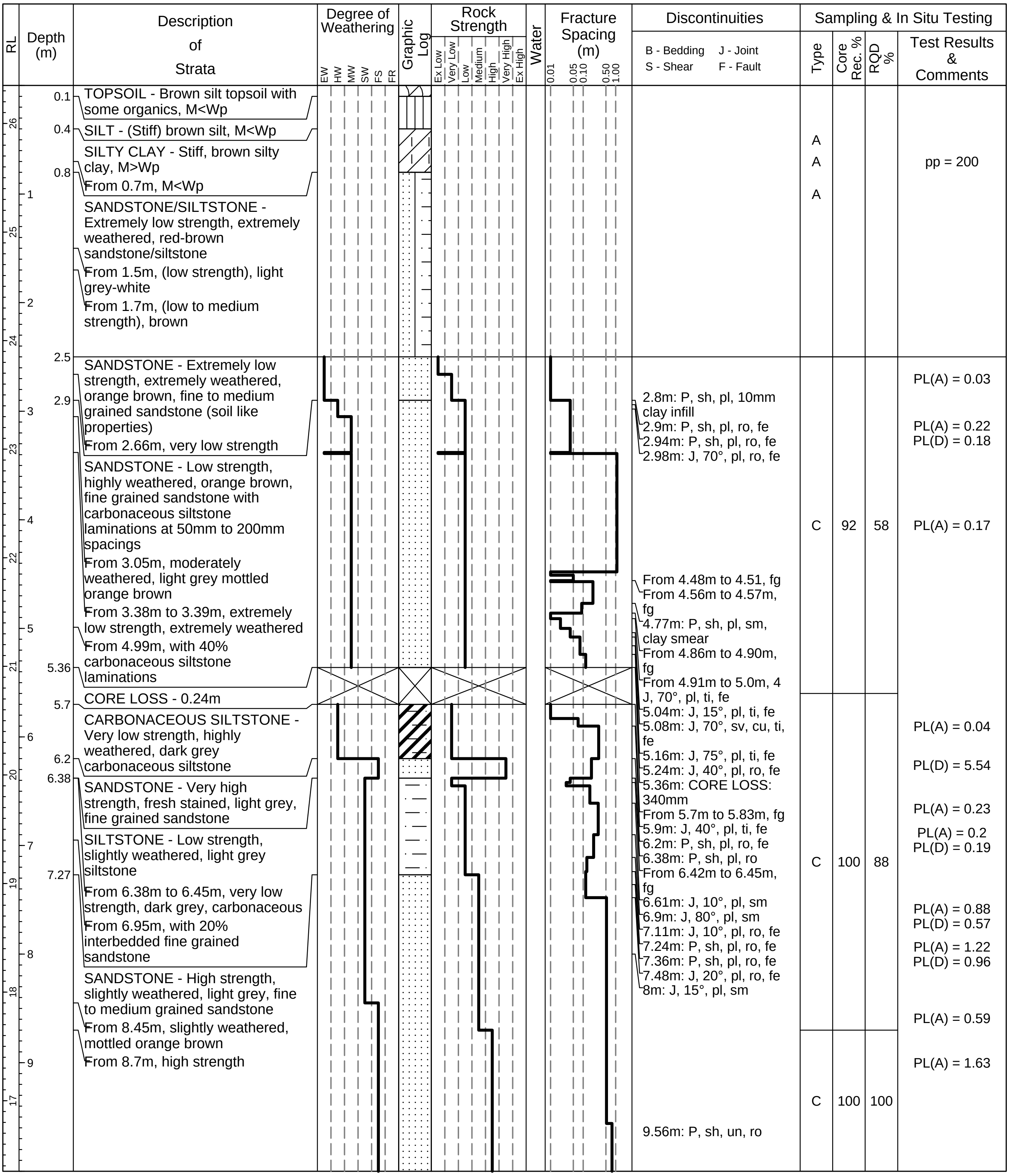
Term	Separation of Stratification Planes
Thinly laminated	< 6 mm
Laminated	6 mm to 20 mm
Very thinly bedded	20 mm to 60 mm
Thinly bedded	60 mm to 0.2 m
Medium bedded	0.2 m to 0.6 m
Thickly bedded	0.6 m to 2 m
Very thickly bedded	> 2 m

BOREHOLE LOG

CLIENT: Mr D Wilton c/- ACM Landmark
PROJECT: Mine Subsidence Assessment
LOCATION: Cnr Wilton Dr & Mount Vincent Rd, East Maitland

SURFACE LEVEL: 26.35 AHD
EASTING: 366295
NORTHING: 6373353
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 81674
DATE: 26/2/2015
SHEET 1 OF 3



Depth (m)	Description of Strata
0.1	TOPSOIL - Brown silt topsoil with some organics, M<Wp
0.4	SILT - (Stiff) brown silt, M<Wp
0.8	SILTY CLAY - Stiff, brown silty clay, M>Wp From 0.7m, M<Wp
2.5	SANDSTONE/SILTSTONE - Extremely low strength, extremely weathered, red-brown sandstone/siltstone From 1.5m, (low strength), light grey-white From 1.7m, (low to medium strength), brown
2.9	SANDSTONE - Extremely low strength, extremely weathered, orange brown, fine to medium grained sandstone (soil like properties) From 2.66m, very low strength
5.36	SANDSTONE - Low strength, highly weathered, orange brown, fine grained sandstone with carbonaceous siltstone laminations at 50mm to 200mm spacings From 3.05m, moderately weathered, light grey mottled orange brown From 3.38m to 3.39m, extremely low strength, extremely weathered From 4.99m, with 40% carbonaceous siltstone laminations
5.7	CORE LOSS - 0.24m
6.2	CARBONACEOUS SILTSTONE - Very low strength, highly weathered, dark grey carbonaceous siltstone
6.38	SANDSTONE - Very high strength, fresh stained, light grey, fine grained sandstone
7.27	SILTSTONE - Low strength, slightly weathered, light grey siltstone From 6.38m to 6.45m, very low strength, dark grey, carbonaceous From 6.95m, with 20% interbedded fine grained sandstone
	SANDSTONE - High strength, slightly weathered, light grey, fine to medium grained sandstone From 8.45m, slightly weathered, mottled orange brown From 8.7m, high strength

Discontinuities

B - Bedding J - Joint
S - Shear F - Fault

2.8m: P, sh, pl, 10mm clay infill
2.9m: P, sh, pl, ro, fe
2.94m: P, sh, pl, ro, fe
2.98m: J, 70°, pl, ro, fe
From 4.48m to 4.51, fg
From 4.56m to 4.57m, fg
4.77m: P, sh, pl, sm, clay smear
From 4.86m to 4.90m, fg
From 4.91m to 5.0m, 4 J, 70°, pl, ti, fe
5.04m: J, 15°, pl, ti, fe
5.08m: J, 70°, sv, cu, ti, fe
5.16m: J, 75°, pl, ti, fe
5.24m: J, 40°, pl, ro, fe
5.36m: CORE LOSS: 340mm
From 5.7m to 5.83m, fg
5.9m: J, 40°, pl, ti, fe
6.2m: P, sh, pl, ro, fe
6.38m: P, sh, pl, ro
From 6.42m to 6.45m, fg
6.61m: J, 10°, pl, sm
6.9m: J, 80°, pl, sm
7.11m: J, 10°, pl, ro, fe
7.24m: P, sh, pl, ro, fe
7.36m: P, sh, pl, ro, fe
7.48m: J, 20°, pl, ro, fe
8m: J, 15°, pl, sm
9.56m: P, sh, un, ro

