Report on Geotechnical Investigation

442 Louth Park Road Residential Subdivision

81022027-002.1

Prepared for
NewPro25 Pty Ltd

8 November 2022

Cardno
now
Stantec

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Our report is based on information made available by the client. The validity and comprehensiveness of supplied information has not been independently verified and, for the purposes of this report, it is assumed that the information provided to Cardno is both complete and accurate. Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, changes may occur to the site conditions, the site context or the applicable planning framework. This report should not be used after any such changes without consulting the provider of the report or a suitably qualified person.

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Tables

1 Introduction

This report presents the results of a geotechnical investigation undertaken by Cardno now Stantec Australia Pty Ltd (Stantec) for a proposed subdivision at Lot 2 DP1286289, Louth Park NSW (the ‘site’). At the time of investigation and planning the site was referred to as portion of Lot 1, DP221762 (original parent lot) at address 442 Louth Park Road, Louth Park. The parent lot has since been subdivided. The address for the site has been assumed to be 442 Louth Park Road for the purpose of reporting, logs and drawings. This address is likely to change in the future as a result of the subdivision. The site can be seen depicted in Drawing 1 and 2 attached in Appendix A.

Stantec were supplied with Development Application (DA) civil plans prepared by GCA Engineering Solutions Pty Ltd to assist with the investigation and report (Project No. 21360C, Dwg No. C01-C29, Rev. 1, Dated. 04/11/2022).

Based on the supplied documentation, it is understood that the proposed development is to comprise;

- Creation of thirty-one (31) rural-residential allotments (101-131);
- Construction of three (3) internal road pavement sections with total length of approximately 580 m. The proposed internal road layout will connect to the existing Hillview residential subdivision to the west (Collaroy Parade);
- A series of concrete driveways providing access to allotments; and
- Grassed line perimeter swales traversing the east and west boundaries are proposed to collect surface water towards two bioretention swales in the northern portion of the site. Surface water flows will then be directed to the north of the site, ultimately to the constructed stormwater quality basin associated with the Stage 1 of Hillview Estate to the west.

It is understood that as part of the development an existing rural dam at the northern boundary of the site will require decommissioning.

The purpose of this investigation was to obtain geotechnical information on subsurface conditions as a basis for the following comments and recommendations:

- Preliminary site classifications of the proposed lots in accordance with AS 2870-2011: Residential Slabs and Footings [1];
- Pavement thickness design for the proposed internal road sections;
- Comment on founding conditions for residential structures; and
- Recommendations for earthwork procedures and guidelines including decommissioning of existing rural farm dams.

The works were commissioned by Tom Goold of NewPro25 Pty Ltd.

2 Previous Investigation and Background

Cardno (NSW/ACT) Pty Ltd (Cardno) have previously undertaken geotechnical assessment both in the current site and adjacent subdivision to the west (Hillview Estate).

2.1 Current Site

Cardno (prior to Stantec) have previously undertaken a series of walkovers and assessments to assess the feasibility of the subdivision development with respect to historic mine workings at the site. In 2021, Cardno undertook a mine subsidence assessment at the site [2], assessing the proposed development with respect to the Subsidence Advisory (SA) NSW Subdivision Assessment Policy [3]. For details on the mine history, investigation findings and assessment, reference should be made to the previous Cardno report under reference *81022027-001.1* [2].

The assessment comprised review of a mine tracing extract (RT318 Sheet 1) from a previous Coffey assessment undertaken on the adjacent property to the west [4]. Based on the review, the proposed subdivision is underlain by historic mine workings of the Rathluba Seam at depths ranging from 0 m (centre of the site) up to approximately 45 m in the south-east corner.

The assessment comprised an intrusive drilling program, downhole camera work and a pillar stability assessment with proposed remedial outcomes depending on the cover depth to the historic workings;

- 0 to 16 m cover depth and former shaft – Elimination of subsidence risk via means such as earthworks or mass infill grouting operations (or a combination of the two); and
- Greater than 16 m cover depth – relevant allotments burdened by estimated subsidence impact parameters.

SA NSW accepted Cardno’s recommendations in the form of a conditional approval on 3 February 2022 [5].

An extract of the mine tracing (RT318 Sheet 1) from the Coffey assessment [4] and previous boreholes can be seen depicted on Drawing 3 attached in Appendix A.

2.2 Hillview Estate

Cardno have also undertaken numerous investigations in the adjacent subdivision to the west for the purpose of providing comments and recommendation for pavement design, site classification, advice on basin construction and decommissioning, earthworks recommendations, construction support and mine impact assessment.

Over-excavation of mine workings was undertaken during Stage 6 of the Hillview development, located adjacent the boundary to the current site.

Relevant data and knowledge from involvement in the adjacent development to the west will be utilised (where appropriate) within the current investigation.

3 Site Description

The site is referred to Lot 2 of DP1286289 with assumed address 442 Louth Park Road, Louth Park NSW. The site is irregular in shape and is bound by existing Louth Park residential development to the west, existing rural development to the east, existing rural development and Louth Park Road to the north and undeveloped open-pasture to the south.

Topographically, the site is situated on generally north facing slopes associated with an east-west trending ridgeline to the south of the site. Two north-trending gulley lines comprising intermittent farm dams are located closely east of the site and in the northwest portion of the site. These gully lines and the site slopes fall and drain to a detention basin northwest of the site, constructed during Stage 1 of the adjacent Hillview development. From the basin, flows traverse to the intersection of Louth Park Road and Dagworth Road and ultimately to the low-lying alluvial floodplains to the north-east.

The following features were also observed at the time of site investigation:

- With the exception of localised falls to the gulley's (east and west trending), the overall site surfaces were measured as sloping generally to the north at slopes in the order of approximately 3-5°. Locally steeper and more level slopes were noted towards the gully lines. General site slopes graded from approx. 5◦ in the southern portion to flatter (approx. 3◦) in the north.
- Vegetation across the site at the time of the fieldwork predominantly comprised unmaintained grass with scattered stands of trees throughout the site ranging from saplings to mature.
- An existing farm dam at the north-western boundary in the envelope of the noted gulley line. The farm dam was noted to be currently holding water with a constructed dam wall estimated to be in the order of 3 m high. The upstream gulley was also noted to have elevated moisture conditions likely a result of recent wet weather patterns. An overflow path was noted in the eastern portion of the basin with slow running water observed.
- Rutting marks in recently tracked areas indicating elevated moistures of surficial soils as a result of prolonged inclement weather preceding the investigation.
- Evidence of a backfilled former air shaft approximately 5 m in diameter noted in the south-western portion of the site surrounded by an old timber wire fence. Review of the mine tracings in Cardno's previous assessment [2] indicates a former air shaft in the south- western portion of the site (mapped as SH3 in Coffey Report [4]).The shaft has evidently been backfilled with site-won material with a small open void indicating piping, consolidation of the backfill or wildlife activity (animal burrow).
- Evidence of minor uncontrolled filling (including coal chitter and concrete) in isolated areas within the central eastern portion of the site based on observed changes in grade and small undulations. Indications of minor subsidence in uncontrolled filling was observed in the eastern portion of the site. It is expected that based on review of mine tracings this is a subsidence feature associated with the former drift entrance to the mine.
- Indications of concentrated overland flows resulting in minor erosion.
- A range of existing boreholes cased with capped pvc piping across the site associated with the drilling program of Cardno's previous mine assessment [2].
- Barb-wire farm fencing traversing across the site in the northern portion as well as the Lot's perimeter boundaries.

Approximate locations and details of key site features can be seen depicted on Drawing 2 attached in Appendix A.

4 Investigation Methodology

4.1 Site Investigation

The current site investigation was undertaken on the 7th of April 2022 and comprised the following:

- Excavation of thirteen (13) test pits (TP01 - TP13) across the proposed lots and road alignments with a 13.5t excavator fitted with a 900 mm wide toothed bucket. All test pits refused prior to the target depth of on shallow weathered rock at depths ranging from 1.1 to 1.7 m below ground level (bgl) with the exception of TP03, TP09 and TP13 which were excavated to 2.0 m bgl (target depth).
- Dynamic Cone Penetrometer (DCP) testing was undertaken at each test pit (where possible) to assess subsurface strength properties.
- An additional three (3) DCP tests (DCP1 to DCP3) were undertaken downslope of the existing farm dam north of the site. The DCP's were undertaken in order to estimate the likely depth of moisture impacted material that would require removal during the dam decommissioning.
- Logging of relevant surface features.
- All test pits were backfilled with excavated spoil on completion.
- Bulk, disturbed and thin walled (U50 tubes) samples were taken for subsequent laboratory assessment.

Field investigation, including logging of subsurface profiles and collection of samples, was carried out by a geologist from Stantec. Test pits were located using a kmz file generated by overlaying proposed test pits onto the supplied development extents. It is expected that test pit accuracy would be in the range of +/- 5 m. The locations of test pits are shown on Drawing 1 and Drawing 2, attached in Appendix A of this report. Subsurface conditions are summarised in the Section 5.2 and detailed in the engineering logs attached in Appendix B, together with explanatory notes.

4.2 Laboratory Testing

Geotechnical laboratory testing on selected samples recovered in the investigation comprised:

- Four (4) Shrink Swell tests to measure soil volume change over an extreme soil moisture content range; and
- Three (3) four-day soaked California Bearing Ratio (CBR) tests for subgrade strength assessment.

The geotechnical testing was conducted by an external NATA accredited construction material testing laboratory with detailed test report sheets attached in Appendix C.

5 Investigation Findings

5.1 Published Data

5.1.1 Acid Sulfate Soil Risk Maps

A review of NSW Government online planning portal [6] indicated the site is mapped as being within a Class 5 (ASS) area. ASS is typically not found within Class 5 areas and are classified as Class 5 as they are located within 500 metres on adjacent class 1,2,3 or 4 land.

5.1.2 Geological Mapping

Reference to the New South Wales Seamless Geology dataset [7] indicates the site is underlain by the Tomago Coal Measures (**Pto**) of the Singleton Supergroup. The formation is known to comprise *'very fine-to-medium-grained grey lithic sandstone, (sporadically interbedded with) laminated to carbonaceous shale and mudstone, siltstone, coal with sporadic interbeds of carbonaceous shale, claystone, sideritic bands, rare pebble paraconglomerate'* and residuals derived by the weathering of these.

5.1.3 Mine Subsidence

A review of the site on NSW Government's online Planning Portal "ePlanning Spatial viewer" [6], indicates that the site is subject to SA NSW Surface Development Guideline 7 [3].

With reference to Subsidence Advisory NSW Development Guidelines, Guideline 7 applies to *"properties within mine subsidence districts where special consideration of the likely subsidence issues is required prior to approval of development. This includes properties assessed as being at risk of subsidence with unknown or severe parameters, properties affected by shallow mine entries or shafts, and properties that are only partially undermined."* [8].

Based on SA NSW Guideline 7 [8], any development at the site is to be assessed by SA NSW risk engineers to consider suitability of the development.

All development at the site shall be undertaken in consultation with SA NSW and in accordance with any conditions imposed on properties. As indicated in Section 2.1, Cardno have undertaken mine investigation at the site with the likely remediation comprising grouting/over-excavation of shallow mine working areas and design mitigation measures (parameters) for deeper mine working areas.

5.2 Subsurface Conditions

The subsurface conditions encountered across the site generally consisted of the following profile:

- UNCONTROLLED FILL: Silty Gravelly SAND fill material encountered in TP11 to a depth of 0.4 m bgl. The fill material was noted to be variable, containing coal chitter and was moist in condition. A nominal 100 mm of material heavily impacted by organics overlaid the filling material given the assumed age. OR
- TOPSOIL: Clayey Sandy / Sandy SILT and Silty SAND surficial material with trace rootlets of thickness generally in the order of 100 to 150 mm in all test pits except TP11. overlying
- COLLUVIUM: Clayey Sandy / Sandy SILT with variable gravel content encountered in all test pits except TP11 to depths ranging from 0.2 to 0.3 m bgl; Thicker Colluvium deposits in the order of 0.5 m bgl were encountered in TP13 in proximity to the gulley line in the north-west and are of a possible alluvium origin. The colluvium materials were generally moist to wet and off soft to firm consistency as a result of inclement weather preceding the investigation. Overlying
- RESIDUAL: Sandy / Silty Sandy CLAY with occasional trace gravel encountered in all test pits to depths ranging from 0.6 to 1.0 m bgl. The residual clays were predominantly medium to high in plasticity, firm to very stiff in consistency (based on DCP blow counts) and in a moisture condition above to equal to plastic limit based on tactile assessment; overlying
- EXTREMELY WEATHERED MATERIAL: Extremely weathered sandstone and/or siltstone encountered in all test pits typically consistent with a very stiff to hard Silty / Silty Sandy / Silty Gravelly / Sandy Gravelly CLAY and dense to very dense Clayey SAND (based on DCP blow counts and excavation resistance) encountered to depths ranging from 1.1 to 2.0 m bgl (Target depth). The materials were

generally medium in plasticity (clays), in a moisture dry of plastic limit (dry to moist), exhibited evidence of rock structure and occasionally contained gravels of parent rock. Overlying

> WEATHERED ROCK: The residual and extremely weathered materials generally graded with depth to more competent underlying rock with bucket refusal encountered on low strength (or stronger) sandstone or siltstone rock (excluding TP03, TP09 and TP13) at depths ranging from 1.1 to 1.7 m bgl. At few locations, excavation advancement through weathered rock (typically very low strength) could be achieved for 0.4 m or less before refusing.

Elevated moisture conditions were noted in surficial soils across the site as a result of prolonged rainfall events during the months preceding the investigation.

No groundwater or seepage was encountered in the test pits at the time of fieldwork. It should be noted that groundwater levels are likely to fluctuate with variations in climatic and site conditions, particularly in proximity to overland drainage paths and the gulley line to the north-west.

The subsurface conditions are detailed in the engineering logs attached in Appendix B together with explanatory notes.

In addition to the test pits, three (3) additional DCP (DCP1-DCP3) test were conducted downstream of the existing farm dam (depicted on Drawing 1 and Drawing 2). The DCPs were undertaken in the overflow path to assess the presence of moisture impacted material and aid in assessing additional stripping depth that may be required beyond topsoils. No DCPs were undertaken within the dam impoundment due to access and safety issues.

The DCPs generally indicated (based on blow counts), saturated soils of lower strength to approximately 0.3 to 0.45 m bgl with soil strength increasing with depth. DCP results can be seen reported in Appendix B.

5.3 Laboratory Results

5.3.1 Geotechnical Laboratory Results

5.3.1.1 Shrink Swell Test Results

The results of the laboratory shrink swell tests undertaken on samples representative of the clayey soils at the site are summarised below in Table 5-1 with the test report sheets attached in Appendix C.

Table 5-1 Summary of Shrink Swell Test Results

Pit ID	Depth (m)	Sample Type	Soil Type	Swell Strain (Esw %)	Shrinkage Strain (Esh %)	Shrink/Swell Index (Iss %)
TP02	0.3 – 0.7	U50	Silty Sandy CLAY	1.1	4.2	**2.6**
TP03	0.4 – 0.9	U50	Silty CLAY	0.8	4.5	**2.7**
TP08	0.4 – 0.8	U50	Silty CLAY	0.3	3.7	**2.1**
TP12	0.3 – 0.5	D	Sandy CLAY	-0.1	1.4	**0.8**

Notes to table:
U50: Testing undertaken on thin walled 50mm diameter tube
D: Disturbed sample to be remoulded for shrink swell test

5.3.1.2 California Bearing Ratio Test Results

The results of the standard compaction four (4) day soak CBR testing undertaken on representative samples of possible road pavement subgrade materials are summarised below in Table 5-2 with the laboratory report sheets attached in Appendix C.

