



SOIL SURVEYS

PLANS AND DOCUMENTS
referred to in the ULDA
APPROVAL dated / /

PROJECT NO. 111-13901

FEBRUARY, 2012

SHAYHER DEVELOPMENTS PTY LTD

**STAGE 1 GEOTECHNICAL
INVESTIGATION
SUBPRECINCT 3A DEVELOPMENT**

**REMORA ROAD, HAMILTON
(NORTHSHORE DEVELOPMENT)**



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29th February, 2012

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ATTENTION: MR PETER SIA

Dear Sir,

**RE: GEOTECHNICAL INVESTIGATION (STAGE 1)
SUBPRECINCT 3A DEVELOPMENT
REMORA ROAD, HAMILTON
(NORTHSHORE DEVELOPMENT)**

Enclosed is one copy of our report for the above project dated February, 2012, of which two hard copies have been issued; with one copy forwarded to Bornhorst & Ward. An electronic copy, in pdf format, has also been issued.

The report has been prepared in general accordance with our proposal 111-13901 dated, 8th December, 2011.

Authority to proceed with the investigation was received on 27th January, 2012 from Peter Sia of Sia & Sia Lawyers.

Should you have any queries regarding this report, please do not hesitate to contact Greg Gray at our Milton Office.

Yours faithfully,

P. J. DIXON (RPEQ 4150)

for and on behalf of
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B	Borehole Records
C	Laboratory Test Results
D	Site Plan

1.0 INTRODUCTION

This report presents the results of the geotechnical investigation (Stage 1) carried out by Soil Surveys Engineering Pty Limited for the proposed Subprecinct 3A development as part of overall Northshore Development scheme.

The objectives of this initial investigation (Stage 1) were to assess subsurface conditions at the site in accordance with the Scope of Services detailed in Section 2.0 for the lodgement of the Development Application (DA) for the above project.

Results from a broadscale study by Soil Surveys Engineering for the proposed Northshore Development in 2006 and 2007 (Soil Surveys Engineering Report No. 106-9336 dated April, 2007) have also been reviewed in this study.

2.0 SCOPE OF GEOTECHNICAL SERVICES

The scope of geotechnical services provided by Soil Surveys Engineering Pty Limited was directed towards evaluating the following items, as detailed in our proposal, 111-13901 dated 8th December, 2011.

- Investigation of the subsurface profile over the proposed development area by drilling, sampling and insitu testing with four boreholes, with Dynamic Cone Penetrometer (DCP's) testing.
- Laboratory testing on selected samples to assess the geotechnical properties of the subsurface materials.
- Geotechnical engineering analysis of the site investigation and laboratory test results to evaluate:-
 - Stage 1 earthworks recommendations
 - traffickability
 - excavatability
 - stripping depths
 - material usage
 - compaction standards
 - fill/cut batter slope stability
 - Stage 1 parameters for the evaluation of the Brisbane City Council's Erosion and Sediment Control.
 - Stage 1 assessment and recommendations for treatment and management of Acid Sulfate soils (ASS/PASS).

- Stage 1 foundation recommendations
 - recommended foundation type
 - design strength parameters
 - site classification
 - predicted ground movement
- Stage 1 settlement behaviour
 - magnitude of settlement under building and fill loads
 - settlement rates
 - variability of settlement/consolidation across the site
- Stage 1 retaining wall design parameters and considerations
- Stage 1 construction recommendations
- Stage 1 site management recommendations

3.0 PROPOSED DEVELOPMENT

It is understood that the proposed development is to consist of predominately residential usage with supporting commercial and retail areas.

The site is designated as Sites C and D on the supplied 'Information Memorandum, Remora Road Northshore Hamilton' which outlines the following:-

- Site C area 4,428m², with maximum 8 storey towers
- Site D area 6,270m², with maximum 12 storey towers

It is further understood that the proposed development will incorporate a basement level for carparking, with excavation depths of between 2.5m and 3.0m below existing surface levels required.

Plates 1 and 2 present plans of the proposed development layout.

