SOIL SURVEYS

GEOTECHNICAL AND ACID SULFATE SOIL INVESTIGATION

PROJECT NO. 117-19420

JULY, 2017

BLIGH TANNER CONSULTING ENGINEERS

PROPOSED LIBRARY & STUDENT FACILITIES

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TABLE OF CONTENTS

Appendices

1.0 INTRODUCTION

This report presents the results of the geotechnical and acid sulfate soil (ASS) investigation carried out by Soil Surveys Engineering Pty Limited for the proposed Library and Student Facilities development at Byron Bay Public School, Byron Bay.

It is understood that the proposed development will comprise the construction of two new two-storey buildings.

Earthworks will comprise minor levelling.

From an ASS perspective, disturbance will extend to depths not greater than 1.0m below existing ground level.

Refer Figure 1.

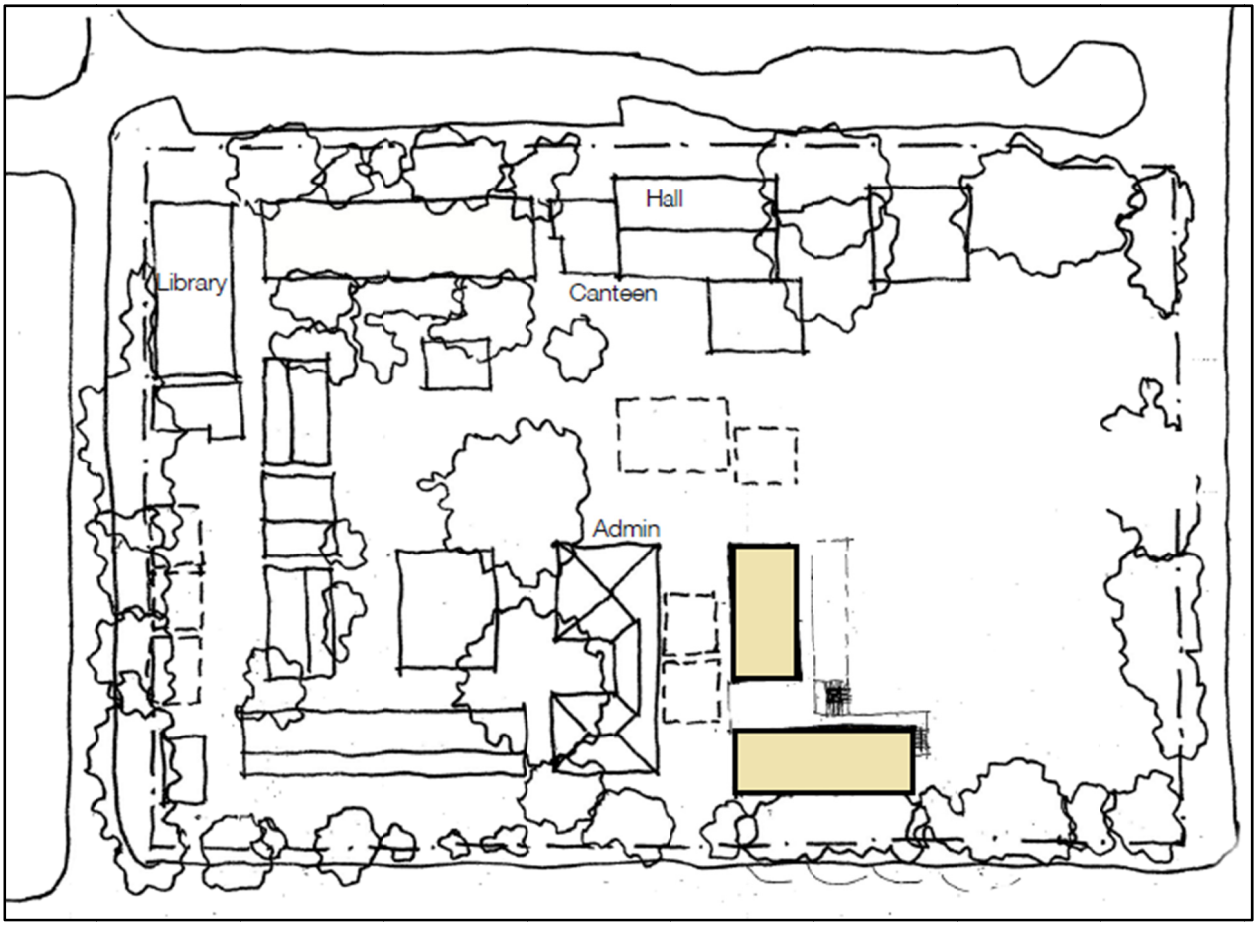

FIGURE 1 - PROPOSED DEVELOPMENT

2.0 SCOPE OF GEOTECHNICAL SERVICES

The scope of geotechnical services provided by Soil Surveys Engineering Pty Limited was directed towards evaluating the following items as detailed in our proposed 1-19420, 2017-04-24, PR VER 2:-

- Investigation of the subsurface profile by drilling, sampling and insitu testing.
- Laboratory testing on selected samples to assess engineering properties.
- Engineering analysis of site investigation and laboratory test results to evaluate:-
    - Trafficability
    - Earthworks recommendations
    - Foundation recommendations
    - Site management recommendations
    - Acid Sulfate Soils

3.0 SITE DESCRIPTION

The site of the proposed development is located at Byron Bay Public School, Kingsley Street, Byron Bay (refer Figure 2).

FIGURE 2 - SITE LOCATION

Site features typical of a school environment, (i.e. school buildings, sports courts, carparks, etc.) were evident.

Vegetation comprised small to large trees and shrubs.

The site is near level, and drainage characteristics were assessed as being fair.

Photographs 1 and 2 indicate typical site conditions.

PHOTOGRAPH 1 - LOOKING NORTH WEST TOWARDS BH5

PHOTOGRAPH 2 – TYPICAL SITE CONDITIONS

4.0 GEOTECHNICAL INVESTIGATION

Subsurface conditions at the site were investigated by drilling and sampling five boreholes to depths of 4.50m to 10.50m, using a Scout and EVH1750 drilling rigs.

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

- AS 1726-1993 “Geotechnical Site Investigations”
- AS 1289 “Methods of Testing Soils for Engineering Purposes”

A description of the investigation method, borehole records, and a site plan showing investigation locations are included in the Appendices. Borehole coordinates were recorded using a hand held GPS device, with accuracy consistent with such devices.

