SOIL SURVEYS

207-7864

JANUARY 2008

WA STOCKWELL PTY LTD

ACID SULFATE SOIL INVESTIGATION

PROPOSED COMMERCIAL DEVELOPMENT

COAST ROAD

CABARITA

Soil Surveys Engineering Pty Limited
Specialists in Applied Geotechnics
A.B.N. 70 054 043 631

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SOIL SURVEYS

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Gold Coast Office
Job No: 207-7864
Ref: 2-7864AR
Author: Peter Elkington

10th January, 2008

WA Stockwell Pty Ltd
PO Box 3144
WEST END QLD 4001

ATTENTION: SHARON WEDDELL

Dear Sir,

**RE: ACID SULFATE SOIL INVESTIGATION -
PROPOSED MIXED USE DEVELOPMENT - COAST ROAD, CABARITA**

Enclosed is a copy of our preliminary acid sulfate soil investigation report and dewatering management plan for the above project dated January, 2008. Three bound copies of the report have been issued.

This report has been prepared in general accordance with our proposal 207-7864P, dated 26th November, 2007.

Should you have any queries regarding this report, please contact Peter Elkington at our Gold Coast Office.

Yours faithfully,

P. ELKINGTON (RPEQ 7226)

for and on behalf of
SOIL SURVEYS ENGINEERING PTY LIMITED

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1.0 INTRODUCTION

This report presents the results of an acid sulfate soil investigation carried out by Soil Surveys Engineering Pty Limited on the 17th December, 2007 for the proposed commercial and residential development at Coast Road, Cabarita.

The objectives of this investigation were to assess the subsurface conditions at the site to fulfil the scope of services as detailed in Section 3.0.

The investigation was carried out at the request of WA Stockwell Pty Ld.

2.0 PROPOSED DEVELOPMENT

It is understood that a multilevel building with single basement is proposed. Earthworks are understood to consist of excavations of up to 5.0m for the proposed carparks, tapering to no excavations on the western borders.

The total volume of material to be excavated is estimated to be in the order of 5000m^3.

3.0 SCOPE OF SERVICES

The scope of services provided by Soil Surveys Engineering Pty Limited for the preliminary acid sulfate soil investigation was directed towards assessment of the following:-

- The nature and type of upper level subsurface materials envisaged to be excavated as part of the proposed development.
- Delineation of Actual and Potential Acid Sulfate Soils, (AASS) and (PASS).
- Development of an Acid Sulfate Management Plan (ASMP) if required.
- Development of a Dewatering Management Plan (DMP) if required.

4.0 INVESTIGATION METHOD

4.1 Field Investigation

Due to the restricted access the following field investigation was undertaken:

- Drilling and sampling of seven boreholes, to depths of between 2.0 and 5.0m using a Jacro 105 drill rig.
- Sampling of the materials encountered at 0.5 increments.
- Installation of a standpipe to allow groundwater measurement and sampling.

All work including the soil classification descriptions and field sampling was carried out in general accordance with the following procedures. However, in terms of the number of boreholes required for the proposed development, this preliminary investigation would at this stage not comply with the relevant procedures listed.

AS1726 - 1993	Geotechnical Site Investigations
ASSMAC	Acid Sulfate Soil Management Advisory Committee

Notes relating to this report, borehole record sheets, laboratory test results and a site plan detailing borehole and sampling locations are included in the appendices.

Fieldwork was carried out on 17th December, 2007. All soil samples were transferred to a chilled esky for transport to the laboratory.

4.2 Laboratory Assessments

4.2.1 Soil

A staged testing program was carried out on recovered soil samples as follows:-

Table 1 Laboratory Test Methods

Test Method	Test Objective
pH_F, pH_{FOX} and Reaction to HCl & H_2O_2	Qualitative screening
TAA (Total Actual Acidity)	Quantitative - acid trail
CRS (Chromium Reducible Sulfur)	Quantitative - sulfur trail

HCl - hydrochloric acid, H_2O_2 - hydrogen peroxide

pH_F, pH_{FOX}, TAA, ANC and CRS testing was carried out in accordance with ASSMAC 'Acid Sulfate Soils Laboratory Methods Guidelines' test methods 2A2, 19A2, 20J, 22B, 23A and 23L.

Laboratory test results are summarised in Section 6.2.1 and certificates are included in Appendix 'C'.

4.2.2 Groundwater

A sample of groundwater recovered from a temporary standpipe installed at the location of Borehole 1 was tested and submitted for an Acid Sulfate Soil Water suite analysis. Field and Laboratory test results are summarized in section 5.4 'Groundwater Levels' and 5.5.3 'Groundwater Quality'.