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
A			
A			pp = 200
A			
C	92	58	PL(A) = 0.03 PL(A) = 0.22 PL(D) = 0.18 PL(A) = 0.17
C	100	88	PL(A) = 0.04 PL(D) = 5.54 PL(A) = 0.23 PL(A) = 0.2 PL(D) = 0.19 PL(A) = 0.88 PL(D) = 0.57 PL(A) = 1.22 PL(D) = 0.96 PL(A) = 0.59
C	100	100	PL(A) = 1.63

RIG: GT (Scout 4) **DRILLER:** Kerney-Emis (GT) **LOGGED:** West **CASING:** HQ - 2.5m
TYPE OF BORING: Solid flight auger to 2.5m, then NMLC coring
WATER OBSERVATIONS: No free groundwater observed whilst augering, then obscured by drilling fluid
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

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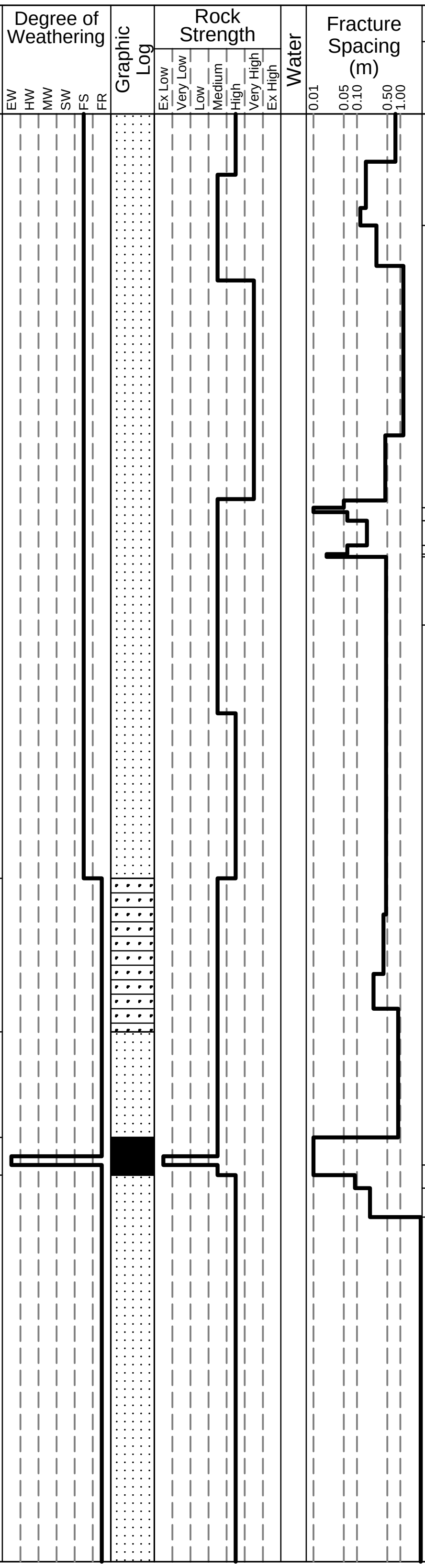
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 81674
DATE: 26/2/2015
SHEET 2 OF 3



Depth (m)	Description of Strata	Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault)	Type	Core Rec. %	RQD %	Test Results & Comments
	SANDSTONE - High strength, slightly weathered, light grey, fine to medium grained sandstone *(continued)*	10.33m: J, 70°, pl, ro, fe 10.49m: P, sh, pl, ro, fe				PL(D) = 1.97 PL(D) = 2.23 PL(D) = 1.92 PL(A) = 0.53
	From 10.42m to 11.15m, medium strength, with carbonaceous siltstone laminations at 50mm to 100mm spacings	10.65m: J, 10°, pl, ro, fe 10.77m: P, 5°, pl, ro 11.05m: P, sh, un, ro, fe	C	100	100	PL(D) = 0.74
	From 11.15m, very high strength, fresh stained					PL(A) = 3.16 PL(D) = 4.98
		12.22m: P, 5°, pl, ro, fe				PL(A) = 4.42 PL(D) = 5.91
	From 12.66m, medium strength	12.67m: J, 10°, pl, ro From 12.72m to 12.75m, fg 12.81m: P, 5°, pl, ro, fe 12.98m: P, 5°, pl, ro, fe 13.04m: P, sh, pl, ro, fe				PL(A) = 0.97 PL(D) = 0.78
	From 13.06m to 13.51m, carbonaceous siltstone laminations up to 10mm thick at 50mm to 200mm spacing	13.06m: P, sh, pl, ro, fe 13.53m: J, 75°, Pl, ro, 10mm iron stain penetration	C	100	93	PL(D) = 0.85
	From 14.14m, high strength, with carbonaceous siltstone laminations up to 5mm thick at 5mm to 100mm spacing					PL(A) = 1.67 PL(D) = 1.1
15.28	LAMINITE - High strength, fresh, light grey, interbedded 60% fine grained sandstone and 40% siltstone	15.94m: P, sh, pl, ro 16.18m: J, 10°, pl, sm				PL(A) = 0.98 PL(D) = 0.65
16.34	SANDSTONE - Medium strength, fresh, light grey, fine to coarse grained sandstone		C	100	89	PL(D) = 0.46
17.07	COAL - Medium strength, fresh, dark grey coal From 17.2m to 17.26m, extremely low strength, extremely weathered claystone	From 17.07m to 17.20m, fg From 17.26m to 17.33m, fg				
17.33	SANDSTONE - High strength, fresh, light grey, fine grained sandstone From 17.33m to 17.44m, carbonaceous siltstone lenses up to 50mm thick	17.42m: P, sh, pl, ro 17.62m: J, 20°, pl, ro				PL(D) = 1.18
			C	100	100	PL(A) = 1.61 PL(D) = 1.01

RIG: GT (Scout 4) **DRILLER:** Kerney-Emis (GT) **LOGGED:** West **CASING:** HQ - 2.5m
TYPE OF BORING: Solid flight auger to 2.5m, then NMLC coring
WATER OBSERVATIONS: No free groundwater observed whilst augering, then obscured by drilling fluid
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

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Geotechnics / Environment / Groundwater

