Reviewed by Tibaer on 7/08/2020
Refer to Appendix E for Acid Sulfate Soil Management P

SOIL SURVEYS

ACID SULFATE SOIL INVESTIGATION

PROJECT NO. 1-22520

MAY, 2020

LEG CONSTRUCTIONS PTY LTD

RESIDENTIAL UNIT DEVELOPMENT

3 MOORES ROAD, REDLAND BAY

PLANS AND DOCUMENTS
referred to in the PDA
DEVELOPMENT APPROVAL

Approval no: DEV2020/1093

Date: 18 December 2020

Queensland Government

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Document Information

Project Number	**1-22520**
Document Title	**Acid Sulfate Soil Investigation - Residential Unit Development**
Site Address	**3 Moores Road, Redland Bay**
Client	**LEG Constructions Pty Ltd**
File ref	**1-22520, 2020-05-14, ASSMP VER 1**
Author	**Cameron Johnson**

Review

Ver No.	Document Type	Reviewed By	Approved for Issue	
			Name	Date
1	Final	Noel Perkins	Cameron Johnson	18/05/2020

Distribution List

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TABLE OF CONTENTS

Appendices

1.0 INTRODUCTION

This report presents the results of the Acid Sulfate Soil Investigation carried out by Soil Surveys Engineering Pty Limited for the proposed residential unit development at 3 Moores Road, Redland Bay.

It is understood that the proposed development will comprise the construction of a five by two or three storey unit buildings overlying a single level basement.

From an Acid Sulfate Soil (ASS) perspective, it is expected that bulk excavations of up to 3.00m will be required to create the various building platforms.

2.0 SCOPE OF SERVICES

The scope of services provided by Soil Surveys Engineering Pty Limited (refer proposal 1-20916, 2018-10-15, PR VER 1) was to carry out an Acid Sulfate Soil (ASS) Investigation Report and development of an Acid Sulfate Soil Management Plan (ASSMP) as required by the Information Request from the Department of State Development, Manufacturing, Infrastructure and Planning (Reference DEV2020/1093) dated 5th March, 2020.

3.0 SITE DESCRIPTION

The development site is located at 3 Moores Road, Redland Bay. Lot 100 on SP309514. Refer Figure 1.

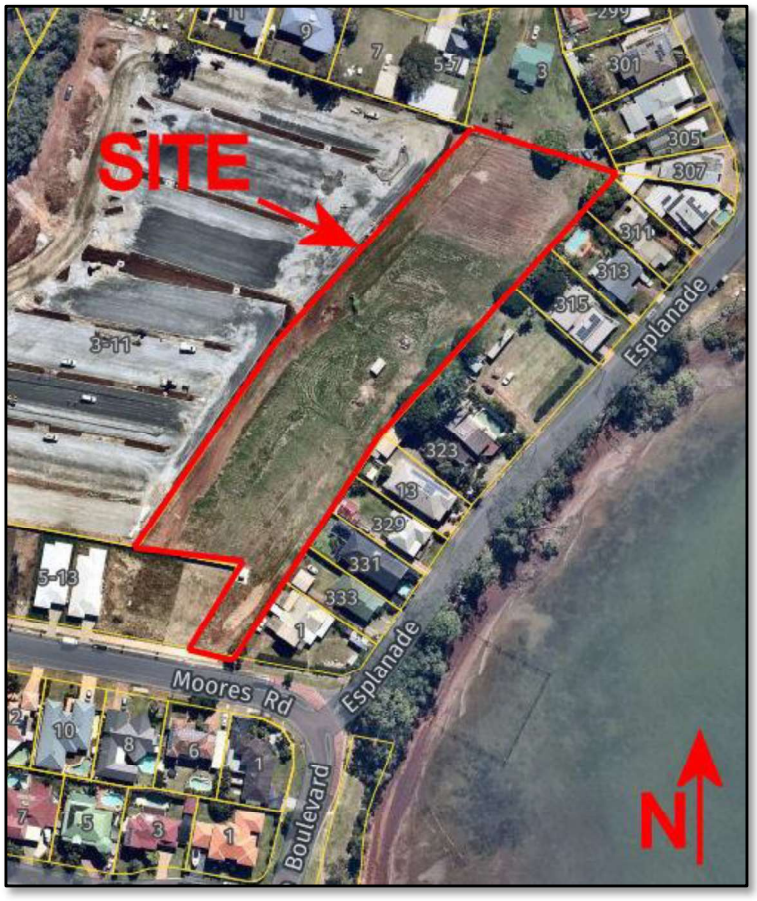
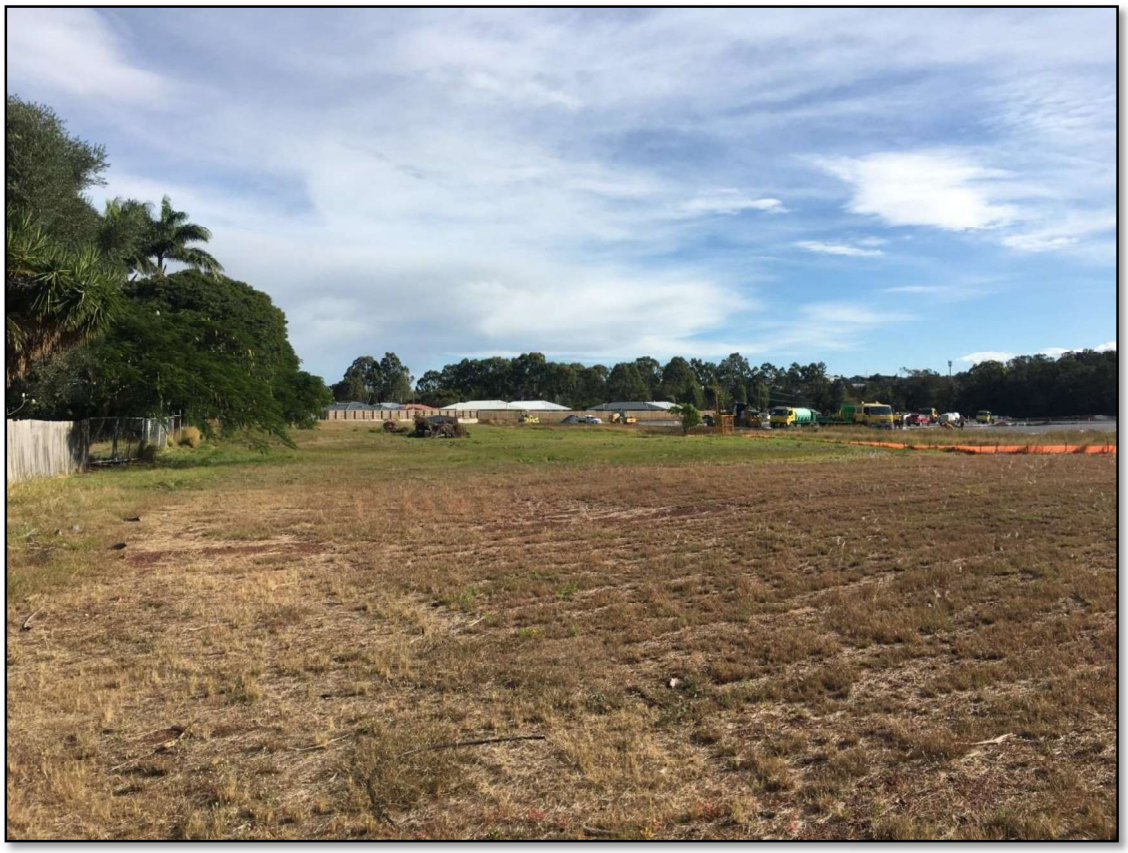