5.0 SUBSURFACE PROFILE

Subsurface conditions encountered are consistent with conditions described on geological maps; subsurface conditions can be broadly grouped into three material types:-

- Fill Material – Medium dense sandy gravel fill material was encountered in Borehole 4 only, to a depth of 0.12m.
- Natural Sand and Gravel – Natural loose sandy gravel (BH1 only) and loose/medium dense/dense sand was encountered at all borehole locations.
- Natural Silty and Sandy Clay – Natural stiff/very stiff/hard silty and sandy clay was encountered at all borehole locations, generally underlying the sand and gravel. Stiff clay was encountered in Boreholes 2, 3 and 5.

  Please note that at Borehole 2, stiff clay was encountered in two distinct zones, i.e. 3.0m to 3.5m and 5.5m to 10.0m.

A summary of the subsurface profile is presented in Table 1.

TABLE 1 SUBSURFACE PROFILE

BH No.	Fill Material (m)	Sand/Gravel (m)		Natural Clay (m)		Termination Depth (m)
		Loose/Medium Dense	Dense	Stiff	Very Stiff/Hard	
BH1	NE	0.00-3.30	NE	NE	3.30-9.00	9.00
BH2	NE	0.00-3.00	NE	3.00-3.50 5.50-10.00	3.50-5.50 10.00-10.50	10.50
BH3	NE	0.00-0.30 0.60-1.50 3.10-3.40	1.50-3.10	0.30-0.60	3.40-4.50	4.50
BH4	0.00-0.12	0.12-0.30 1.00-2.20	NE	NE	0.30-1.00 2.20-4.50	4.50
BH5	NE	0.00-0.25 0.50-1.70	1.70-2.50	0.25-0.50	2.50-4.50	4.50

Note: NE - Not Encountered.

Groundwater was encountered at all borehole locations at the time of the investigation; Table 2 refers.

TABLE 2 GROUNDWATER

Borehole No.	Groundwater Noted (m)
1	1.00
2	1.00
3	0.70
4	1.70
5	1.20

Notes:-
1. Groundwater noted indicates depth at which groundwater was observed during open hole augering.
2. Groundwater levels may vary due to climatic influences.

It should be noted that groundwater levels can vary with prevailing weather conditions.

6.0 ENGINEERING ASSESSMENT

6.1 Trafficability – Light Weight Construction Vehicles

The fieldwork for this investigation was carried out following dry weather conditions and trafficability conditions were considered to be fair. However, some problems (consistent with a sand subgrade) may be anticipated for even light weight 4WD vehicles.

Problems may also arise from disturbance of the upper level soil fabric with removal of any existing structures, services, vegetation, etc.

It is recommended that after any demolition, stripping, clearing, etc., the exposed surface in the construction area be proof rolled (where appropriate) to assist in identifying weak areas and to improve trafficability for light weight construction vehicles.

Maintaining adequate drainage conditions is essential.

To assist, placement of a working platform as a final layer across building platforms is recommended. This could be achieved by placing a 150mm layer of sub-base, extending a minimum 1.5m beyond the building perimeter, across the building platform as the final layer. The sub-base material should be compacted to a density not less than 95% of maximum dry density in accordance with AS 1289 5.2.1 (Modified compaction). Sub-base material should be of good quality conforming to requirements (minimum) of Material Type 2.4 as specified in the Queensland Department of Transport and Main Roads, Technical Specification MRTS05, Unbound Pavements (April, 2011).

Nevertheless, the contractors (earthworks, building, etc.) should fully inform themselves of the ground conditions on site prior to commencement of construction. This requirement should be explicit in any specifications or contract.

Demolition and Clearing Activities

Extreme care should be exercised during any demolition and the clearing phase to ensure that excessive subgrade disturbance is not caused during removal of existing structures, trees, services, etc.

Working Platforms For Tracked Plant and Heavy Construction Vehicles

The scope of Soil Surveys Engineering's study **DOES NOT** include the design of a working platform for heavy construction vehicles or heavy tracked plant.

Detailed design of a working platform should be carried out considering the operation of actual machinery proposed to be used. This is particularly important when considering the use of **heavy** piling rigs and **heavy** cranes - the piling/crane contractor should be consulted regarding their requirements.

6.2 Earthworks

It is understood that earthworks will be limited to minor levelling.

Earthwork procedures should be carried out in a responsible manner in accordance with AS 3798-2007 "Guidelines on Earthworks for Commercial and Residential Developments", incorporating the following recommendations.

- Clearing, stripping and grubbing should be carried out in areas subject to earthworks (as trafficability conditions allow). Also all soils containing organic matter should be stripped from the construction area; this material is not considered suitable for use as structural fill.
- Depressions formed by the removal of existing structures, vegetation, underground elements etc. should have all disturbed weakened soil cleaned out and be backfilled with compacted select material.
- The subgrade should be proof rolled (where appropriate) under the supervision of Soil Surveys Engineering in accordance with methods and equipment as per Clause 5.5 of AS 3798-2007. Areas demonstrating excessive movement should be treated (dried and recompacted) or removed and replaced with compacted fill.
- Any fill material encountered should be considered uncontrolled and requiring treatment (i.e. excavate/condition/replace/compact as required).
- Please note that the silty sand soils are sensitive to water and will lose strength if they become wet. Should these soils be wet at time of construction, significant works to treat these soils would be required (or removal/replacement).
- **Imported GENERAL fill** material is recommended for any filling. This material should be cohesive and non-dispersive in nature, and be a good quality low plasticity (Liquid Limit of less than 45%, Plasticity Index of less than 15%) select fill material with a Soaked CBR >10%, a maximum particle size of 75mm with at least 80% passing the 19mm sieve. Quality testing to confirm imported fill quality should be carried out prior to delivery to site.
- Imported fill placed should be compacted in layers (approximately 250mm loose thickness) to a density not less than 98% of maximum dry density in accordance with AS 1289 5.1.1 (Standard Compaction).
- Field density testing should be carried out to check the standard of compaction achieved and the placement moisture content. The frequency and extent of testing should be as per guidelines in AS 3798-2007, Section 8.0.
- Backfilling for service trenches, etc. should use good quality material. The backfill should be placed in uniform layers over the full width of the excavations with the layers not exceeding 200mm thickness, loosely placed using wheeled plant and 100mm loose thickness using hand held vibrating plates. The backfill material should be compacted to the specifications outlined above for insitu or imported cohesive material.
- Soils encountered on site (to borehole depths) should be within the excavation limits of a small dozer (e.g. Cat D4 or similar) in bulk earthworks and a medium sized backhoe (e.g. Case 580 or similar) in trench excavations.

Trenching

The onsite soils have the potential to "collapse/fail" unexpectedly in a trenching situation, particularly where seepage is encountered. Trenches excavated on this site should be considered unstable; shoring of deep trench excavations are recommended. Suitable precautions to satisfy Health & Safety requirements must be adopted. Construction procedures (i.e. operation of plant, storage of materials, etc.) should also consider the nature of the onsite soils.