Table 5-2 Summary of CBR Test Results

ID	Depth (m)	Material Description	W (%)	SOMC (%)	SMDD (%)	Swell (%)	CBR (%)
TP04	0.3 – 0.5	Silty CLAY	21.7	19.0	1.61	2.0	**3.5**
TP09	1.2 – 1.4	Silty CLAY w gravel (XWM)	11.7	16.0	1.80	0.5	**10.0**
TP10	0.3 – 0.6	Silty CLAY	21.6	18.0	1.72	2.0	**4.0**

Notes to table:
XWM: Extremely Weathered Rock Material
W: Field Moisture Content
SOMC: Standard Optimum Moisture Content and SMDD: Standard Maximum Dry Density

6 Comments and Recommendations

6.1 Earthworks

Based on supplied Regrade and long section plans, internal road pavements comprise predominantly cutting generally in the order of less than 1.0 m deep (including pavement boxout). The Western portion of Road 10 will require cuts in the order of 2.0 m deep (including pavement boxout) to accommodate site levels with other sections of pavements (including driveways) with cuts anticipated in the order of 1.0 to 1.5 m deep.

Deeper cuts to those stated above are also anticipated for the installation of in ground services (i.e. stormwater and sewer). Excavations will also be required for over-excavation of deleterious material including decommission of the existing farm dam.

Earthworks methodologies associated with remediating mine workings are proposed with details to be reported under separate cover (reference - *81022027-003.0*). It is envisaged that where shallow mine workings at the site are remediated via earthworks operations, significant excavations will be required. The extent of the potential mine remediation earthworks is shown depicted on Drawing 4 in Appendix A. At the present time, there is a potential for the extent of the mine excavations to be altered with other remediations considered i.e. grouting. However, as a minimum, the existing filling in the former drift will be removed to a depth of approximately 5 m below existing ground levels based on review of the mine plans and observations.

6.1.1 Excavations

Based on the likely depths of cut and encountered subsurface conditions at the test pit locations, excavations are expected to be undertaken within the existing fill, alluvium, colluvium, residual soils, and weathered rock profile. Excavations into the existing fill, alluvium, colluvium and residual soils are expected to be readily undertaken utilising conventional earthmoving equipment, such as backhoes and small excavators.

During the current investigation, when using a 13.5-tonne excavator with a 900 mm toothed bucket attachment, refusal was encountered within the weathered rock profile in majority of the test pits at depths ranging from 1.1 – 1.7 m bgl. Based on the anticipated excavations outlined above, bedrock is expected to be encountered during construction, particularly in areas of deeper cut for proposed in ground service excavations and road box out including the western portion of Road 10. Based on experience during construction of the adjacent Hillview Estate development, during deeper stormwater, sewer installation and mine remediation works, a significant amount of excavations within high strength sandstone is likely.

Considering the variable rock depth encountered at the test locations across site, it would be considered prudent to make allowance for hydraulic rock hammer excavation or use of large capacity excavators with a single ripper attachment.

Excavations or trenches in the colluvium soils, residual stiff or better soils and the weathered rock profile could be expected to stand close to vertical in the short-term. Unsupported excavations into the natural site soils will likely be subject to local slumping if elevated groundwater conditions exist and seepage occurs (e.g. after sustained periods of wet weather and in proximity to the gulley line). Should areas of instability or significant groundwater flows be encountered during excavation, a suitably qualified geotechnical engineer should inspect the excavations with respect to stability.

Where personnel are to enter excavations, options for short-term excavations include benching or battering back of the excavations at 1H:1V or the support of excavations within the residual soil and extremely weathered rock profile. Short-term excavations within the more competent rock may be battered at steeper than 1H:1V and may not require support, however this would be subject to specific geotechnical assessment.

It is recommended that long-term excavations should be either battered at 2H:1V or flatter and protected against erosion or be supported by engineer designed and suitably constructed retaining walls. Excavations may be battered steeper than 2H:1V in rock materials, subject to specific geotechnical assessment.

6.1.2 Filling

Based on review of the supplied DA plans, filling is proposed in proposed Lots 128-131, with fill depths in the order of up to 3.0 anticipated associated with filling of the existing farm dam and gulley. Filling is also required for the eastern verges of Road 10 and portions of Collaroy Parade with depths up to 1.0 m. In addition to the filling shown on the DA plans, filling will also be required where the historic mine workings are over-excavated. The approximate extent can be seen on Drawing 4 attached in Appendix A.

Fill should be placed and compacted in accordance with AS 3798-2007 *Guidelines on Earthworks for Commercial and Residential Developments* [9].

It is expected that construction of fill platforms during bulk earthworks, which would be suitable to support structural loads associated with residential developments would include the following:

- Removal of any existing uncontrolled fill, stockpiles, topsoil, colluvium or deleterious materials from the areas where fill is to be placed. Any unsuitable material including foreign matter must be removed from the fill areas.
- It is noted that the former drift to mine workings has been backfilled. A portion, as minimum of remedial works, will required removal. As part of the remedial works, any fill removed from the former drift will need to be assesses both Geotechnically and environmentally for either reuse onsite or off-site disposal in accordance with regulatory requirements. This would also be required for any backfill material removed from the former shaft.
- Breaching and draining of any ponded water within the existing rural farm dam and gulley line as soon as practical to allow any sediment to dry as much as possible prior to construction/removal. Assessment of the dam and associated sediment should be undertaken during construction by a suitable consultant.
- Stripping within the existing rural farm dam and gulley line footprints. It should be noted that the removal of all sediment as well as dam walls from the development area is required. Inspection should be undertaken by a geotechnical consultant to confirm removal of all deleterious material. DCPs blow counts downstream of the existing dam indicate over-excavation may be required up to approximately 1.0 m. The extent of additional removal within the basin and downstream areas will be subject to geotechnical assessment during construction.
- The fill materials must be free of vegetation including tree stumps, roots, root fibres or other organic matter. Silts or material with high silt portions such as the colluvium material must be blended with other site soils to be used as fill.
- Fill should not comprise material with particle sizes of greater than 200 mm or 2/3 of the compacted layer thickness. On-site ripped rock may need to be treated to allow the reuse in road alignments and for general filling during bulk earthworks.
- Benching of the slopes where fill is to be placed with slopes steeper than 8H:1V will be required.
- Placement of fill in uniform horizontal layers with compaction of each layer to a minimum dry density ratio of 95% standard Compaction (AS 1289-5.5.1) at moisture contents in the order of 85-115% of SOMC or ±2% but generally as close to SOMC as practical. Over compaction should be avoided.
- Within the road alignment, subgrade formation should be in accordance with Section 7.3.1 and the moisture specification will need to be maintain at -2 to 0% of OMC.
- Specific requirements for filling associated with the mine remediation earthworks are contained under separate cover (*ref. 81022027-003*).

Where high reactivity material is used as fill, it should be placed a suitable distance from the surface to avoid the material impacting negatively on-site classifications. It is suggested that this material only be used in lots requiring filling of >1.0m, where the top 1.0 m of filling consists of lower reactivity material.

All fill should be battered at a slope of 2H:1V or preferably flatter and temporary erosion control should be provided. To prevent erosion in the long term, provision of protection by vegetation and with the provision of adequate drainage is also required. Where a batter of 2H:1V is not possible, the fill should be supported by an engineer designed and suitably constructed retaining walls.

Fill materials are expected to comprise of the following:

- Site won residual soils: Generally, soils excavated on site with the exception of topsoil and high silt content soils are considered suitable for reuse as engineering fill. All vegetation including tree stumps, roots, root fibres or other organic material should be removed from the site won materials. Given the density of the mature trees at the site, issues relating to removal of organics are likely. Additional work may be necessary including braking up of excavated clays and hand removal of roots.

- Site won ripped weathered rock: Generally, all site won ripped rock would be suitable for re-use following reconditions and grading for particle size requirements. It is recommended to use the sandstone material at levels close to the road subgrade.

Prior to removal of any excavated materials from the site, classification would be required in accordance with the EPA guidelines "Waste Classification Guidelines, Part 1: Classifying Waste" [10].

6.2 Preliminary Site Classification

Australian Standard AS 2870-2011 [1] established performance requirements and specific designs for common foundation conditions as well as providing guidance on the design of footing systems using engineering principles. Site classes are defined on Table 2.1 and 2.3 of AS 2870-2011 [1] and are presented in Table 6-1 below.

Table 6-1 General Definition of Site Classes

Site Class	Foundation	Characteristic Surface Movement
A	Most sand and rock sites with little or no ground movement from moisture changes	
S	Slightly reactive clay sites, which may experience only slight ground movement from moisture changes	0 - 20mm
M	Moderately reactive clay or silt sites, which may experience moderate ground movement from moisture changes	20 - 40mm
H1	Highly reactive clay sites, which may experience high ground movement from moisture changes	40 - 60mm
H2	Highly reactive clay sites, which may experience very high ground movement from moisture changes	60 - 75mm
E	Extremely reactive sites, which may experience extreme ground movement from moisture changes	> 75mm
A to P	Filled sites (refer to clause 2.5.3 of AS 2870)	
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise.	

Reactive sites are sites consisting of clayey soils that swell on wetting and shrink on drying, resulting in ground movements that can damage lightly loaded structures. The amount of ground movement is related to the physical properties of the clay and environmental factors such as climate, vegetation and watering. A higher probability of damage can occur on reactive sites where abnormal moisture conditions occur, as defined in AS 2870, due to factors such as:

- Presence of trees on the building site or adjacent site, removal of trees prior to or after construction, and the growth of trees too close to a footing. The proximity of mature trees and their effect on foundations should be considered when determining building areas within each allotment (refer to AS 2870);
- Failure to provide adequate site drainage or lack of maintenance of site drainage, failure to repair plumbing leaks and excessive or irregular watering of gardens;
- Unusual moisture conditions caused by removal of structures, ground covers (such as pavements), drains, dams, swimming pools, tanks etc.
- In regard to the performance of footings systems, AS 2870 states "…footing systems designed and constructed in accordance with this Standard on a normal site (see Clause 1.3.2) [1] that is:
- (a) not subject to abnormal moisture conditions; and
- (b) maintained such that the original site classification remains valid and abnormal moisture conditions do not develop;

> are expected to experience usually no damage, a low incidence of damage category 1 and an occasional incidence of damage category 2."

Damage categories are defined in Appendix C of AS 2870, which is reproduced in CSIRO Information Sheet BTF 18, *Foundation Maintenance and Footing Performance: A Homeowners Guide* [11].

The laboratory shrink-swell test results summarised in Table 5-1 indicate that the tested clay soils across and surrounding the site area generally range from slightly to moderately reactive with I_{ss} values in the range of 0.8% to 2.7%.

The classification of sites with controlled fill of depths greater than 0.8 m in sand and 0.4 m in material other than sand (i.e. deep fill) would be classified as Class P. An alternative classification may be given to sites with controlled fill where consideration is made to the potential movement of the fill and underlying soil based on the moisture conditions at the time of construction and the long-term equilibrium moisture conditions.

Trees located in proximity to allotments are a potential source of abnormal moisture conditions possibly leading to a Class P site classification. Upon removal of trees within proposed allotments across the site, sufficient time should be allowed for equilibrium of moisture conditions to be reached prior to founding of a structure.

A farm dam currently holding water and upstream gulley with elevated moisture conditions were noted in within portions of Lots 128 to 131. The lots burdened by farm dams would result in a Class P site classification in their current condition. However, during bulk earthworks, corrected treatment including breaching, draining, stripping and controlled filling in accordance with AS3798-2007 [9] should be undertaken and would likely achieved a more favourable site classification.

Former mine workings are also noted to be impacting lots 107-108, 111-115 and 118-124 in the southern portion. Lots that are burdened by the former mine activities would be classified as a Class P site in accordance with AS2870 [1] in their current state.

Based on the subsurface profiles encountered during the investigation, the above discussion, and in accordance with the AS2870-2011 [1], The proposed rural-residential lots (Lot 101-131) in their existing condition and in the absence of abnormal moisture conditions would be classified as outlined below in Table 6-2. Anticipated classifications have also been provided which would need confirmation after completion of earthworks.

Table 6-2 Preliminary Site Classification for proposed rural-residential Lots (101-131)

Preliminary Site Classification	Existing Condition Classification Lot Numbers	Anticipated Classification Lot Numbers
Class P	Lot 107-108, Lot 111-115 and Lot 118-124 (3) Lot 128-131(2)	Lot 112-115 and Lot 118-123 (5)
Class M – Moderately Reactive	Lot 101-106, Lot 109-110, Lot 116-117 and Lot 125-127	Lot 101-106, Lot 109-110, Lot 116-117 and Lot 125-128(1)
Class H1 – Highly Reactive	-	Lot 129-131(1) Lot 107-108, Lot 111 and Lot 124(4)

Table Note:

(1) This is the likely classifications based on the proposed regrade of the site as per supplied regrade plan. Filling depths have been interpreted off the regrade plan and assuming to be site won fill materials with a maximum Iss of 2.0%.

(2) Due to the presence of an existing rural farm dam and gulley within proposed lot envelopes resulting in abnormal moisture conditions. On the basis that the existing rural farm dam is suitably decommissioned and filled with controlled filling, the lots may be reclassified.

(3) Impacted by historical mine workings based on available extracts of mine tracing RT318 Sheet 1 [4].

(4) Allotments where grouting and/or excavation of mine voids has been undertaken appropriately (i.e. subsidence risk eliminated and uncontrolled fill removed and replaced) may be potentially reclassified subject to SA NSW approval, where outside the angle of draw of non-remediated mine workings. These anticipated classifications are based purely on reactive soil movement with filling using site won fill materials with a maximum Iss of 2.0%.

(5) Likely burdened by mine subsidence impact parameters based on mine tracing and proposed remediation methodology (ref. 81022027-003).

The above preliminary classifications are based on a characteristic free surface movement of less than 40 mm calculated for the lots in their existing condition using subsurface conditions encountered in the test pits. The estimated classifications for lots with potential regrade have been based on utilisation of site won materials as fill with a max I_{ss} of 2.0%.

Following the proposed earthworks activities for the development, reduction of the subsurface cracked zone depth within the lots subject to cutting and filling will result in potentially higher classification depending on the reactivity of the soils to be used as lot filling. The range of classifications assumes that all footings are founded below any topsoil or unsuitable materials, in the natural clay and rock profiles.

It should be noted that the above site classifications are general classifications across the allotment areas based on the subsurface conditions encountered within the test pits. The applicable site classification may be dependent on the proposed location of the residential structure within each individual lot envelope. Individual site classification within the proposed structural envelope may be necessary prior to footing design.

It is understood that remedial works are proposed for the shallower mine workings (up to cover depths of 16 m) to eliminate the subsidence risk. Reclassification of Lots 107-108, 111 and 124 after remediation may be viable subject to approval by SA NSW; However, the remaining lots impacted by the underground mine workings will likely be burdened with subsidence parameters and are anticipated to be classified as Class-P in accordance with AS2870. This would require confirmation after completion of remediation works. The site classifications following regrade of the remaining lots will be highly dependent on the material used to achieve finish levels, the extent of filling and the depth at which reactive materials are placed.

Care will be required to manage material to avoid Class H2 to E classifications following regrading activities. This will require placing the more reactive clay fill materials in the lower areas of deeper fill and utilising less reactive clays in the upper layers of the fill profile. Strict moisture control is essential with material being placed as close to SOMC as practical while avoiding placing clays that are wet of optimum, with care taken not to over compact materials. Where high reactivity material is used as fill, the site classifications may increase. Reactive clay material should be placed a suitable distance from the surface to avoid the material impacting negatively on the site classifications. Imported fill should be generally *Iss* ≤1.0% to achieve classifications below H1 – Highly reactive.