FIGURE 1 - SITE LOCATION

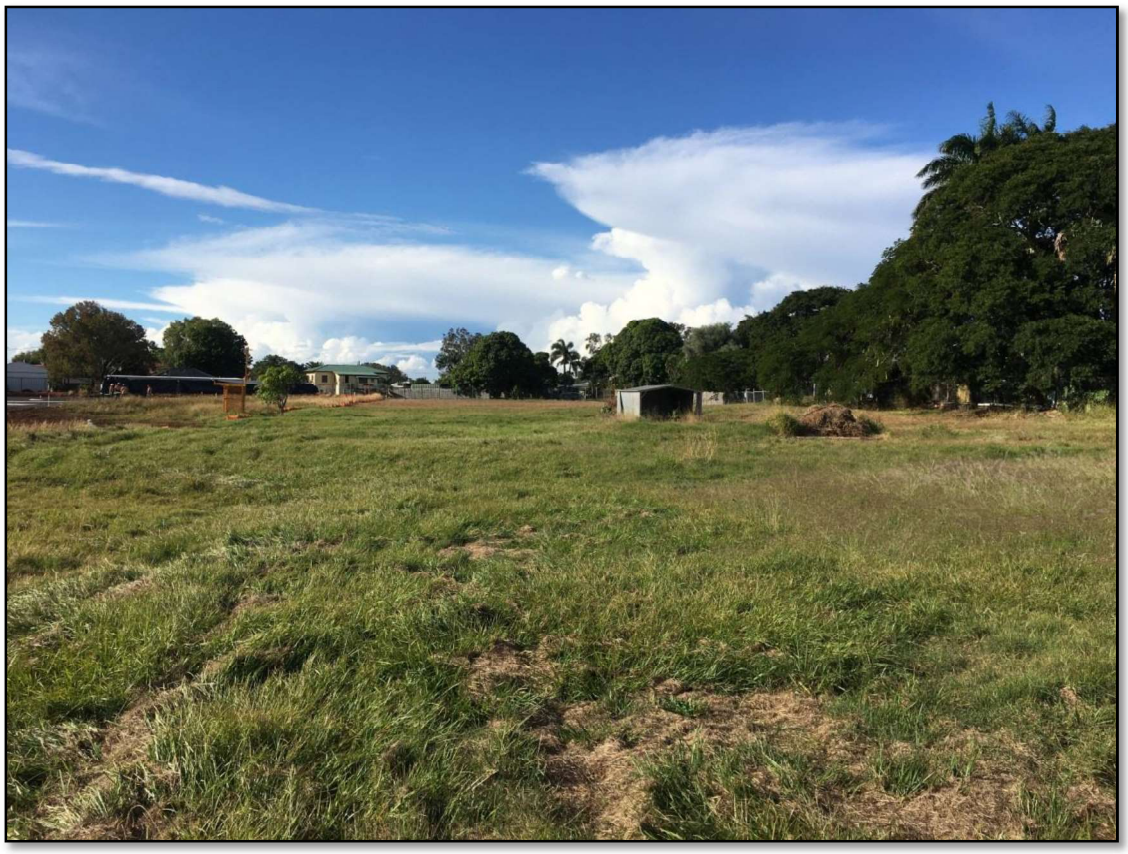
At the time of the investigation the site was cleared with a surface covering of short grass. A small shed is located within the central part of the site.

Redland City Council contour plans indicate the site slopes slightly generally towards the west. Surface levels ranged between RL 2.00m and RL 3.75m.

Photographs 1 and 2 indicate existing site conditions.



PHOTOGRAPH 1 – LOOKING SOUTH ACROSS THE SITE



PHOTOGRAPH 2 – SITE LOOKING TOWARDS THE NORTH

4.0 GEOTECHNICAL INVESTIGATION

4.1 Field Investigation

Subsurface conditions at the site were investigated by drilling and sampling four boreholes, to depths of 4.00m, using a lightweight 4WD mounted drilling rig.