Laboratory Assessments

Laboratory assessments were undertaken by the following NATA registered laboratory:-

- Soil and Water Laboratories
  Unit 16-39 Corporation Circuit
  South Tweed Heads, NSW
  Telephone: (07) 5523 4422

5.0 INVESTIGATION FINDINGS

5.1 Site Description

The site of the proposed developments is at 184 to 187 and 191 to 194 Hastings Road and 20 to 23 Coast Road, Cabarita.

A motel, service station and newsagency are located on the site.

The remainder of the site was vacant or in use of carparking.

The site fell steeply from the eastern boundary towards the western boundary of the site.

The attached photos indicate the site at the time of the investigation.

5.2 Regional Geology

The coastal landforms, of which this site forms part of, are essentially dunal sands deposited as part of the coastal erosion process.

Prominent along the low lying areas of the eastern, northern and north-western coasts of Australia, particularly below RL 5.0 AHD, iron sulfide layers are found. These sulfide layers formed when the sea level rose and inundated the land. Seawater containing sulfate mixed with land sediments. These sulfide sediments, when exposed to air oxidise to produce sulfuric acid, thus the term Acid Sulfate Soils.

5.3 Subsurface Conditions

The subsurface profile encountered comprised upper level silty sand and clay fill to depths of up to 2.7m, overlying natural silty sand and sands.

Borehole records are presented in Appendix 'B'.

5.4 Groundwater Levels

Groundwater was first encountered in the boreholes at depths of between 2.0m and 5.1m below ground level. A steady groundwater level of 5.0m was recorded in a temporary standpipe installed in Borehole 1 at the time of drilling.

Typically the standing ground water level would be expected at about RL 0.5m with fluctuations of ±0.5m under normal (non-flood) conditions. Rises in groundwater to RL 1.5m (AHD) have been recorded in the area following heavy and prolonged rainfall periods (flood conditions).

Water levels can be expected to vary with seasonal and climatic conditions and fluctuate with tide movements on a damped cycle. A groundwater sample was recovered from Borehole 1 to establish groundwater baseline conditions.

5.5 Laboratory Testing - Soils

A total of 32 soil samples were submitted to a staged acid sulfate testing program. The testing program was as follows:-

5.5.1 Preliminary Screening Tests

Testing was carried out on representative soil samples recovered from the boreholes to provide preliminary qualitative assessment of the presence of acid sulfate soils (ASS). This testing was in the form of assessing the pH of the sample before and following oxidation with 30% hydrogen peroxide (H_2O_2). This test involved measuring a known quantity of soil sample from a particular depth in the strata; the field pH (pH_F) of the sample was then measured and recorded. Following this, a uniform volume of hydrogen peroxide was then added to the sample. Each sample was left to react / oxidise for 1 hour and the pH following oxidation (pH_{FOX}) was recorded.

This is a quick, qualitative assessment of the potential acidity of the soil. Reactivity to hydrochloric acid (HCl) was also assessed as a qualitative determination of the neutralising carbonate content including calcium carbonate (shells) within the soil. The results of these screening tests were used as an additional tool in determining which soil samples should be further assessed by quantitative laboratory testing.

Test results are summarised in Section 6.2.1

Laboratory test certificates containing screening (qualitative) test results of pH_F and pH_{FOX} are presented in Appendix 'C'.

5.5.2 Quantitative Tests

A total of 14 CRS + TAA analyses (Chromium Reducible Sulfur and Total Actual Acidity) were carried out on recovered soil samples based on the results of the screening tests to quantify the potential and actual acid hazard within the soils.

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

Test results are summarised in section 6.2.1. Laboratory test certificates are presented in Appendix 'C'.

5.5.3 Groundwater Quality

A sample of groundwater obtained from Borehole 1 was tested on site and in the laboratory for pH, Electrical Conductivity, Aluminium and Total and Dissolved Iron. The results of the testing are summarised in Table 2 with a laboratory test certificate detailing full analysis results presented in Appendix 'C'.

TABLE 2 GROUNDWATER TEST RESULTS

BH1 (Standpipe)	Result
Groundwater Depth	5.0m bgl
pH	6.4
Electrical Conductivity (EC)	686
Aluminium (Al)	0.01mg/L
Iron (Fe) Dissolved	0.01mg/L
Note: bgl - below ground level	

6.0 DISCUSSION OF RESULTS

6.1 Soil Classification

Samples recovered from the field investigation program were generally classified as sandy clay or clayey sand fill overlying layers of natural silty clayey sand and sand to borehole termination depths.

An appraisal of the topography and soil classifications suggested that there is minimal potential for acid sulfate conditions to develop at depth across the site.