6.3 Site Classification

While a site classification in accordance with AS 2870 'Residential Slabs and Footings' relates to residential type construction and is not directly applicable for this development, it is, however, a valuable method of classification.

The site may be classified 'P' due to the allowable bearing pressure at foundation level (loose sands) being less than 100kPa.

* * *

It is recommended that the designer satisfy themselves that the use of AS 2870 is applicable for the proposed design.

6.4 Building Foundations

6.4.1 General

As noted in Section 5.1, loose sands (fill and natural) were encountered; further, subsurface conditions are variable. Considering the subsurface profile conditions and likely structure loads, potential differential settlement associated with a high level footing system founding in loose sands is expected to exceed acceptable limits. A deep foundation system in conjunction with a fully suspended slab is recommended.

6.4.2 Deep Foundations

A deep foundation system incorporating piers extending into the lower level stiff (or better) silty clay could be considered.

Deep foundations should be designed in accordance with AS 2159-1995 'Piling - Design and Installation'. This code uses the limit state design method.

Screw piers could be considered (considering likely loads, the presence of loose sands, groundwater, and proximity of adjacent structures), however, other pier types (CFA, bored etc.) could also be considered.

Note that the depth to the very stiff clay was variable. In Borehole 2, the very stiff clay was first encountered between 3.50m and 5.50m and was underlain by a zone of weaker stiff clay (5.50m to 10.00m). Very stiff clay was then encountered at a depth of 10.00m and continued to the borehole termination depth at 10.50m.

The design of a single pier must be such that both the geotechnical strength R*g and the structural strength R*s, are greater than or equal to the design action effect S*, i.e.

$$R^*g \geq S^* \text{ and } R^*s \geq S^*$$

The design geotechnical strength (R*g) can be calculated as the ultimate geotechnical strength (Rug) multiplied by the geotechnical strength reduction factor Øg. Ultimate geotechnical strength (Rug) parameters for the materials encountered on the site are outlined in Table 3.

TABLE 3 ULTIMATE GEOTECHNICAL STRENGTH ($R_{d,ug}$) PARAMETERS

Material	fb - Base Bearing (kPa)	fm,s - Skin Friction (kPa)
Fill Material	NR	NC
Natural Sand/Gravel	NR	NC
Natural Clay - Stiff - Very Stiff/Hard	 450 450(8)	 15 30-60

Notes:
1. NR - Not Recommended; NC - Not Considered in skin friction calculations.
2. Ultimate geotechnical strength for compression can be determined from $R_{d,ug} = f_{m,s} A_s + fbAb$.
3. For determination of geotechnical strength reduction factor (Øg) refer Section 4.3.2 AS 2159-2009.
4. Considering limit state analysis (AS 2159-2009), the design geotechnical strength $R_{d,g}$ is calculated by multiplying the ultimate geotechnical strength $R_{d,ug}$ by the geotechnical strength reduction factor Øg, i.e. $R_{d,g} = R_{d,ug} \times Øg$.
5. Should a "working stress" approach be adopted, a minimum factor of safety of 3.0 on base and 2.0 on skin friction is recommended.
6. The above parameters are for single piers. If piers are spaced at closer than three diameters, a reduction factor (Group Efficiency Ratio) may apply.
7. Piers should found at least four times the pier diameter below platform level.
8. Base capacity was downgraded due to underlying stiff clay.

Bored Piers

Some difficulty with fall-in may occur with bored piers, particularly when drilling through fill material and natural sand. It should be ensured that all loose material is removed from the base of piers prior to pouring of concrete. The use of a 'clean-out' bucket or vacuum truck should be explicit in instructions to the drilling contractor. The practice of 'using water and spinning the augers' to remove loose material from the pier base is generally unacceptable.

Groundwater was encountered in all boreholes (refer Section 5.0) at the time of the investigation. Should a bored pier foundation system be adopted, an allowance for dewatering and the use of liners should be made.

Screw Piers

The presence of dense silty sand (e.g. Borehole 3 and Borehole 5) may cause some difficulty for screw piers being installed to levels below the dense sands. Pre-boring through the dense sands may be required to found screw piers in the underlying clay (recommended).

6.4.3 Adjacent Feature/Excavation Considerations

Where existing (e.g. adjacent structures) footings/piers are located adjacent to proposed or existing feature/excavations (e.g. underground service trenches, etc.), the effect of the feature/excavation on existing footings/piers must be carefully considered.

Soil Surveys Engineering and the Structural Engineer should be consulted on this matter prior to construction.

6.4.4 Articulation and Detailing

It is recommended that any masonry walls be articulated. This articulation may be achieved by the use of full height (footings to eaves) openings or vertical construction joints at regular intervals. Guidelines on articulation are contained in the Cement and Concrete Association's Technical Note 61, 'Articulated Walling'.

6.5 Site Management

It is important that proper site management methods be observed for the existing soil conditions by both the builder at the time of the construction and the owner(s) throughout the life of the proposed development.

Particular reference to site management matters is set out in AS 2870-2011, particularly Appendix B of this Australian Standard.

The following are some general comments with respect to site management. However, the reader is directed to AS 2870-2011 (particularly Appendix B) and the CSIRO publication, "Foundation Maintenance and Footing Performance: A Homeowners Guide" (Building Technology File 18), for a complete discussion and further information on foundation performance and maintenance:-

- It is important that the site be well drained. The ground around the structures should slope away at 1 in 50 and then fall to the stormwater system to prevent ponding of water against or near to the structures.
- Roof downpipes and garden taps should not be allowed to wet founding soils.

7.0 ACID SULFATE SOIL INVESTIGATION

7.1 Field Investigation

The ASS field investigation comprised drilling and sampling at two borehole locations (BH3 and BH4); samples were taken to a minimum depth of 2.0m, i.e. a minimum of 1.0m below proposed disturbance levels.

Field investigation work, including the soil classification descriptions and field sampling, were carried out in general accordance with the following procedures:-

- AS1726 - 1993 Geotechnical Site Investigations
- ASSMAC - New South Wales Acid Sulfate Soils Management Advisory Committee Guidelines - 1998

A description of the investigation method, borehole records and a site plan showing the location of boreholes are included in the Appendices.

7.2 Laboratory Assessments

A staged testing program was carried out on recovered soil samples; Table 4 refers:-

TABLE 4 LABORATORY TESTING

Test Method	Test Objective
pH_F, pH_{FOX} and Reaction to HCl & H_2O_2	Qualitative screening
ANC (Acid Neutralising Capacity)	Quantitative - acid trail
TAA (Total Actual Acidity)	Quantitative - acid trail
SCr (Chromium Reducible Sulfur)	Quantitative - sulfur trail
S-NAS (Retained Acidity)	Quantitative - sulfur trail

A total of 16 samples were screened by Soils Surveys Engineering to assess field pH (pH_F) and pH after oxidation (pH_{FOX}) using 30% hydrogen solution buffered to between pH 4.5 to pH 5.5.