The field work was carried out on the 5th May, 2020.

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

4.2 Standards

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

- AS 1726 - 2017 Geotechnical Site Investigations
- Queensland Acid Sulfate Soil Investigation Team, Dept. of Natural Resources, 'Guidelines for Sampling and Analysis of Lowland Acid Sulfate Soils (ASS) in Queensland, 1998' (Oct. 1998, Revision 4.0).
- The State Planning Policy Guideline: State interest - emissions and hazardous activities - Guidance on acid sulfate soils, December, 2013.
- Queensland Acid Sulfate Soil Technical Manual Soil Management Guidelines v4.0.

4.3 Laboratory Assessments

A staged testing program was carried out on recovered soil samples; Table 1 refers:-

TABLE 1 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

Thirty six (36) samples were screened by Soils Surveys Engineering as part of this study 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.

Samples were also subject to quantitative analysis by the Chromium Reducible Sulfur suite in accordance with appropriate laboratory procedures.

The Chromium Reducible Sulfur suite had been adopted by QASSIT in Queensland for the testing of ASS in Queensland. This method includes analysis of 'inherent buffering capacity' from naturally occurring alkaline materials (i.e. calcite, coral debris, fine shell fragments) and 'retained acidity' which includes sulfur held in stable oxidation minerals such as 'jarosite' and allows for calculation of 'net acidity'. The Chromium Reducible Sulfur test method was selected in preference to the Suspension Peroxide Oxidation Combined Acidity & Sulfur (SPOCAS) method as it is gives more accurate indications of pyrite content where significant amounts of organic matter (and organic derived acidity) are present in the soil samples.

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.

5.0 GEOTECHNICAL MODEL

5.1 Subsurface Profile

Subsurface conditions encountered at the borehole locations generally comprised natural clay soils extending to the borehole termination depths at 4.00m.

Clay fill was encountered to a depth of 0.70m at the location of Borehole 3.

Refer the borehole records for a detailed subsurface profile description.

5.2 Groundwater

Groundwater was not encountered at borehole locations at the time of the investigation. Whilst groundwater was not encountered in the boreholes, it should be noted that groundwater may be present; please note that the period of time available (during the drilling of boreholes) is relatively short, and hence, the opportunity to observe the presence (or otherwise) of groundwater is limited.

Further, groundwater conditions may fluctuate due to seasonal and climatic variations and localised seepage may occur.

6.0 ACID SULFATE SOILS (ASS) - DISCUSSION OF RESULTS

6.1 Summary of Quantitative Tests

The results of the quantitative test results via the Chromium Suite testing are summarised below in Table 2.

TABLE 2 QUANTITATIVE TEST RESULTS SUMMARY

BH No.	Depth (m)	pH_f	pH_{fox}	pH kCl	TAA (mol H^+/t)	S-NAS (%S)	CRS (%S)	Net Acidity (%S)
1	0.50-0.70	6.3	4.9	5.46	213	-	0.009	0.029
1	2.00-2.20	5.8	4.3	5.02	15	-	0.013	0.033
1	3.00-3.20	5.6	4.6	4.91	12	-	0.003	0.023
2	1.00-1.20	5.9	5.4	4.98	320	-	0.003	0.033
2	2.50-2.70	4.7	4.1	4.54	426	-	0.008	0.048
3	0.50-0.60	5.0	4.8	4.88	215	-	0.008	0.028
3	2.00-2.10	4.5	3.7	4.55	640	-	0.003	0.063
4	1.00-1.20	5.0	4.2	4.80	317	-	0.005	0.035
4	3.50-3.60	3.9	13.1	4.51	487	-	0.008	0.148

6.2 Criteria for Evaluation of ASS

Preliminary Screening

Criteria for comparison of results of screening tests (pH and pH_{fox}) to indicate possible actual acid sulfate soils (AASS) or potential acid sulfate soils (PASS) were based on QASSIT guidelines and in accordance with the Moreton Bay Regional Council - Planning Scheme Policy Acid Sulfate Soils:-

- pH_f<4 may indicate that oxidation has occurred in the past and that AASS is present. No samples tested had pH_f values <4.
- pH_{fox}<3 with a large unit change from pH_f to pH_{fox}, strongly indicates the presence of PASS. No samples tested recorded pH_{fox} value <3.

Quantitative Tests

Texture based acid sulfate soils action criteria (QLD Acid Sulfate Soil Technical Manual v4.0 2014) considering quantitative test results as a guide to assess the need for an ASSMP is presented in Table 3.

TABLE 3 ACTION CRITERIA (QASSTM 2014 VERSION 4.0)

Texture Range/ Classification	Approximate Clay Content (%)	Action Criteria 1-1000 tonnes disturbed		Action Criteria >1000 tonnes disturbed	
		S (%)	TAA (mol H^+/t)	S (%)	TAA (mol 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	0.10	62	0.03	18

It can be seen from comparison of results from Tables 4 and the above Action Criteria that some of the presented laboratory TAA test results do exceed action levels.

6.3 Assessment

Based on the stratigraphy encountered in ASS boreholes drilled at the site and results of the screening and quantitative analysis carried out, it is apparent that the clay material contains very low levels of acidity.

The results of laboratory analysis indicates the presence of Acidic Soils within the natural soils. No test results recorded levels of Potential Acid Sulfate Soil (CRS) above the nominated action criteria. The acidity present in the tested samples are due to Titratable Actual Acidity (TAA) values exceeding the Action Criteria values with these soil samples located below depths of 1.00m.

Test results indicate that acidity in the soil consists predominantly of TAA, therefore these soils can be described as Acidic Soils with the origin of the acidity unclear but can be attributed to a variety of influences including geology age, landscape position, geochemist interactions or other soil-forming processes.