6.2 Results of Laboratory Testing

6.2.1 Soil Tests

The qualitative test results indicate that potential acidity may be present in the soils below about the groundwater level. Potential acid sulfate soils have had limited previous oxidation.

Generally pH_F values ranged between 6.1 and 6.3 and pH_{FOX} values ranged between 2.5 and 4.2.

Scr values of between 0.00% and 0.02%S and a maximum TAA value of 12 mole H^+/t resulted from the samples tested.

For comparison of test results, ASSMAC Action Criteria are presented in Table 4.

TABLE 4 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 (mol H^+/t)	S_{pos} (%)	TPA (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	0.1	62	0.03	18

The testing indicated the material encountered exhibited generally low levels of actual and potential acidity. Combined AASS and PASS results indicated acidity levels below action criteria and therefore an Acid Sulfate Management Plan (ASMP) would not be required.

6.2.2 Groundwater Tests

On this basis of the testing undertaken, waters to be discharged from the site will require treatment prior to release, to bring the water to the release criteria.

However, it is recommended further monitoring and testing of the groundwater be undertaken to confirm the results of the initial testing, including weekly background monitoring on the site for a minimum of four weeks prior to commencement of dewatering. Refer Section 7.0 ‘Dewatering Management Plan’.

7.0 DEWATERING MANAGEMENT PLAN (DMP)

7.1 Introduction

A Dewatering Management Plan (DMP) is required for the proposed development.

The DMP relates specifically to the excavation of the proposed basement below the existing ground surface. Minimal dewatering will be required during construction. Permanent dewatering of the site is not required.

For the proposed development, including basement excavations to approximately 2.0 to 5.0m below existing ground level. On the basis of the groundwater levels encountered, no dewatering will be required as part of the development.

7.2 Existing Groundwater Levels

Groundwater was first encountered in all boreholes at depths of between 2.2m and 5.0m below ground level. A steady water level was recorded at 5.0m below ground level in Borehole 1 at the time of drilling (standpipe).

Typically the standing ground water level would be expected at about RL 0.5m with fluctuations of ±0.5m under normal (non-flood) conditions. Rises in groundwater to RL 1.5m (AHD) have been recorded in the area following heavy and prolonged rainfall periods (flood conditions).

Water levels can be expected to vary with seasonal and climatic conditions and fluctuate with tide movements on a damped cycle.

7.3 Dewatering Methods

If required, it is envisaged that a system of spears and/or sump pumps will be used to lower the water table on the site to a minimum depth of 0.5m below proposed excavation level.

If dewatering is required, water collected from the proposed dewatering system shall be directed towards a holding tank or suitably lined pit prior to release into the environment. The holding tank/pit will be used to monitor/test waters followed by remediation of any waters which are below acceptable discharge quality guidelines.

Based on the field testing carried out it is anticipated that treatment of the discharge water will be required to increase dissolved oxygen levels prior to discharge, if dewatering is required.

Water quality criteria must be maintained to those presented as baseline conditions or better, prior to discharge. Additionally, it shall be the contractor's intention to maintain the holding tank/pit pH levels between 7.0 and 8.4 and the D.O. above 6.0mg/L at all times. Refer also Table 6.

7.4 Groundwater Monitoring

7.4.1 Background Monitoring

Refer section 5.5.3 'Groundwater Quality' and Appendix 'C' for initial groundwater quality test results.

Prior to works commencing on site groundwater monitoring wells should be undertaken from the installed onsite to allow background monitoring to be undertaken.

Background monitoring of the groundwater should be undertaken weekly for 4 weeks prior to the commencement of dewatering on site. The results of the background monitoring will be used to determine the groundwater quality trigger values that will indicate the need for corrective action to be undertaken during the dewatering operation.

The wells will be monitored for groundwater levels, pH, DO, temperature, turbidity, electrical conductivity, Fe and Al.

As a general guideline a deviation of 20% from the established baseline criteria would be considered a trigger for corrective action, however this should be reassessed depending on the results and consistency of the background monitoring.

The release criteria will be confirmed and reported to the Tweed Shire Council prior to the commencement of dewatering on-site, if required.

7.4.2 Monitoring During Construction

The following groundwater monitoring frequency is recommended during dewatering operations, if dewatering is required.

- Daily monitoring of groundwater levels and pH for the first 2-3 weeks. If the results of monitoring prove consistent, the monitoring could be reduced to twice weekly, subject to council approval.

- Weekly sampling and testing for pH, DO, temperature, turbidity, electrical conductivity, Fe and Al for the first month. If the monitoring results prove consistent after the first month of monitoring, the sampling frequency could be reduced to fortnightly for the duration of the dewatering operation, subject to council approval.