BOREHOLE LOG

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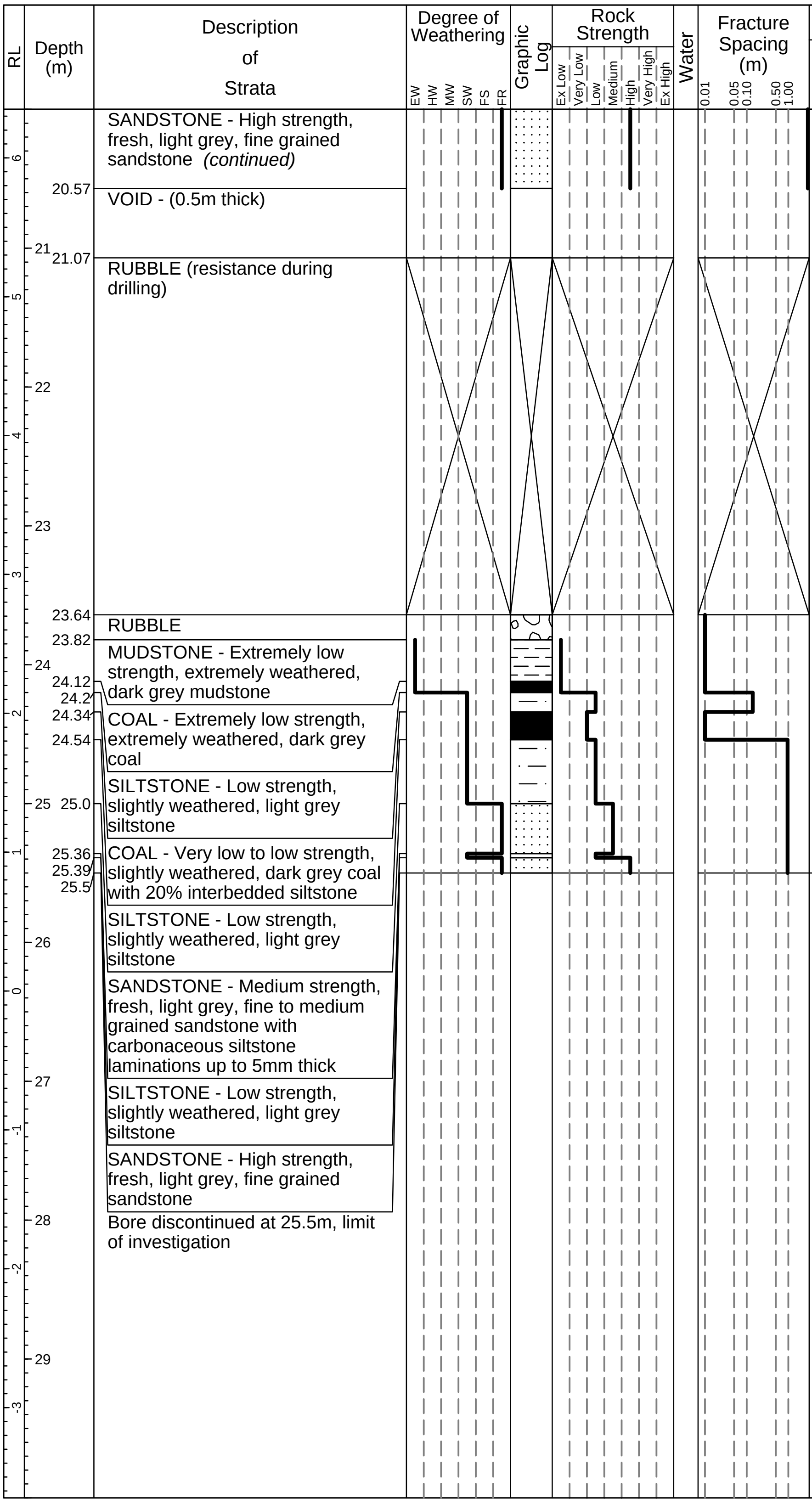
SHEET 3 **OF** 3

Depth (m)	Description of Strata
	SANDSTONE - High strength, fresh, light grey, fine grained sandstone *(continued)*
20.57	VOID - (0.5m thick)
21.07	RUBBLE (resistance during drilling)
23.64	RUBBLE
23.82	MUDSTONE - Extremely low strength, extremely weathered, dark grey mudstone
24.12	COAL - Extremely low strength, extremely weathered, dark grey coal
24.2	SILTSTONE - Low strength, slightly weathered, light grey siltstone
24.34	COAL - Very low to low strength, slightly weathered, dark grey coal with 20% interbedded siltstone
24.54	SILTSTONE - Low strength, slightly weathered, light grey siltstone
25.0	SANDSTONE - Medium strength, fresh, light grey, fine to medium grained sandstone with carbonaceous siltstone laminations up to 5mm thick
25.36	SILTSTONE - Low strength, slightly weathered, light grey siltstone
25.39	SANDSTONE - High strength, fresh, light grey, fine grained sandstone
25.5	Bore discontinued at 25.5m, limit of investigation

Discontinuities (B - Bedding, J - Joint, S - Shear, F - Fault):
21.07m: CORE LOSS: 2570mm

Sampling & In Situ Testing

Type	Core Rec. %	RQD %	Test Results & Comments
C	100	100	PL(A) = 1.62 PL(D) = 1
C	0	0	
C	66	0	pp = 150
C	100	79	PL(A) = 0.5 PL(D) = 0.82



RIG: GT (Scout 4) **DRILLER:** Kerney-Emis (GT) **LOGGED:** West **CASING:** HQ - 2.5m
TYPE OF BORING: Solid flight auger to 2.5m, then NMLC coring
WATER OBSERVATIONS: No free groundwater observed whilst augering, then obscured by drilling fluid
REMARKS:

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

DOUGLAS PARTNERS PTY LTD

MINE SUBSIDENCE ASSESSMENT

BORE 1 PROJECT 81674 FEB 2015

2.50 m – 7.00 m

DOUGLAS PARTNERS PTY LTD

MINE SUBSIDENCE ASSESSMENT

BORE 1 PROJECT 81674 FEB 2015

7.00 m – 12.00 m

Douglas Partners Geotechnics / Environment / Groundwater	**Core Photoplates**	PROJECT:	81674
	Mine Subsidence Assessment	PLATE No:	1
	Corner Wilton Drive and Mount Vincent Road, East Maitland	REV:	A
	CLIENT: Mr D Wilton c/- ACM Landmark	DATE:	29-Apr-15

DOUGLAS PARTNERS PTY LTD

MINE SUBSIDENCE ASSESSMENT

BORE 1 PROJECT 81674 FEB 2015

12.00 m – 17.00 m

DOUGLAS PARTNERS PTY LTD

MINE SUBSIDENCE ASSESSMENT

BORE 1 PROJECT 81674 FEB 2015

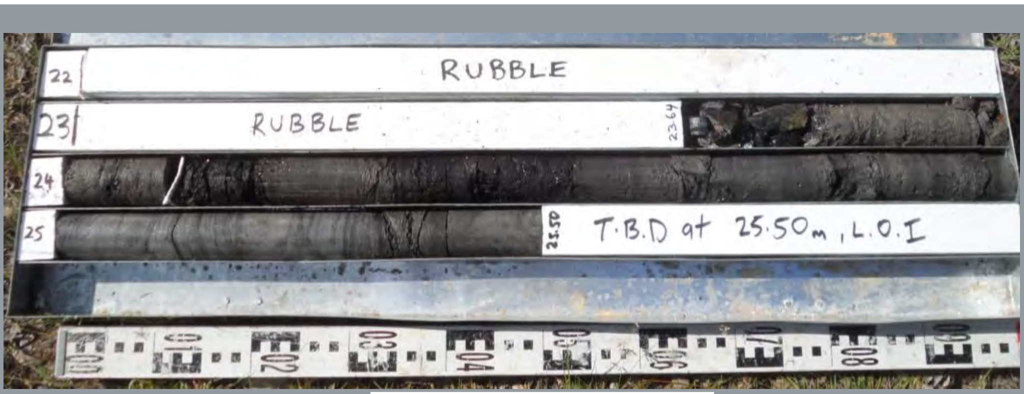
17.00 m – 22.00

Core Photoplates		PROJECT:	81674
Mine Subsidence Assessment		PLATE No:	2
Corner Wilton Drive and Mount Vincent Road, East Maitland		REV:	A
CLIENT:	Mr D Wilton c/- ACM Landmark	DATE:	29-Apr-15