TAA values exceeded the nominated action criteria recorded pH_{KCl} values of ≤5.5. In accordance with Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines, when pH_{KCl} values are ≤5.5, an Acid Soil Management Plan is required in areas of the site where Acidic Soils have been identified.

An Acid Soil Management plan for the identified areas of the site is presented in Appendix E.

7.0 LIMITATIONS

We have prepared this report for the use of **LEG Constructions Pty Ltd**, 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 **LEG Constructions Pty Ltd**; 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 and depth 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 and below boreholes may vary significantly from conditions encountered at the borehole locations.

Please note, if following detailed design, the founding depth of any footings or piers/piles is within 3B (B = footing width/pier diameter) above the termination depth of the boreholes/pits/CPTU or if any excavations extend below the borehole/pit/CPTU termination levels, then Soil Surveys Engineering should be contacted immediately.

If the above were to occur then the geotechnical data in this report should be considered preliminary only; additional investigation is likely to be required.

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 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 can not be held responsible for the effect 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.

C. P. JOHNSON (RPEQ 7052)
PRINCIPAL GEOTECHNICAL 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 1726-2017 (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.-

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

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.

APPENDIX B

BOREHOLE RECORD SHEETS

Soil Surveys Engineering Pty. Limited
Specialists in Applied Geotechnics
PO Box 317, Paddington, 4064
+61 7 3369 6000
info@soilsurveys.com.au
www.soilsurveys.com.au
SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 01

Project Number: 1-22520
Project Name: Proposed Residential Development
Location: 3 Moores Road, Redland Bay
Client: LEG Constructions Pty Ltd
Date: 05/05/2020 Page: 1 OF 1

Easting: 530510 Northing: 6944608 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
	0.10		NATURAL Silty CLAY (CH) Hard, high plasticity, red brown, trace of fine to medium sized gravel, with organics, moist.		ASS
			Silty CLAY (CH) Hard, high plasticity, red brown, trace of fine to medium sized gravel, moist.		
	0.5 0.50		Silty CLAY (CH) Hard, high plasticity, red brown mottled dark brown, trace of fine to medium sized gravel, moist.		ASS
	0.90		Silty CLAY (CH) Hard, high plasticity, red brown mottled dark brown, with fine to medium sized gravel, moist.		ASS
	1.0				
	1.5				ASS
	1.80		Silty CLAY (CH) Hard, high plasticity, mottled red brown light brown, with fine to medium sized gravel, moist.		ASS
	2.0				
	2.5 2.50		Silty CLAY (CH) Very stiff, high plasticity, mottled red brown light grey light brown, with fine to medium sized gravel, moist.		ASS
	3.0				ASS
	3.5				ASS
	4.0 4.00		BOREHOLE BH 01 TERMINATED AT 4.00 m		ASS
	4.5				
	5.0				

Comments:
1. Groundwater not encountered during augering.
2. DCP refusal at 2.09m.
3. Hand augered to 0.20m.

Water First Noted Water Steady Level

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: CPJ
Date: 18/05/2020

SOIL SURVEYS 2.00 LIB 2017-07-13.GLB Log SOIL_SURVEY_AUGER_LOG2 1-22520_GINT.GPJ <<DrawingFile>> 18/05/2020 15:42 10.0.000 Developed by Datgel

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www.soilsurveys.com.au
SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 02

Project Number: 1-22520
Project Name: Proposed Residential Development
Location: 3 Moores Road, Redland Bay
Client: LEG Constructions Pty Ltd
Date: 05/05/2020 Page: 1 OF 1

Easting: 530571 Northing: 6944651 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		NATURAL Silty CLAY (CI-CH) Hard, medium to high plasticity, dark brown, trace of fine to medium sized gravel, with organics, moist.		ASS
	0.5		Silty CLAY (CI-CH) Hard, medium to high plasticity, dark brown, trace of fine to medium sized gravel, moist.		ASS
	0.90		Silty CLAY (CH) Hard, high plasticity, mottled red brown dark brown, trace of fine to medium sized gravel, moist.		ASS
	1.0				
	1.5				ASS
	1.80		Silty CLAY (CH) Very stiff, high plasticity, mottled red brown light grey, trace of fine to medium sized gravel, moist.		ASS
	2.0				
	2.40		Silty CLAY (CH) Very stiff, high plasticity, light grey mottled red brown, trace of fine to medium sized gravel, moist.		ASS
	2.5				
	3.0				ASS
	3.5				ASS
	4.0	4.00			ASS
			BOREHOLE BH 02 TERMINATED AT 4.00 m		
	4.5				
	5.0				

Comments:
1. Groundwater not encountered during augering.
2. DCP refusal at 3.58m.
3. Hand augered to 0.30m.

Water First Noted Water Steady Level

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: CPJ
Date: 18/05/2020

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 03

Project Number: 1-22520

Project Name: Proposed Residential Development

Location: 3 Moores Road, Redland Bay

Client: LEG Constructions Pty Ltd

Date: 05/05/2020 Page: 1 OF 1

Easting: Northing: 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
	0.10		FILL Gravelly CLAY (CH) Very stiff, high plasticity, red brown mottled dark bron, fine to medium sized gravel, with organics, moist.		ASS
	0.5		FILL Gravelly CLAY (CH) Very stiff, high plasticity, red brown mottled dark brown, fine to medium sized gravel, moist.		ASS
	0.70		NATURAL Sandy CLAY (CH) Very stiff, high plasticity, dark grey mottled red brown dark brown, fine to coarse grained sand, trace of fine to medium sized gravel, moist.		ASS
	1.0				ASS
	1.5				
	1.70		Silty CLAY (CH) Very stiff, high plasticity, mottled red brown light grey light brown, trace of fine to medium sized gravel, moist.		ASS
	2.0				
	2.5				ASS
	3.0				ASS
	3.5				ASS
	4.0	4.00			ASS
			BOREHOLE BH 03 TERMINATED AT 4.00 m		
	4.5				
	5.0				

Comments:
1. Groundwater not encountered during augering.
2. DCP refusal at 3.79m.
3. Hand augered to 0.70m.