7.5 Discharge Monitoring

A discharge monitoring program will be implemented to provide feedback on the effectiveness of the dewatering management strategy and provide early warning should environmental degradation begin, if dewatering is required.

Monitoring will be carried out at the holding tank/pit prior to release into the environment.

The following monitoring frequency is recommended during any earthworks operations:

- Daily - pH, Dissolved Oxygen (DO), Temperature, Turbidity and Conductivity.
- Weekly - As above plus Fe and Al.

Further to the above, monitoring of the pH levels should also be carried out immediately after rain. If the results of monitoring prove consistent, the frequency of monitoring could be reduced. Refer also Table 6.

Prior to discharge, the groundwater discharge shall meet the guidelines outlined below which form part of from the ANZECC Australian Water Quality Guidelines for Fresh and Marine Waters (2000). Refer also Table 6.

TABLE 6 WATER QUALITY CRITERIA

Indicator	Lowland River / Estuarine
pH	7.0-8.4
Turbidity	≤8 NTU
Dissolved Oxygen (DO)	85%-100% sat
Aluminium (Al) (total)	30µg/L
Iron (Fe) (dissolved)	300µg/L

Appropriate neutralising agents, eg. hydrated lime, sodium bicarbonate or quick lime can be used to treat the pH of the water to an acceptable level, if required, prior to discharge.

Hydrated lime (pH12) is the most common agent used to neutralise low pH water as it is quite 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 or quick lime.

Turbidity can be reduced by the use of settling tanks or the addition of slaking agents and dissolved oxygen can be increased by aeration of the discharge water.

7.6 Contingency

For sudden drops in water pH across the site, it is vital that the contractor has hydrated lime, sodium bicarbonate or quick lime available for adding to any low pH waters.

7.7 Reporting

A monthly dewatering report shall be prepared and submitted to Tweed Shire Council. The report shall include, as a minimum, details of the retention method, water quality results, treatment required, status of the existing groundwater and any unforeseen issues.

8.0 LIMITATIONS

We have prepared this preliminary report for use by **WA STOCKWELL PTY LTD** for preliminary acid sulfate assessment purposes in accordance with currently accepted environmental and geotechnical guidelines. 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 **WA STOCKWELL PTY LTD** or their associated consultants, nominated representatives and regulatory authorities. It may not contain sufficient information for the purposes of other parties or for other uses.

Further drilling, sampling and testing will be required to comply with the requirements of the relevant authorities and to finalise and confirm our recommendations.

Soil Surveys Engineering Pty Limited offers a documentation review service to verify that the intent of recommendations is properly reflected in the A.S.M.P and D.M.P. It is recommended that clients avail themselves of this service; our standard rates will apply.

P. ELKINGTON (RPEQ 7226)

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 facts 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 facts 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.

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. 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.

REPRODUCTION OF INFORMATION FOR CONTRACTUAL PURPOSES

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", 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.

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.

Soil Surveys Engineering Pty. Limited

Consulting Geotechnical engineers RPECQ No. 195
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LEGEND SHEET

Information

DRILLING TYPES
V - open hole drilling using augers and a steel "V" bit
TC - open hole drilling using augers and a Tungsten Carbide bit
WB - wash boring using a drag or blade bit
RR - wash boring using a rock roller bit
NMLC - coring using a NMLC core barrel
Casing - steel casing in hole

DEPTH
Expressed in metres below the surface unless otherwise noted

ROCK DESCRIPTION
Rock name, grain size, colour, texture, fabric and any other relevent comments

WEATHERING GRADES
XW - Extremely Weathered
DW - Distinctly Weathered
SW - Slightly Weathered
FR - Fresh

STRENGTH
(estimate of UCS)
EW- extremely weak <1.0 MPa
VW - very weak 1.0 to 5.0 MPa
W - weak 5.0 to 25.0 MPa
MS - medium strong 25 to 50 MPa
S - strong 50 to 100 MPa
VS - very strong 100 to 250 MPa
ES - extremely strong >250 MPa

CORING DETAILS
Rec - core recovery in each run expressed as a %
RQD - Rock Quality Description expressed as a %

Defect Description

3.00m;J45;p,s,o,z

Depth in metres; Defect Type and angle with the core axis;planarity,roughness,aperture, infill

Defect Type	Planarity	Roughness	Aperture	Infill
J - Joint	p - Planar	s - Smooth	o - Open	z - Clean
F - Foliation	s - Sub-planar	r - Rough	c - Closed	c - Clay
B - Bedding	c - Curvi-linear	v - Very Rough		q - Quartz
V - Vein	u - Undulating	l - Slickensides		k - Calcite
S - Shear Zone				w - Weathered Rock
T - Fault				l - Limonite
C - Clay Seam				
Z - Contorted Zone				
RJ - Relict Joint				