DOUGLAS PARTNERS PTY LTD

MINE SUBSIDENCE ASSESSMENT

BORE 1 PROJECT 81674 FEB 2015



22.00 m – 25.50 m

Douglas Partners
Geotechnics / Environment / Groundwater

Core Photoplates

Mine Subsidence Assessment

Corner Wilton Drive and Mount Vincent Road, East Maitland

PROJECT:	81674
PLATE No:	3
REV:	A
DATE:	29-Apr-15

CLIENT: Mr D Wilton
c/- ACM Landmark

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	1	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.5 m above Ground Level
0.9	PVC Casing
16	Water Level
16.9 – 17.2	Coal bands
20.3	Top of Void
20.8	Rubble
20.8	Collapsed Rubble in Borehole
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L3-02	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.4	PVC Casing
18.3	Water Level
19.2-19.7	Coal bands
22.4	Top of Void
22.8	Rubble
22.9	Collapsed Rubble in Borehole
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L3-01	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.5	PVC Casing
17.1	Water Level
20.7	Coal Veneer along roof/ Top of Void
21.1	Rubble
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L3-05	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.4	PVC Casing
12.0	Void
12.2	Top of Void – Dry workings
12.6	Rubble
12.7	Collapsed Rubble in borehole
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L2-03	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.4	PVC Casing
8.7	Top of Void
9.5	Rubble
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L2-05	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.3	PVC Casing
9.8	Water Level
11.1	Top of Void
11.8	Rubble
12.1	Rubble in borehole
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L2-07	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.5	PVC Casing
10.2	Coal
10.7	Break out 0.4m thick
11.1	Top of Void
11.4	Rubble
11.7	Rubble in borehole
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L1-01	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.4	PVC Casing
9.8	Water Level
15.6-15.9	Coal
19.4	Top of Void
20.0	Rubble
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

CCTV CAMERA RECORD SHEET

Project	Mine Subsidence Assessment	**Project No.**	81674	**Bore**	L1-06	**Date**	11/3/15
Location	Cnr Wilton Dr & Mount Vincent Rd, East Maitland						

Depth (m)	**Comments**
0.0	Ground Level, Note: Top of Casing at 0.05 m above Ground Level
0.4	PVC Casing
4.4	Water Level
8.0	Top of Void
8.5	Rubble
	Camera Discontinued Due to Borehole Collapse Preventing Further Assessment
Notes	The accuracy of depths recorded during CCTV down the boreholes as presented in the CCTV Camera Record Sheets are considered to be typically within ± 0.4 m

Appendix B

Drawing by Client Titled – Conceptual Road Layout & Urban Precincts

PLAN:

SCALE: 1:1500 (A1)
SCALE: 1:750 (A3)
CONTOUR INTERVAL 1.0m

NOTES:

DETAIL SURVEY OF VISUAL FEATURES ONLY.
NO UNDERGROUND PUBLIC OR PRIVATE UTILITY INVESTIGATION HAS BEEN UNDERTAKEN.

DETAIL SURVEY FOR THE PURPOSE OF LAYOUT DESIGNS ONLY AND NOT TO BE USED FOR ENGINEERING DESIGN PURPOSES.

NO UNDERGROUND DRAINAGE LOCATED OR INVESTIGATED.

LEVELS ON A.H.D. SSM 90982 R.L 45.500 USED.

DETAIL SURVEY ON M.G.A COORDINATES.

BOUNDARYS PLACED FROM LIMITED INFORMATION AND ARE APPROXIMATE ONLY, TO BE VERIFIED AND CONFIRMED BEFORE ANY WORK TAKES PLACE.

LEGEND:

———	EXISTING LOT BOUNDARY	▨	TELSTRA PIT
— — —	1% AEP FLOOD LEVEL - RL 10.1	○PP	POWER POLE
- - - -	VEGETATION BUFFER	○	SEWER MANHOLE
-·-·-	SEWER LINE	🟥	PROPOSED RESIDENTIAL LOT PRECINCTS
—•—•—	OVERHEAD POWER LINES	⬜	PROPOSED ROADWAY
——/——	EXISTING FENCING	🟩	PROPOSED FOOTPATH

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WARNING

The location of existing public utilities shown on these drawings is approximate only and in some cases may be inaccurate or incomplete. No responsibility is accepted for nor is any guarantee made as to the accuracy of the locations shown that have been plotted from information provided by the relevant public utility authorities. The attention of the user of these drawings is directed to the possible existence of underground public utilities and private service lines not shown or at locations different from those shown on these drawings. It is the responsibility of those persons using these drawings to confirm the existence of all public utilities and private service lines within the vicinity of the works in conjunction with the relevant public utility authority and/or by physical location.

AutoCAD FILE.
ACMDOCUMENTS/PA/C/0955/CADRAW/6/REV A/0955-6002-A.dwg

CIVILCAD FILE.
ACMDOCUMENTS/PA/

No.	Date	Amendment Details	Initial
A	13.12.12	ORIGINAL ISSUE TO COUNCIL FOR APPROVAL	DW

No.	Date	Amendment Details	Initial

ACM LANDMARK
LAND DEVELOPMENT CONSULTANTS
Suite 3/5 Edward St, PO Box 627, CESSNOCK NSW 2325
P: (02) 4991 7171 - F: (02) 4991 7272 - E: admin@acmlandmark.com.au

Client: MR D. WILTON

Surveyed by: RKM SURVEY PTY LTD
Geotechnical by: COFFEY GEOTECHNICS
Datum: AHD
Coord:
Designed: ML
Checked: ML
Drawn: DW
Approved: ML