The classifications assume that all footings (edge beams, internal beams and load support thickenings) are founded below any topsoil, uncontrolled fill or deleterious materials.

Details on appropriate site and foundation maintenance practices are presented in Appendix B of AS 2870-2011 and in CSIRO Information Sheet BTF 18, *Foundation Maintenance and Footing Performance: A Homeowner’s Guide*, which is attached as Appendix D of this report.

Adherence to the detailing requirement outlined in Section 5 of AS 2870 is essential, in particular Section 5.6 *Additional requirements for Classes M, H1, H2 and E sites*, including architectural restrictions, plumbing and drainage requirements.

The site classification presented is the predicted classification based on site conditions present at the time of investigation and needs to be confirmed after the completion of regrading, mine working remediation and earthwork operations.

6.3 Footings

All footings should be founded below any topsoil, uncontrolled fill or deleterious materials. All footings for the same structure should be founded on strata of similar stiffness and reactivity to minimise the risk of differential movements.

All footings excavations should be inspected prior to installation of structural steel by a suitably experienced engineer or geotechnical consultant to confirm that the founding conditions are as described in this report. All loose material should be cleared from the footing excavations before concrete is poured.

All footings shall be design to accommodate any restrictions placed on the lots by SA NSW including subsidence impact parameters.

6.3.1 High Level Footings

High-level footing alternatives could be expected to comprise slabs-on-ground with edge beams or pad footings for the support of concentrated loads. Such footings designed in accordance with engineering principles and founded in stiff or better soils (below topsoil, uncontrolled fill or other deleterious material) may be proportioned on an allowable bearing capacity of 150kPa or 500kPa if founded on rock. The founding conditions should be assessed by a geotechnical consultant or experienced engineer to confirm suitable conditions.

6.3.2 Piered Footings

Piered footings are considered as an alternative to deep edge beams or high-level footings. It is suggested that piered footings, founded in the weathered rock could be proportioned on an end bearing pressure of 500kPa. Piered footings, founded in the stiff or better residual clay could be proportioned on an end bearing pressure of 150kPa.

7 Preliminary Pavement Thickness Design

Pavement thickness design has been undertaken based on the findings of the geotechnical investigation and Maitland City Council (MCC) requirements. The following guidelines have been adopted for the design of the internal roads:

- Austroads Guide to Pavement Technology, Part 2: Pavement Structural Design (AGPT02-17) [12]; and
- Maitland City Council's (MCC) Manual of Engineering Standards [13](MoES).

7.1 Design Parameters

7.1.1 Design Traffic Loadings

Design traffic loadings for the internal roads have been calculated using MoES based on the assumed road designations as indicated below in Table 7-1.

Table 7-1 Design Traffic Loadings

Road Names	Designation	Design Traffic
Collaroy Parade	Collector – Primary	1.5 x 10^6 DESA
Eldon Drive	Local – Secondary	2 x 10^5 DESA
Road 10	Local – Place	1 x 10^5 DESA

The number of serviceable lots has been estimated for each of the proposed sections of road as well as consideration of future and existing developments to determine the corresponding design traffic loadings for the purpose of pavement design. Where the anticipated design traffic loadings differ from those presented in Table 7-1 above, additional consultation with Stantec would be required and amendment of the pavement thickness designs.

7.1.2 Design Subgrade

Based on the encountered subsurface profiles within the test pits, the provided regrade and considering a nominal 500 mm box out to accommodate pavement construction, subgrade conditions at the site are expected to comprise predominantly of residual silty clays with areas of extremely weathered materials (EWM) and weathered rock in deeper cut areas. Controlled filling may also be encountered at design subgrade level where over-excavation of unsuitable material is required.

A review of the DA plans has indicated that variable cut depths are required across the cross-section of proposed pavements as a result of the geometric design. As such, differential subgrade conditions may be encountered. This would require over- excavation and replacement to provide uniform subgrade conditions, subject to on-site inspection and guidance by a suitable geotechnical consultant.

The results of the CBR test undertaken on potential subgrade materials indicate that CBR values for the sites natural residual clay soils encountered within the test pits and in previous investigations produced CBR values ranging from 3.5 to 4.0%. To account for variability of the residual clays a design CBR of 3.0% has been adopted for design. The CBR testing also indicated the residual clays at the site are in a moisture condition above optimum by approximately 3 %.

Swell testing conducted during CBR testing indicates the residual clay subgrade materials have a moderate swell potential as defined in Table 5.2 of Austroads [14] with swell results of 2.0%. It should be noted that experience in the area has indicated the potential for zones of more reactive material. As a result, strategies to minimise volume change as outlined in clause 5.3.5 of Austroads [14] should be considered. Inspection by a geotechnical consultant to identify the presence of reactive subgrade materials during construction should also be undertaken to determine the need for any implementation of strategies. Utilisation of a select material is understood to be a preference of MCC and would also assist in addressing the excessive moisture of the residual clay materials, depending on conditions at the time of construction. Allowance has been made for a minimum 300 mm select layer with CBR≥15% which when placed on suitable clays, can increase the overall design CBR to 8%.

CBR testing undertaken on Extremely Weathered Material (EWM) in TP09 produced a CBR value of 10.0% and indicated the weathered materials to be in a moisture condition dry of optimum. It is expected that a design CBR of 8.0% would be suitable for these materials subject to inspection by a suitable geotechnical consultant.

The design subgrade CBR for any filling is dependent on the material being utilised. Allowance has been made for the use of site-won clays as general filling (i.e. CBR-3.0%).

Where weathered rock is encountered at design subgrade level for a sufficient length during construction, relative design subgrade CBR value of 8% may be adopted for the proposed subgrade, however would be subject to inspection by an experience geotechnical consultant.

Based on the results of the laboratory testing, the encountered subsurface conditions along the proposed road alignments and the discussion above, the following design CBR values have been adopted for pavement design of the internal roads:

> CBR = 3.0%, Residual CLAY and General FILL;

> CBR = 8.0%, 300 mm of Select FILL (CBR≥15%), EWM and Weathered Rock

7.2 Pavement Design

Based on the conditions present at the time of investigation, design traffic loads and the results of the CBR testing, flexible unbound granular pavement would be the most cost-effective option for the construction of the internal roads.

Pavement compositions associated with a design CBR of 8% should only be used for design purposes under direction from an experienced geotechnical consultant who has inspected and confirmed the material type present at design subgrade level.

It should be noted that the layer thicknesses detailed in Table 7-2 and Table 7-3 below are minimum thicknesses regardless of construction tolerances.

Table 7-2 Internal Pavement Compositions - Flexible pavements founded on General Fill / Suitable Clay Subgrade

Road Section	Collaroy Parade	Eldon Drive	Road 10
Wearing Course (mm)	30 (AC10)	30 (AC10)	30 (AC10)
Basecourse(1) (mm)	150	150	150
Subbase (mm)	360	245	210
Total Thickness (mm)	540	425	390
Design traffic	1.5 x 10^6 DESA	2 x 10^5 DESA	1 x 10^5 DESA
Design CBR	3.0 %		
Design Life	30 years		

Notes:
For material specifications refer to Section 7.3.2.
(1) Minimum 150 mm basecourse has been adopted to accommodate kerb and gutter construction.

Table 7-3 Internal Pavement Compositions - Flexible pavements founded on Select Fill OR Weathered Rock Subgrade

Road Section	Collaroy Parade	Eldon Drive	Road 10
Wearing Course (mm)	30 (AC10)	30 (AC10)	30 (AC10)
Basecourse(1) (mm)	150	150	150
Subbase(2) (mm)	130	130	130
Total Thickness(3) (mm)	310	310	310
Select Fill (mm)(5)(6)	300	300	300
Design traffic	1.5 x 10^6 DESA	2 x 10^5 DESA	1 x 10^5 DESA
Design CBR	8.0 %		
Design Life	30 years		

Notes:
For material specifications refer to Section 7.3.2.
(1) Minimum 150mm basecourse has been adopted to accommodate kerb and gutter construction.
(2) Minimum Subbase thickness of 125mm as specified by MoES.
(3) Minimum total thickness of 300mm as specified by MoES does not include select fill layer.
(4) Where a sufficient length of pavement has weathered rock at design subgrade level, utilisation of this table may be appropriate subject to inspection by a geotechnical consultant to confirm conditions.
(5) Select fill not included in total thickness.
(6) Select fill not required for weathered rock option, subject to inspection.

During boxing out of subgrade levels, where thin clay layers are present in locations such as transitions between bedrock and subgrade, over-excavation may be required to remove these thin layers and allow replacement with select material. Where thin layers of surficial topsoil material are present, these should also be over-excavated and replaced with suitable general or select fill material.

Inspection of the finished subgrade by a geotechnical engineer during boxing is required to assess subgrade conditions, over-excavation and select subgrade quality.

7.3 Pavement Construction

7.3.1 Subgrade Preparation

At the time of the investigation, elevated in-situ moisture conditions were evident and may require remedial earthworks, depending on the conditions prior to and during construction. The observed elevated moisture in surficial soils is likely to be associated with the extended rainfall events in the months preceding the fieldwork. Options to ameliorate the subgrade conditions may include:

- Removal and replacement of the materials significantly wet of SOMC;
- Moisture re-conditioning and blending of site won granular material with cohesive materials to improve structure and ability to support the proposed pavements. It should be appreciated that moisture re-conditioning will need to allow sufficient time for the materials to ‘dry back’ and will extend the construction program; or
- Reconditioning including the addition of lime to the subgrade to reduce moisture content only.

The most efficient and cost-effective treatment would be best determined at construction as soil moisture levels and the final design levels will impact on suitable treatment options.

Subgrade preparation for pavement formation for new pavements could generally be expected to comprise the following.

- Removal of topsoil, uncontrolled fill, colluvium/alluvium and deleterious or unsuitable material to subgrade formation level, with the spoiling of any deleterious or over wet material to either allow reconditioning and appropriate reuse or offsite disposal;
- Additional removal is anticipated in the northern portion of Eldon Drive given the presence of the existing farm dam adjacent the road envelope.

- Identification of the need for removal and replacement of any potential higher reactive clays would be undertaken by visual inspection. Where highly reactive materials are identified at subgrade level by an experienced geotechnical consultant during construction, strategies outlined in clause 5.3.5 of Austroads [14] should be adopted to minimise the potential for volume change to occur as discussed in Section 7.1.
- A review of the supplied regrade plan revealed areas involving part fill and part cut (or variable cut depth) as part of the proposed regrade and geometric design. In such areas, over excavation and replacement with a suitable fill material to provide uniformity may be necessary subject to inspection by a geotechnical professional;
- Excavation of any loose and oversize filling and elimination of abrupt changes between subgrade conditions, such from rock to soil, and from granular fill to fine grained natural soils.
- Loose or yielding areas should be excavated and replaced with compacted select fill or suitable subgrade replacement comprising of material of similar consistency to the subgrade.
- Proof rolling of the exposed subgrade with a heavy (minimum 10 tonne static) roller. Results of the proof roll could be used to determine the extent of remedial treatment required, as directed by the on-site geotechnical consultant;
- Compaction of the subgrade or filling should be to a minimum 100% of SMDD (or 70% Density Index for non-cohesive materials) in layers of not greater than 250 mm loose thickness. Moisture contents should generally be within -2% to 0% of SOMC.
- Fill material to be used as subgrade shall conform to the appropriate specifications as detailed in this report and MCC Specifications.
- Where sections of pavement proposed to comprise a combination of fill and cut as part of the proposed regrade and geometric design, over-excavation and replacement with a suitable fill material may be necessary subject to inspection by an experienced geotechnical consultant.
- Protection of the subgrade to prevent any excessive wetting or drying; and
- Following satisfactory preparation of the subgrade, the pavement should be placed in accordance with the requirements of the appropriate section of this report, depending on the proposed pavement type.

It is recommended that trafficking of the subgrade be minimised or avoided (where possible) during construction to prevent the permanent deformation of the subgrade. The boxed road alignment should not be used as a haul road during construction, with footpath areas outside the road alignment offering alternate areas for construction traffic.

Particular care should be taken in the choice of compaction equipment and methods where pavement construction is to be undertaken in the vicinity of existing structures. Observation and monitoring of residences within adjacent Louth Park stages for signs of distress should be undertaken in conjunction with proof rolling and compaction of the subgrade and pavement materials.

7.3.2 Specification and Compaction Requirements

Pavement materials and compaction requirements for the new pavement construction should conform to Maitland City Council specifications and the following requirements seen in Table 7-4 below.

Table 7-4 Material Specification and Compaction Requirements

Pavement Course	Material Specification	Compaction Requirements
Wearing Course Asphalt	In accordance with MCC Construction Specification [13]	As specified by the supplier
Base Course High quality crushed rock	Material complying with TfNSW QA Specification [15] and MCC MoES [13]and a CBR > 80%, PI < 6%	Min 98% Modified (AS1289 5.2.1) or Min 102% standard (AS1289 5.1.1)
Subbase Subbase quality crushed rock	Material complying with TfNSW QA Specification [15] and MCC MoES [13] and a CBR > 30%, PI < 10%	Min 95% Modified (AS1289 5.2.1) or 100% Standard (AS1289 5.1.1)
Select Crushed rock or gravel	CBR >15%	Min 100% Standard (AS1289 5.1.1)

Subgrade or replacement	Min CBR 3% Clay and General Fill Min CBR 8% EWM, Weathered Rock (If encountered)	Min 100% Standard (AS1289 5.1.1)

All granular pavement material quality should be in general accordance with Transport for New South Wales (TfNSW) QA Specification 3051 [15] for Traffic Category C “Medium” for Collaroy Parade and Traffic Category D “Light” for all other roads.

Minimum testing on all potential imported pavement materials should be to TfNSW QA Specification 3051 [15] including a four-day soaked CBR, Atterberg Limits, Particle Size Distribution analysis and Wet/Dry strength determination. Pre-treatment of material prior to testing would be advisable for materials subject to breakdown.

The selection of appropriate construction materials that are durable and insensitive to moisture change is essential in areas subject to periodic inundation and/or wet ground conditions, such as the site areas in proximity to the existing drainage lines.

7.3.3 Wearing Course

Wearing courses should be in accordance with Maitland City Council specifications with consideration to TfNSW QA Specifications R116 [16] and Austroads AGPT04B-07 Guide to Pavement Technology, Part 4B: Asphalt [17].

The design and construction of wearing courses should be in in consultation with the preferred supplier taking into account the traffic volume and type. All pavement surfaces should be primed or primer sealed prior to the application of asphalt surfacing.

7.3.4 Pavement Drainage

The moisture regime associated with a pavement has a major influence on the performance considering the stiffness/strength of the pavement materials is dependent on the moisture content of the material used. Accordingly, to protect the pavement materials from wetting up and softening, particular care would be required to provide a waterproof seal for the pavement materials, together with adequate surface and sub-surface drainage of the pavement and adjacent areas.

It is suggested that an intra-pavement drain should be provided at the interface between any sections of variable pavements, and where new pavements join to existing pavements. Intra-pavement subsoil drains should be in accordance with TfNSW QA Specification R37 [18] or equivalent and should penetrate to the subgrade or to the base of any replaced subgrade material.

7.3.5 Subsoil drainage

It is recommended that subsoil drainage be installed at subgrade level along both sides of constructed pavements where the road is in cut, to intercept any subsurface flows. Detailing of subsoil drainage should be in accordance with Austroads 2017 [14].