Water First Noted Water Steady Level

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: CPJ
Date: 18/05/2020

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SOIL SURVEYS

BOREHOLE RECORD SHEET

Location Number: BH 04

Project Number: 1-22520
Project Name: Proposed Residential Development
Location: 3 Moores Road, Redland Bay
Client: LEG Constructions Pty Ltd
Date: 05/05/2020 Page: 1 OF 1

Easting: 530646 Northing: 6944731 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
	0.20		NATURAL Gravelly CLAY (CH) Hard, high plasticity, red brown, fine to medium sized gravel, with organics, moist.		ASS
	1.20		Gravelly CLAY (CH) Hard, high plasticity, red brown, fine to medium sized gravel, moist.		ASS
	1.70		Sandy CLAY (CL-CI) Very stiff, low to medium plasticity, mottled light grey red brown, fine to coarse grained sand, with fine to medium sized gravel, moist.		ASS
	4.00		Silty CLAY (CH) Very stiff, high plasticity, red brown mottled light grey, trace of fine to medium sized gravel, some light seepage, wet.		ASS
			BOREHOLE BH 04 TERMINATED AT 4.00 m		ASS

Comments:
1. Groundwater noted at 1.70m during augering.
2. DCP refusal at 3.29m.
3. Hand augered to 0.20m.

Water First Noted Water Steady Level

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: CPJ
Date: 18/05/2020

APPENDIX C

LABORATORY TEST CERTIFICATES

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

SOIL SURVEYS

Screening Test

Client: LEG Constructions Pty Ltd
Address: C/O 2/19 Finchley Street, Milton, QLD, 4064
Project: Townhouse Development
Location: 3 Moores Road, Redland Bay

Job Number: 1-22520

Certificate Number: WHL20-0308-S1-S36 pHox

Issue Number: 1

Date Received: 7-May-20 Date Tested: 8-May-20 Date Issued: 8-May-20

Sample Number	Identification			Reaction to		pH	
	Borehole/Location	From	To	H2O2	HCl	pHf	pHfox
S1	BH - 1	0.00	0.30	HIGH	LOW	6.8	4.9
S2	BH - 1	0.50	0.70	HIGH	LOW	6.3	4.9
S3	BH - 1	1.00	1.20	MODERATE	LOW	6.2	4.9
S4	BH - 1	1.50	1.80	HIGH	LOW	5.9	4.4
S5	BH - 1	2.00	2.20	LOW	LOW	5.8	4.3
S6	BH - 1	2.50	2.70	LOW	LOW	5.6	4.4
S7	BH - 1	3.00	3.20	LOW	LOW	5.6	4.6
S8	BH - 1	3.50	3.70	LOW	LOW	5.3	4.0
S9	BH - 1	3.90	4.00	LOW	LOW	5.3	4.9
S10	BH - 2	0.00	0.15	VERY HIGH	HIGH	5.6	5.1
S11	BH - 2	0.50	0.70	HIGH	MODERATE	6.3	5.2
S12	BH - 2	1.00	1.20	LOW	LOW	5.9	5.4
S13	BH - 2	1.50	1.70	LOW	LOW	5.1	4.0
S14	BH - 2	2.00	2.20	LOW	MODERATE	5.0	4.9
S15	BH - 2	2.50	2.70	LOW	LOW	4.7	4.1
S16	BH - 2	3.00	3.10	LOW	MODERATE	4.7	5.3
S17	BH - 2	3.50	3.60	LOW	LOW	5.2	4.6
S18	BH - 2	3.90	4.00	LOW	LOW	4.9	4.6
S19	BH - 3	0.00	0.10	VERY HIGH	HIGH	5.1	5.2
S20	BH - 3	0.50	0.60	MODERATE	MODERATE	5.0	4.8
S21	BH - 3	1.00	1.20	LOW	MODERATE	4.6	3.9
S22	BH - 3	1.50	1.60	LOW	LOW	4.4	3.8
S23	BH - 3	2.00	2.10	LOW	LOW	4.5	3.7
S24	BH - 3	2.50	2.70	LOW	LOW	4.8	4.1
S25	BH - 3	3.00	3.10	LOW	LOW	5.5	4.5
S26	BH - 3	3.50	3.60	LOW	LOW	5.7	4.5
S27	BH - 3	3.90	4.00	LOW	MODERATE	5.6	4.3
S28	BH - 4	0.00	0.10	MODERATE	HIGH	6.5	5.8
S29	BH - 4	0.50	0.60	LOW	MODERATE	5.7	4.6
S30	BH - 4	1.00	1.20	LOW	HIGH	5.0	4.2
S31	BH - 4	1.50	1.60	LOW	MODERATE	4.1	3.8
S32	BH - 4	2.00	2.20	LOW	MODERATE	4.0	3.6
S33	BH - 4	2.50	2.60	LOW	MODERATE	3.8	3.3
S34	BH - 4	3.00	3.10	LOW	MODERATE	3.8	3.2
S35	BH - 4	3.50	3.60	LOW	LOW	3.9	3.1
S36	BH - 4	3.90	4.00	LOW	LOW	3.9	3.5

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

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:LEG Constructions Pty Ltd
ADDRESS: C/O 2/19 FInchley Street, Milton, QLD, 4064
PROJECT: Townhouse Development
LOCATION: 3 Moores Road, Redland Bay