Testing

SPT 10,15,15	SPT testing N value Blows/150mm or as noted
U50 (50) PP = 500 kPa	U50 Tube Samples (% Recovery) Pocket penetrometer reading
VS 1,30,5 : 25	Vane Shear Testing Seating, peak and residual : Corrected value
DIST	Disturbed Samples

Water Intersections

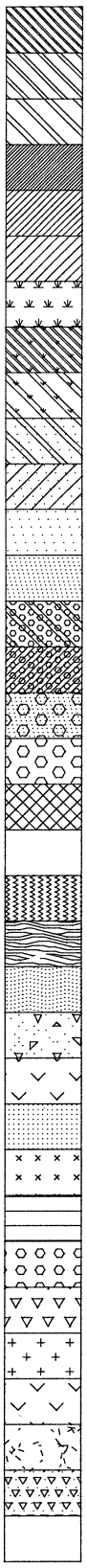
Water steady level

Water first noted

Testing Results

Is50=4 (A) Corrected Point Load Test Result
A - Axial, D - Diametral

Graphic Legend



CH - CLAY of high plasticity

CI - CLAY of intermediate plasticity

CL - CLAY of low plasticity

MH - SILT of high plasticity

MI - SILT of intermediate plasticity

ML - SILT of low plasticity

Pt - PEAT

OH - Organic SILTS and CLAYS of high plasticity

OL - Organic SILTS and CLAYS of low plasticity

SC - Clayey SAND

SM - Silty SAND

SP - poorly graded SAND

SW - Well graded SAND

GC - Clayey GRAVEL

GM - Silty GRAVEL

GP - poorly graded GRAVEL

GW -well graded GRAVEL

Fill

Core loss

Phyllite

Meta-Siltstone

Meta-Sandstone

Greywacke

Tuff

Sandstone

Siltstone

Mudstone

Conglomerate

Breccia

Granite

Basalt

VOLCANIC ASH

VOLCANIC AGGOLMERATE

MARINE DEPOSITS

APPENDIX B

BOREHOLE RECORDS

Soil Surveys Engineering Pty. Limited

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BOREHOLE RECORD SHEET

Borehole Number : 1

Project Number : 207-7864

Project Name : Service Station

Location : Cabarita

Client : Geo Enviromental

Date : 17/12/2007

Page : 1

Easting : Northing : RL :

Logger : CW Driller : CW Drilling Rig : Jacro 105

Drilling Method (V / TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	DCP Test (blows/100mm) 5 10 15 20 25	Samples and Remarks
	0.02		FILL ASPHALT		
	0.40		FILL Sandy GRAVEL (GC) Dense, fine to medium size, yellow brown, fine to coarse grained sand, moist.		
	1.00		FILL Gravelly SAND (SP) Medium dense, fine to medium grained, dark brown, fine to coarse size gravel, moist.		
	1.50		FILL Silty Clayey SAND (SC) Medium dense, fine to medium grained, dark brown, low to medium plasticity fines, with fine to medium size gravel, with organics, moist.		
	2.00		FILL Silty CLAY (CH) Very stiff, high plasticity, dark brown, with fine to medium grained, with fine to medium size gravel, with rubbish, moist.		
	2.70		FILL Silty CLAY (CH) Very stiff, high plasticity, dark brown, with fine to medium grained, with fine to medium size gravel, with cobbles and boulders, with rubbish, moist.		
			NATURAL SAND (SP) Medium dense, fine to medium grained, light brown, moist.		
	5.00		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, moist.		
	6.00		Borehole Terminated 6.00m		

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

COMMENTS

1) Groundwater not observed.

▼ Water First Noted ▽ Water Steady Level

Approved : _____

Date : ____/____/____

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BOREHOLE RECORD SHEET

Borehole Number : 2

Project Number : 207-7864

Project Name : Service Station

Location : Cabarita

Client : Geo Enviromental

Date : 17/12/2007

Page : 1

Easting : Northing : RL :

Logger : CW Driller : CW Drilling Rig : Jacro 105

Drilling Method (V / TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	DCP Test (blows/100mm) 5 10 15 20 25	Samples and Remarks
	0.30		FILL Sandy GRAVEL (GC) Dense, fine to medium size, yellow brown, fine to coarse grained sand, moist.		
			NATURAL SAND (SP) Medium dense, fine to medium grained, light brown, moist.		
	1.0				
	2.0				
	2.20		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, moist.		
	2.70 ▼				
	3.0		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, wet.		
	4.0				
	4.50		Borehole Terminated 4.50m		
	5.0				
	6.0				
	7.0				
	8.0				
	9.0				
	10.0				

COMMENTS

1) Groundwater noted at 2.7m.