The subgrade should be constructed with sufficient cross fall (normally 3%) to assist with any moisture entering the pavement not becoming trapped. The drains should be located below or behind the kerb to intercept any moisture ingress from outside and within the road alignment. Where there is no kerb or gutter the subsoil drain should be placed at the edge of the pavement formation. Subsoil drains will require flush-out points and regular maintenance to ensure their correct operation.

Attention to detail in drainage design and construction is essential for optimum performance. Expensive drainage systems can be blocked or otherwise prevented from operating by inappropriate construction procedures or drainage design. Poor performance of a drainage system can, in turn result in major deficiencies in pavement performance. It is acknowledged that provision of adequate surface and subsoil drainage in low-lying areas can be difficult; however, the provision of adequate pavement drainage is essential to performance. In these circumstances, the selection, construction and maintenance of appropriate drainage mechanisms is essential.

The suitability of subsoil drainage systems is dependent on the ability to adequately drain the pavement. Where there is insufficient fall to allow drainage, other pavement drainage measures such as drainage blankets and high permeability non-moisture sensitive pavement materials should be considered. The pavement design provided assumes drained pavement conditions.

The selection of appropriate construction materials that are insensitive to moisture change is essential in areas subject to periodic inundation and/or wet ground conditions.

7.3.6 Pavement Compaction

Difficulty obtaining specified compaction requirements can be expected in areas of low strength subgrade which are evident in areas where the road is to be constructed in fill and firm clays near surface are expected and subgrade replacement is not undertaken. Vibratory compaction can lead to potential problems with the development of excess pore pressures and permanent deformation of the subgrade. Large capacity oscillating rollers are better suited to deep lift compaction. Static or low amplitude rolling may be appropriate in conjunction with thinner layers in poor subgrade areas.

It is essential to ensure that compaction is achieved though the full thickness of any pavement layers. A rough interface and bond is required between all pavement layers, generally achieved through scarification of the first layer prior to placement and compaction of the second and subsequent pavement layers.

7.3.7 Pavement Interface and Tie-in

It is recommended that where new pavement sections abut existing sections, the pavement should have a vertical construction joint to match the existing section. It should be noted that when variable pavements are abutted then the potential for localised failure is greater. Care should be exercised in the placement and compaction of the subgrade and pavements in this area to maximise the performance of the pavement.

Owing to the potential for cracking along the interface where new pavements are joined to existing pavements or where variable pavement abut, an intra-pavement drain should be provided as discussed above. Consideration should also be given to sealing any cracks that may develop between existing and new pavements, benching to tie in pavements and the use of a strain relieving membranes at the interface may be appropriate. The need for an intra-pavement drain can be assessed at the time of construction.

7.3.8 Inspections

The subgrade will require inspection by an experienced geotechnical consultant after boxing out or before and after filling to design subgrade level. The purpose of inspections is to confirm design parameters, assess the suitability of the subgrade to support the pavement, and delineate areas which may require subgrade replacement or remedial treatment prior to construction.

7.3.9 References

All works and materials used in construction should be designed and constructed in accordance with Maitland City Council Specifications or as specified in this report. Where discrepancies may occur, clarification should be sought from Council.

Earthworks and testing should generally be undertaken in accordance with AS 3798-2007 *Guidelines on Earthworks for Commercial and Residential Developments* [9] where not otherwise specified.

8 Limitations

Stantec have performed investigation and consulting services for this project in general accordance with current professional and industry standards. The extent of testing was limited to discrete test locations and variations in ground conditions can occur between test locations that cannot be inferred or predicted.

A geotechnical consultant or qualified engineer shall provide inspections during construction to confirm assumed conditions in this assessment. If subsurface conditions encountered during construction differ from those given in this report, further advice shall be sought without delay.

Stantec, or any other reputable consultant, cannot provide unqualified warranties nor does it assume any liability for the site conditions not observed or accessible during the investigations. Site conditions may also change subsequent to the investigations and assessment due to ongoing use.

This report and associated documentation was undertaken for the specific purpose described in the report and shall not be relied on for other purposes. This report was prepared solely for the use by NewPro25 Pty Ltd and any reliance assumed by other parties on this report shall be at such parties own risk.

9 References

[1] Australian Standard AS2870-2011, “Residential Slabs and Footings,” Standards Australia, 2011.

[2] Cardno (NSW/ACT) Pty Ltd, report on Mine Impact Statement - Proposed Subdivision - 442 Louth Park Road, Louth Park - 81022027-001.1, 20 January 2022 - Version 1.

[3] S. A. NSW, “Development Appliaction - Subdivision Assessment Policy,” NSW Governement, May 2018.

[4] Coffey, Proposed Residential Subdivision - 314 Dagworth Road, Louth Park - Phase 1 - Mine Subsidence Assessment - GEOTWARA22546AA-AB, 10 September 2015.

[5] Subsidence Advisory NSW, RE PRPOPOSED SUBDIVISION AT 442 LOUTH PAR RD LOUTH PARK; LOT 1 DP 221762; TSUB22-00020, 3 February 2022.

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[7] State of New South Wales (Department of Planning, Industries and Environment), “Minview - Geosciences NSW,” State of New South Wales (Department of Planning, Industries and Environment), 2020. [Online]. Available: https://minview.geoscience.nsw.gov.au/#/?lon=151.5512&lat=-32.78154&z=17&bm=bm1&l=ge611:n:100,ge610:n:100,ge69:n:100,ge68:n:100,ge67:n:100,ge66:n:100,ge65:n:100,ge64:n:100,ge63:n:100,ge62:n:100,ge61:n:100,ge612:y:100,hi1:n:25,wa1:y:100,ut1:y:50,ad0:y:100. [Accessed 14 April 2022].

[8] Subsidence Advisory NSW, Surface Development Guideline 7 - On Aapplication, may 2018.

[9] Australian Standard AS3798-2007, “Guidelines on Earthworks for Commercial and Residential Structures,” Standards Australia, 2007.

[10] NSW EPA, Waste Classification Guidelines - Part 1: Classifying Waste, State of NSW, Environment Protection Authority, November 2014.

[11] Building Technology File 18 (BTF 18), “Foundation Maintenance and Footing Performance: A Homeowner’s Guide,” CSIRO Publishing, 2003.

[12] Austroads AGPT02-17, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2017.

[13] maitland City Council (MCC), “Manual of Engineering Standards,” 2019. [Online]. Available: https://www.maitland.nsw.gov.au/my-council/planning-and-reporting/publications-plans-and-strategies/planning-strategies/manual-of-engineering-standards. [Accessed 23 May 2022].

[14] Austroads AGPT02-17, “Guide to Pavement Technology Part 2: Pavement Structural Design,” Austroads Ltd, 2017.

[15] Transport for New South Wales (TfNSW) , “QA Specification 3051 (Ed 7 Rev 1) - Granular Base and Subbase Materials for Surfaced Road Pavements,” TfNSW, 22.06.2022.

[16] Transport For New South Wales (TfNSW), “TfNSW QA Specification R116 (Ed 9 Rev 2) Heavy Duty Dense Graded Asphalt,” TfNSW, January 2012.

[17] Austroads AGPT04B-07, Guide to Pavement Technology Part 4B: Asphalt, Austroads Ltd, May 2007.

[18] Transport for New South Wales (TfNSW), “TfNSW QA Specification R37 (Ed 4 Rev 14) Intra-pavement Drains,” 22/06/2020.

442 Louth Park Road Residential Subdivision

APPENDIX

A

ENGINEERING DRAWINGS

Cardno

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Stantec

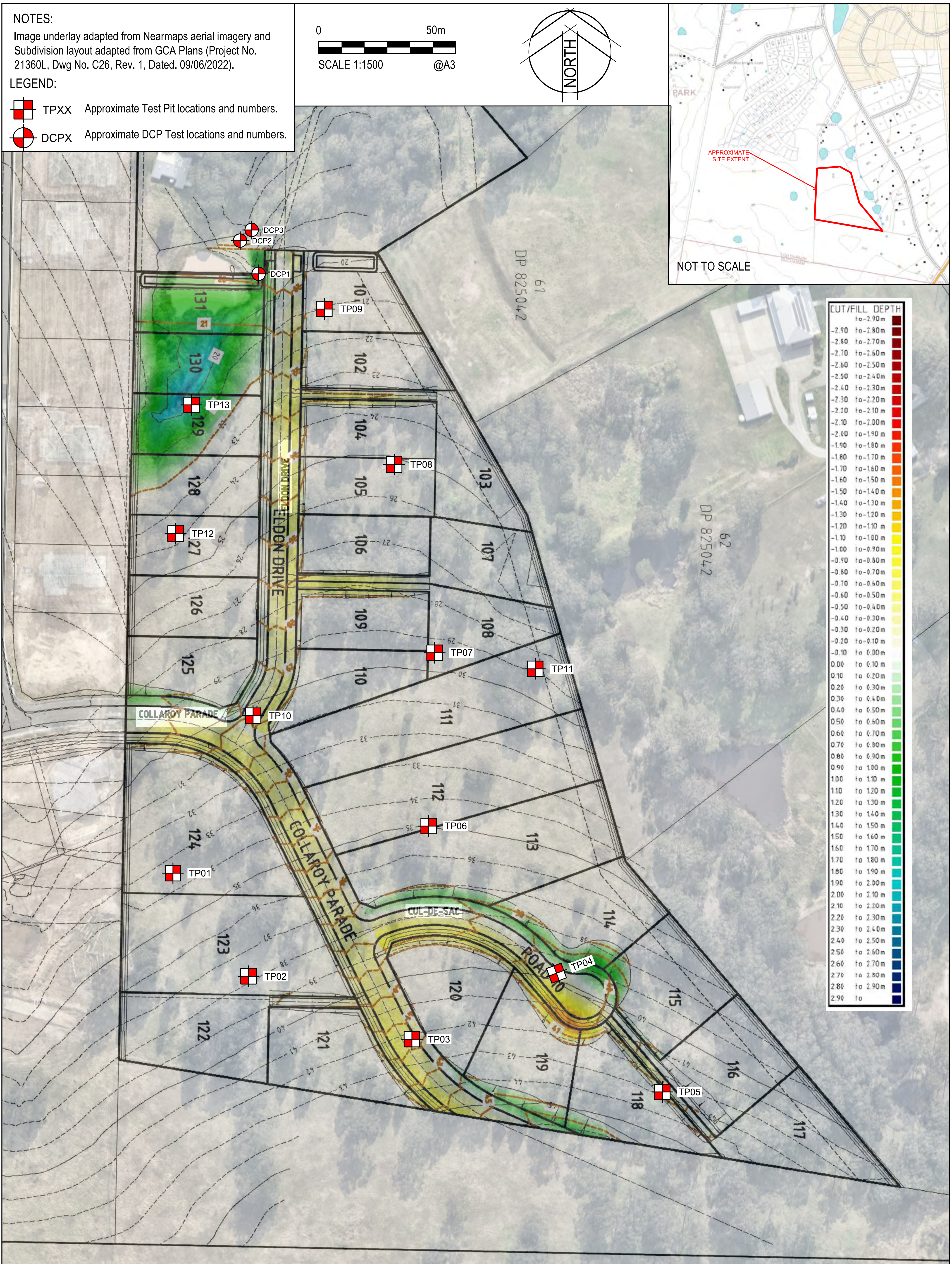
DATE PLOTTED: 7 November 2022 2:03 PM BY : JESSE GRACZYK

NOTES:

Image underlay adapted from Nearmaps aerial imagery and Subdivision layout adapted from GCA Plans (Project No. 21360L, Dwg No. C26, Rev. 1, Dated. 09/06/2022).

LEGEND:

TPXX	Approximate Test Pit locations and numbers.
DCPX	Approximate DCP Test locations and numbers.



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Drawn JG	Date 07/11/2022	
Checked	Date	
Designed	Date	
Verified	Date	
Approved		

Client NewPro25 Pty Ltd

Project Geotechnical Investigation
Proposed Subdivision
442 Louth Park Road, Louth Park NSW

Title Site Plan

Status FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
81022027-002	1:1500	A3

Figure Number	Revision
Drawing 1	A

XREF's:
CAD File: N:\Projects\810\FY22\027_442 Louth Park Rd\Drawing\dwg\002 - 442 Louth Park Rd GI\81022027-002 - Geotechnical Investigation (FINAL v2).dwg

DATE PLOTTED: 7 November 2022 9:24 PM BY : JESSE GRACZYK

NOTES:
Image underlay adapted from Nearmaps aerial imagery.

LEGEND:

🟥 TPXX	Approximate Test Pit locations and numbers.
● DCPX	Approximate DCP Test locations and numbers.

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Drawn JG	Date 08/09/2022	
Checked	Date	
Designed	Date	
Verified	Date	
Approved		

Client NewPro25 Pty Ltd

Project Geotechnical Investigation
Proposed Subdivision
442 Louth Park Road, Louth Park NSW

Title Site Plan

Status FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES

Project Number	Scale	Size
81022027-002	1:1500	A3

Figure Number	Revision
Drawing 2	A

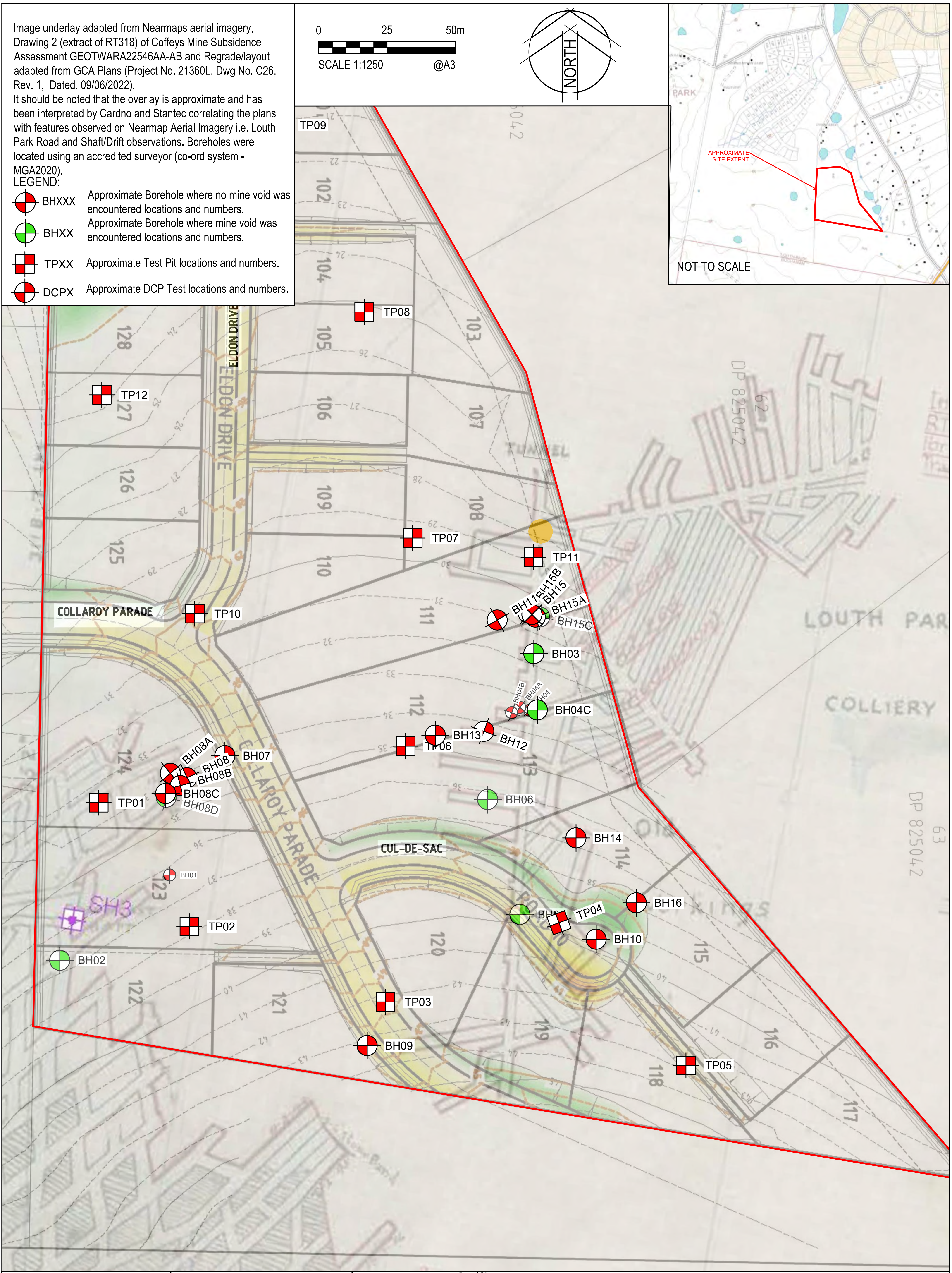
XREF's:
CAD File: N:\Projects\810\FY22\027_442 Louth Park Rd\Drawing\dwg\002 - 442 Louth Park Rd GI\81022027-002 - Geotechnical Investigation (FINAL v2).dwg

DATE PLOTTED: 7 November 2022 2:04 PM BY : JESSE GRACZYK

Image underlay adapted from Nearmaps aerial imagery, Drawing 2 (extract of RT318) of Coffeys Mine Subsidence Assessment GEOTWARA22546AA-AB and Regrade/layout adapted from GCA Plans (Project No. 21360L, Dwg No. C26, Rev. 1, Dated. 09/06/2022).
It should be noted that the overlay is approximate and has been interpreted by Cardno and Stantec correlating the plans with features observed on Nearmap Aerial Imagery i.e. Louth Park Road and Shaft/Drift observations. Boreholes were located using an accredited surveyor (co-ord system - MGA2020).

