SOIL SURVEYS

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Specialists in Applied Geotechnics
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PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL
Approval no: DEV2024/1557
Date: 20 January 2025
Queensland
Government

Brisbane Office
Project No: 1-276881-27688
Ref: 1-27688 LR 1.1
Author: Glen Burkitt/ntp

13 May 2024

Best Builder For You
Email: bill@bestbuilderforyou.com.au

ATTENTION: BILL MORRIS

RE: SLOPE STABILITY ASSESSMENT
PROPOSED NEW RESIDENCE
LOT 1, 26 SONGBIRD STREET, OXLEY

1.0 INTRODUCTION

1.1 General

This report presents the results of the geotechnical investigation carried out by Soil Surveys Engineering Pty Limited at the above site.

The investigation was carried out following authorisation from Bill Morris of Best Builder For You on the 9th May, 2024.

1.2 Proposed Development

It is understood that the proposed development is to consist of the construction of a new stepped two-level residence at the above site.

Building loads have not been provided, however based on the provided drawings it has been assumed that they would be generally consistent with domestic type structural loads.

From the provided drawings (refer Pavilion Studios Issue K, sheets 1 to 10, dated 23/02/2024), earthworks are expected to consist of retained cuts of up to approx. 2.8m and retained filling of up to approx. 2.0m.

1.3 Required Works

As part of the subdivisional sales and development applications, this lot includes a Covenant over the lot requiring 'Geotechnically Compliant Residential Development'.

Based upon the provided Form 31 Covenant document, dated 3rd December, 2021, the relevant wording includes the following:-

*"**Geotechnically Compliant Residential Development** means for the purpose of the preservation of the Lot and any building to be constructed on the Lot so that it may be used for residential purposes without risk of subterranean movement that could render the Lot unfit for residential use:*

(a) All Works must be completed in accordance with the Geotechnical Report and any subsequent geotechnical report relating specifically to the Lot;

(b) Prior to commencing Works, the Owner must engage a registered professional engineer experienced in geotechnical investigation to drill a 10 metre deep geotechnical investigation bore on the Lot and;

i. if the results of the bore and groundwater levels are, in the opinion of the experienced geotechnical consultants, consistent with the outcomes of the Geotechnical Report, then no further action is required, provided that the Works fully comply with the development restrictions contained in the Geotechnical report; or

ii. if the results of the bore and groundwater levels are, in the opinion of the experienced geotechnical consultant, indicative of worse ground/groundwater conditions than are outlined in the Geotechnical Report, than a detailed, site specific slope stability assessment, should be undertaken for the Lot (including the proposed Lot specific development). If the results of the assessment do not provide factor of safety values equal to or greater than the minimum acceptable values nominated in the Geotechnical Report, detailed remedial design work must be prepared by the experienced geotechnical consultant to raise the factor of safety values to not less than the nominated minimum values.

***Geotechnical Report** means the combination of the following documents, copies of which are contained in Annexure A:*

(a) Butler Partner's Individual Lot Slope Stability Assessments Technical Note dated 15 October 2021;

(b) Butler Partner's Approved Slope Stability Assessment report dated 29 September 2020; and

(c) Butler Partner's Groundwater Assessment report dated 15 September 2020,

which the Covenantee has obtained as part of its development application."

1.4 Scope of Works

Given the above required works, the objective of this study was to undertake a site investigation and site mapping to assess the existing geotechnical conditions to provide a slope stability assessment for the subject lot as required by the Covenant. Two variations of scope have been prepared to reflect the Covenant items b(i) and b(ii):-

- Item b(i) – Conditions are consistent with Butler Partners (BP) Reports
  - Drill the required 10m geotechnical borehole on the lot
  - Provided reports will be reviewed and confirmed as consistent via a brief report.

- Item b(ii) – Conditions are worse than outlined in Butler Partners (BP) Reports
  - Drill the required 10m geotechnical borehole on the lot
  - Undertake a detailed site specific slope stability report in accordance with:-
    - National Disaster Mitigation Program (NDMP), Landslide Risk Management (LRM) Guidelines, Practice Notes and Geoguidelines as

published in the "Australian Geomechanics Journal" Volume 42 No. 1 March, 2007.
- State Planning Policy July, 2017-SPP.
- Brisbane City Council (BCC) City Plan 2014.
- Form 31 Geotechnically Compliant Residential Development Covenant

2.0 SITE INVESTIGATION

2.1 Field Investigation

As required, subsurface conditions were investigated by auger drilling and sampling one borehole (BH03) to a depth of 10.0m, using a contract track mounted GEO601 drilling rig in 2022. In addition, standard penetrometer tests (SPT) were carried out within the borehole.

The above site investigation was carried out in 2022 for a previous landowner and included as part of the land sale to the current owner. The site was also reinspected in 2024 by a Senior Engineering Geologist, experienced in slope stability assessments.

The nearest Butler Partners (from 2020 Reports in Section 1.3) borehole (BBH105) was located approx. 20m to the northwest of BH03 (2022), located within the adjacent lot (Lot 2) (refer to Figure 2).

The soil classification descriptions and field tests were carried out in general accordance with the following Australian Standards:-

AS 1726-2017	Geotechnical Site Investigations
AS 1289	Methods of Testing Soils for Engineering Purposes

Details of the investigation method and borehole record are attached with a site plan showing the location of the SSE 2022 borehole included in Figure 2.