Job Name
REZONING MUSS SUBMISSION
LOT 42, DP 846326
EAST MAITLAND

Scale AS SHOWN
Drawing No. 0955-6002

Title
CONCEPTUAL ROAD LAYOUT & URBAN PRECINCTS

Sheet No. 1 OF 2
Amdt. A

Appendix C

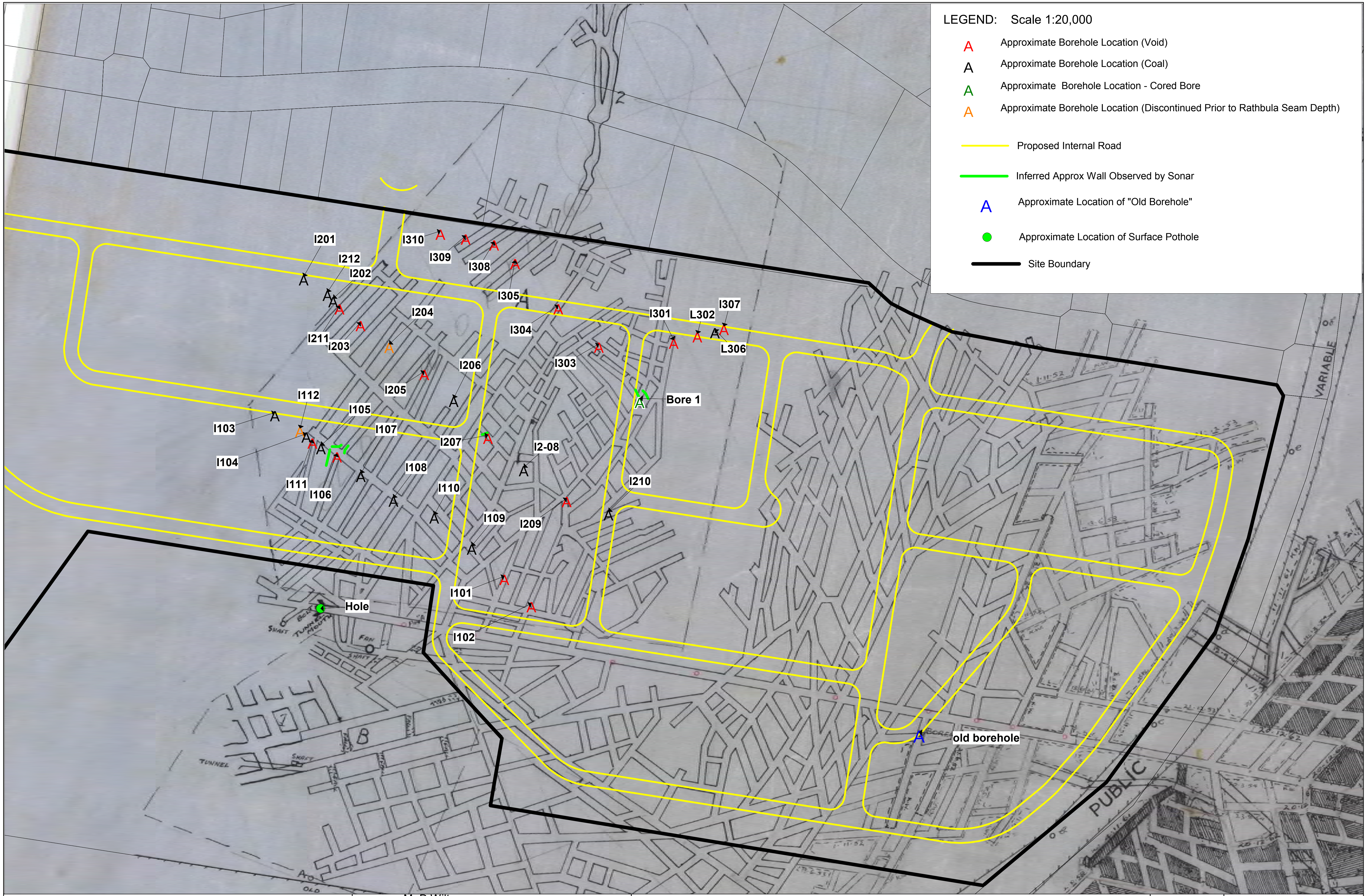
Drawing 1 – Test Location Plan
Drawing 2 – Inferred RT Layout and Depth of Cover Plan
Drawing 3 – Inferred Depth of Cover Plan
Drawing 4 – Pillar Labels

Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Mr D Wilton C/- ACM Landmark		TITLE: **Proposed Test Location Plan**
OFFICE: Newcastle	DRAWN BY: MAS	**Mine Subsidence Assessment, Proposed Rezoning Lot 42, DP846326**
SCALE: As shown	DATE: 20.2.2015	**Cnr of Wilton Drive and Mount Vincent Drive, East Maitland**

N
MGA

PROJECT No: 81674
DRAWING No: 1
REVISION: 0



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Mr D Wilton
C/- ACM Landmark

OFFICE: Newcastle

DRAWN BY: MRH

SCALE: As shown

DATE: 25.3.2015

TITLE: **Inferred RT603 Approximate Location**

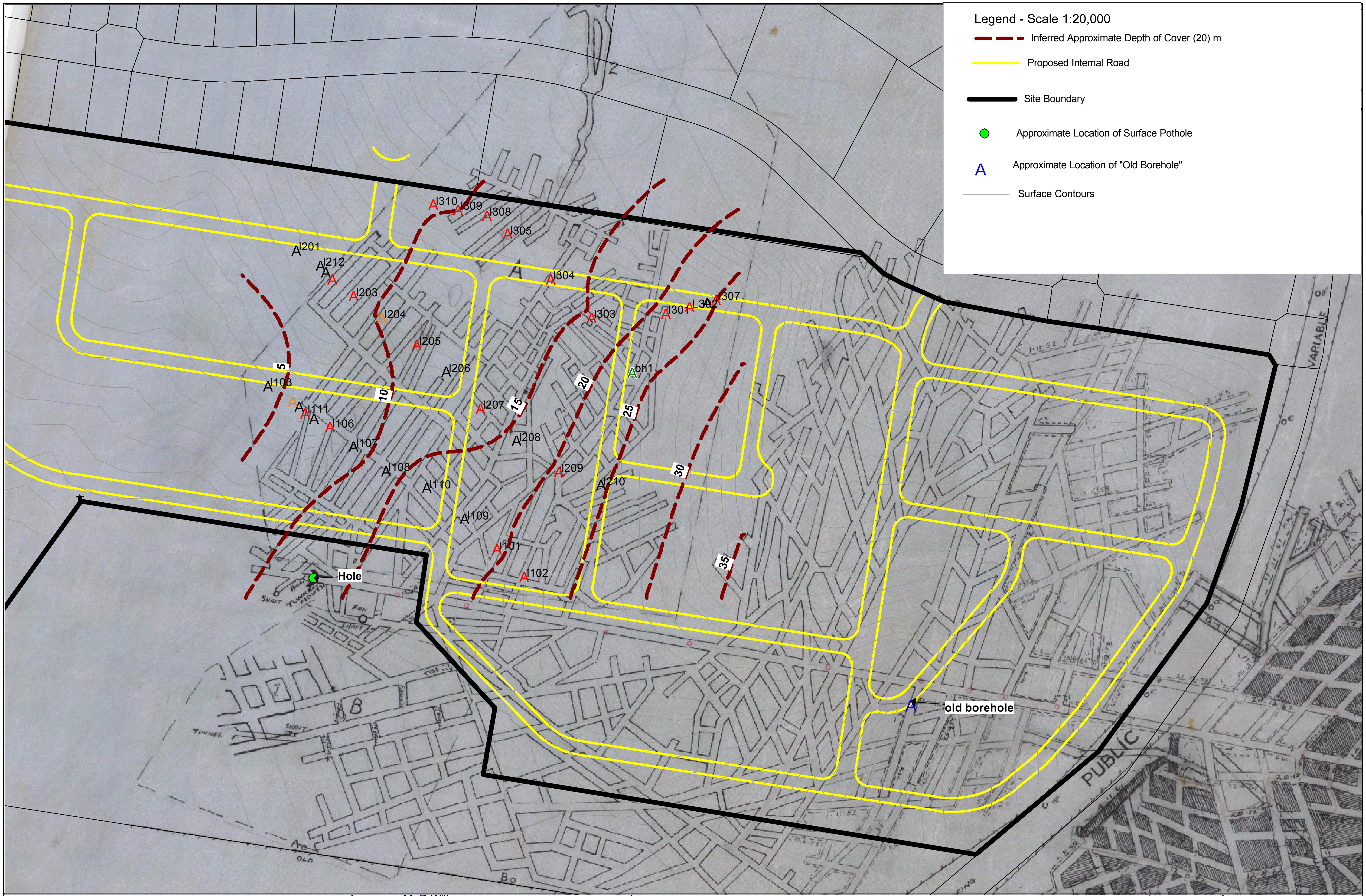
Mine Subsidence Assessment, Proposed Rezoning Lot 42, DP846326