▼ Water First Noted ▽ Water Steady Level

Approved : _____

Date : ____ / ____ / ____

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BOREHOLE RECORD SHEET

Borehole Number : 5

Project Number : 207-7864

Project Name : Service Station

Location : Cabarita

Client : Geo Enviromental

Date : 17/12/2007

Page : 1

Easting : Northing : RL :

Logger : CW Driller : CW Drilling Rig : Jacro 105

Drilling Method (V / TC / WB / RR / NMLC / Casing)	Depth	Graphic	Description	DCP Test (blows/100mm) 5 10 15 20 25	Samples and Remarks
	0.30		FILL Silty Clayey SAND (SC) Loose, fine to medium grained, dark brown, low to medium plasticity fine, with organics, moist.		D
			NATURAL SAND (SP) Medium dense, fine to medium grained, light brown, moist.		D
	1.0				D
					D
					D
					D
	2.0				D
	2.00		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, moist.		D
					D
	2.60 ▼				D
	2.70		Silty SAND (SM) Medium dense, fine to medium grained, dark brown, wet.		D
	3.0		Silty SAND (SM) Dense, fine to medium grained, dark brown, wet.		D
					D
					D
	4.0				D
					D
					D
					D
	5.0				D
	5.50				D
			Borehole Terminated 5.50m		
	6.0				
	7.0				
	8.0				
	9.0				
	10.0				

COMMENTS

1) Groundwater noted at 2.6m. 2) DCP Refusal at 2.8m.

▼ Water First Noted ▽ Water Steady Level

Approved : _____

Date : ____ / ____ / ____

APPENDIX C

LABORATORY TEST RESULTS

Soil & Water Laboratories P/L
16/39 Corporation Circuit, Tweed Heads, NSW. 2486.
Phone: (02) 5523 4422; Fax: (07) 3503 9063

Screening Test

For Soil Surveys Engineering Pty Ltd, Unit 8, 140 Milleroo Drive, Hellensvale, Qld 4212.

-
207-7864

Reference Number: 13 - 7864

Certificate Number: 200474

Date Received: 20/12/2007 Date Tested: 20/12/2007 Date Issued: 07/01/2008

Sample Number	Identification			Reaction to		pH (1:5 susp.) H2O	
	Borehole/Location	From	To	H2O2	HCl	pHf	pHfox
2	BH - 01	0.50	1.00	Nil	Nil	5.6	4.0
4	BH - 01	1.50	2.00	Nil	Nil	5.4	4.2
6	BH - 01	2.50	3.00	Nil	Nil	5.9	4.5
8	BH - 02	0.50	1.00	Nil	Nil	5.5	4.0
10	BH - 02	1.50	2.00	Nil	Nil	4.9	4.1
12	BH - 02	2.50	3.00	Low	Nil	3.1	2.2
14	BH - 03	0.50	1.00	Nil	Nil	6.0	4.1
16	BH - 03	1.50	2.00	Nil	Nil	6.6	4.5
18	BH - 03	2.50	3.00	Nil	Nil	3.8	2.5
20	BH - 03	3.50	4.00	Nil	Nil	3.9	2.8
23	BH - 04	0.50	1.00	Nil	Nil	5.5	3.9
25	BH - 04	1.50	2.00	Nil	Nil	5.4	3.9
27	BH - 04	2.50	3.00	Nil	Nil	5.4	4.1
29	BH - 04	3.50	4.00	Nil	Nil	4.5	3.4
32	BH - 05	0.50	1.00	Nil	Nil	6.2	4.2
34	BH - 05	1.50	2.00	Nil	Nil	3.6	2.5
36	BH - 05	2.50	3.00	Low	Nil	3.6	2.6
38	BH - 06	0.50	1.00	Nil	Nil	5.9	4.0
40	BH - 06	1.50	2.00	Low	Nil	3.8	3.0
42	BH - 06	2.50	3.00	Low	Nil	3.4	2.5
44	BH - 06	3.50	4.00	Low	Nil	3.5	2.5
47	BH - 07	0.25	0.50	Nil	Nil	5.3	4.1
49	BH - 07	0.75	1.00	Nil	Nil	6.0	4.0
51	BH - 07	1.25	1.50	Nil	Nil	5.9	4.0
53	BH - 07	1.75	2.00	Nil	Nil	6.3	3.9
55	BH - 07	2.25	2.50	Nil	Nil	6.2	4.7
57	BH - 07	2.75	3.00	Nil	Nil	6.2	4.9
59	BH - 07	3.25	3.50	Nil	Nil	6.2	4.6
61	BH - 07	3.75	4.00	Low	Nil	6.2	4.5
63	BH - 07	4.25	4.50	Low	Nil	6.1	4.4
65	BH - 07	4.75	5.00	Low	Nil	5.9	4.2