The classification of soils in the field is subjective, based on the experience and judgement of the geotechnical driller and some variations in the soil description, from the actual material type may occur.

2.2 Site Description

The site is located at Lot 1, 26 Songbird Street, Oxley, within the recently constructed Songbird Development off Seventeen Mile Rocks Road (refer Figure 1).

At the time of the investigation, the lot was vacant land, with slopes of up to approx. 10° to 15° falling towards the northeast. The surface was generally well grassed with areas of exposed loose soil towards the northern side (refer Photos 1 and 2). Concrete drainage infrastructure and fencing has also been constructed along the southern boundary of the lot (refer Figure 1 and Photo 2). We understand that the drain has been engineer designed to intercept upslope drainage from the neighbouring lots.

Based upon the provided Disclosure Plans from EDQ, it is understood that no subdivisional filling has been undertaken on the lot with cuts likely to have occurred to reshape the surface profile as part of the subdivision construction.

The site has been described as moderately to well drained with no seepage noted.

Typical site conditions are shown in Photo 1 (2022) and Photo 2 (2024).

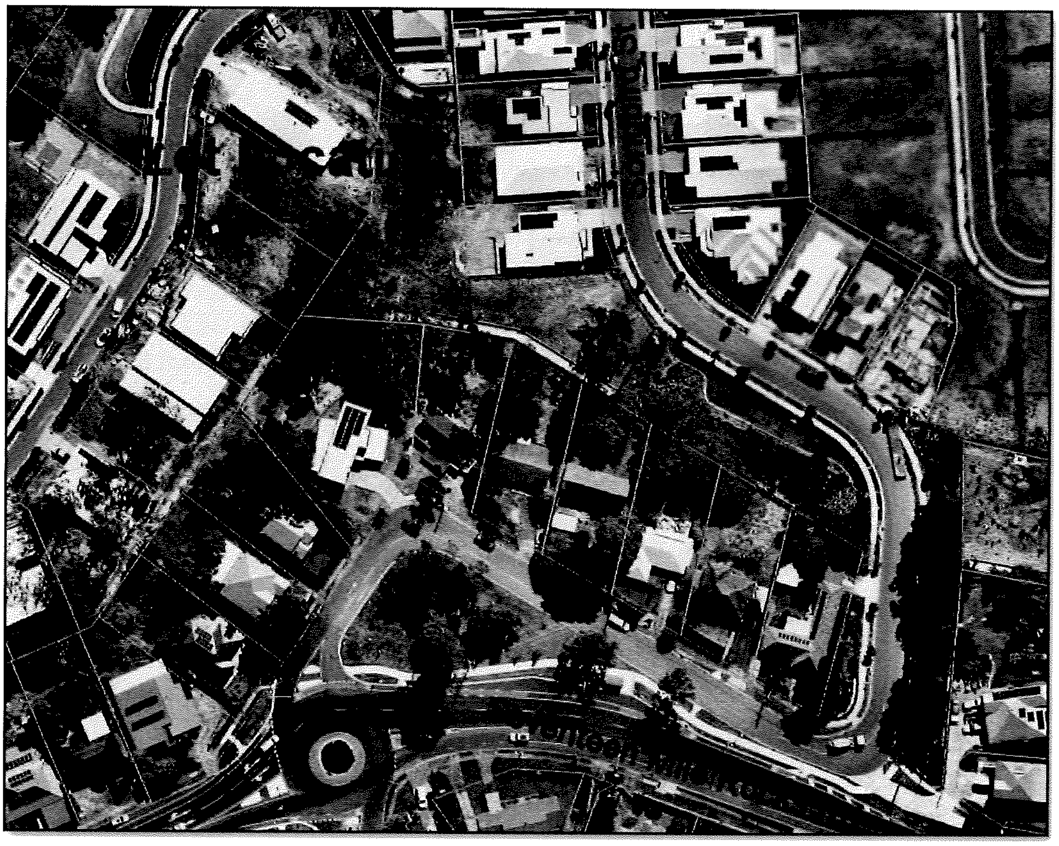

FIGURE 1 – SITE LOCATION

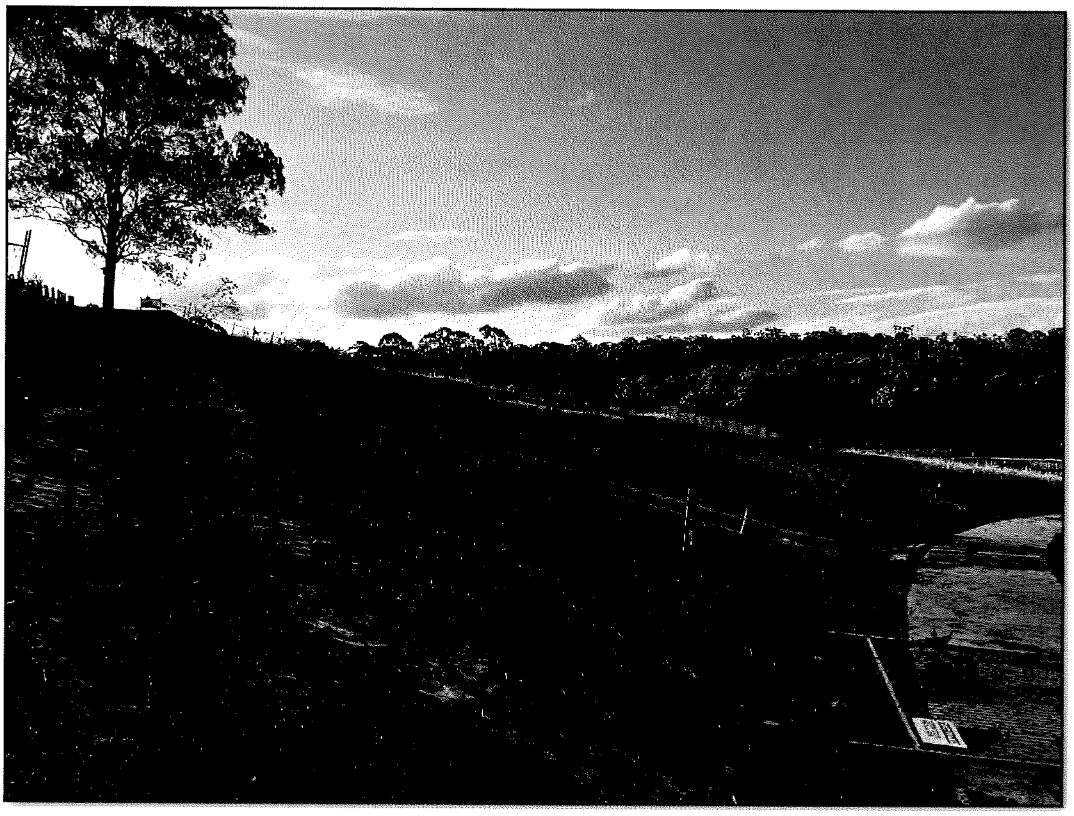

PHOTO 1 – SITE LOOKING NORTHWEST 31st JANUARY, 2022

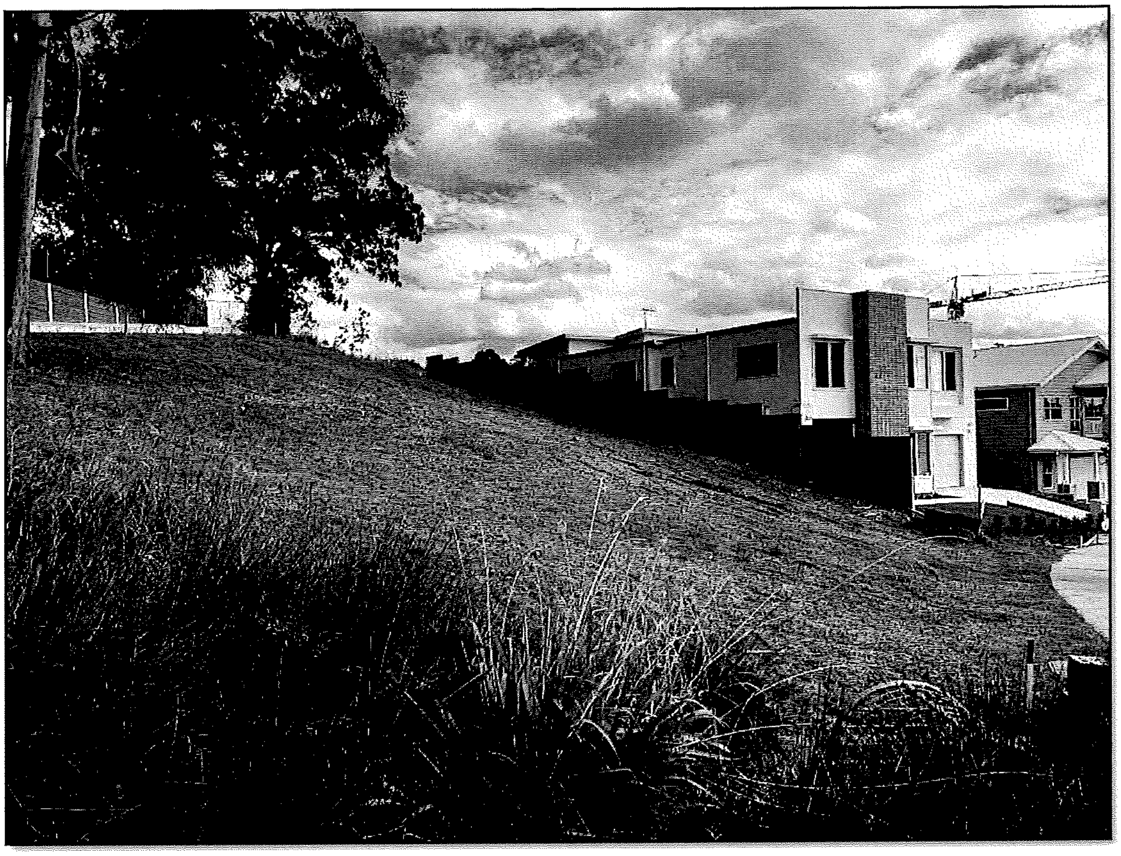

PHOTO 2 – SITE LOOKING NORTHWEST 9th MAY, 2024

2.3 Regional Geology

As discussed in the Butler reports and confirmed on published geology maps, the geology of the site consists of sedimentary deposits from the Tertiary Age (~65 to 1.8 Mya) Darra Formation, comprising sandstone, conglomerate, claystone, siltstone.