Cnr of Wilton Drive and Mount Vincent Drive, East Maitland

PROJECT No: 81674

DRAWING No: 2

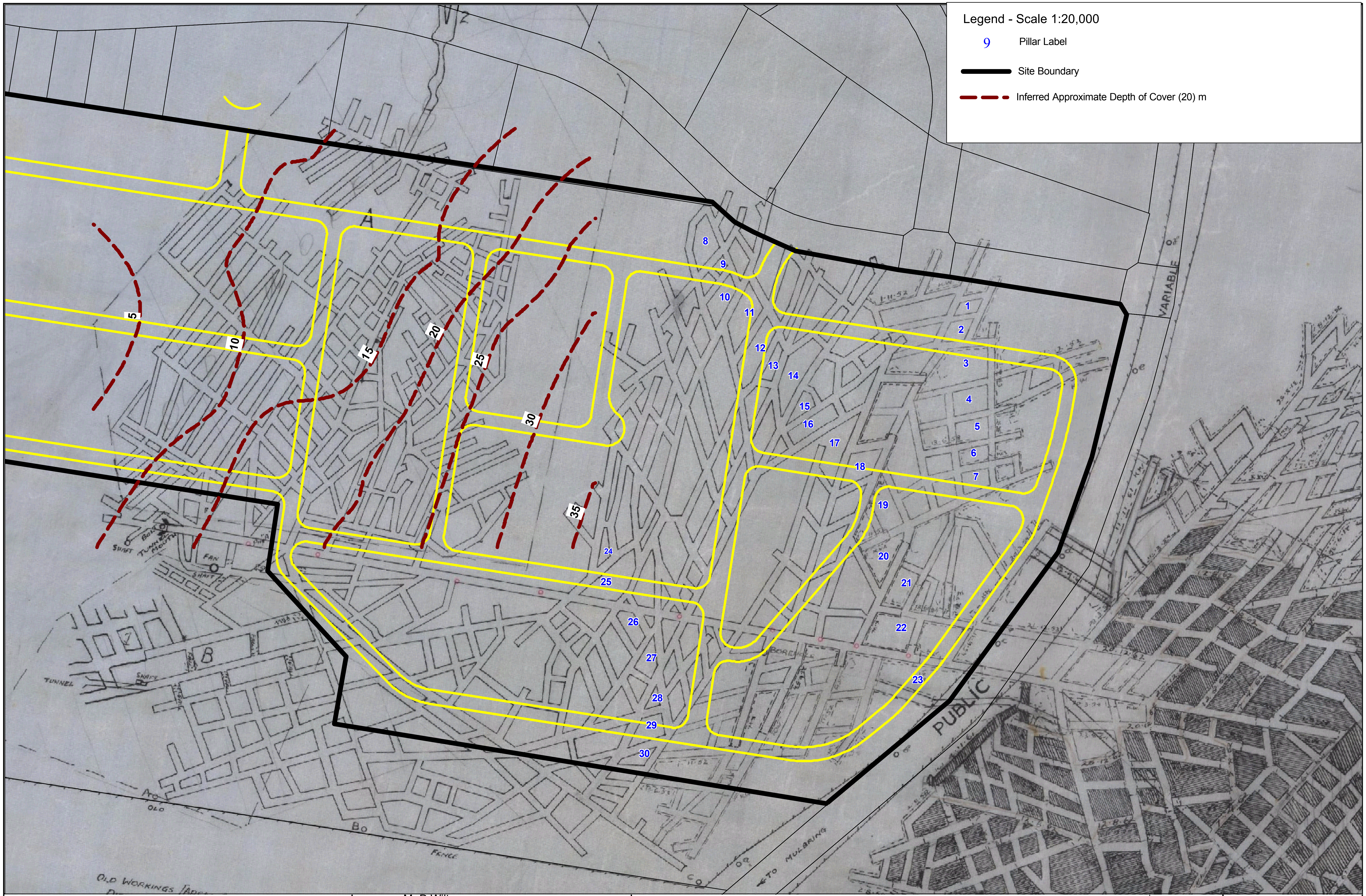
REVISION: 0



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Mr D Wilton C/- ACM Landmark		TITLE: **Inferred Approximate Depth of Cover**	PROJECT No: 81674
OFFICE: Newcastle	DRAWN BY: MRH	**Mine Subsidence Assessment, Proposed Rezoning Lot 42, DP846326**	DRAWING No: 3
SCALE: As shown	DATE: 25.3.2015	**Cnr of Wilton Drive and Mount Vincent Drive, East Maitland**	REVISION: 0

N
MGA



Douglas Partners
Geotechnics | Environment | Groundwater

CLIENT: Mr D Wilton C/- ACM Landmark	
OFFICE: Newcastle	DRAWN BY: MRH
SCALE: As shown	DATE: 25.3.2015