Signed: _____ for and on behalf of Soil and Water Laboratories P/L
Trevor Nelson - Laboratory Manger - Acid Sulphate Soils and Waters

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

Soil & Water Laboratories P/L

16/39 Corporation Circuit, Tweed Heads South, NSW. 2486
Phone: (02) 5523 4422; Fax: (07) 3503 9063

Accreditation Number: 15277

Chromium Reducible Sulphur & Titratable Actual Acidity Test Results

For Soil Surveys Engineering Pty Ltd, Unit 8, 140 Milleroo Drive, Hellensvale, Qld 4212.

Certificate Number:200473

Ref. Number: 13 - 7864

Date: 07-Jan-08

Project Number: 207-7864

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/	from	to	Date	Shell	Gravel	2B2	23A	19A2	A19A2	s - 23F	23F	20B	23C	20J	s - 20J	22B	a - 22B
	Testpit	(m)		Sampled	(%d.w.)			(1M KCl)	(%CaCO3 Eq.)	(eq. mol. H+/t)	(%S Eq.)	(mol. H+/t)		(% S)		(eq. mol. H+/t)	(% S)	(eq. mol. H+/t)
4	1	1.50	2.00	11/12/2007	0.0	0.0	10.7	6.53	n/a	n/a	0.00	0	n/a	n/a	n/a	n/a	<0.01	1
8	2	0.50	1.00	11/12/2007	0.0	0.0	3.5	6.97	n/a	n/a	0.00	0	n/a	n/a	n/a	n/a	<0.01	4
12	2	2.50	3.00	11/12/2007	0.0	0.0	21.3	4.66	n/a	n/a	0.02	15	n/a	n/a	n/a	n/a	0.02	12
16	3	1.50	2.00	11/12/2007	0.0	2.5	3.3	6.56	n/a	n/a	0.00	0	n/a	n/a	n/a	n/a	<0.01	5
20	3	3.50	4.00	11/12/2007	0.0	0.0	21.8	5.02	n/a	n/a	0.01	9	n/a	n/a	n/a	n/a	0.01	7
23	4	0.50	1.00	11/12/2007	0.0	0.0	1.6	6.86	n/a	n/a	0.00	0	n/a	n/a	n/a	n/a	<0.01	5
27	4	2.50	3.00	11/12/2007	0.0	0.0	6.8	5.97	n/a	n/a	0.00	2	n/a	n/a	n/a	n/a	<0.01	5
32	5	0.50	1.00	11/12/2007	0.0	0.0	3.1	7.08	n/r	n/r	0.00	0	n/a	n/a	n/a	n/a	0.01	7
44	6	3.50	4.00	11/12/2007	0.0	0.0	20.5	4.81	n/a	n/a	0.02	11	n/a	n/a	n/a	n/a	<0.01	5
49	7	0.75	1.00	11/12/2007	0.0	0.0	4.2	6.33	n/a	n/a	0.00	1	n/a	n/a	n/a	n/a	<0.01	5
53	7	1.75	2.00	11/12/2007	0.0	0.0	4.2	7.03	n/r	n/r	0.00	0	n/a	n/a	n/a	n/a	<0.01	3
57	7	2.75	3.00	11/12/2007	0.0	0.0	16.4	6.01	n/a	n/a	0.00	2	n/a	n/a	n/a	n/a	<0.01	5
61	7	3.75	4.00	11/12/2007	0.0	0.0	13.0	6.37	n/a	n/a	0.00	1	n/a	n/a	n/a	n/a	<0.01	4
65	7	4.75	5.00	11/12/2007	0.0	0.0	19.4	6.20	n/a	n/a	0.00	1	n/a	n/a	n/a	n/a	<0.01	5

Tests Completed: 07-Jan-08

Samples Received: 03-Jan-08

Signed: _____ and on behalf of Soil and Water Laboratories P/L

Trevor Nelson - Chemical Laboratory Manger

Determinations have been derived by the adoption of published test methods recommended by National Committee for Acid Sulphate Soils (NatCASS); Queensland Acid Sulphate Soils Management Advisory Committee
1 (QASSMAC); Queensland Acid Sulphate Soils Investigation Team (QASSIT) & Queensland Department of Natural Resources, Mines and Energy; as described in the 'Acid Sulphate Soils Laboratory Methods Guidelines 2004'.