2.4 Subsurface Profile

The subsurface profile encountered within the 10m borehole (BH03) by SSE consisted of:-

- A minor surface fill layer of Sandy CLAY (CI) 0.5m thick, over;
- Residual Silty and Sandy CLAY (CH and CL-CI), very stiff to hard, high plasticity and low to medium plasticity, with fissuring noted, over;
- Sandstone (XW), extremely weathered, very low strength (recovered as Clayey SAND), over;
- Clayey Gravelly SAND (SC), dense, over;
- Mudstone (XW-DW), extremely weathered (recovered as Silty CLAY) to distinctly weathered, very low to low strength, extending to the termination depth of the borehole.
- Groundwater was encountered during drilling at a depth of approx. 6.0m (RL26.0m) below ground level at the borehole location (RL32.0).

A site plan of the approximate SSE borehole location along with the nearest approximate Butler Partners borehole locations are included in Figure 2. The detailed SSE bore log is included at the rear of this report.

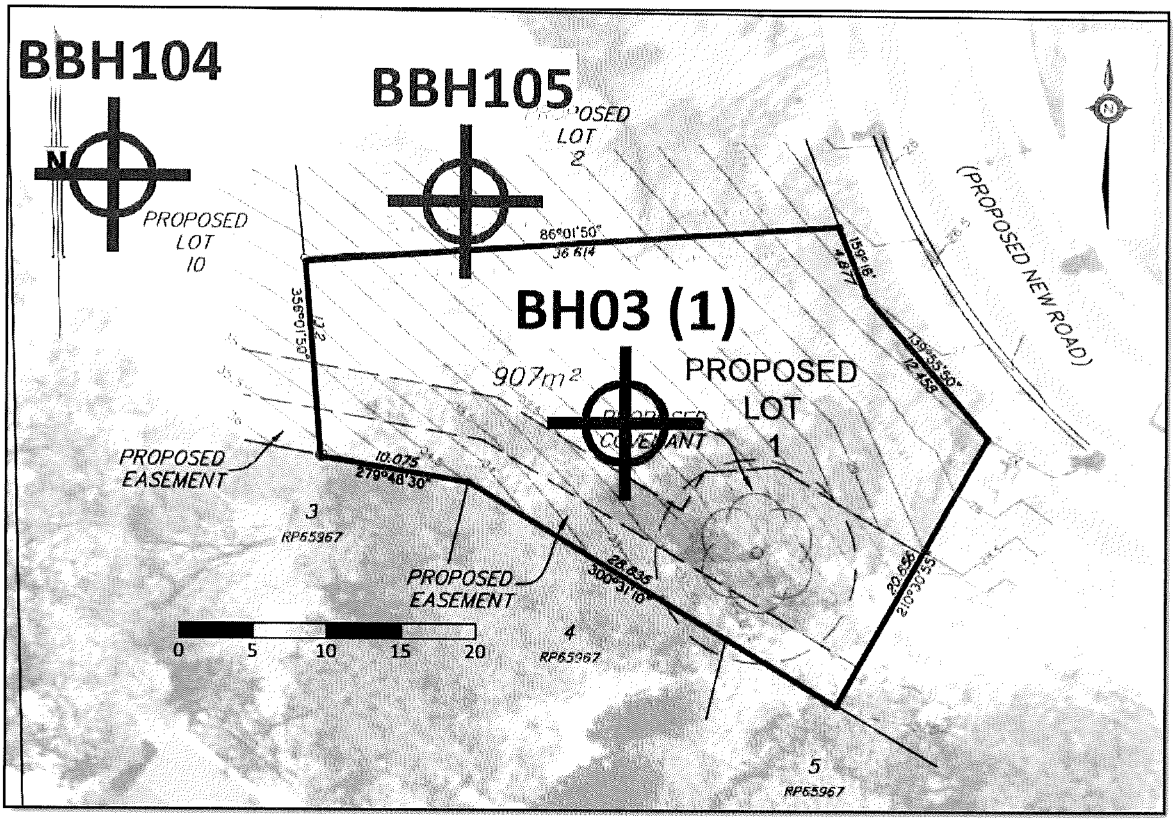

FIGURE 2 – SITE PLAN

3.0 ENGINEERING ASSESSMENT

3.1 Review of Previous Reports

To address the Covenant requirements, the previous geotechnical investigations and reports were reviewed. The review included the following Butler Partners reports:-

- Butlers Partner's Individual Lot Slope Stability Assessments Technical Note dated 15 October 2021;
- Butlers Partner's Approved Slope Stability Assessment report dated 29 September 2020; and
- Butlers Partner's Groundwater Assessment report dated 15 September 2020.

3.2 Borehole Comparison

For this lot, the general subsurface profile to a depth of 10m presented in the Butler reports (BH104 & 105) consisted of residual Silty CLAY (CH), stiff to hard, with slickensides, over interbedded layers of hard clay and very dense sand (BH105) and a significant Extremely Weathered Sandstone (XW) layer (BH104), over Extremely Weathered Mudstone (XW) extending below 10m depth. Groundwater was not encountered (possibly due to the use of water circulation drilling methods below 2.5m depth).