LEGEND:

BHXXX	Approximate Borehole where no mine void was encountered locations and numbers.
BHXX	Approximate Borehole where mine void was encountered locations and numbers.
TPXX	Approximate Test Pit locations and numbers.
DCPX	Approximate DCP Test locations and numbers.



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Drawn JG	Date 07/11/2022	Client: NewPro25 Pty Ltd
Checked	Date	Project: Geotechnical Investigation Proposed Subdivision 442 Louth Park Road, Louth Park NSW
Designed	Date	
Verified	Date	Title: Site Plan
Approved		

Status: FOR INFORMATION ONLY NOT TO BE USED FOR CONSTRUCTION PURPOSES		
Project Number 81022027-002	Scale 1:1250	Size A3
Figure Number Drawing 3		Revision A

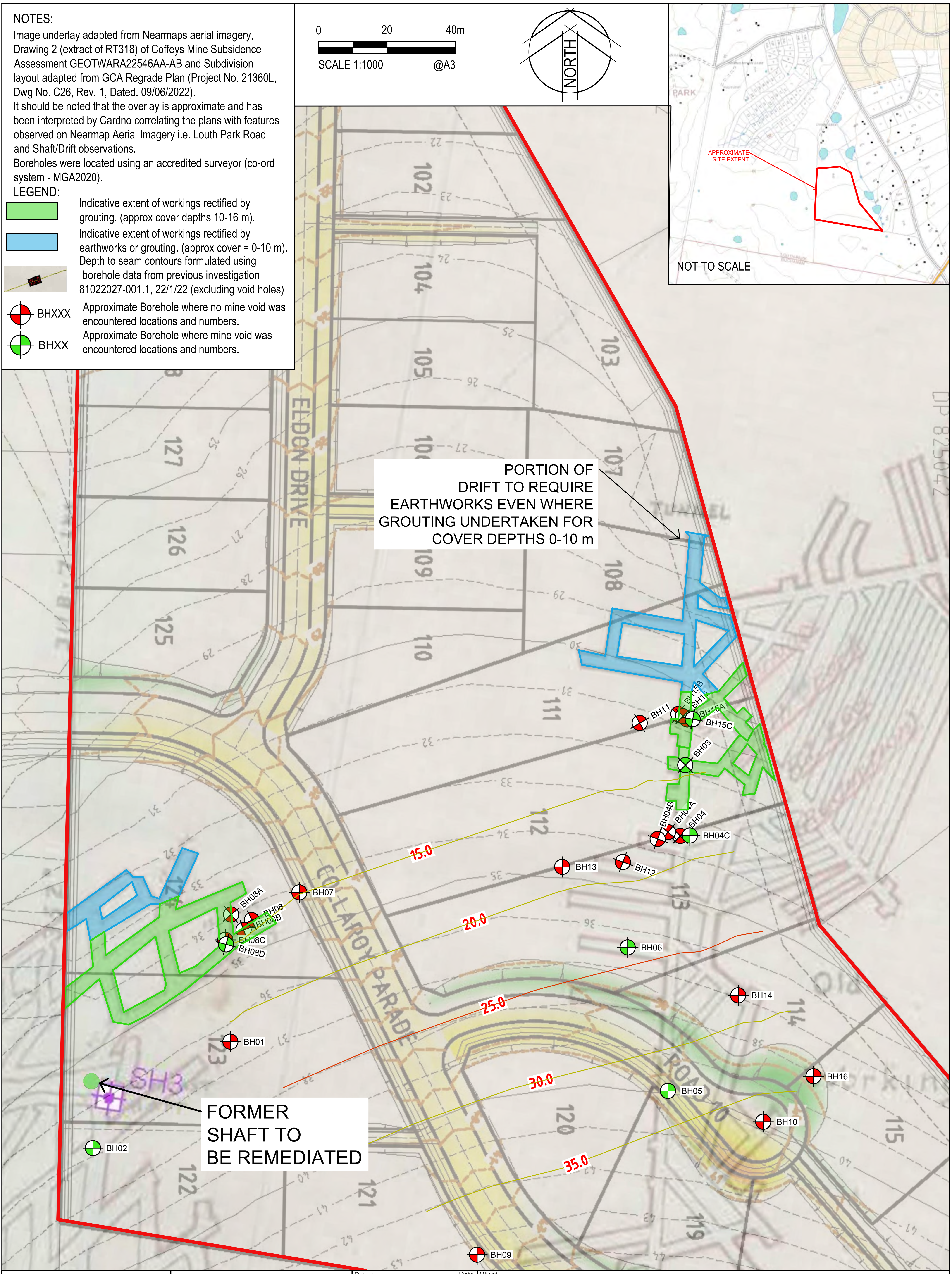
XREF's:
CAD File: N:\Projects\810\FY22\027_442 Louth Park Rd\Drawing\dwg\002 - 442 Louth Park Rd GI\81022027-002 - Geotechnical Investigation (FINAL v2).dwg

DATE PLOTTED: 8 November 2022 7:28 AM BY : JESSE GRACZYK

NOTES:
Image underlay adapted from Nearmaps aerial imagery, Drawing 2 (extract of RT318) of Coffeys Mine Subsidence Assessment GEOTWARA22546AA-AB and Subdivision layout adapted from GCA Regrade Plan (Project No. 21360L, Dwg No. C26, Rev. 1, Dated. 09/06/2022).
It should be noted that the overlay is approximate and has been interpreted by Cardno correlating the plans with features observed on Nearmap Aerial Imagery i.e. Louth Park Road and Shaft/Drift observations.
Boreholes were located using an accredited surveyor (co-ord system - MGA2020).

LEGEND:

🟩	Indicative extent of workings rectified by grouting. (approx cover depths 10-16 m).
🟦	Indicative extent of workings rectified by earthworks or grouting. (approx cover = 0-10 m).
	Depth to seam contours formulated using borehole data from previous investigation 81022027-001.1, 22/1/22 (excluding void holes)
BHXXX	Approximate Borehole where no mine void was encountered locations and numbers.
BHXX	Approximate Borehole where mine void was encountered locations and numbers.



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Drawn JG Date 7/11/22
Checked Date
Designed Date
Verified Date
Approved

Client NewPro25 Pty Ltd
Project Mine Remediation Methodology
442 Louth Park Road
Louth Park NSW
Title
Mine Remediation Plan

Status FOR INFORMATION ONLY
NOT TO BE USED FOR CONSTRUCTION PURPOSES
Project Number 81022027
Scale 1:1000
Size A3
Figure Number Drawing 4
Revision A

XREF's:
CAD File: N:\Projects\810\FY22\027_442 Louth Park Rd\Drawing\dwg\003 - Grouting Works\81022027-003 - Grout Plan (alternative Location).dwg

442 Louth Park Road Residential
Subdivision

APPENDIX

B

ENGINEERING LOGS

Cardno

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TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park
Job No: 82222027-001

Hole No: TP01

Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		0.10m		TOPSOIL: Clayey Sandy SILT; low plasticity, dark brown, fine to medium sand, trace rootlets	M (>PL)		TOPSOIL
					0.25m		Clayey Sandy SILT; low plasticity, grey/brown, fine to medium sand, trace fine to medium gravel	M (>PL)		COLLUVIUM
					0.80m		Sandy CLAY; medium plasticity, brown mottled orange, fine to medium grained sand, with fine to medium gravel (Sandstone fragments)	M (>PL)	VSt H	RESIDUAL SOIL
							Clayey SAND; fine to medium grained, grey-brown mottled orange	M to D	D - VD	EXTREMELY WEATHERED
					1.50m		As above, colour change to grey with orange lenses, with fine to coarse gravel, trace cobbles and boulders (sandstone fragments)	D		
							TERMINATED AT 1.50 m Refusal on weathered rock			

DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm (scale 3 6 9 12)

Depth (m)	Blows/150 mm
0.00–0.15	1
0.15–0.30	3
0.30–0.45	9
0.45–0.60	29
0.60–0.75	23

Depth (m): 0.5, 1.0, 1.5, 2.0

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- ▽ Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS

SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE

D	Dry
M	Moist
W	Wet
PL	Plastic limit
LL	Liquid limit
w	Moisture content

SOIL CONSISTENCY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard

RELATIVE DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park
Job No: 82222027-001

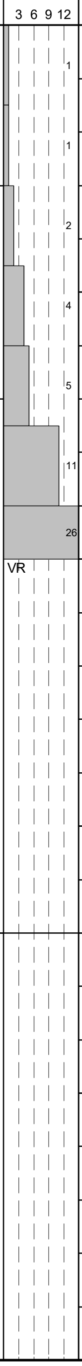
Hole No: TP02

Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket (0.00 - 1.70 m)		Stable	Not Observed		0.10m		TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	M (>PL)		TOPSOIL
					0.20m		Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel			COLLUVIUM
				B 0.30 - 0.70 m U50 0.30 - 0.70 m	0.70m		Silty Sandy CLAY; medium to high plasticity, grey/brown mottled orange, fine to medium grained sand	M (>PL)	F St	RESIDUAL SOIL
					1.30m		Silty Sandy CLAY; medium plasticity, grey-brown mottled orange, fine to medium grained sand, with fine to coarse gravel (Sandstone fragments)	M (≈PL) to M (>PL)	VSt H	EXTREMELY WEATHERED
					1.70m		Clayey SAND; fine to medium grained, pale grey mottled orange, fine to coarse gravel, with cobbles (Sandstone fragments)	D	D - VD	WEATHERED ROCK
							TERMINATED AT 1.70 m Refusal on weathered rock			

DCP TEST (AS 1289.6.3.2-1997) Blows/ 150 mm



Depth (m): 0.5, 1.0, 1.5, 2.0

METHOD		PENETRATION		FIELD TESTS		SAMPLES		SOIL CONSISTENCY	
EX	Excavator bucket	VE	Very Easy (No Resistance)	SPT -	Standard Penetration Test	B -	Bulk disturbed sample	VS -	Very Soft
R	Ripper	E	Easy	HP -	Hand/Pocket Penetrometer	D -	Disturbed sample	S -	Soft
HA	Hand auger	F	Firm	DCP -	Dynamic Cone Penetrometer	ES -	Environmental sample	F -	Firm
PT	Push tube	H	Hard	PSP -	Perth Sand Penetrometer	U -	Thin wall tube 'undisturbed'	St -	Stiff
SON	Sonic drilling	VH	Very Hard (Refusal)	MC -	Moisture Content			VSt -	Very Stiff
AH	Air hammer			PBT -	Plate Bearing Test	**MOISTURE**		H -	Hard
PS	Percussion sampler	**WATER**		IMP -	Borehole Impression Test	D -	Dry	**RELATIVE DENSITY**	
AS	Short spiral auger	▽	Water Level on Date shown	PID -	Photoionisation Detector	M -	Moist	VL -	Very Loose
AD/V	Solid flight auger: V-Bit	▶	water inflow	VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)	W -	Wet	L -	Loose
AD/T	Solid flight auger: TC-Bit	◀	water outflow			PL -	Plastic limit	MD -	Medium Dense
HFA	Hollow flight auger					LL -	Liquid limit	D -	Dense
WB	Washbore drilling					*w* -	Moisture content	VD -	Very Dense
RR	Rock roller								

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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TEST PIT LOG SHEET

Hole No: TP03

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park
Job No: 82222027-001
Sheet: 1 of 1
Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation				Sampling & Testing			Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm 3 6 9 12	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		2	0.10m			TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	M (>PL)		TOPSOIL
					1	0.20m			Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel	M (>PL)		COLLUVIUM
				B 0.20 - 0.40 m U50 0.40 - 0.90 m	2 3 6 12	0.5 0.70m			Silty CLAY; medium to high plasticity, grey mottled red	M (>PL)	F St	RESIDUAL SOIL
					20 15 ref	1.0 1.5 2.00m			Silty CLAY; medium plasticity, grey-brown mottled orange-yellow, fine to medium grained sand, trace fine to coarse gravel (Sandstone fragements) As above, with parent rock fragments	M (<PL)	VSt H	EXTREMELY WEATHERED
						2.0			TERMINATED AT 2.00 m Target depth			

METHOD		PENETRATION		FIELD TESTS		SAMPLES		SOIL CONSISTENCY	
EX	Excavator bucket	VE	Very Easy (No Resistance)	SPT -	Standard Penetration Test	B -	Bulk disturbed sample	VS -	Very Soft
R	Ripper	E	Easy	HP -	Hand/Pocket Penetrometer	D -	Disturbed sample	S -	Soft
HA	Hand auger	F	Firm	DCP -	Dynamic Cone Penetrometer	ES -	Environmental sample	F -	Firm
PT	Push tube	H	Hard	PSP -	Perth Sand Penetrometer	U -	Thin wall tube 'undisturbed'	St -	Stiff
SON	Sonic drilling	VH	Very Hard (Refusal)	MC -	Moisture Content			VSt -	Very Stiff
AH	Air hammer			PBT -	Plate Bearing Test	**MOISTURE**		H -	Hard
PS	Percussion sampler	**WATER**		IMP -	Borehole Impression Test	D -	Dry	**RELATIVE DENSITY**	
AS	Short spiral auger	▽	Water Level on Date shown	PID -	Photoionisation Detector	M -	Moist	VL -	Very Loose
AD/V	Solid flight auger: V-Bit	▶	water inflow	VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)	W -	Wet	L -	Loose
AD/T	Solid flight auger: TC-Bit	◀	water outflow			PL -	Plastic limit	MD -	Medium Dense
HFA	Hollow flight auger					LL -	Liquid limit	D -	Dense
WB	Washbore drilling					*w* -	Moisture content	VD -	Very Dense
RR	Rock roller								