The pH_F/pH_{FOX} screening method consists of two steps. In the first step, the field pH of a 1:5 soil/water suspension is measured (pH_F). In the second step, a 30% Hydrogen Peroxide solution is added to the sample which is then heated to accelerate the oxidation of the sample. The pH after oxidation (pH_{FOX}) is then measured. A significant difference between the pH_F and pH_{FOX} result is indicative of PASS; however, test results may be affected by other inclusions such as shell material and organics.

Based upon the results of these screening tests, 8 samples were selected to undergo quantitative analysis by the Chromium Reducible Sulfur suite in accordance with appropriate laboratory procedures.

TAA and RA are a measure of the soils existing acidity prior to oxidation of sulfidic material. The CRS test quantifies the sulfur trail.

An overall acid-base accounting method was used to calculate a 'net acidity' value which is used to qualify analytical test results and calculate liming rates. This equation is given by:

Net Acidity = Actual Acidity (as TAA) + Retained Acidity (as S_{NAS}) + Potential Acidity (as S_{CR}) - insitu Acid Neutralising Capacity (ANC).

Laboratory test results are included in Appendix C.

7.3 Results of Quantitative Laboratory Testing

Tables 5 presents quantitative test results

TABLE 5 QUANTITATIVE TEST RESULTS

BH No.	Depth (m)	ANC (mole H^+/t)	TAA (mole H^+/t)	S-NAS (mole H^+/t)	Scr (mole H^+/t)	Net Acidity (mole H^+/t)
3	0.00-0.15	NA	0	NA	3	3
3	0.30-0.60	NA	74	NA	6	80
3	0.70-1.00	NA	7	NA	4	11
3	1.70-2.00	NA	41	NA	10	51
4	0.00-0.12	NA	14	NA	3	17
4	0.30-0.50	NA	54	NA	10	64
4	0.75-1.00	NA	32	NA	9	41
4	1.50-1.75	NA	48	NA	7	55

Action Criteria

Indicator or action levels considering quantitative test results are used as a guide to assess the need for an ASSMP. Indicator or action levels are presented in Table 6 (reference: ASSMAC - August, 1998).

TABLE 6 ACTION CRITERIA - (ASSMAC AUG. 1998 TABLE 4.4)

Texture Range/Classification	Approximate Clay Content (%)	Action Criteria 1-1000 tonnes disturbed		Action Criteria >1000 tonnes disturbed	
		S_{pos} (%)	TPA (mole H^+/t)	S_{pos} (%)	TPA (mole H^+/t)
Coarse / Sands to Loamy Sands	≤5	0.03	18	0.03	18
Medium / Sandy Loams to Light Clays	5-40	0.06	36	0.03	18
Fine / Medium to Heavy Clays and Silty Clays	≥40	0.1	62	0.03	18

The laboratory test results indicate actual and potential acidity exceeds the action criteria across the site. Therefore an acid sulfate management plan will be required for the development.

7.4 Acid Sulfate Soil Management Plan

7.4.1 General

The laboratory test results indicate that the action criteria have been exceeded for the onsite soils. When these soils are disturbed or drained, toxic quantities of acid, aluminium, iron and heavy metals may contaminate land and waterways. For this reason, it is critical that any excavation operations be carried out in such a way as to limit or avoid any adverse environmental or infrastructure impacts.

Management strategies have been proposed for prevention and treatment to address the following concerns:-

- Prevention of oxidation.
- Management of the acid sulfate soils.
- Treatment of the acid sulfate soils as necessary.
- Control of acid leachate.
- Neutralisation of acid leachate.
- Prevention of acid leachate seepage to the surrounding environment

It is advised that this ASSMP considers that excavated material will be treated off site.

The preferred management strategy for ASS is to avoid or minimise the disturbance of these materials.

Given the proposed development, avoidance of ASS may not be possible and neutralisation of the disturbed material will be required.

7.4.2 Neutralisation of Disturbed Soils

Current experience suggests that one of the most effective methods that can be implemented to limit or prevent the adverse consequences of excavation of ASS material, is the controlled application of a suitable neutralising agent.

Various neutralising agents are available, with aglime being the most widely used product for ASS treatment.

It is advised that this ASSMP considers that excavated material will be treated off site.

Treatment of ASS should be carried out in accordance with this management plan. Validation testing would be required to confirm neutralisation.

7.4.3 Lime Application

The following table presents the estimated lime dosages per cubic metre of soil disturbed, based on the results of the field investigation and laboratory testing programs.

TABLE 7 DESIGN LIMING RATE

Predominant Material Type	Maximum Net Acidity Value (mole H^+/t)	Factored Lime Rate (kg/m^3 of soil)
Silty Sand /Sand	55	6
Silty Clay and Silty/Sandy Clay	80	9

Notes:
1. NA - Not Applicable
2. Bulk (dry) density 1.5t/m^3 assumed
3. Lime dosing rates include a factor of safety of 1.5
4. 100% purity (neutralising value) is assumed for the aglime (any variation must be factored accordingly).
5. Dosing rate calculations were carried out in general accordance with the method set out in the guidelines.

It should be noted that the liming rates arrived at in Table 7 are based on the most severe laboratory results. Should verification testing indicate that disturbed soils have net acidity values greater/lower than Table 7 values, appropriate modification to factored liming rates must be taken.

7.4.4 Construction Techniques

The construction technique implemented during the lime application is critical and as such, the following measures will be undertaken:-

- Excavated soils are to be moved from site to offsite designated treatment areas following excavation.
- Following earthworks, the surface is to be lime treated with a liming rate of 5kg/m^2.
- Only aglime (calcium carbonate) should be used, as quicklime or slaked lime is not considered a long term neutralising agent of sulfuric acid, and eventually may raise groundwater pH to unacceptable levels.
- The recommended lime dosing rates refer to a 100% pure lime product. The actual liming rate would need to be factored according to the product's quoted neutralising value in order to reach the ideal neutralising capacity.
- The aglime must be fine grained to ensure better mixing and decreased chance of acid leachate runoff occurring.
- The maximum time between exposure on excavation and treatment should not exceed 18 hours. This would require all disturbed material to be treated on the day of excavation or the following day. Alternatively, untreated material would need to be suitably stockpiled (refer Section 7.4.5).
- Treatment should be undertaken on a suitably prepared treatment pad (refer Section 7.4.5).
- Thorough mixing of the aglime is critical. Following excavation of the material, it must be dried and ploughed, followed by lime dosing. This is to be followed by further ploughing and harrowing to provide a homogeneous mix of the excavated material and the lime.
- Each layer of material to be treated must not be greater than 200mm to 300mm in thickness to ensure thorough mixing of the lime.