We also understand from the provided drawings that subdivisional earthworks within the vicinity of the lot have likely reduced the natural surface levels (i.e. the Butler boreholes was drilled nearby at an RL of approx. 33.0m {BH104} and RL 32.0m {BH105}).

However, the subsurface profile intersected in our BH03 drilled from approx. RL 32.0m during the additional fieldwork was assessed being better than BP BH105 and much better than BP BH104 based upon description and in situ testing. Given the new levels and elevation difference across the lot, BH104 is more likely to be a closer comparison to our BH03.

Groundwater was noted at a depth of 6.0m (RL 26.0m) during the drilling of the BH03, within a dense sand layer between sandstone and mudstone horizons.

3.3 Assessment with respect to the Covenant

We confirm that the subsurface profile between the three relevant boreholes (SSE BH03 and BP BH104 & BH105) was considered to be consistent or better within a geotechnical context.

A review of the Butler reports confirms that a groundwater table at depths of 4m and 6m below the surface was assessed in computer model cross sections near this site. Results indicated that a satisfactory Factor of Safety (FOS) was maintained for these groundwater levels using their assumptions, which also correlates with the recent findings.

The presence of heavily fissured or slickensided clays within the profile was also assessed using residual strength analyses in the Butler reports. This was carried out in conjunction with groundwater assumed at a depth of 4m below the surface level. FOS values were considered to be within or in excess of the acceptable long term slope stability range.

Therefore, the presence of groundwater and/or fissured clays within our recent borehole (BH03) could be considered to be within the constraints already assessed by Butler Partners.

3.4 Summary

Based upon the above review and assessment, we believe that the results of the borehole and groundwater levels are, in our opinion, consistent with the outcomes of the Geotechnical Report as per the required works in Section 1.3.

We confirm that works on the site will also need to fully comply with the development restrictions contained in the Butler geotechnical report dated 29th September, 2020.

4.0 LIMITATIONS

We have prepared this report for the use of **Best Builder For You**, for design purposes in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made as to the professional advice included in this report. This report has not been prepared for use by parties other than **Best Builder For You**; it may not contain sufficient information for purposes of other parties or for other uses. Please note that any third party relying on the information contained in this report for any purpose whatsoever does so entirely at its own risk, and any duty of care to that third party is excluded.

Any interpretation or recommendation given by Soil Surveys Engineering shall be understood to be based on judgement and experience and not on greater knowledge of the facts than the reported investigations would imply. The interpretation and recommendations are therefore opinions provided for our client's sole use in accordance with the specific brief. As such they do not necessarily address all aspects of ground behaviour on the subject site. Information provided by others has been taken in good faith, but no liability can be accepted for information provided by others.

Your attention is drawn to the attachment, 'Notes Relating to this Report'. Interpretation of factual data given in this report is based on judgement, not a greater knowledge of facts other than those reported.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore consider the spacing and depth of test locations, the method of investigation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the test locations. Subsurface conditions between and below test locations may vary significantly from conditions encountered at the test locations.

If conditions encountered on site during construction appear to vary from those expected from the information contained in the report, the Company strongly recommends that it immediately be notified. Most problems are more readily resolved when conditions are exposed than at some later stage, after the event. Should Soil Surveys Engineering not be notified or if this notification is delayed, then Soil Surveys cannot be held responsible for the affect that any variation has on any aspect of the development.

Soil Surveys Engineering consider that a documentation review service (during the design phase and prior to construction) to verify that the intent of geotechnical recommendations is properly reflected in the design, along with construction inspections, forms a very important component of the geotechnical engineering design service/process.

The geotechnical review ensures geotechnical risks to our client and their project are minimised at the design and tender stage of the project. Further, with Soil Surveys Engineering being commissioned to carry out geotechnical construction inspections, an opportunity at the time of construction to confirm any assumptions made in the preparation of the report and allow the effect of any normally occurring variation in ground conditions to be assessed with respect to construction becomes available.

The above statements are not intended to reduce the level of responsibility accepted by Soil Surveys Engineering in accordance with our commission, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in doing so and the risks they accept should they decline to have Soil Surveys Engineering carry out a geotechnical documentation review and geotechnical construction inspections.

It is highly recommended that the Client avail themselves of these review and inspection services; our standard rates will apply.

Yours faithfully,

Noel Perkins (May 13, 2024 10:25 GMT+10)

G. BURKITT
SENIOR ENGINEERING GEOLOGIST

N. T. PERKINS (RPEQ 7527)
PRINCIPAL GEOTECHNICAL ENGINEER

for and on behalf of
SOIL SURVEYS ENGINEERING PTY LIMITED

Attachments:
1) Borehole Record
2) Notes Relating to this Report

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 03
Project Number: 1-24802
Project Name: Proposed Residence
Location: Lot 1 Songbird Street, Oxley
Client: Luke Hable & Noemi Kern
Date: 09/02/2022
Page: 1 OF 1

Easting: Northing: RL: 32.0 m
Logger: JP/KM Operator: JP Machine: COMACCHIO GEO 601