Job Number: 1 - 22520

NATA Accreditation number 15301

Accredited for Compliance with ISO/IEC 17025-Testing

Certificate Number : WHL20-0308-S2-S35 CrS

Issue Number: 1

Date : 15-May-20

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)
S2	1	0.50	0.70	05-May-20	0.0	0.0	24.4	5.46	n/a	n/a	0.02	13	n/a	n/a	n/a	n/a	0.009	6
S5	1	2.00	2.20	05-May-20	0.0	0.0	28.0	5.02	n/a	n/a	0.02	15	n/a	n/a	n/a	n/a	0.013	8
S7	1	3.00	3.20	05-May-20	0.0	0.0	26.5	4.91	n/a	n/a	0.02	12	n/a	n/a	n/a	n/a	0.003	2
S12	2	1.00	1.20	05-May-20	0.0	0.0	23.6	4.98	n/a	n/a	0.03	20	n/a	n/a	n/a	n/a	0.003	2
S15	2	2.50	2.70	05-May-20	0.0	0.0	29.3	4.54	n/a	n/a	0.04	26	n/a	n/a	n/a	n/a	0.008	5
S20	3	0.50	0.60	05-May-20	0.0	5.4	15.4	4.88	n/a	n/a	0.02	15	n/a	n/a	n/a	n/a	0.008	5
S23	3	2.00	2.10	05-May-20	0.0	0.0	30.3	4.55	n/a	n/a	0.06	40	n/a	n/a	n/a	n/a	0.003	2
S30	4	1.00	1.20	05-May-20	0.0	0.1	10.4	4.80	n/a	n/a	0.03	17	n/a	n/a	n/a	n/a	0.005	3
S35	4	3.50	3.60	05-May-20	0.0	0.0	36.6	4.51	n/a	n/a	0.14	87	n/a	n/a	n/a	n/a	0.008	5

Samples Received: 07-May-20

Tests Completed: 15-May-20

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

Craig Ferguson-Hannah-Delegated Signatory - 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. Results only relate to items tested in this report

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

5 AS4969.13 Includes a safety factor of 1.5

Form Number : REP-CRS-01 V2

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:LEG Constructions Pty Ltd
ADDRESS: C/O 2/19 FInchley Street, Milton, QLD, 4064
PROJECT: Townhouse Development
LOCATION: 3 Moores Road, Redland Bay

Job Number: 1 - 22520

NATA Accreditation number 15301

Accredited for Compliance with ISO/IEC 17025-Testing

Certificate Number : WHL20-0308-S2-S35 CrS

Issue Number: 1

Date : 15-May-20

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)
S2	1	0.50	0.70	05-May-20	0.0	0.0	24.4	5.46	n/a	n/a	0.02	13	n/a	n/a	n/a	n/a	0.009	6
S5	1	2.00	2.20	05-May-20	0.0	0.0	28.0	5.02	n/a	n/a	0.02	15	n/a	n/a	n/a	n/a	0.013	8
S7	1	3.00	3.20	05-May-20	0.0	0.0	26.5	4.91	n/a	n/a	0.02	12	n/a	n/a	n/a	n/a	0.003	2
S12	2	1.00	1.20	05-May-20	0.0	0.0	23.6	4.98	n/a	n/a	0.03	20	n/a	n/a	n/a	n/a	0.003	2
S15	2	2.50	2.70	05-May-20	0.0	0.0	29.3	4.54	n/a	n/a	0.04	26	n/a	n/a	n/a	n/a	0.008	5
S20	3	0.50	0.60	05-May-20	0.0	5.4	15.4	4.88	n/a	n/a	0.02	15	n/a	n/a	n/a	n/a	0.008	5
S23	3	2.00	2.10	05-May-20	0.0	0.0	30.3	4.55	n/a	n/a	0.06	40	n/a	n/a	n/a	n/a	0.003	2
S30	4	1.00	1.20	05-May-20	0.0	0.1	10.4	4.80	n/a	n/a	0.03	17	n/a	n/a	n/a	n/a	0.005	3
S35	4	3.50	3.60	05-May-20	0.0	0.0	36.6	4.51	n/a	n/a	0.14	87	n/a	n/a	n/a	n/a	0.008	5

Samples Received: 07-May-20

Tests Completed: 15-May-20

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

Craig Ferguson-Hannah-Delegated Signatory - 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. Results only relate to items tested in this report