7.4.5 Treatment Pads and Stockpile Areas

The treatment and/or stockpiling of ASS (on and off site) should be located in settings that will ensure minimal risk of adverse environmental impacts as a result of acid leachate. The following recommendations are made for the design of treatment pads and/or stockpiling areas.

- The treatment pad or stockpile area should be surrounded by bunded drains to allow collection, containment and treatment of surface runoff and leachate from the stockpile.
- It is important that agricultural lime be added to the material used in the bund walls.
- At treatment pad or stockpile locations agricultural lime (at a **minimum** rate of 5.0kg/m^2 per vertical metre of stockpiled soil) should be tyned into the underlying soil for a depth of 0.3m below surface level. However, the actual guard layer rate should be calculated in accordance with Authority requirements. As construction proceeds, additional lime may be added should any of the leachate neutralise the original lime.
- Regular testing of water/discharge in these areas should be undertaken (refer Section 7.4.7).

7.4.6 Groundwater Discharge

Groundwater /discharge encountered on site should be pumped to tanks for treatment prior to discharge.

Further, it is critical that all discharge, construction drains and site runoffs at the off-site treatment facility be directed towards catchponds. Catchponds can be used to remedy waters which are below acceptable discharge quality.

Treatment

Waters must be treated to bring water quality criteria to acceptable levels and in accordance with ANZECC Water Quality Guidelines for Fresh and Marine Waters (2000) and NSW government regulations including dissolved metal concentration. Appropriate neutralising agents, e.g. aglime, slaked lime or magnesium/calcium hydroxide may be used to treat catchpond water. However, it should be the intention to maintain off-site catchpond waters at pH levels between 6.5 and 8.5 at all times.

Waters should only discharged upon acceptable water quality criteria being achieved

7.4.7 Monitoring Program

A monitoring program will be implemented to provide feedback on the effectiveness of the management strategy and provide early warning should environmental degradation begin.

The following aspects have been considered in the monitoring program:-

- Parameters to be monitored
- Location of monitoring systems
- Frequency
- Type of analysis
- Procedures to be undertaken should monitoring indicate problems

It is recommended that Soil Surveys Engineering, who have relevant experience in this field, be appointed to supervise on site monitoring of the project.

Soil Monitoring

On-site and off-site testing and monitoring should be performed throughout the construction period.

Verification testing (testing prior to neutralisation and during construction) of excavated material will be carried out at a rate of at least one sample per 250m^3, with the sampling and testing intensity increasing should results prove to be extremely variable. Verification testing should be carried out using the Chromium Suite.

Further, when incorporation of the lime is complete Chromium Suite **validation** testing should be carried out at a rate of 1 test per 250m^3 to establish that aglime has been sufficiently added to neutralise the soil. The following performance criteria must be attained for soil that has been treated using neutralisation:-

1) The neutralising capacity of the treated soil must exceed the existing plus potential acidity of the soil.
2) Post neutralisation, the soil pH is to be greater than 6.5.
3) Excess neutralising agent should remain within the soil until all acid generation reactions are complete and the soil has no further capacity to generate acidity.

Water Monitoring

The following water monitoring frequency is recommended:

- Daily - pH, Dissolved Oxygen (DO), Temperature, Turbidity and Conductivity.
- Weekly - As above plus chloride, sulphate, total iron, dissolved iron, filtered aluminium, bicarbonate and calcium.

Further to the above, monitoring of the pH levels of the off-site catchponds should also be carried out immediately after rain. If the results of monitoring prove consistent, the frequency of monitoring could be reduced.

Water must be treated to bring water quality criteria to acceptable levels and in accordance with ANZECC Water Quality Guidelines for Fresh and Marine Water (2000) and NSW government guidelines, including dissolved metal concentration.

Appropriate neutralising agents, e.g. aglime, slaked lime or magnesium/calcium hydroxide may be used to treat catchpond water. However, it is the intention to maintain waters at pH levels between 6.5 and 8.5 at all times.

8.0 LIMITATIONS

We have prepared this report for the use of **Bligh Tanner Consulting Engineers**, 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 **Bligh Tanner Consulting Engineers**; 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 'Appendix A', '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 take into account the spacing of boreholes, the method of drilling, the frequency of sampling and testing and the possibility of other than "straight line" variations between the boreholes. Subsurface conditions between boreholes may vary significantly from conditions encountered at the borehole locations.

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, after the event.

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.

M. V. GEALE (RPEQ 3839)
PRINCIPAL ENGINEER

for and on behalf of
SOIL SURVEYS ENGINEERING PTY LIMITED

APPENDICES

APPENDIX A

NOTES RELATING TO THIS REPORT

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 1726-1993 (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 1726-1993.

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 AS1726-1993 Table A4.

Non-cohesive soils are classified on the basis of relative density usually based on insitu testing or engineering examination (see AS1726-1993 Table A5).

Rocks - Rock types are classified by their geological names (AS1726-1993 Table A6), together with descriptive terms regarding weathering (AS1726-1993 Table A9), strength (refer Table 1 below), defects (AS1726-1993 Table A10), etc. Where strength testing (ie Point Loads) is carried out, AS1726-1993 Table A8 is used. Where relevant, further information regarding rock classification is attached.

Table 1 Estimated strength descriptions given to rock based on engineering examination

Strength Term	Approximate Qu (MPa)
Extremely Weak	< 1.0
Very Weak	1.0 - 5.0
Weak	5.0 - 25
Medium Strong	25 - 50
Strong	50 - 100
Very Strong	100 - 250
Extremely Strong	> 250

Ref ISRM "Suggested Methods for the Quantitative Description of Discontinuities in Rock Masses"

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.

TEST LOCATIONS

Test locations (e.g. boreholes, CPT's, test pits etc.) were based on available access at the time of testing (access may need to be provided "by others"). 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 about 3m for a backhoe and up to 6m 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 50 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 75 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 two different bit types are used. The 'V' bit is a V shaped steel bit and the 'TC' bit is a tungsten carbide tipped screw type bit.

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 (eg. 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 60^0 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 6.5.1-1977, 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, ie.-

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

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 (eg. 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, eg. 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 proposed 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.