Drilling Method: TC | WB | RR | NMLC | Casing

Depth	Description	Samples and Remarks
0.00 – 0.50	FILL Sandy CLAY (CI): Stiff to very stiff, medium plasticity, dark brown, fine to medium grained sand, trace fine to medium sized gravel, moist	D
0.50 – 2.20	NATURAL Silty CLAY (CH): Very stiff to hard, high plasticity, pale grey pale brown, with fine grained sand, moist (fissured)	D D U50 Rec = 65%
2.20 – 2.80	Sandy CLAY (CL-CI): Hard, low to medium plasticity, pale yellow brown, fine grained sand, w<pl (tending to extremely weathered rock)	SPT 3, 11, 19 N=30 D
2.80 – 6.50	SANDSTONE (XW): Extremely weathered, very low strength, pale yellow brown pale grey, with fine grained sand (recovered as Clayey SAND [SC])	SPT 9, 20, 30/140mm N=R D SPT 21, 30/145mm N=R D SPT 30/140mm N=R D SPT 30/135mm N=R
6.50 – 7.80	Clayey Gravelly SAND (SC): Dense, fine to medium grained, red brown, low to medium plasticity clay, fine to medium sized gravel	D SPT 28, 14, 20 N=34 D
7.80 – 9.00	MUDSTONE (XW): Extremely weathered, very low strength, dark brown (recovered as Silty CLAY [CI])	SPT 30/145mm N=R D
9.00 – 10.00	MUDSTONE (DW): Distinctly weathered, low strength, dark brown black	SPT 24, 30/90mm N=R D
10.00	BOREHOLE BH 03 TERMINATED AT 10.00 m	SPT 30/120mm N=R

Depth scale: 1.0, 2.0, 3.0, 4.0, 5.0, 6.0 ▽, 7.0, 8.0, 9.0, 10.0

Comments:
1. Groundwater noted at a depth of 6.00m.
2. RL estimated from provided data.

▽ Water First Noted ▼ Water Steady Level ◄ Water Loss

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
HW - Highly weathered
DW - Distinctly weathered
MW - Moderately weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VL - Very low
L - Low
M - Medium
H - High
VH - Very high
EH - Extremely high

Samples
U50 ▮
SPT]
Disturbed Sample [
Bulk Sample [

Approved: GB
Date: 11/03/2022

NOTES RELATING TO THIS REPORT

September, 2019

INTRODUCTION

These notes are provided by Soil Surveys Engineering Pty Limited (the Company) to complement the geotechnical report in regard to classification methods and field procedures. Not all notes are necessarily relevant to all reports.

The ground is a product of continuing natural and man-made processes and therefore exhibits a variety of characteristics and properties which vary from place to place and can change with time. Geotechnical engineering involves gathering and assimilating limited information about these characteristics and properties in order to understand or predict the behaviour of the ground on a particular site under certain conditions. This report may contain such information obtained by inspection, excavation, probing, sampling, testing or other means of investigation. If so, they are directly relevant only to the ground at the place where and at the time when the investigation was carried out.

DESCRIPTION AND CLASSIFICATION METHODS

Soils - The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726-2017 (Geotechnical Site Investigations), where appropriate. In general, descriptions cover the following properties - soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the dominant particle size and behaviour as set out in AS 1726-2017.

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, shear vane, laboratory testing or engineering examination. The strength terms are defined in AS 1726-2017 Table 11.

Non-cohesive soils are classified on the basis of relative density usually based on insitu testing or engineering examination (see AS 1726-2017 Table 12).

Rocks - Rock types are classified by their geological names (AS 1726-2017 Tables 15 to 18), together with descriptive terms regarding weathering (AS 1726-2017 Table 20), strength (AS 1726-2017 Table 19), defects (AS 1726-2017 Table 22), etc.

SAMPLING

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

Disturbed samples taken during drilling provide information on plasticity, grain size, colour, moisture content, minor constituents and, depending upon sample disturbance, (information on strength and structure).

Undisturbed samples are taken by pushing a thin walled sample tube, usually 50mm diameter (U50), into the soil and withdrawing it with a sample of the soil contained in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength, volume change potential and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling used are given on the attached logs.

SAMPLE STORAGE – SOIL, ROCK AND WATER SAMPLES

Soil samples (not subject to testing) are not stored beyond a period of 90 days of taking or receiving said soil sample. Rock core (not subject to testing) is not stored beyond a period of six months of taking or receiving said rock core.

Should any party require that soil samples (not subject to testing) be stored beyond 90 days, or rock core (not subject to testing) be stored beyond six months, please contact Soil Surveys Engineering.

Water samples (not subject to testing) are not stored beyond a period of seven days of taking or receiving water samples.

TEST LOCATIONS

Test locations (e.g. boreholes, CPT's, test pits etc.) were based on available access at the time of testing. Test locations may have been shifted if access was not suitable.

Unless noted otherwise, accuracy of test locations are to the accuracy of hand held GPS equipment.

INVESTIGATION METHODS

The following is a brief summary of investigation methods currently adopted by the Company and some comments on their use and application.

Test Pits - These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to approximately 3.0m for a backhoe and up to 6.0m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

Hand Auger Drilling - A borehole of 50mm to 100mm diameter is advanced by manually operated equipment. Refusal of the augers can occur on a variety of materials such as hard clay, gravel or rock fragments and does not necessarily indicate rock level.