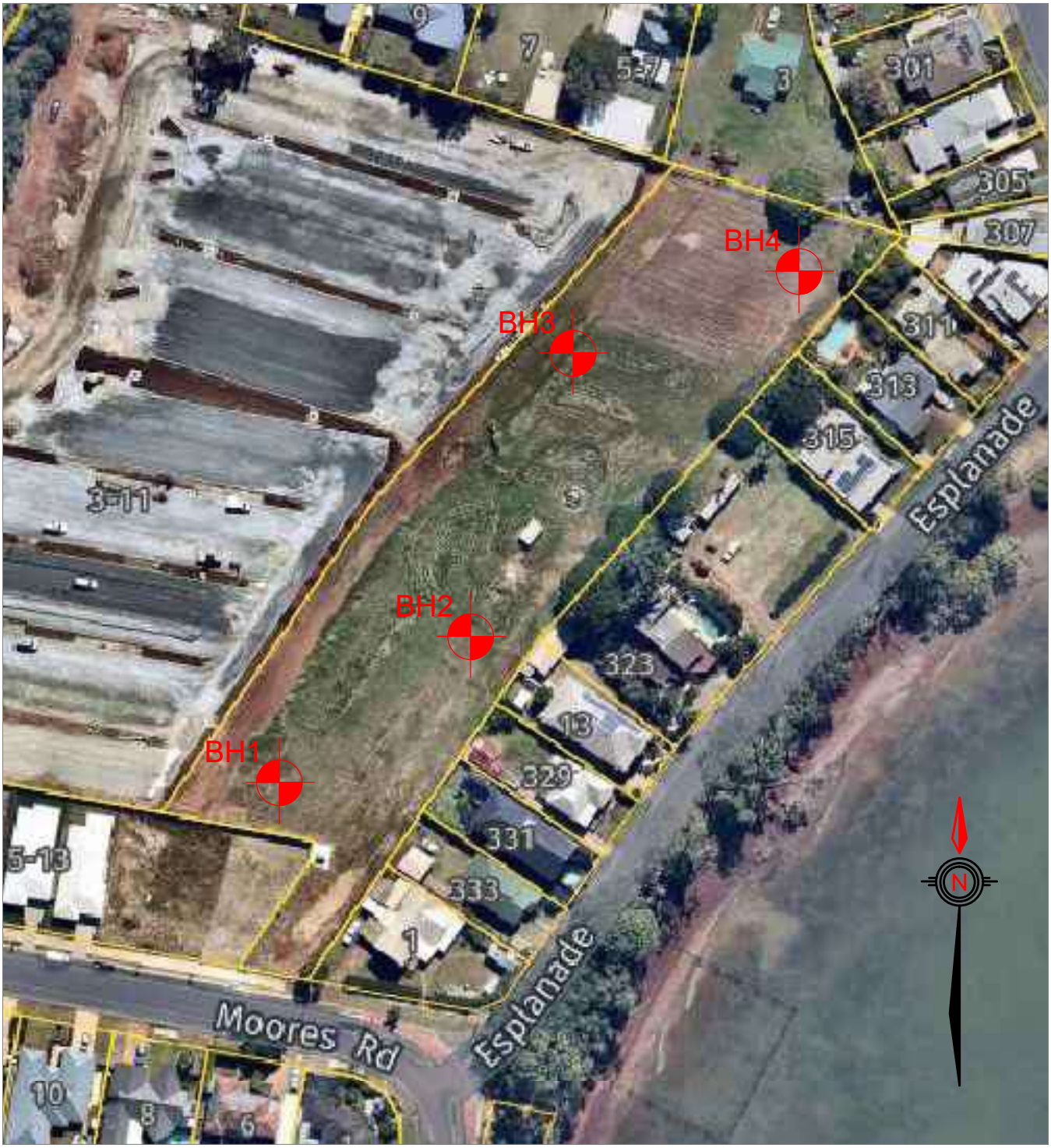
4 AS4969.4,8,11 Are not covered by this laboratories current scope of accreditation

5 AS4969.13 Includes a safety factor of 1.5

Form Number : REP-CRS-01 V2

APPENDIX D

SITE PLAN



CLIENT
LEG CONSTRUCTIONS PTY LTD

LOCATION
3 MOORES ROAD, REDLAND BAY

SCALE
NOT TO SCALE

TITLE
RESIDENTIAL UNIT DEVLOPMENT

ACID SULFATE SOIL BOREHOLE LOCATION PLAN

A4	DRAWING NO.	DATE	CHECKED
	1-22520-01	18/05/2020	CJ

Soil Surveys
SOIL SURVEYS ENGINEERING PTY.LTD.
CONSULTING GEOTECHNICAL ENGINEERS

APPENDIX E

ACID SULFATE SOIL MANAGEMENT PLAN (ASSMP)

Residential Unit Development

3 Moores Road, Redland Bay

E1.0 ACID SOIL MANAGEMENT PLAN (ASMP)

E1.1 Introduction

The results of the Acid Sulfate Soil Investigation indicates that the soils contained within sections of the site are considered to be Acidic Soils as opposed to Acid Sulfate Soils.

Management outlines in the following section are in general accordance with recommendations outlines in the Queensland Acid Sulfate Soils Technical Manual - Soil Management Guidelines V.4.0 June, 2014.

E1.2 Management Plan

Based on the results of the laboratory tests, it was considered that the natural soils below depths of 1.00m contain Acidic Soils and will require treatment and management.

In accordance with the Queensland Acid Sulfate Soil Technical Manual: Soil Management Guidelines to prevent the potential for acid leachate from disturbed soils it is recommended that a neutralising agent be applied during site works. The following should be considered:-

1. The application of a neutralising agent below any fill or stockpile areas is required to intercept acid migration through the soil profile to underlying ground water horizons.
2. Position lime enriched perimeters around any temporary stockpiles, permanent stockpiles or fill areas.
3. The implementation of surface water controls to ensure that water runoff form earthworks zones has pH correction prior to entering detention basins or adjacent watercourses.
4. Lime treatment of the upper fill layers of fill platforms and batters to mitigate against the potential for acid migration form fill embankments, as well as addressing the root zone of landscape areas which may be located over such areas.
5. Lime dusting the base of cut areas, with the area compacted following lime application to ensure that ag-lime is incorporated into the surface material.

E1.3 Avoiding or Minimising Disturbance

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

Given the proposed development, avoidance of Acidic Soils is not possible and neutralisation of the disturbed soil material will be required.

E2.0 ACID NEUTRALISATION

The material excavated during the excavation may be used as controlled backfill on this site provides management of the soils as required is carried out.

Current experience suggests that one of the most effective methods that can be implemented to limit or prevent the adverse consequences of disturbing acidic soils and material is the controlled application of agricultural lime (aglime).

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

E2.1 Lime Application

The application of aglime to the soil requires thorough mixing and incorporation into the soil. The distribution of actual acid production is sufficiently consistent to allow an approach for lime dosing that is based on the depth of excavation.

It is recommended that strict sampling and testing of the material be carried out during excavation. Not only will this lead to economy in the lime requirement, but it would also reduce the potential for over-correction in neutralisation and conversely under-correction in some cases.

Based on the assessment of the investigation results and in accordance with guidelines, the recommended lime dosing rates are presented in Table E1, using the minimum industry safety factor of 1.5. The actual liming rates 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.

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 fill material and the lime.

Only aglime (calcium carbonate) should be used, as quicklime or slaked lime is not considered a long term neutralising agent of sulfuric acid.

Table E1 presents the estimated lime dosages per cubic metre of soil, based on the results of the field investigation and laboratory testing programs.