TITLE: **Pillar Labels**

Mine Subsidence Assessment, Proposed Rezoning Lot 42, DP846326

Cnr of Wilton Drive and Mount Vincent Drive, East Maitland

N
MGA

PROJECT No: 81674
DRAWING No: 4
REVISION: 0

Appendix D

Pillar Stability Analysis Results

Table D1 – Case 1

Table D2 – Case 2

TABLE D1 - CASE 1 - Pillars Stability Analysis - Borehole Seam Workings

Douglas Partners
Geotechnics · Environment · Groundwater

Mine Workings 603
Project: Subsidence Asessment
Location: East Maitland

Client: Mr. D. Wilton
Date: March 2015
Case 1

Project No: 81674

Pillar Id:	Comment	Depth	Seam Thickness	Working Section	Pillar Height Section	Unit Weigth	Pillar Details			Roadway Details		Extract. Ratio	Pillar Area	Total Area	Width/ Height Ratio	Width Modifier		Pillar Stress (Tributary)	Pillar Load (Tributary)	Abut (A) Yield (Y)	Shed Load	Lodad Received	Pillar Stress ("Yield")	Pillar Stress ("Abut")	Power Law			
		D (m)	(m)	H (m)	H (m)	γ (kN/m^3)	Width Wp (m)	Length Lp (m)	Internal Angle (°)	Wr (m)	Lr (m)	(%)	m^3	m^3	Wp/H	Θ_0	Θ	(MPa)	MN	(?)	MN	MN	(MPa)	(MPa)	Strength (MPa)	"Ultimate" Load MN	FoS	Probability of Failure
1		70.0	3.5	1.9	1.9	25	13.1	6.6	90.0	3.3	4.3	51.6	86.5	178.8	6.9	0.670	0.670	3.62	313						16.18	1399	4.47	2.2E-21
2		70.0	3.5	1.9	1.9	25	13.5	11.2	90.0	4.3	4.3	45.2	151.2	275.9	7.1	0.907	0.907	3.19	483						19.46	2942	6.09	1.7E-31
3		70.0	3.5	1.9	1.9	25	21.3	32.0	90.0	3.7	4.5	25.3	681.6	912.5	11.2	1.201	1.201	2.34	1597						41.72	28436	17.81	1.0E-104
4		70.0	3.5	1.9	1.9	25	13.5	20.8	90.0	4.1	4.0	35.7	280.8	436.5	7.1	1.213	1.213	2.72	764						22.56	6336	8.29	2.9E-45
5		70.0	3.5	1.9	1.9	25	12.7	19.6	90.0	3.5	3.9	34.6	248.9	380.7	6.7	1.214	1.214	2.68	666						21.27	5295	7.95	4.3E-43
6		70.0	3.5	1.9	1.9	25	8.9	17.5	90.0	4.5	3.7	45.2	155.8	284.1	4.7	1.326	1.172	3.19	497						16.58	2582	5.19	6.8E-26
7		70.0	3.5	1.9	1.9	25	11.0	15.7	90.0	4.9	4.1	45.1	172.7	314.8	5.8	1.176	1.163	3.19	551						18.51	3197	5.80	1.1E-29
8		70.0	3.5	1.9	1.9	25	15.0	16.2	90.0	3.9	5.0	39.4	243.0	400.7	7.9	1.038	1.038	2.89	701						23.41	5689	8.11	3.9E-44
9		40.0	3.5	1.9	1.9	25	6.6	7.7	90.0	4.4	4.4	61.8	50.8	133.1	3.5	1.077	1.012	2.62	133						13.21	671	5.04	6.0E-25
10		40.0	3.5	1.9	1.9	25	11.7	23.3	90.0	5.0	4.3	40.9	272.6	460.9	6.2	1.331	1.331	1.69	461						20.78	5665	12.29	3.1E-70
11		40.0	3.5	1.9	1.9	25	16.6	27.6	90.0	5.3	5.1	36.0	458.2	716.1	8.7	1.249	1.249	1.56	716						29.23	13391	18.70	2.7E-110
12		40.0	3.5	1.9	1.9	25	12.5	34.3	90.0	4.6	5.4	36.8	428.8	678.9	6.6	1.466	1.466	1.58	679						23.08	9897	14.58	1.5E-84
13		40.0	3.5	1.9	1.9	25	5.5	21.2	90.0	4.3	5.4	55.3	116.6	260.7	2.9	1.588	1.000	2.24	261						11.97	1395	5.35	7.1E-27
14		40.0	3.5	1.9	1.9	25	11.0	36.0	90.0	4.2	4.2	35.2	396.0	611.0	5.8	1.532	1.487	1.54	611						20.98	8310	13.60	2.0E-78
15		60.0	3.5	1.9	1.9	25	6.7	21.2	90.0	4.0	3.5	46.3	142.0	264.3	3.5	1.520	1.076	2.79	396						13.74	1951	4.92	3.5E-24
16		60.0	3.5	1.9	1.9	25	8.0	30.5	90.0	4.3	4.7	43.6	244.0	433.0	4.2	1.584	1.204	2.66	649						15.92	3885	5.98	8.1E-31
17		60.0	3.5	1.9	1.9	25	10.4	34.0	90.0	4.7	4.0	38.4	353.6	573.8	5.5	1.532	1.421	2.43	861						19.76	6985	8.12	3.8E-44
18		60.0	3.5	1.9	1.9	25	16.3	17.0	90.0	5.1	5.2	41.7	277.1	475.1	8.6	1.021	1.021	2.57	713						25.74	7134	10.01	5.4E-56
19		60.0	3.5	1.9	1.9	25	11.8	25.0	90.0	4.0	5.0	37.8	295.0	474.0	6.2	1.359	1.359	2.41	711						21.14	6236	8.77	3.0E-48
20		60.0	3.5	1.9	1.9	25	14.6	11.8	90.0	4.0	4.5	43.2	172.3	303.2	7.7	0.894	0.894	2.64	455						21.02	3621	7.96	3.4E-43
21		60.0	3.5	1.9	1.9	25	12.2	23.3	90.0	4.5	4.0	37.6	284.3	455.9	6.4	1.313	1.313	2.41	684						21.36	6071	8.88	6.5E-49
22		60.0	3.5	1.9	1.9	25	20.5	24.5	90.0	4.9	4.1	30.9	502.3	726.4	10.8	1.089	1.089	2.17	1090						37.27	18718	17.18	8.7E-101
23		60.0	3.5	1.9	1.9	25	15.0	39.0	90.0	4.8	4.2	31.6	585.0	855.4	7.9	1.444	1.444	2.19	1283						27.70	16207	12.63	2.3E-72
24		40.0	3.5	1.9	1.9	25	4.5	19.0	90.0	4.3	5.0	59.5	85.5	211.2	2.4	1.617	1.000	2.47	211						10.80	924	4.37	9.4E-21
25		40.0	3.5	1.9	1.9	25	13.4	27.0	90.0	3.8	6.5	37.2	361.8	576.2	7.1	1.337	1.337	1.59	576						23.53	8514	14.78	8.9E-86
26		50.0	3.5	1.9	1.9	25	9.6	26.0	90.0	4.4	5.4	43.2	249.6	439.6	5.1	1.461	1.296	2.20	550						18.00	4494	8.18	1.5E-44
27		60.0	3.5	1.9	1.9	25	6.5	15.5	90.0	3.8	5.0	52.3	100.8	211.2	3.4	1.409	1.049	3.14	317						13.35	1345	4.25	5.7E-20
28		60.0	3.5	1.9	1.9	25	6.0	7.0	90.0	4.5	5.3	67.5	42.0	129.2	3.2	1.077	1.004	4.61	194						12.53	526	2.72	2.1E-10
29		60.0	3.5	1.9	1.9	25	13.2	16.1	90.0	4.8	5.5	45.3	212.5	388.8	6.9	1.099	1.099	2.74	583						20.98	4459	7.65	3.3E-41
30		60.0	3.5	1.9	1.9	25	7.8	15.2	90.0	4.6	5.4	53.6	118.6	255.4	4.1	1.322	1.108	3.23	383						15.07	1787	4.66	1.4E-22
												Total	7769.6	12817.2														

Notes:

1. Pillar stability analysis based on the methods of Galvin, Hebbelwhite, Salamon and Lin (1998) UNSW Mining Research Centre Report RR3/98.
2. Relationship between Factor of Safety (FoS) and probability of coal pillar failure is based on interpolation and extrapolation of data in the above publication. It should be noted that the probability of failure does not extend beyond a FoS of 2.11 (equivalent to a probability of failure of 1 in 1,000,000) in the above and therefore probabilities of failure for FoSs above this are an extrapolation based on a curve of best fit for data for FoSs of 2.11 and less
3. Load on weaker pillars reduced by 30% as discussed in “Prefailure Pillar Yielding”, by Agapto and Goodrich (2002) Load transferred to adjacent pillars.