Continuous Spiral Flight Augers - The borehole is advanced using 75mm to 300 mm diameter continuous spiral flight augers, which are withdrawn at intervals to allow sampling or insitu testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface by the flights or may be collected after withdrawal of the augers. Information from the drilling (as distinct from specific sampling) is of relatively lower reliability due to remoulding, inclusion of cuttings from above or softening of samples by groundwater, or uncertainties as to the original depth of the samples. Augering below the groundwater table has a lower reliability than augering above the water table. Various drill bits are attached to the base of the augers during the drilling. The depth of refusal of the different bit types can provide information as to the strength of the material encountered. Generally the 'TC' bit (a tungsten carbide tipped screw type bit) is used.

Wash Boring - The borehole is usually advanced by a rotary bit with water or fluid pumped down the hollow drill rods and returned up in the space between the rods and the soil or casing, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from "feel" and rate of penetration. More accurate information on soil strata is gained by regular testing and sampling using the Standard Penetration Test (SPT) and undisturbed thin walled tube samples (U50).

Mud Stabilized Drilling - Either Wash Boring or Continuous Core Drilling can use drilling mud as a circulating fluid to stabilize the borehole. The term "mud" encompasses a range of products ranging from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is only possible from regular intact sampling (e.g. from SPT and U50 samples) or from rock coring, etc.

Continuous Core Drilling - A continuous core sample is obtained using a diamond or tungsten carbide tipped core barrel. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable method of investigation. In rocks, NMLC coring (nominal 52 mm diameter) is usually used with water flush. The length of core recovered is compared to the length drilled and any length not recovered is shown as CORE LOSS. The location of losses is determined on site by the supervisor. If the location of the loss is uncertain, it is placed at the top end of the run, when the core is placed in a storage tray and recorded on the log.

Standard Penetration Tests - Standard Penetration Tests (SPT) are used mainly in non-cohesive soils, but can also be used in cohesive soils, as a means of indicating density or strength. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" - Test 6.3.1.

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

In the case where full penetration is obtained with successive blow counts for each 150 mm of, say 4, 6 and 7 blows, the record shows,

4, 6, 7 N = 13

In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm, the record shows:

15, 30/40mm

The results of the test can be related empirically to the engineering properties of the soil.

Occasionally, the drop hammer is used to drive 50mm diameter thin walled sample tubes (U50) in clays. In such circumstances, it is noted on the borehole logs.

A modification to the SPT test is where the same driving system is used with a solid 600 tipped steel cone of the same diameter as the SPT hollow sampler. The solid cone can be continuously driven for some distance in soft clays or loose sands, or may be used where damage would otherwise occur to the SPT. The results of this Solid SPT are shown as "N_c" on the borehole logs, together with the number of blows per 150 mm penetration.

Cone Penetration Tests - Test Method - Cone Penetration Tests (CPT) are carried out in accordance with AS 1289 Test 6.5.1-1999, using an electrical friction-cone penetrometer.

The test essentially comprises the measurement of resistance to penetration of a cone of 35.7 mm diameter pushed into the soil at a rate of 10-20 mm per second by hydraulic force. The resistance to penetration is recorded in terms of pressure on the end area of the cone (cone resistance, q_c, in MPa) and friction on the side of the 135 mm long sleeve immediately above the top of the cone (friction resistance, f_s, in kPa). These forces are measured by electrical transducers (strain gauges) within the cone device. The ratio between friction resistance and cone resistance is also calculated as a percentage, i.e.-

$$\textbf{Friction Ratio (FR)} = \frac{\textit{Friction Resistance, } f_s\ (kPa)\ x\ 100}{\textit{cone resistance, } q_c\ (kPa)}$$

The friction ratio, FR, is generally low in sands (less than 1% or 2%) and generally higher in clays (say 3% or more). The interpretation of sandy clays, clayey sands and material with a high silt content is more difficult, but intermediate values (between 1% and 3%) would be expected. Highly organic clays and peats generally have a friction ratio in excess of 5%.

Static cone data is recorded in the field on disc for later presentation using computer aided drafting.

The equipment can be operated from any conventional drill rig. A total applied load in the range of 4 to 10 tonnes is required for practical purposes, although lighter loads may be used. The cone penetrometers are available with various capacities of cone resistance ranging up to 100 MPa for general purpose investigations, while a range of 0 to 10 MPa can be used where more sensitive investigations of soft clay are required.

The cone resistance value provides a continuous measure of soil strength or density, and together with the friction ratio, provide very useful indications of the presence of narrow bands of geotechnically significant layers such as thin, soft clay layers or lenses of sand which might otherwise be missed using conventional drilling methods.

The lithology of the encountered soils is interpreted from static cone data and is generally presented on the static cone log sheets.

It is important to note that the lithology is interpreted information and is based on research by Schmertmann (1970), Sanglerat (1972), Robinson and Campinalli (1986), modified to suit local conditions as indicated by borehole information and laboratory testing.

As soils generally change gradually it is sometimes difficult to accurately describe depths of strata changes, although greater accuracy is obtained with the static cone compared with conventional drilling. In addition, friction ratios decrease in accuracy with low cone resistance values, and in desiccated soils. As a result, some overlap and minor discrepancies may exist between static cone and nearby borehole information.