TABLE E1 RECOMMENDED LIMING RATES

Material Type	Factored Lime Rate (kg/m^3 of disturbed soil)
Fill Material	NR
Natural Soils – Clay (above 1.0m depth)	NR
Natural Soils – Clay (below 1.0m depth)	3 to 12

Notes:
1. NR – Not Required. Does not exceed action criteria values.
2. Bulk density 1.70t/m^3 assumed.
3. Lime dosing rates include a factor of safety of 1.5 and based on upper bound results.
4. 100% purity (neutralising value) is assumed for the aglime (any variation from 100% in the product actually used must be factored accordingly).

It is recommended that the estimated dosing rates shown be refined by on-site sampling and further testing at the time of construction thus allowing appropriate adjustments to be made if and when required. This would help safeguard against errors in identifying material types, poor mixing methods and potential unknown 'hot spots' of acid sulfate material.

Dosing rate calculations were carried out in general accordance with the method set out in the Qld Acid Sulfate Soil Technical Manual.

E3.0 CONSTRUCTION TECHNIQUES

E3.1 Stockpiled Material

All stockpiles of Acidic Soils should be located in settings that will ensure minimal risk of adverse environmental impacts following from acid leachate. The following recommendations are made for stockpiled material:-

- Acidic Soils must not be stockpiled for a period greater than 18 hours unless it is neutralised first. Stockpiling untreated material any longer may reduce the pH of any leachate to the level at which aluminium precipitates out of solution. This will have a detrimental effect on the surrounding environment.
- Stockpiling untreated material can be undertaken in an appropriate setting where all leachate/runoff can be controlled.
- All stockpiles should have bunded drains surrounding them to allow collection, containment and treatment of surface runoff and leachate from the stockpile; the drains should flow to catchponds.
- At stockpile locations, aglime (at the rate of 5kg/m^2) should be tyned into the underlying soil for a depth of 0.3m below surface level. As each stockpile of soil is removed for treatment, additional aglime may be added should any of the leachate neutralise the original lime placed in the bunds (to be verified through testing).

E3.2 Acidic Soils Treatment

Acidic Soils material excavated from the excavation may be placed in nominated areas for immediate treatment. The Acidic Soils material should be placed in layers less than 300mm thick to allow for adequate drying, ploughing and subsequent treatment with aglime.

When each soil layer is spread and adequately dried, the contractor should add lime at the prescribed rate and mix thoroughly using agricultural spreaders and ploughs as appropriate to ensure a homogeneous mix.

E3.3 Groundwater

Groundwater if encountered should be pumped to detention basin or holding tank for treatment prior to discharge.

The water contained within the treatment bunds should not be removed until the target values have been achieved as presented below.

TABLE E2 TARGET LEVELS OF NEUTRALISED SOIL AND WATER

Parameter	Criteria	Unit
pH	6.5-8.5	pH
Tubidity	<10%[1]	NTU
Suspended Solids	<50	Mg/L

Notes:-
5. Released waters from the approved discharge point(s) to have turbidity (NTU) less than 10% above the receiving waters turbidity - measured immediately upstream of the site.
6. Water Quality Objectives based on Draft urban stormwater - Queensland best practise environmental management guidelines, 2009.

The water must then be treated to bring the pH and other water quality criteria to acceptable levels. Appropriate neutralising agents, e.g. aglime, slaked lime or magnesium / calcium hydroxide must be used to treat the water to an acceptable level prior to discharge.

E4.0 SITE MONITORING

E4.1 General

A monitoring program should 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
- Frequency of monitoring
- Procedures to be undertaken should monitoring indicate problems

The following should be monitored during construction:-

- Groundwater, leachate and discharge directed to ponds/holding tanks.
- Neutralised soils (soils post liming).

E4.2 Stockpiled & Neutralised Soil

Testing and monitoring of stockpiled and neutralised soils should be performed throughout the construction period in the interests of efficient lime dosing. Verification testing by CRS/ANC test methods should be carried out at a rate of at least one sample per 500m^3, with the sampling and testing intensity increasing should results prove to be variable.

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.

E4.3 Contingency

During construction, the contractor will have stored on site at all times, at least 500kg of Aglime to ensure that potentially hazardous situations can be controlled should the need arise.

In addition, for sudden drops in water pH across the site, it is vital that the contractor has hydrated or slaked lime available for adding to any low pH waters.

Hydrated (slaked) lime, although slightly more expensive than Aglime, is recommended to neutralise water as it is more soluble. However, a strict pH monitoring program must be carried out to ensure an acceptable pH range is maintained. Aglime can also be used although it is far less effective and hence more expensive for this purpose than alternatives such as hydrated lime.

E5.0 REPORTING

Monthly reports are to be submitted to the project principle noting the monitoring requirements as outlined below.

E5.1 Water Quality Monitoring

Water Quality Monitoring is to be conducted on retained waters and receiving waters 50m downstream of the site boundary within 24 hours following rainfall events greater than 20mm in 24 hours.

E5.2 Inspection of Lime runoff protection measures

Conduct weekly inspections and post rainfall (>20mm in 24 hours) inspections of the lime protection measures install as:-

- Perimeter protection of fill areas and stockpiles and
- Surface water lows controls

E5.3 Acidic Material Excavation

Material excavated conduct Chromium Suite testing at a rate of 1 per 500m^3 prior to re-use of material as backfill. Only required for the natural soil not the existing fill material.

E5.4 Material Scheduled for off-site disposal

Implement pH correction strategies for material to be removed form site as either unsuitable or excess fill. Conduct and record pH test results - as per AS 4969 Chromium Suite with samples tested to consist of a minimum of 4 sub samples. Nominated test frequency 1 test per 500m^3 - test results to be received prior to material being removed form site. Exported Material register to be completed to ensure that acidic soil is not removed form site with a pH below 6.5.