2 Samples supplied by others

3 Samples tested in 'as received' condition

4 The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards

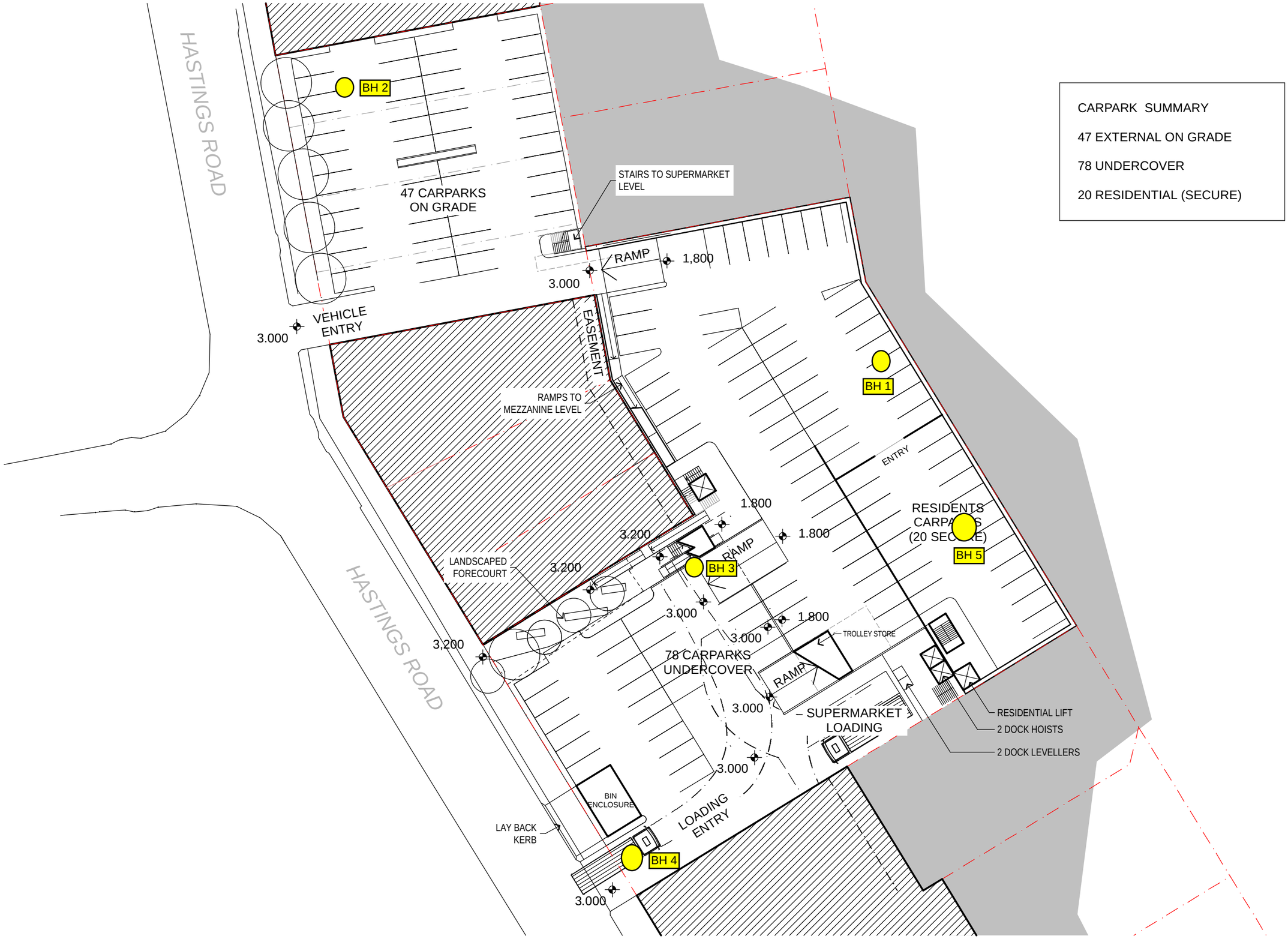
5 NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.

6 Denotation: n/a - not applicable; n/r - not requested

7 Shell & gravel removed is not covered by the scope of accreditation

APPENDIX D

SITE PLAN



CARPARK SUMMARY

47 EXTERNAL ON GRADE

78 UNDERCOVER

20 RESIDENTIAL (SECURE)

CABARITA

SK02 LOWER GROUND LEVEL

SCALE 1:500 @ A3

1/11/2007

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