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP04

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket (0.00 - 1.60 m)		Stable	Not Observed		0.10m	TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	M		TOPSOIL
					0.20m	Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel	M		COLLUVIUM
				B 0.30 - 0.50 m	0.90m	Silty CLAY; medium to high plasticity, grey mottled red	M (>PL)	F - St St	RESIDUAL SOIL
					1.60m	Silty CLAY; medium plasticity, grey-brown mottled orange-yellow, fine to medium grained sand, trace fine to coarse gravel (Sandstone fragments) As above, with parent rock fragments	M (<PL)	H	EXTREMELY WEATHERED
						TERMINATED AT 1.60 m Refusal on weathered rock			

DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm

Depth (m)	Blows
0.00 - 0.15	1
0.15 - 0.30	1
0.30 - 0.45	3
0.45 - 0.60	2
0.60 - 0.75	5
0.75 - 0.90	7
0.90 - 1.05	13
1.05 - 1.20	24

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Job No: 82222027-001

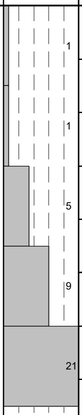
Hole No: TP05

Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation – Method: 600mm toothed bucket (0 to 1.10 m); Resistance: –; Stability: Stable; Water: Not Observed

Sampling & Testing – DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm



Depth (m)	Graphic Log	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
0.10m	⊥⊥	TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	W		TOPSOIL
0.30m	▨	Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel			COLLUVIUM
0.70m	▨	Silty Sandy CLAY; medium plasticity, grey mottled yellow and red, fine to medium grained sand	M (>PL)	St - VSt	RESIDUAL SOIL
1.10m	▨	Sandy Gravelly CLAY; medium plasticity, grey mottled yellow and red, fine to medium grained sand, fine to coarse gravel (sandstone fragments), with cobbles (Parent fragments)	M (<PL)	H	EXTREMELY WEATHERED
		TERMINATED AT 1.10 m Refusal on weathered rock			

Depth scale (m): 0.5, 1.0, 1.5, 2.0

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- ▽ Water Level on Date shown
- ► water inflow
- ◄ water outflow

FIELD TESTS

SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE

D	Dry
M	Moist
W	Wet
PL	Plastic limit
LL	Liquid limit
w	Moisture content

SOIL CONSISTENCY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard

RELATIVE DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

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TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP06

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Machine Type: 12 tonne Excavator	**Excavation Method:**	
Excavation Dimensions:		**Contractor:** Dannenberg
Date Excavated: 6/4/22	**Logged By:** GE	**Checked By:** JG

Excavation: Method	Excavation: Resistance	Excavation: Stability	Water	Sampling & Testing: Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		1	0.10m			TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	W		TOPSOIL
					1	0.25m			Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel			COLLUVIUM
					6 15 Ref	0.60m			Silty Sandy CLAY; medium plasticity, grey mottled yellow, fine to medium grained sand	M (>PL)	St	RESIDUAL SOIL
						1.30m			Silty Sandy CLAY; low plasticity, grey mottled yellow, fine to medium grained sand, with fine to coarse gravel (Sandstone fragments)	M (<PL)	H	EXTREMELY WEATHERED
						1.70m			Clayey SAND; fine to medium grained, grey mottled yellow	D	D - VD	WEATHERED ROCK
									TERMINATED AT 1.70 m Refusal on weathered rock			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- ▽ Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS

SPT -	Standard Penetration Test
HP -	Hand/Pocket Penetrometer
DCP -	Dynamic Cone Penetrometer
PSP -	Perth Sand Penetrometer
MC -	Moisture Content
PBT -	Plate Bearing Test
IMP -	Borehole Impression Test
PID -	Photoionisation Detector
VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B -	Bulk disturbed sample
D -	Disturbed sample
ES -	Environmental sample
U -	Thin wall tube 'undisturbed'

MOISTURE

D -	Dry
M -	Moist
W -	Wet
PL -	Plastic limit
LL -	Liquid limit
w -	Moisture content

SOIL CONSISTENCY

VS -	Very Soft
S -	Soft
F -	Firm
St -	Stiff
VSt -	Very Stiff
H -	Hard

RELATIVE DENSITY

VL -	Very Loose
L -	Loose
MD -	Medium Dense
D -	Dense
VD -	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

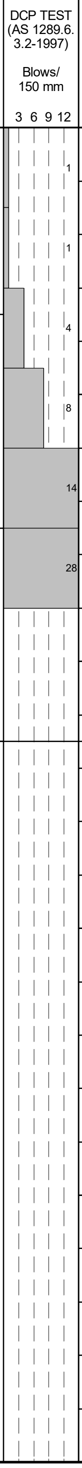
TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP07

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Machine Type: 12 tonne Excavator	**Excavation Method:**	
Excavation Dimensions:		**Contractor:** Dannenberg
Date Excavated: 6/4/22	**Logged By:** GE	**Checked By:** JG



Excavation: Method	Excavation: Resistance	Excavation: Stability	Water	Sample or Field Test	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		0.10m		TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	W		TOPSOIL
					0.20m		Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine gravel			COLLUVIUM
				U50 0.35 - 0.75 m	0.5 0.60m		Silty CLAY; medium to high plasticity, grey/brown mottled orange, with fine to medium grained sand	M (>PL) M (≈PL)	F St	RESIDUAL SOIL
					1.0 1.15m		Clayey SAND; fine to medium grained, grey mottled orange, with fine to coarse gravel (Sandstone fragments)	D	D - VD	EXTREMELY WEATHERED
					1.5 2.0		TERMINATED AT 1.15 m Refusal on weathered rock			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS

SPT	- Standard Penetration Test
HP	- Hand/Pocket Penetrometer
DCP	- Dynamic Cone Penetrometer
PSP	- Perth Sand Penetrometer
MC	- Moisture Content
PBT	- Plate Bearing Test
IMP	- Borehole Impression Test
PID	- Photoionisation Detector
VS	- Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	- Bulk disturbed sample
D	- Disturbed sample
ES	- Environmental sample
U	- Thin wall tube 'undisturbed'

MOISTURE

D	- Dry
M	- Moist
W	- Wet
PL	- Plastic limit
LL	- Liquid limit
w	- Moisture content

SOIL CONSISTENCY

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard

RELATIVE DENSITY

VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP08

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:

Machine Type: 12 tonne Excavator
Excavation Method:

Excavation Dimensions:
Contractor: Dannenberg

Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation: Method	Excavation: Resistance	Excavation: Stability	Water	Sampling & Testing: Sample or Field Test	Depth (m)	Classification	Material Description: SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		0.10m		TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	W		TOPSOIL
					0.20m		Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine to medium gravel			COLLUVIUM
				U50 0.40 - 0.80 m	0.70m		Silty CLAY; medium to high plasticity, grey mottled yellow	M (>PL)	F St	RESIDUAL SOIL
					1.20m		Silty Sandy CLAY; medium plasticity, grey mottled yellow, fine to medium sand	M (≈PL) becoming M (<PL)	H	EXTREMELY WEATHERED
					1.60m		Clayey SAND; fine to medium grained, grey mottled yellow, with fine to coarse gravel (Sandstone fragments)	D		
							TERMINATED AT 1.60 m Refusal on weathered rock			

DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm

3	
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13	
ref	

METHOD	
EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION	
VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS	
SPT -	Standard Penetration Test
HP -	Hand/Pocket Penetrometer
DCP -	Dynamic Cone Penetrometer
PSP -	Perth Sand Penetrometer
MC -	Moisture Content
PBT -	Plate Bearing Test
IMP -	Borehole Impression Test
PID -	Photoionisation Detector
VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES	
B -	Bulk disturbed sample
D -	Disturbed sample
ES -	Environmental sample
U -	Thin wall tube 'undisturbed'

MOISTURE	
D -	Dry
M -	Moist
W -	Wet
PL -	Plastic limit
LL -	Liquid limit
w -	Moisture content

SOIL CONSISTENCY	
VS -	Very Soft
S -	Soft
F -	Firm
St -	Stiff
VSt -	Very Stiff
H -	Hard

RELATIVE DENSITY	
VL -	Very Loose
L -	Loose
MD -	Medium Dense
D -	Dense
VD -	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

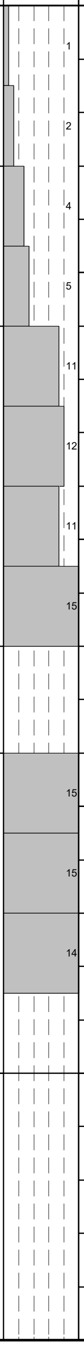
TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP09

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan	**Angle from Horizontal:** 90°	**Surface Elevation:**
Machine Type: 12 tonne Excavator	**Excavation Method:**	
Excavation Dimensions:		**Contractor:** Dannenberg
Date Excavated: 6/4/22	**Logged By:** GE	**Checked By:** JG



Excavation				Sampling & Testing		Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		0.10m			TOPSOIL: Sandy SILT; low plasticity, dark brown, fine to medium grained sand, trace rootlets	M (>PL)		TOPSOIL
					0.20m			Clayey Sandy SILT; low plasticity, grey, fine to medium grained sand, trace fine to medium gravel	M (>PL)		COLLUVIUM
				B 0.30 - 0.60 m	0.5 1.00m			Silty CLAY; medium to high plasticity, brown mottled orange	M (>PL) M (≈PL) becoming M (<PL)	St VSt	RESIDUAL SOIL
				B 1.20 - 1.40 m	1.0 1.40m			Silty CLAY; medium plasticity, grey mottled yellow, trace fine to coarse gravel (Siltstone fragments)	M (<PL)	H	EXTREMELY WEATHERED
					1.5 1.90m			Silty Gravelly CLAY; low to medium plasticity, grey mottled yellow, fine to coarse gravel (Siltstone fragments)	M (<PL)		
					2.00m			Silty CLAY; low to medium plasticity, grey/black (carbonaceous siltstone/weathered coal)	M (<PL) to M (≈ PL)		
					2.0			TERMINATED AT 2.00 m Target depth			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽	Water Level on Date shown
▶	water inflow
◀	water outflow

FIELD TESTS

SPT -	Standard Penetration Test
HP -	Hand/Pocket Penetrometer
DCP -	Dynamic Cone Penetrometer
PSP -	Perth Sand Penetrometer
MC -	Moisture Content
PBT -	Plate Bearing Test
IMP -	Borehole Impression Test
PID -	Photoionisation Detector
VS -	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B -	Bulk disturbed sample
D -	Disturbed sample
ES -	Environmental sample
U -	Thin wall tube 'undisturbed'

MOISTURE

D -	Dry
M -	Moist
W -	Wet
PL -	Plastic limit
LL -	Liquid limit
w -	Moisture content

SOIL CONSISTENCY

VS -	Very Soft
S -	Soft
F -	Firm
St -	Stiff
VSt -	Very Stiff
H -	Hard

RELATIVE DENSITY

VL -	Very Loose
L -	Loose
MD -	Medium Dense
D -	Dense
VD -	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

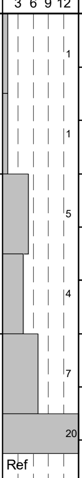
TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP10

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG



Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/ 150 mm	Depth (m)	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		1	0.15m		TOPSOIL: Silty SAND; fine to coarse grained, black/brown, with fine to medium gravel, trace rootlets	M		TOPSOIL
					1	0.25m		Clayey Sandy SILT; low plasticity, grey, fine to coarse grained sand, with sub-angular to sub-rounded gravel, trace rootlets	M (>PL)		COLLUVIUM
				B 0.30 - 0.60 m	5 4 7 20 Ref	0.90m		Silty CLAY; medium to high plasticity, grey/brown mottled orange, trace fine gravel, trace fine to medium sand	M (>PL)	St	RESIDUAL SOIL
				B 0.90 - 1.10 m		1.10m		Clayey SAND; fine to medium grained, brown/orange mottled pale grey, with fine to coarse gravel (Sandstone fragments), trace cobbles,gravel and cobble content increasing with depth	M becoming D	D - VD	EXTREMELY WEATHERED
						1.25m		Clayey Gravelly SAND; fine to medium grained, grey mottled orange, fine to coarse gravel (Sandstone fragments)	D		

TERMINATED AT 1.25 m
Refusal
on weathered rock

METHOD	
EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION	
VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER
- Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS	
SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES	
B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE	
D	Dry
M	Moist
W	Wet
PL	Plastic limit
LL	Liquid limit
w	Moisture content

SOIL CONSISTENCY	
VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard

RELATIVE DENSITY	
VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Job No: 82222027-001

Hole No: TP11

Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation				Sampling & Testing		Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		0.10m	▩		TOPSOIL FILL : Silty Gravelly SAND; fine to coarse grained, brown, fine gravel, trace rootlets	M		FILL
					0.40m	▩		FILL: Silty Gravelly SAND; fine to coarse grained, dark brown/grey, fine to coarse gravel (variable Sandstone and Coal chitter), trace clay	M		
					0.5 0.80m	▨		Silty CLAY; medium to high plasticity, pale grey/brown mottled orange	M (>PL)		RESIDUAL SOIL
					1.0 1.10m	▨		Silty CLAY; low to medium plasticity, pale grey mottled orange-brown, with fine gravel, with fine to medium sand (lenses of Clayey SAND present)	M (≈PL)		EXTREMELY WEATHERED
					1.50m	🟩		SANDSTONE; fine to medium grained, pale grey mottled pale brown orange, very low strength			WEATHERED ROCK
					1.5			TERMINATED AT 1.50 m Refusal on weathered rock			
					2.0						

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

▽ Water Level on Date shown
▶ water inflow
◀ water outflow

FIELD TESTS

SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE

D	Dry
M	Moist
W	Wet
PL	Plastic limit
LL	Liquid limit
w	Moisture content

SOIL CONSISTENCY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard

RELATIVE DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP12

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation				Sampling & Testing			Material Description					
Method	Resistance	Stability	Water	Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		1	0.10m			TOPSOIL: Sandy SILT; low plasticity, black,fine to coarse grained sand, trace fine gravel, trace rootlets	M		TOPSOIL
					2	0.25m			Clayey Sandy SILT; low plasticity, grey, fine to coarse grained sand, with sub-angular to sub-rounded gravel, trace rootlets	M		COLLUVIUM
				B 0.30 - 0.50 m	2 9	0.5 0.60m			Sandy CLAY; medium plasticity, grey/brown mottled yellow, fine to medium sand	M (>PL) becoming M (≈PL)	F VSt	RESIDUAL SOIL
					20 Ref	1.0 1.10m			Clayey SAND; fine to medium grained, grey mottled yellow, with fine to coarse gravel (Sandstone fragments), trace cobbles increasing with depth, silty clay lenses present	D	D - VD	EXTREMELY WEATHERED
						1.5 2.0			TERMINATED AT 1.10 m Refusal on weathered rock			

STANTEC 2.02.0 LIB.GLB Log CARDNO NON-CORED 81022027-001 MINE SUBSIDENCE INVESTIGATION.GPJ <<DrawingFile>> 08/09/2022 14:26 10.03.00.09 Datgel AGS RTA, Photo, Monitoring Tools

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
RR Rock roller

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
▽ Water Level on Date shown
► water inflow
◄ water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

Stantec

TEST PIT LOG SHEET

Client: Newpro25 Pty Ltd
Project: Mine Subsidence Investigation
Location: 442 Louth Park Road, Louth Park

Hole No: TP13

Job No: 82222027-001
Sheet: 1 of 1

Position: Refer to site plan
Angle from Horizontal: 90°
Surface Elevation:
Machine Type: 12 tonne Excavator
Excavation Method:
Excavation Dimensions:
Contractor: Dannenberg
Date Excavated: 6/4/22
Logged By: GE
Checked By: JG