Portable Dynamic Cone Penetrometers - Portable Dynamic Cone Penetrometer (DCP) tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 100mm increments of penetration.

The DCP comprises a Cone of 20 mm diameter with 30 degree taper attached to steel rods of smaller section.

The cone end is driven with a 9 kg hammer falling 510 mm (AS 1289 Test 6.3.2). The test was developed initially for pavement subgrade investigations, and empirical correlations of the test results with California Bearing Ratio have been published by various Road Authorities. The Company has developed their own correlations with Standard Penetration tests and Density Index tests in sands.

LOGS

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

The attached explanatory notes define the terms and symbols used in preparation of the logs.

Interpretation of the information shown on the logs, and its application to design and construction, should therefore take into account the spacing of boreholes or test pits, the method of drilling or excavation, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes or test pits. Subsurface conditions between boreholes or test pits may vary significantly from conditions encountered at the borehole or test pit locations.

GROUNDWATER

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

- Although groundwater may be present in lower permeability soils, it may enter the hole slowly or perhaps not at all during the time the hole is open.
- A localized perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes and may not be the same at the time of construction.
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be bailed out of the bore and mud must be washed out of the hole or "reverted" if water observations are to be made.

More reliable measurements can be made by use of standpipes which are read after stabilizing at periods ranging from several days to perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from perched water tables or surface water.

FILL

The presence of fill materials can often be determined only by the inclusion of foreign objects (e.g. bricks, steel, etc.) or by distinctly unusual colour, texture or fabric. Identification of the extent of fill materials will also depend on investigation methods and frequency. Where natural soils similar to those at the site are used for fill, it may be difficult with limited testing and sampling to reliably determine the extent of the fill.

The presence of fill materials is usually regarded with caution as the possible variation in density, strength and material type is much greater than with natural soil deposits. Consequently, there is an increased risk of adverse engineering characteristics or behaviour. If the volume and quality of fill is important to a project, then frequent test pit excavations are preferable to boreholes.

LABORATORY TESTING

Laboratory testing is normally carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms and the attached explanatory notes summarize important aspects of the Laboratory Test Procedures adopted.

ENGINEERING REPORTS

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. The information provided in Soil Surveys Engineering reports is opinion and interpretation and not factual. The client/contractor increases their risk by not retaining the person who authored the geotechnical report, to carry out site inspection and review (overseeing role) during construction, to confirm opinion and interpretation expressed in the report is accurate. Where the report has been prepared for a specific design proposal the information and interpretation may not be relevant if the design proposal is changed. If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical aspects and recommendations or suggestions for design and construction. Since the test sites in any exploration represent a very small proportion of the total site and since the exploration only identifies actual ground conditions at the test sites, even under the best circumstances actual conditions may vary from those inferred to exist. No responsibility is taken for:-

- Unexpected variations in ground and/or groundwater conditions.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of other persons.
- Any work where the company is not given the opportunity to supervise the construction using the Companies designs/recommendations.

If differences occur, the Company will be pleased to assist with investigation or advice to resolve any problems occurring.

SITE ANOMALIES

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

Extreme events including but not limited to the results of climate change, e.g. flood levels above previously identified levels, beach scour or erosion beyond normal expectations (as identified by local authorities) extreme rainfall events, war, espionage, sabotage may result in different conditions between time of investigation and time of construction.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Construction Contracts (1987)", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances, where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

REVIEW OF DESIGN

Where major civil or structural developments are propose or where only a limited investigation has been completed or where the geotechnical conditions/ constraints are quite complex, it is prudent to have a joint design review which involves a senior geotechnical engineer. We would be happy to assist in this regard as an extension of our investigation commission. Construction drawings should be reviewed by Soil Surveys Engineering, with sufficient time to allow changes if required, prior to inspections. Otherwise Soil Surveys Engineering reserves the right to refuse to carry out inspections.

SITE INSPECTION

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related.

i. Site visits during construction to confirm reported ground conditions
ii. Site visits to assist the contractor or other site personnel in identifying various soil/rock types such as appropriate footing or pier founding depths, the stability of a filled or excavated slope; or
iii. Full-time engineering presence on site.

In the vast majority of cases it is advantageous to the principal for the geotechnical engineer who wrote the investigation report to be involved in the construction stage of the project.

The geotechnical engineer cannot take responsibility for variations in encountered conditions, where he is not given the opportunity to review plans for the proposed development with sufficient time to allow review and make changes to the proposed development if required, and where he is not given the opportunity to inspect the site and oversee construction methods with regard to site conditions with sufficient time to observe all relevant site conditions and operations.

RESPONSIBLE USE OF GEOTECHNICAL INFORMATION

Recommendations in our report are for design purposes only and provided on the basis that inspections are carried out to allow finalisation of opinions and recommendations contained in our report.

The geotechnical investigation consisting of field and laboratory testing has been carried out to indicate typical conditions by indicating conditions and parameters at the specific locations of boreholes/test pits. Subsurface conditions are indicated at these locations only and the inference of conditions between or away from these locations (interpolation and extrapolation) involves a certain degree of risk. Persons inferring such conditions or carrying out such inferences should do so with a degree of caution and conservatism which is commensurate with the consequences of the risk of error.

Estimates of volumes based on our findings require interpolation and extrapolation between test locations and as such may be significantly different from actual volumes.