APPENDIX B

BOREHOLE RECORD SHEETS

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 01

Project Number: 117-19420
Project Name: Library and Student Facilities
Location: Byron Bay Public School
Client: Bligh Tanner Consulting Engineers
Date: 01/07/2017 Page: 1 OF 1

Easting: 560098 Northing: 6830905 RL:
Logger: MD Operator: MD Machine: Scout 2

Drilling Method (TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	Samples and Remarks
	0.20		NATURAL Silty SAND (SM) Medium dense, fine to medium grained, dark grey brown, low to medium plasticity fines, moist.	
	0.70		SAND (SP) Loose, fine grained, grey, trace of low plasticity fines, moist.	
	1.00		Silty SAND (SM) Loose to medium dense, fine grained, dark grey, low plasticity fines, moist.	SPT 1, 2, 1 N=3
	1.75		SAND (SP) Loose, fine grained, grey, with low plasticity fines, with fine to medium sized gravel, wet.	SPT 1, 2, 7 N=9
	3.30		Sandy GRAVEL (GP) Loose, fine to coarse sized, grey, fine to medium grained sand, wet.	SPT 3, 6, 14 N=20
	5.00		Silty CLAY (CH) Very stiff, high plasticity, light grey mottled orange brown, moist.	U50 PP=300 Rec = 70%
	6.90		Silty CLAY (CH) Very stiff, high plasticity, light grey mottled red brown, moist.	SPT 9, 10, 13 N=23
	9.00		Silty CLAY (CH) Very stiff to hard, high plasticity, light grey mottled red brown, moist.	SPT 7, 17, 28 N=45
			BOREHOLE BH 01 TERMINATED AT 9.00 m	SPT 7, 9, 12 N=21

01/07/17 ▼ 1.0

Comments:
1. Groundwater noted at 1.00m.

▽ Water First Noted ▼ Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 02

Project Number: 117-19420
Project Name: Library and Student Facilities
Location: Byron Bay Public School
Client: Bligh Tanner Consulting Engineers
Date: 01/07/2017

Easting: 560119 Northing: 6830877 RL:
Logger: MD Operator: MD Machine: Scout 2

Drilling Method (TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	Samples and Remarks
	0.20		NATURAL Silty SAND (SM) Loose, fine grained, dark grey brown, low plasticity fines, moist.	
	1.00		Silty SAND (SM) Loose, fine grained, dark grey, medium plasticity fines, moist.	SPT 1, 2, 1 N=3
	1.20		SAND (SP) Loose, fine grained, grey, trace of low plasticity clay fines, wet.	
			Clayey SAND (SC) Loose, fine to medium grained, grey, low plasticity fines, with fine to medium sized gravel, wet.	SPT 1, 2, 3 N=5
	3.00		Silty CLAY (CH) Stiff, high plasticity, light grey mottled orange brown, moist.	SPT 3, 5, 8 N=13
	3.50		Silty CLAY (CH) Very stiff, high plasticity, light grey, moist.	U50 PP=250 Rec = 68%
	5.50		Silty CLAY (CH) Stiff, high plasticity, light grey, moist.	U50 PP=150 Rec = 88%
	8.00		Silty CLAY (CH) Stiff, high plasticity, light grey mottled orange brown.	SPT 1, 3, 4 N=7
	10.00			SPT 1, 3, 5 N=8

01/07/17

Comments:
1. Groundwater noted at 1.00m.

Water First Noted Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 02

Project Number: 117-19420
Project Name: Library and Student Facilities
Location: Byron Bay Public School
Client: Bligh Tanner Consulting Engineers
Date: 01/07/2017 Page: 2 OF 2

Easting: 560119 Northing: 6830877 RL:
Logger: MD Operator: MD Machine: Scout 2

Drilling Method (TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	Samples and Remarks
WB	10.50		Silty CLAY (CH) Very stiff, high plasticity, light grey mottled orange brown, moist.	
WB			BOREHOLE BH 02 TERMINATED AT 10.50 m	SPT 7, 10, 15 N=25

11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0

Comments:
1. Groundwater noted at 1.00m.

Water First Noted Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 03

Project Number: 117-19420
Project Name: Library and Student Facilities
Location: Byron Bay Public School
Client: Bligh Tanner Consulting Engineers
Date: 01/07/2017 Page: 1 OF 1

Easting: 560106 Northing: 6830893 RL:
Logger: RH Operator: RH Machine: EVH1750

Drilling Method (TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	DCP Test (blows/100mm) 0 6 12 18 24 30	Samples and Remarks
	0.15		NATURAL Silty SAND (SM) Loose, fine to coarse grained, dark brown, with organics, moist.		ASS
	0.30		Silty SAND (SM) Loose, fine to coarse grained, dark brown, moist.		ASS
	0.60				ASS
	0.70 ▽		Sandy CLAY (CI-CH) Stiff, medium to high plasticity, dark brown, fine to medium grained sand, moist.		ASS
	1.0		Silty SAND (SM) Loose, fine to medium grained, dark brown, moist.		ASS
	1.50		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, wet.		ASS
	1.70		Silty SAND (SM) Dense, fine to coarse grained, dark brown, wet (cemented).		D
	2.0		Silty SAND (SM) Dense, fine to coarse grained, dark brown, with fine to coarse sized gravel, wet.		ASS
	3.0				D
	3.10		Silty SAND (SM) Medium dense, fine to coarse grained, dark brown, with fine to coarse sized gravel, wet.		
	3.40		Silty CLAY (CI) Very stiff, medium plasticity, light grey white, with fine to coarse grained sand, moist.		
	4.0				D
	4.50		BOREHOLE BH 03 TERMINATED AT 4.50 m		
	5.0				
	6.0				
	7.0				
	8.0				
	9.0				
	10.0				

Comments:
1. Groundwater noted at 0.70m.
2. DCP refusal at 1.47m and 2.28m.

▽ Water First Noted ▼ Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

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Soil Surveys Engineering Pty. Limited
Specialist in Applied Geotechnics
PO Box 317, Paddington, 4064
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info@soilsurveys.com.au
www.soilsurveys.com.au
SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 04

Project Number: 117-19420

Project Name: Library and Student Facilities

Location: Byron Bay Public School

Client: Bligh Tanner Consulting Engineers

Date: 01/07/2017 Page: 1 OF 1

Easting: 560090 Northing: 6830869 RL:

Logger: RH Operator: RH Machine: EVH1750

Drilling Method (TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	DCP Test (blows/100mm) 0 6 12 18 24 30	Samples and Remarks
	0.12		FILL Sandy GRAVEL (GP) Medium dense, fine to coarse sized, light grey, fine to coarse grained sand, trace of organics, moist.		ASS
	0.30				ASS
	0.50		NATURAL Silty SAND (SM) Loose to medium dense, fine to coarse grained, dark brown, moist.		ASS
	1.0				D
	1.00		Sandy CLAY (CI-CH) Very stiff, medium to high plasticity, light brown, fine to coarse grained sand, trace of fine to medium sized gravel, moist.		ASS
	1.70		Clayey SAND (SC) Medium dense, fine to coarse grained, light grey mottled light brown, low to medium plasticity fines, moist.		ASS
	2.0				ASS
	2.20		Silty SAND (SM) Medium dense, fine to medium grained, light grey, moist.		ASS
			Silty SAND (SM) Medium dense, fine to medium grained, light grey, wet.		
	3.0		Silty CLAY (CI) Very stiff, medium plasticity, light grey white, with fine to coarse grained sand, moist.		
	4.0				
	4.50		BOREHOLE BH 04 TERMINATED AT 4.50 m		
	5.0				
	6.0				
	7.0				
	8.0				
	9.0				
	10.0				

Comments:
1. Groundwater noted at 1.70m.