Excavation: Method	Excavation: Resistance	Excavation: Stability	Water	Sampling & Testing: Sample or Field Test	DCP TEST (AS 1289.6.3.2-1997) Blows/150 mm	Depth (m)	Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
600mm toothed bucket		Stable	Not Observed		1	0.10m			TOPSOIL: Sandy SILT; low plasticity, black,fine to coarse grained sand, trace fine gravel, trace rootlets	W	S to F	TOPSOIL
					1 2	0.50m			Clayey Sandy SILT; low plasticity, grey, fine to coarse grained sand, with sub-angular to sub-rounded gravel, trace rootlets	W		COLLUVIUM
					6 11 15	0.80m			Silty CLAY; medium plasticity, dark brown mottled yellow, with fine to medium sand, trace fine gravel	M (>PL)	VSt	RESIDUAL SOIL
				B 0.80 - 0.90 m		1.60m			Silty Sandy CLAY; low to medium plasticity, dark brown mottled orange, fine to medium sand, with fine to coarse gravel (iron rich parent fragments)	M (<PL)	H	EXTREMELY WEATHERED
						2.00m			Sandy CLAY; low plasticity, grey mottled orange, fine to medium sand, trace cobbles (Sandstone fragments)	D	D - VD	
									TERMINATED AT 2.00 m Target depth			

METHOD

EX	Excavator bucket
R	Ripper
HA	Hand auger
PT	Push tube
SON	Sonic drilling
AH	Air hammer
PS	Percussion sampler
AS	Short spiral auger
AD/V	Solid flight auger: V-Bit
AD/T	Solid flight auger: TC-Bit
HFA	Hollow flight auger
WB	Washbore drilling
RR	Rock roller

PENETRATION

VE	Very Easy (No Resistance)
E	Easy
F	Firm
H	Hard
VH	Very Hard (Refusal)

WATER

- ▽ Water Level on Date shown
- ▶ water inflow
- ◀ water outflow

FIELD TESTS

SPT	Standard Penetration Test
HP	Hand/Pocket Penetrometer
DCP	Dynamic Cone Penetrometer
PSP	Perth Sand Penetrometer
MC	Moisture Content
PBT	Plate Bearing Test
IMP	Borehole Impression Test
PID	Photoionisation Detector
VS	Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES

B	Bulk disturbed sample
D	Disturbed sample
ES	Environmental sample
U	Thin wall tube 'undisturbed'

MOISTURE

D	Dry
M	Moist
W	Wet
PL	Plastic limit
LL	Liquid limit
w	Moisture content

SOIL CONSISTENCY

VS	Very Soft
S	Soft
F	Firm
St	Stiff
VSt	Very Stiff
H	Hard

RELATIVE DENSITY

VL	Very Loose
L	Loose
MD	Medium Dense
D	Dense
VD	Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

STANTEC AUSTRALIA PTY LTD

STANTEC 2.02.0 LIB.GLB Log CARDNO NON-CORED 81022027-001 MINE SUBSIDENCE INVESTIGATION.GPJ <<DrawingFile>> 08/09/2022 14:26 10.03.00.09 Datgel AGS RTA, Photo, Monitoring Tools

Explanatory Notes

The methods of description and classification of soils and rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. Material descriptions are deduced from field observation or engineering examination, and may be appended or confirmed by in situ or laboratory testing. The information is dependent on the scope of investigation, the extent of sampling and testing, and the inherent variability of the conditions encountered.

Subsurface investigation may be conducted by one or a combination of the following methods.

Method	
Test Pitting: excavation/trench	
BH	Backhoe bucket
EX	Excavator bucket
R	Ripper
H	Hydraulic Hammer
X	Existing excavation
N	Natural exposure
Manual drilling: hand operated tools	
HA	Hand Auger
Continuous sample drilling	
PT	Push tube
PS	Percussion sampling
SON	Sonic drilling
Hammer drilling	
AH	Air hammer
AT	Air track
Spiral flight auger drilling	
AS	Auger screwing
AD/V	Continuous flight auger: V-bit
AD/T	Continuous spiral flight auger: TC-Bit
HFA	Continuous hollow flight auger
Rotary non-core drilling	
WB	Washbore drilling
RR	Rock roller
Rotary core drilling	
PQ	85mm core (wire line core barrel)
HQ	63.5mm core (wire line core barrel)
NMLC	51.94mm core (conventional core barrel)
NQ	47.6mm core (wire line core barrel)
DT	Diatube (concrete coring)

Sampling is conducted to facilitate further assessment of selected materials encountered.

Sampling method	
Soil sampling	
B	Bulk disturbed sample
D	Disturbed sample
C	Core sample
ES	Environmental soil sample
SPT	Standard Penetration Test sample
U	Thin wall tube 'undisturbed' sample
Water sampling	
WS	Environmental water sample

Field testing may be conducted as a means of assessment of the in situ conditions of materials.

Field testing		
SPT	Standard Penetration Test	
HP/PP	Hand/Pocket Penetrometer	
Dynamic Penetrometers (blows per noted increment)		
	DCP	Dynamic Cone Penetrometer
	PSP	Perth Sand Penetrometer
MC	Moisture Content	
VS	Vane Shear	
PBT	Plate Bearing Test	
IMP	Borehole Impression Test	
PID	Photo Ionization Detector	

If encountered, refusal (R), virtual refusal (VR) or hammer bouncing (HB) of penetrometers may be noted.

The quality of the rock can be assessed by the degree of natural defects/fractures and the following.

Rock quality description	
TCR	Total Core Recovery (%) (length of core recovered divided by the length of core run)
RQD	Rock Quality Designation (%) (sum of axial lengths of core greater than 100mm long divided by the length of core run)

Notes on groundwater conditions encountered may include.

Groundwater	
Not Encountered	Excavation is dry in the short term
Not Observed	Water level observation not possible
Seepage	Water seeping into hole
Inflow	Water flowing/flooding into hole

Perched groundwater may result in a misleading indication of the depth to the true water table. Groundwater levels are also likely to fluctuate with variations in climatic and site conditions.

Notes on the stability of excavations may include.

Excavation conditions	
Stable	No obvious/gross short term instability noted
Spalling	Material falling into excavation (minor/major)
Unstable	Collapse of the majority, or one or more face of the excavation

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Explanatory Notes: General Soil Description

The methods of description and classification of soils used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, a material is described as a soil if it can be remoulded by hand in its field condition or in water. The dominant component is shown in upper case, with secondary components in lower case. In general descriptions cover: soil type, plasticity or particle size/shape, colour, strength or density, moisture and inclusions.

In general, soil types are classified according to the dominant particle on the basis of the following particle sizes.

Soil Classification		**Particle Size (mm)**
CLAY		< 0.002
SILT		0.002 0.075
SAND	fine	0.075 to 0.21
	medium	0.21 to 0.6
	coarse	0.6 to 2.36
GRAVEL	fine	2.36 to 6.7
	medium	6.7 to 19
	coarse	19 to 63
COBBLES		63 to 200
BOULDERS		> 200

Soil types may be qualified by the presence of minor components on the basis of field examination methods and/or the soil grading.

Terminology	**In coarse grained soils**		**In fine soils**
	% fines	**% coarse**	**% coarse**
Trace	≤5	≤15	≤15
With	>5, ≤12	>15, ≤30	>15, ≤30

The strength of cohesive soils is classified by engineering assessment or field/lab testing as follows.

Strength	**Symbol**	**Undrained shear strength**
Very Soft	VS	≤12kPa
Soft	S	12kPa to ≤25kPa
Firm	F	25kPa to ≤50kPa
Stiff	St	50kPa to ≤100kPa
Very Stiff	VSt	100kPa to ≤200kPa
Hard	H	>200kPa

Cohesionless soils are classified on the basis of relative density as follows.

Relative Density	**Symbol**	**Density Index**
Very Loose	VL	<15%
Loose	L	15% to ≤35%
Medium Dense	MD	35% to ≤65%
Dense	D	65% to ≤85%
Very Dense	VD	>85%

The plasticity of cohesive soils is defined by the Liquid Limit (LL) as follows.

Plasticity	**Silt LL**	**Clay LL**
Low plasticity	≤ 35%	≤ 35%
Medium plasticity	N/A	> 35% ≤ 50%
High plasticity	> 50%	> 50%

The moisture condition of soil (*w*) is described by appearance and feel and may be described in relation to the Plastic Limit (PL), Liquid Limit (LL) or Optimum Moisture Content (OMC).

Moisture condition and description	
Dry	Cohesive soils: hard, friable, dry of plastic limit. Granular soils: cohesionless and free-running
Moist	Cool feel and darkened colour: Cohesive soils can be moulded. Granular soils tend to cohere
Wet	Cool feel and darkened colour: Cohesive soils usually weakened and free water forms when handling. Granular soils tend to cohere

The structure of the soil may be described as follows.

Zoning	**Description**
Layer	Continuous across exposure or sample
Lens	Discontinuous layer (lenticular shape)
Pocket	Irregular inclusion of different material

The structure of soil layers may include: defects such as softened zones, fissures, cracks, joints and root-holes; and coarse grained soils may be described as strongly or weakly cemented.

The soil origin may also be noted if possible to deduce.

Soil origin and description	
Fill	Anthropogenic deposits or disturbed material
Topsoil	Zone of soil affected by roots and root fibres
Peat	Significantly organic soils
Colluvial	Transported down slopes by gravity/water
Aeolian	Transported and deposited by wind
Alluvial	Deposited by rivers
Estuarine	Deposited in coastal estuaries
Lacustrine	Deposited in freshwater lakes
Marine	Deposits in marine environments
Residual soil	Soil formed by in situ weathering of rock, with no structure/fabric of parent rock evident
Extremely weathered material	Formed by in situ weathering of geological formations, with the structure/fabric of parent rock intact but with soil strength properties

The origin of the soil generally cannot be deduced solely on the appearance of the material and the inference may be supplemented by further geological evidence or other field observation. Where there is doubt, the terms ‘possibly’ or ‘probably’ may be used

Explanatory Notes: General Rock Description

The methods of description and classification of rocks used in this report are based on Australian Standard AS1726-2017 Geotechnical Site Investigations. In practice, if a material cannot be remoulded by hand in its field condition or in water, it is described as a rock. In general, descriptions cover: rock type, grain size, structure, colour, degree of weathering, strength, minor components or inclusions, and where applicable, the defect types, shape, roughness and coating/infill.

Rock types are generally described according to the predominant grain or crystal size, and in groups for each rock type as follows.

Rock type	**Groups**
Sedimentary	Deposited, carbonate (porous or non), volcanic ejection
Igneous	Felsic (much quartz, pale), Intermediate, or mafic (little quartz, dark)
Metamorphic	Foliated or non-foliated
Duricrust	Cementing minerology (iron oxides or hydroxides, silica, calcium carbonate, gypsum)

Reference should be made to AS1726 for details of the rock types and methods of classification.

The classification of rock weathering is described based on definitions in AS1726 and summarised as follows.

Term and symbol		**Definition**
Residual Soil	RS	Soil developed on rock with the mass structure and substance of the parent rock no longer evident
Extremely weathered	XW	Weathered to such an extent that the rock has ‘soil-like’ properties. Mass structure and substance still evident
Distinctly weathered	DW	The strength is usually changed and may be highly discoloured. Porosity may be increased by leaching, or decreased due to deposition in pores. May be distinguished into MW (Moderately Weathered) and HW (Highly Weathered).
Slightly weathered	SW	Slightly discoloured; little or no change of strength from fresh rock
Fresh Rock	FR	The rock shows no sign of decomposition or staining

The rock material strength can be defined based on the point load index as follows.

Term and symbol		**Point Load Index I_s50 (MPa)**
Very Low	VL	0.03 to 0.1
Low	L	0.1 to 0.3
Medium	M	0.3 to 1.0
High	H	1.0 to 3
Very High	VH	3 to 10
Extremely High	EH	> 10

It is important to note that the rock material strength as above is distinct from the rock mass strength which can be significantly weaker due to the effect of defects.

A preliminary assessment of rock strength may be made using the field guide detailed in AS1726, and this is conducted in the absence of point load testing.

The defect spacing measured normal to defects of the same set or bedding, is described as follows.

Definition	**Defect Spacing (mm)**
Thinly laminated	< 6
Laminated	6 to 20
Very thinly bedded	20 to 60
Thinly bedded	60 to 200
Medium bedded	200 to 600
Thickly bedded	600 to 2000
Very thickly bedded	> 2000

Terms for describing rock and defects are as follows.

Defect Terms			
Joint	JT	Sheared zone	SZ
Bedding Parting	BP	Seam	SM
Foliation	FL	Vein	VN
Cleavage	CL	Drill Lift	DL
Crushed Seam	CS	Handling Break	HB
Fracture Zone	FZ	Drilling Break	DB

The shape and roughness of defects in the rock mass are described using the following terms.

Planarity		**Roughness**	
Planar	PR	Very Rough	VR
Curved	CU	Rough	RF
Undulose	UN	Smooth	S
Irregular	IR	Slickensided	SL
Stepped	ST	Polished	POL
Discontinuous	DIS		

The coating or infill associated with defects in the rock mass are described as follows.

Infill and Coating		
Clean	CN	
Stained	SN	
Carbonaceous	X	
Minerals	MU	Unidentified mineral
	MS	Secondary mineral
	KT	Chlorite
	CA	Calcite
	Fe	Iron Oxide
	Qz	Quartz
Veneer	VNR	Thin or patchy coating
Coating	CT	Infill up to 1mm

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Graphic Symbols Index

- ▨ CLAY
- ▨ Silty CLAY
- ▨ Sandy CLAY
- ▨ Gravelly CLAY
- ▨ Silty Gravelly CLAY
- ▨ Silty Sandy CLAY
- ▨ Sandy Gravelly CLAY

- ▨ SILT
- ▨ Clayey SILT
- ▨ Sandy SILT
- ▨ Gravelly SILT
- ▨ Clayey Sandy SILT
- ▨ Clayey Gravelly SILT
- ▨ Sandy Gravelly SILT

- ▨ SAND
- ▨ Clayey SAND
- ▨ Silty SAND
- ▨ Gravelly SAND
- ▨ Clayey Silty SAND
- ▨ Clayey Gravelly SAND
- ▨ Silty Gravelly SAND

- ▨ GRAVEL
- ▨ Clayey GRAVEL
- ▨ Silty GRAVEL
- ▨ Sandy GRAVEL
- ▨ Clayey Silty GRAVEL
- ▨ Clayey Sandy GRAVEL
- ▨ Silty Sandy GRAVEL

- ▨ COBBLES & BOULDERS
- ▨ PEAT, highly organic soil
- ▨ TOPSOIL
- ▨ FILL
- ⬛ FILL: Asphalt or Bituminous Seal
- ▨ FILL: Ballast
- ▨ FILL: Concrete
- ▨ FILL: Roadbase

- 🟦 Sedimentary rock: fine, mostly clay (CLAYSTONE)
- 🟦 Sedimentary rock: fine, mostly silt (SILTSTONE)
- 🟦 Sedimentary rock: fine, silt and clay (MUDSTONE, SHALE, LAMINITE)
- 🟩 Sedimentary rock: medium (SANDSTONE, GREYWACKE)
- 🟩 Sedimentary rock: fine to coarse, angular (BRECCIA)
- 🟫 Sedimentary rock: coarse, rounded (CONGLOMERATE)
- ⬛ Sedimentary rock: Organic (COAL)
- 🟫 Sedimentary rock: Carbonate (LIMESTONE, DOLOMITE)
- 🟥 Sedimentary rock: Volcanic (TUFF, VOLCANIC BRECCIA, AGGLOMERATE)