Summary		FoS
	Max	18.70
	Min	2.72
	Mean	8.81

Panel Factor of safety Based on Tributary load

Panel Extraction Ratio 0.39

Total Pillar Load 18087.84 MN

TABLE D2 - CASE 2 - Pillars Stability Analysis - Borehole Seam Workings

Douglas Partners
Geotechnics · Environment · Groundwater

Mine Workings 603
Project: Subsidence Asessment
Location: East Maitland

Client: Mr. D. Wilton
Date: March 2015
Case 2

Project No: 81674

Pillar	Comment	Depth	Seam	Working	Pillar Height	Unit	Pillar Details			Roadway Details		Extract.	Pillar	Total	Width/	Width Modifier		Pillar	Pillar		Shed	Lodad	Pillar	Pillar	Power Law			
Id:		D (m)	Thickness (m)	Section H (m)	Section H (m)	Weigth γ (kN/m^3)	Width Wp (m)	Length Lp (m)	Internal Angle (°)	Wr (m)	Lr (m)	Ratio (%)	Area m^3	Area m^3	Height Ratio Wp/H	Θ_0	Θ	Stress (Tributary) (MPa)	Load (Tributary) MN	Abut (A) Yield (Y) (?)	Load MN	Received MN	Stress ("Yield") (MPa)	Stress ("Abut") (MPa)	Strength (MPa)	"Ultimate" Load MN	FoS	Probability of Failure
1		70.0	3.5	3.5	3.5	25	12.1	5.6	90.0	4.3	5.3	62.1	67.8	178.8	3.5	0.633	0.933	4.62	313						10.33	700	2.24	2.0E-07
2		70.0	3.5	3.5	3.5	25	12.5	10.2	90.0	5.3	5.3	53.8	127.5	275.9	3.6	0.899	0.980	3.79	483						10.77	1374	2.85	3.3E-11
3		70.0	3.5	3.5	3.5	25	20.3	31.0	90.0	4.7	5.5	31.0	629.3	912.5	5.8	1.209	1.193	2.54	1597						15.35	9663	6.05	3.0E-31
4		70.0	3.5	3.5	3.5	25	12.5	19.8	90.0	5.1	5.0	43.3	247.5	436.5	3.6	1.226	1.040	3.09	764						11.10	2748	3.60	6.5E-16
5		70.0	3.5	3.5	3.5	25	11.7	18.6	90.0	4.5	4.9	42.8	217.6	380.7	3.3	1.228	1.024	3.06	666						10.65	2318	3.48	3.6E-15
6		70.0	3.5	3.5	3.5	25	7.9	16.5	90.0	5.5	4.7	54.1	130.4	284.1	2.3	1.352	1.000	3.81	497						8.62	1123	2.26	1.5E-07
7		70.0	3.5	3.5	3.5	25	10.0	14.7	90.0	5.9	5.1	53.3	147.0	314.8	2.9	1.190	1.000	3.75	551						9.72	1428	2.59	1.3E-09
8		70.0	3.5	3.5	3.5	25	14.0	15.2	90.0	4.9	6.0	46.9	212.8	400.7	4.0	1.041	1.014	3.30	701						11.61	2471	3.52	1.9E-15
9		40.0	3.5	3.5	3.5	25	5.6	6.7	90.0	5.4	5.4	71.8	37.5	133.1	1.6	1.089	1.000	3.55	133						7.23	271	2.04	3.7E-06
10		40.0	3.5	3.5	3.5	25	10.7	22.3	90.0	6.0	5.3	48.2	238.6	460.9	3.1	1.352	1.006	1.93	461						10.09	2407	5.22	4.6E-26
11		40.0	3.5	3.5	3.5	25	15.6	26.6	90.0	6.3	6.1	42.1	415.0	716.1	4.5	1.261	1.119	1.73	716						12.91	5357	7.48	3.6E-40
12		40.0	3.5	3.5	3.5	25	11.5	33.3	90.0	5.6	6.4	43.6	383.0	678.9	3.3	1.487	1.038	1.77	679						10.64	4073	6.00	6.3E-31
13		40.0	3.5	3.5	3.5	25	4.5	20.2	90.0	5.3	6.4	65.1	90.9	260.7	1.3	1.636	1.000	2.87	261						6.47	588	2.25	1.6E-07
14		40.0	3.5	3.5	3.5	25	10.0	35.0	90.0	5.2	5.2	42.7	350.0	611.0	2.9	1.556	1.000	1.75	611						9.72	3401	5.57	3.3E-28
15		60.0	3.5	3.5	3.5	25	5.7	20.2	90.0	5.0	4.5	56.4	115.1	264.3	1.6	1.560	1.000	3.44	396						7.29	840	2.12	1.1E-06
16		60.0	3.5	3.5	3.5	25	7.0	29.5	90.0	5.3	5.7	52.3	206.5	433.0	2.0	1.616	1.000	3.14	649						8.10	1673	2.58	1.6E-09
17		60.0	3.5	3.5	3.5	25	9.4	33.0	90.0	5.7	5.0	45.9	310.2	573.8	2.7	1.557	1.000	2.77	861						9.41	2920	3.39	1.2E-14
18		60.0	3.5	3.5	3.5	25	15.3	16.0	90.0	6.1	6.2	48.5	244.8	475.1	4.4	1.022	1.010	2.91	713						12.13	2970	4.17	1.8E-19
19		60.0	3.5	3.5	3.5	25	10.8	24.0	90.0	5.0	6.0	45.3	259.2	474.0	3.1	1.379	1.009	2.74	711						10.15	2631	3.70	1.5E-16
20		60.0	3.5	3.5	3.5	25	13.6	10.8	90.0	5.0	5.5	51.6	146.9	303.2	3.9	0.885	0.965	3.10	455						11.16	1639	3.60	6.0E-16
21		60.0	3.5	3.5	3.5	25	11.2	22.3	90.0	5.5	5.0	45.2	249.8	455.9	3.2	1.331	1.019	2.74	684						10.39	2596	3.80	3.8E-17
22		60.0	3.5	3.5	3.5	25	19.5	23.5	90.0	5.9	5.1	36.9	458.3	726.4	5.6	1.093	1.079	2.38	1090						14.19	6504	5.97	9.9E-31
23		60.0	3.5	3.5	3.5	25	14.0	38.0	90.0	5.8	5.2	37.8	532.0	855.4	4.0	1.462	1.135	2.41	1283						12.30	6545	5.10	2.6E-25
24		40.0	3.5	3.5	3.5	25	3.5	18.0	90.0	5.3	6.0	70.2	63.0	211.2	1.0	1.674	1.000	3.35	211						5.69	358	1.70	5.0E-04
25		40.0	3.5	3.5	3.5	25	12.4	26.0	90.0	4.8	7.5	44.0	322.4	576.2	3.5	1.354	1.056	1.79	576						11.15	3595	6.24	2.0E-32
26		50.0	3.5	3.5	3.5	25	8.6	25.0	90.0	5.4	6.4	51.1	215.0	439.6	2.5	1.488	1.000	2.56	550						9.00	1934	3.52	2.0E-15
27		60.0	3.5	3.5	3.5	25	5.5	14.5	90.0	4.8	6.0	62.2	79.8	211.2	1.6	1.450	1.000	3.97	317						7.16	571	1.80	1.1E-04
28		60.0	3.5	3.5	3.5	25	5.0	6.0	90.0	5.5	6.3	76.8	30.0	129.2	1.4	1.091	1.000	6.46	194						6.82	205	1.06	3.8E-01
29		60.0	3.5	3.5	3.5	25	12.2	15.1	90.0	5.8	6.5	52.6	184.2	388.8	3.5	1.106	1.016	3.17	583						10.84	1997	3.43	7.8E-15
30		60.0	3.5	3.5	3.5	25	6.8	14.2	90.0	5.6	6.4	62.2	96.6	255.4	1.9	1.352	1.000	3.97	383						7.98	771	2.01	5.4E-06
												Total	6808.4	12817.2														

Notes:

1. Pillar stability analysis based on the methods of Galvin, Hebbelwhite, Salamon and Lin (1998) UNSW Mining Research Centre Report RR3/98.
2. Relationship between Factor of Safety (FoS) and probability of coal pillar failure is based on interpolation and extrapolation of data in the above publication. It should be noted that the probability of failure does not extend beyond a FoS of 2.11 (equivalent to a probability of failure of 1 in 1,000,000) in the above and therefore probabilities of failure for FoSs above this are an extrapolation based on a curve of best fit for data for FoSs of 2.11 and less
3. Load on weaker pillars reduced by 30% as discussed in “Prefailure Pillar Yielding”, by Agapto and Goodrich (2002) Load transferred to adjacent pillars.

Summary		FoS
	Max	7.48
	Min	1.06
	Mean	3.64

Panel Extraction Ratio 0.47

Panel Factor of safety Based on Tributary load

Total Pillar Load 18087.84 MN