Water First Noted Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 05

Project Number: 117-19420
Project Name: Library and Student Facilities
Location: Byron Bay Public School
Client: Bligh Tanner Consulting Engineers
Date: 01/07/2017 Page: 1 OF 1

Easting: 560107 Northing: 6830876 RL:
Logger: RH Operator: RH Machine: EVH1750

Depth	Graphic	Description	DCP Test (blows/100mm) 0 6 12 18 24 30	Samples and Remarks
0.12		NATURAL Silty SAND (SM) Loose, fine to coarse grained, dark brown, with organics, moist.		ASS
0.25		Silty SAND (SM) Loose, fine to coarse grained, dark brown, moist.		D, ASS
0.50				ASS
0.70		Sandy CLAY (CI-CH) Stiff, medium to high plasticity, dark brown, fine to medium grained sand, moist.		ASS
1.0				ASS
1.20 ▽		Clayey SAND (SC) Medium dense, fine to coarse grained, dark brown, low to medium plasticity fines, moist.		ASS
1.70		Silty SAND (SM) Medium dense, fine to medium grained, light grey, moist.		ASS
2.0		Silty SAND (SM) Medium dense, fine to medium grained, light grey, wet.		ASS
2.50		Silty SAND (SM) Dense to very dense, fine to coarse grained, dark brown, with fine to coarse sized gravel, wet.		
3.0		Silty CLAY (CI) Very stiff, medium plasticity, light grey white, with fine grained sand, moist.		
4.0				D
4.50		BOREHOLE BH 05 TERMINATED AT 4.50 m		
5.0				
6.0				
7.0				
8.0				
9.0				
10.0				

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

Comments:
1. Groundwater noted at 1.20m.
2. DCP refusal at 1.78m.

▽ Water First Noted ▼ Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh

Rock Strength
RS - Residual Soil
VW - Very weak
W - Weak
MS - Medium Strong
S - Strong
VS - Very Strong
ES - Extremely Strong

Samples
U50
SPT
Disturbed Sample
Bulk Sample

Approved: MG
Date: 21/07/2017

SOIL SURVEYS 2.00 LIB 2017-07-13.GLB Log SOIL_SURVEY_AUGER_LOG 1-19420 GINT.GPJ <<DrawingFile>> 21/07/2017 16:33 10.0.000 Developed by Datgel

APPENDIX C

LABORATORY TEST CERTIFICATES

SOIL SURVEYS ENGINEERING P/L
8/140 Millaroo Dr, Helensvale, QLD. 4212.
Phone: (07) 5502 6795; Fax: (07) 5502 6724

SOIL SURVEYS

Screening Test

Client: Bligh Tanner
Address: C/O 2/19 Finchley Street, Milton, QLD, 4064
Project: Proposed Library & Student Facilities Building
Location: Byron Bay Public School

Job Number: 1-19420

Certificate Number: WHL17-0734-S1-S16 pHox

Issue Number: 1

Date Received: 03-Jul-17 Date Tested: 10-Jul-17 Date Issued: 10-Jul-17

Sample Number	Identification			Reaction to		pH	
	Borehole/ Location	From	To	H2O2	HCl	pHf	pHfox
S1	BH - 3	0.00	0.15	MODERATE	LOW	5.6	4.3
S2	BH - 3	0.30	0.60	MODERATE	LOW	5.2	3.7
S3	BH - 3	0.60	0.70	LOW	LOW	4.9	4.3
S4	BH - 3	0.70	1.00	LOW	LOW	5.1	5.0
S5	BH - 3	1.00	1.10	LOW	LOW	5.2	4.6
S6	BH - 3	1.10	1.50	LOW	LOW	5.2	4.3
S7	BH - 3	1.50	1.70	LOW	NIL	5.2	4.5
S8	BH - 3	1.70	2.00	LOW	NIL	5.2	4.3
S9	BH - 4	0.00	0.12	LOW	NIL	5.8	4.7
S10	BH - 4	0.30	0.50	LOW	LOW	4.2	3.7
S11	BH - 4	0.50	0.75	LOW	MODERATE	4.3	3.8
S12	BH - 4	0.75	1.00	LOW	MODERATE	4.2	3.7
S13	BH - 4	1.00	1.25	LOW	MODERATE	4.0	3.6
S14	BH - 4	1.25	1.50	LOW	LOW	3.8	3.2
S15	BH - 4	1.50	1.70	LOW	LOW	3.6	2.6
S16	BH - 4	1.70	2.00	LOW	LOW	3.8	2.5

Signed: _____ for and on behalf of Soil Surveys Engineering P/L
Craig ferguson-Hannah BSc - Laboratory Supervisor - Acid Sulfate Soils and Waters

1. Samples supplied by SSE
2. Samples tested in 'as received' condition

Form Number: REP-SCRN-01 V1

SOIL SURVEYS ENGINEERING P/L

8/140 Millaroo Dr, Helensvale, QLD. 4212.
Phone: (07) 5502 6795; Fax: (07) 5502 6724

Chromium Reducible Sulfur Suite Test Results

CLIENT: Bligh Tanner
ADDRESS: C/O 2/19 Finchley Street, Mlton, QLD, 4064
PROJECT: Proposed Library & Student Facilities Building
LOCATION: Byron Bay Public School