- 🟧 Igneous rock: Felsic, fine (RHYOLITE)
- 🟧 Igneous rock: Felsic, coarse (GRANITE)
- 🟫 Igneous rock: Mafic, fine to medium (BASALT, DOLERITE)
- 🟫 Igneous rock: Mafic, coarse (GABBRO)
- 🟦 Metamorphic rock: Foliated, fine to medium (SLATE, PHYLLITE, SHIST)
- 🟦 Metamorphic rock: Foliated, coarse (GNEISS)
- 🟪 Metamorphic rock: Non-foliated (QUARTZITE, HORNFELS, MARBLE)

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DYNAMIC CONE PENETROMETER

(blows per measurement)

Client:	NewPro25 Pty Ltd	Project Number:	81022027-002.1
Project:	Geotechnical Investigation	Test Request	-
Location:	442 Louth Park Road	Lot Number:	-
Tested By:	GE Date Tested: 6/04/2022	Material Source:	In-situ

Procedures:	AS1289.6.3.2	Hammer: 9kgs
Drop Height Checked [✓]	DCP Tip Checked [✓]	Drop Height: 510mm

Sample Number	DCP1	DCP2	DCP3			
Moisture Condition						
Ground Water Level (m)						
Site Area:	See Site Plan Appendix A	See Site Plan Appendix A	See Site Plan Appendix A			
Surface RL (m):						
Fill Depth (m):						
Depth (m)	Blows / 150mm	Blows / 150mm	Blows / 150mm			
0.0 - 0.15	0	0	0			
0.15 - 0.3 m	0	0	0			
0.3 - 0.45 m	0	2	0			
0.45 - 0.6 m	4	1	1			
0.6 - 0.75 m	5	2	2			
0.75 - 0.9 m	15/50	1	2			
0.9 - 1.05 m		4	3			
1.05 - 1.2 m		6	5			
1.2 - 1.35 m		15	9			
1.35 - 1.5 m		16	15			
1.5 - 1.65 m		20	18			
1.65 - 1.8 m			21			

442 Louth Park Road Residential Subdivision

APPENDIX

C

LABORATORY TESTING

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Material Test Report

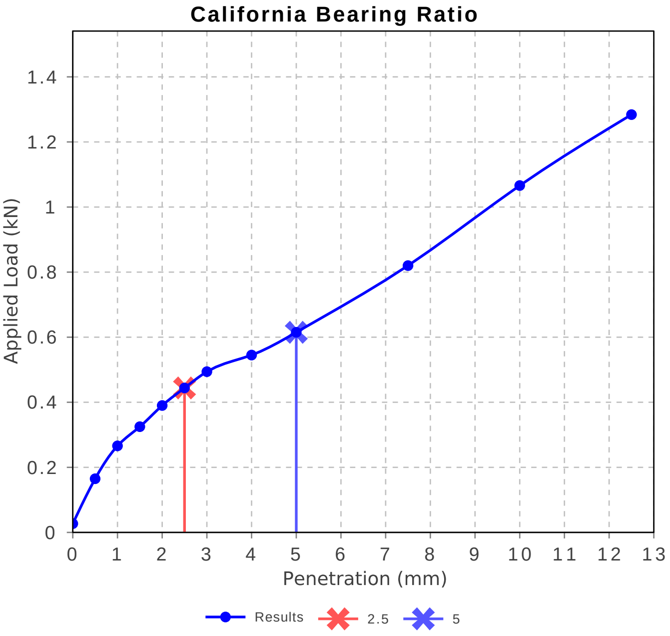
Intrax Consulting Engineers Pty Ltd
Morisset Laboratory
Unit 2, 50 Alliance Avenue Morisset NSW 2264
Phone: 0499 779 118
Email: steve.waugh@intrax.com.au

Accredited for compliance with ISO/IEC 17025 - Testing

Approved Signatory: Steve Waugh
Laboratory Manager
NATA Accredited Laboratory Number: 19862

Report Number: **PRJ721955-1**
Issue Number: 1
Date Issued: 05/05/2022
Client: Cardno NSW
Unit 1, 10 Denny Street, Broadmeadow NSW 2292
Contact: Ian Piper
Project Number: PRJ721955
Project Name: Louth park future stage
Project Location: 442 Louth Park Road, Louth park NSW
Client Reference: 81022027-002
Work Request: 3763
Sample Number: M22-3763C
Date Sampled: 05/04/2022
Dates Tested: 11/04/2022 - 22/04/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: **TP4, Depth: 0.3 - 0.5m**
Material: Refer to Client logs

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**3.5**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	visual		
Maximum Dry Density (t/m^3)	1.61		
Optimum Moisture Content (%)	19.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.5		
Dry Density after Soaking (t/m^3)	1.58		
Field Moisture Content (%)	21.7		
Moisture Content at Placement (%)	19.1		
Moisture Content Top 30mm (%)	25.8		
Moisture Content Rest of Sample (%)	21.6		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	144.0		
Swell (%)	2.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



Material Test Report

Report Number: **PRJ721955-1**
Issue Number: 1
Date Issued: 05/05/2022
Client: Cardno NSW
Unit 1, 10 Denny Street, Broadmeadow NSW 2292
Contact: Ian Piper
Project Number: PRJ721955
Project Name: Louth park future stage
Project Location: 442 Louth Park Road, Louth park NSW
Client Reference: 81022027-002
Work Request: 3763
Sample Number: M22-3763E
Date Sampled: 05/04/2022
Dates Tested: 11/04/2022 - 22/04/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Sample Location: **TP9, Depth: 1.2 - 1.4m**
Material: Refer to Client logs

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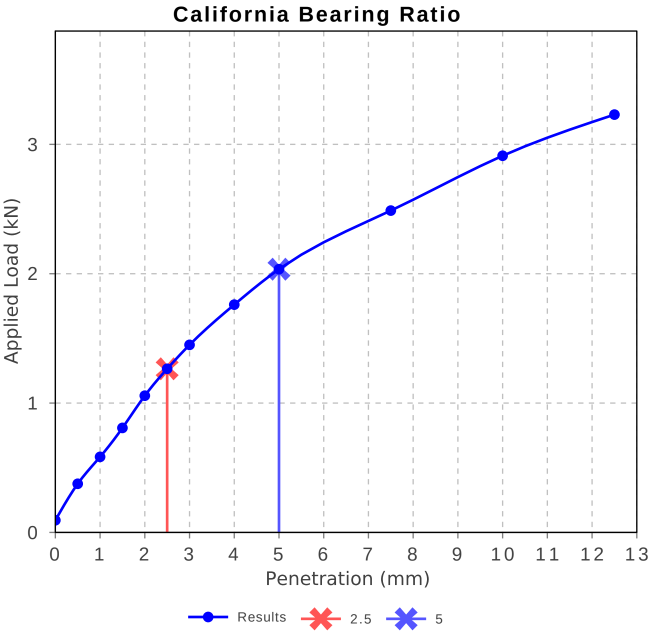
Approved Signatory: Steve Waugh
Laboratory Manager
NATA Accredited Laboratory Number: 19862

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	5 mm		
CBR %	**10**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	visual		
Maximum Dry Density (t/m^3)	1.80		
Optimum Moisture Content (%)	16.0		
Laboratory Density Ratio (%)	100.5		
Laboratory Moisture Ratio (%)	96.5		
Dry Density after Soaking (t/m^3)	1.81		
Field Moisture Content (%)	11.7		
Moisture Content at Placement (%)	15.6		
Moisture Content Top 30mm (%)	18.5		
Moisture Content Rest of Sample (%)	17.8		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	120.0		
Swell (%)	0.5		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0.0		



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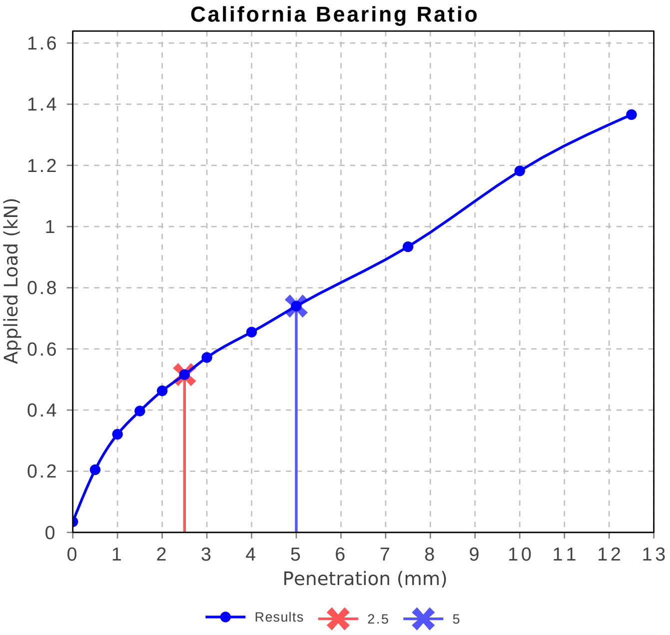
Report Number:	**PRJ721955-1**
Issue Number:	1
Date Issued:	05/05/2022
Client:	Cardno NSW Unit 1, 10 Denny Street, Broadmeadow NSW 2292
Contact:	Ian Piper
Project Number:	PRJ721955
Project Name:	Louth park future stage
Project Location:	442 Louth Park Road, Louth park NSW
Client Reference:	81022027-002
Work Request:	3763
Sample Number:	M22-3763F
Date Sampled:	05/04/2022
Dates Tested:	11/04/2022 - 19/04/2022
Sampling Method:	Sampled by Client - Tested as Received *The results apply to the sample as received*
Sample Location:	**TP10, Depth: 0.3 - 0.6m**
Material:	Refer to Client logs

California Bearing Ratio (AS 1289 6.1.1 & 2.1.1)		Min	Max
CBR taken at	2.5 mm		
CBR %	**4.0**		
Method of Compactive Effort	Standard		
Method used to Determine MDD	AS 1289 5.1.1 & 2.1.1		
Method used to Determine Plasticity	visual		
Maximum Dry Density (t/m^3)	1.72		
Optimum Moisture Content (%)	18.0		
Laboratory Density Ratio (%)	100.0		
Laboratory Moisture Ratio (%)	100.0		
Dry Density after Soaking (t/m^3)	1.69		
Field Moisture Content (%)	21.6		
Moisture Content at Placement (%)	17.9		
Moisture Content Top 30mm (%)	22.3		
Moisture Content Rest of Sample (%)	19.1		
Mass Surcharge (kg)	4.5		
Soaking Period (days)	4		
Curing Hours	120.0		
Swell (%)	2.0		
Oversize Material (mm)	19		
Oversize Material Included	Excluded		
Oversize Material (%)	0		



This document shall not be reproduced except in full without approval of the laboratory.
Results relate only to the items tested/sampled.

Material Test Report

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Client: Cardno NSW
Unit 1, 10 Denny Street, Broadmeadow NSW 2292
Contact: Ian Piper
Project Number: PRJ721955
Project Name: Louth park future stage
Project Location: 442 Louth Park Road, Louth park NSW
Client Reference: 81022027-002
Work Request: 3763
Date Sampled: 05/04/2022
Dates Tested: 05/04/2022 - 05/04/2022
Sampling Method: Sampled by Client - Tested as Received
The results apply to the sample as received
Location: Louth park
Material: Refer to Client logs
Material Source: insitu

Shrink Swell Index AS 1289 7.1.1 & 2.1.1					
Sample Number	M22-3763A	M22-3763B	M22-3763D	M22-3763G	
Date Sampled	11/04/2022	11/04/2022	05/04/2022	05/04/2022	
Date Tested	05/04/2022	05/04/2022	05/04/2022	05/04/2022	
Material Source	insitu	insitu	insitu	insitu	
Sample Location	TP2 (0.3 - 0.7m)	TP3 (0.4 - 0.9m)	TP8 (0.4 - 0.8m)	TP12 (0.3 - 0.5m)	
Inert Material Estimate (%)	0	0	0	0	
Pocket Penetrometer before (kPa)	**	**	**	**	
Pocket Penetrometer after (kPa)	**	**	**	**	
Shrinkage Moisture Content (%)	21.1	22.7	19.8	17.5	
Shrinkage (%)	**4.2**	**4.5**	**3.7**	**1.4**	
Swell Moisture Content Before (%)	20.0	24.2	23.0	17.7	
Swell Moisture Content After (%)	21.3	26.2	24.3	20.6	
Swell (%)	**1.1**	**0.8**	**0.3**	**-0.1**	
Shrink Swell Index Iss (%)	**2.6**	**2.7**	**2.1**	**0.8**	
Visual Description	Refer to Client logs	Refer to Client logs	Refer to Client logs	Refer to Client logs	
Cracking	SC	SC	SC	SC	
Crumbling	**	**	**	**	
Remarks	**	**	**	**	

Shrink Swell Index (Iss) reported as the percentage vertical strain per pF change in suction.
Cracking Terminology: UC Uncracked, SC Slightly Cracked, MC Moderately Cracked, HC Highly Cracked, FR Fragmented.
NATA Accreditation does not cover the performance of pocket penetrometer readings.

442 Louth Park Road Residential Subdivision

APPENDIX

D

BTF SHEET 18

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Foundation Maintenance and Footing Performance:

A Homeowner's Guide

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

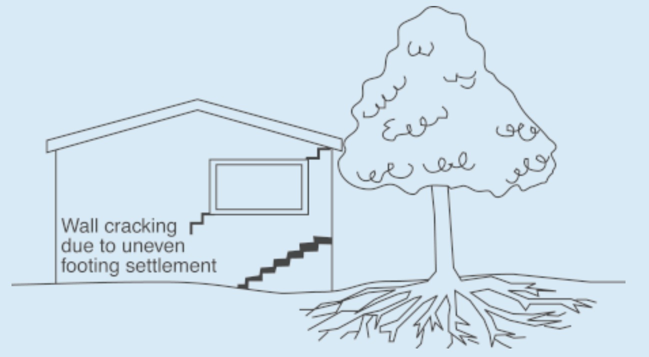
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation’s ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

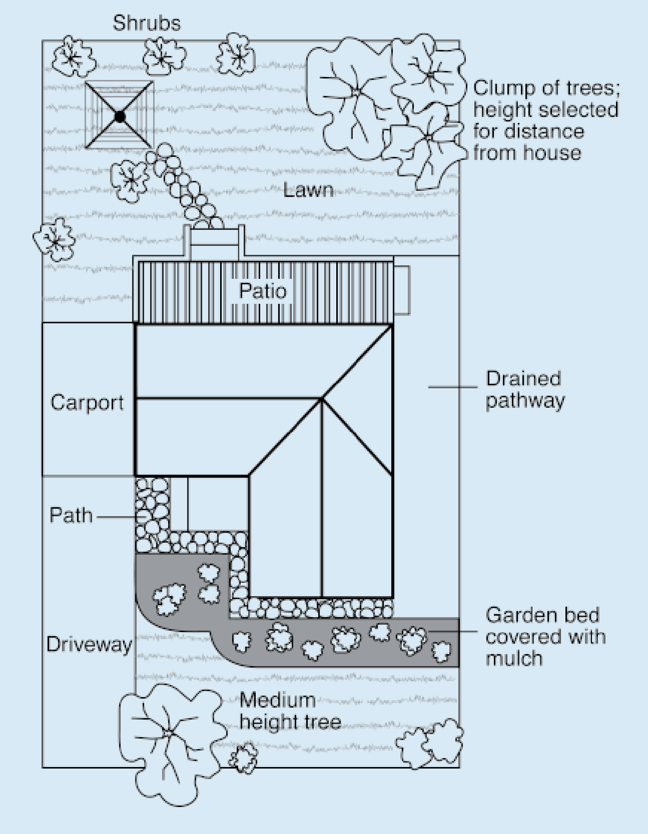
Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4

Gardens for a reactive site



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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