Job Number: 1 - 19420

NATA Accreditation number 15301

Accredited for Compliance with ISO/IEC 17025-Testing

Certificate Number : WHL17-0734-S1-S15 CrS

Issue Number 1

Date : 19-Jul-17

Sample Number	Identification/...				Excluded Material		Moisture as Received (85oC)	Init. pH	ANC - bt	a - ANC - bt	s - TAA	TAA	S - HCl	S - KCl	S - NAS	s - S - NAS	SCr	
	Borehole/ Testpit	from (m)	to	Date Sampled	Shell (%d.w.)	Gravel	AS4969.1	AS4969.2 (1M KCl)	AS4969.13 (%CaCO3 Eq.)	AS4969.13 (eq. mol. H+/t)	AS 4969.2 (%S Eq.)	AS4969.2 (mol. H+/t)	AS4969.8	AS4969.4 (% S)	AS4969.11	AS4969.11 (eq. mol. H+/t)	AS4969.7 (% S)	AS4969.7 (eq. mol. H+/t)
S1	3	0.00	0.15	01-Jul-17	0.0	0.0	8.7	7.51	n/a	n/a	0.00	0	n/a	n/a	n/a	n/a	<0.01	3
S2	3	0.30	0.60	01-Jul-17	0.0	0.0	28.6	4.76	n/a	n/a	0.12	74	n/a	n/a	n/a	n/a	<0.01	6
S4	3	0.70	1.00	01-Jul-17	0.0	0.0	24.8	6.18	n/a	n/a	0.01	7	n/a	n/a	n/a	n/a	<0.01	4
S8	3	1.70	2.00	01-Jul-17	0.0	31.0	14.7	5.05	n/a	n/a	0.07	41	n/a	n/a	n/a	n/a	0.02	10
S9	4	0.00	0.12	01-Jul-17	0.0	86.9	2.6	5.84	n/a	n/a	0.02	14	n/a	n/a	n/a	n/a	<0.01	3
S10	4	0.30	0.50	01-Jul-17	0.0	1.1	14.0	4.86	n/a	n/a	0.09	54	n/a	n/a	n/a	n/a	0.02	10
S12	4	0.75	1.00	01-Jul-17	0.0	0.0	12.7	4.73	n/a	n/a	0.05	32	n/a	n/a	n/a	n/a	0.01	9
S15	4	1.50	1.75	01-Jul-17	0.0	7.2	0.0	4.65	n/a	n/a	0.08	48	n/a	n/a	n/a	n/a	0.01	7

Samples Received: 03-Jul-17

Tests Completed: 18-Jul-17

Approved Signatory: Signed: _____ for and on behalf of Soil Surveys Engineering P/L

Craig Ferguson-Hannah BSc - Laboratory Supervisor - Acid Sulfate Soils and Waters

1 Samples supplied by SSE

2 Samples tested in 'as received' condition

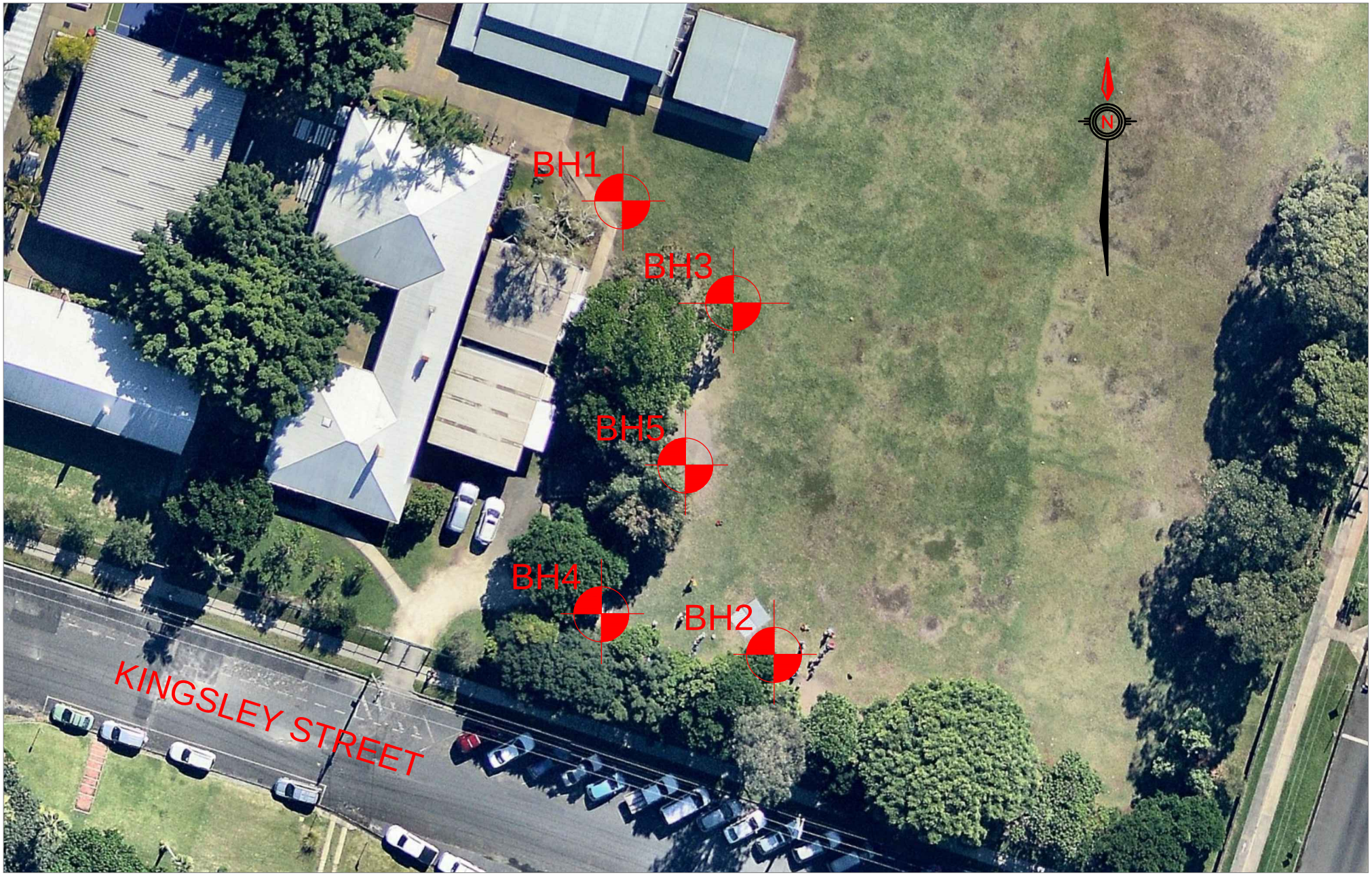
3 Tests herein were performed according to Soil Surveys Engineering Quality Management System. This report shall not be reproduced, except in full.

4 AS4969.4,8,11 Are not covered by this laboratories current scope of accreditation

Form Number: REP-CRS-01 V2

APPENDIX D

SITE PLAN



Borehole Location Plan reproduced from plan Nearmap Imagery

SCALE 1:500 (5 0 15)	DRAWING TITLE	CLIENT	Soil Surveys
REFERENCE V:\Milton\Milton 19001 - 20000\1-19401 - 1-19600\1-19420 Byron Bay\Graphics	PROPOSED LIBRARY & STUDENT FACILITIES BOREHOLE LOCATION PLAN	BLIGH TANNER	SOIL SURVEYS ENGINEERING PTY.LIMITED
A4 / DRW. NO 117-19420-01 / DATE 18/07/2017 / CHECKED MG		LOCATION BYRON BAY PUBLIC SCHOOL	Specialists in Applied Geotechnics