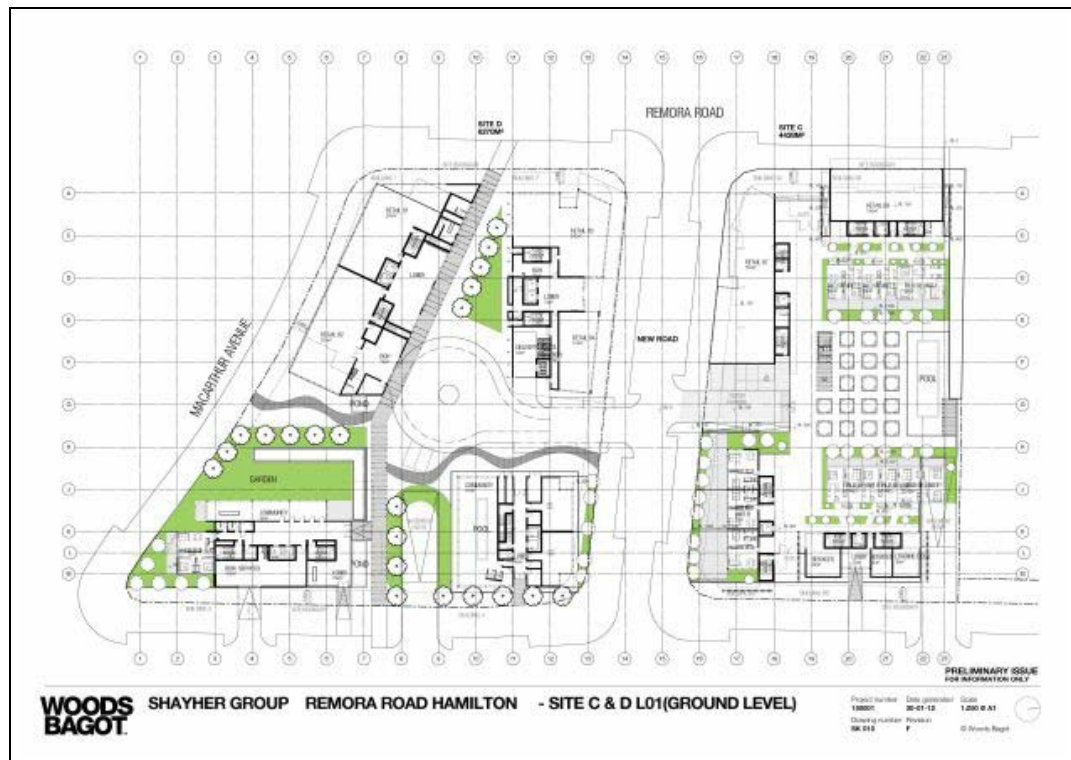


PLATE 1



PLATE 2

4.0 GEOTECHNICAL INVESTIGATION

4.1 Site Description

The site is bounded by Remora Road to the west, Macarthur Avenue to the south and industrial sites to the north and east.

The site was previously occupied by industrial businesses with demolition and clearing having occurred prior to 2001. Ground slabs and pavement areas remain, together with unknown subground structures and services.

Review of historical aerial photography shows the site has been utilised for various purposes subsequent to demolition, including storage of pallets, containers, temporary sheds, etc.

Currently, the site is clear of above ground structures with a boundary fence. The surfacing comprises concrete slabs, bitumen pavements, grassed and gravel areas. Levels across the site have been advised as RL 3.5m to 4.0m AHD.

The site location, aerial view (Google / Nearmap) and photographs of typical site conditions are presented in Plates 3 and 4 and Photographs 1 and 2.



PLATE 3



PLATE 4



PHOTOGRAPH 1



PHOTOGRAPH 2

4.2 Field Investigation

To provide the required assessments, the following investigation was carried out:-

- Setting out the test hole locations for GPS co-ordinates derived from supplied plans and electronic data.
- Clearing the test hole locations for underground services prior to drilling using a certified service locator.
- Drilling, logging, insitu testing and sampling of four boreholes, to depths from 3.0m to 27.0m, using an EVH1750 (BH's 2, 3 and 4) and Hydrapower Scout (BH1) drilling rigs. Samples of representative materials were retrieved from the boreholes.
- Dynamic cone penetrometer tests adjacent to the shallow boreholes (BH's 2, 3 and 4).

Please note that should, following detailed design, footings or piers be required to extend within $3B$ (B = footing width/pier diameter) of the termination level of the boreholes, Soil Surveys Engineering should be contacted immediately. In this case, geotechnical data in this report should be considered preliminary only; additional investigation is likely to be required.

The classification of soils in the field is subjective, based on the experience and judgement of the supervising geotechnical engineer and some variations in the soil description, from the actual material type may occur. In order to reduce any inconsistencies which may have occurred, the field descriptions have been corrected, where appropriate, to reflect the available laboratory test results.

The soil classification descriptions, field and laboratory testing were carried out in general accordance with the following Australian Standards AS.1726 - 1993 Geotechnical Site Investigations.

General notes that outline general information about the investigation and the investigation method, together with the borehole records and a site plan showing the location of the boreholes are included in the Appendices.

4.3 Geotechnical Laboratory Testing

Laboratory testing was carried out on selected samples retrieved from the site investigation program and was directed towards assessing the reactivity, strength, subgrade characteristics and erosion potential of the subsurface material.

Acid sulfate soil test results are presented in the Appendices and discussed in Section 6.1.3 of this report.

The laboratory testing was carried out in general accordance with the following standards:-

- A.S.1289 - Methods of Testing Soils for Engineering Purposes.
- QASSMAC - Queensland Acid Sulfate Soils Management Advisory Committee, Department of natural resources, 'Queensland Acid Sulfate Soil and Technical Manual' (Nov., 2002 Rev. 3.8).
- SPP/02 - State Planning Policy 2/02 Guideline, Acid Sulfate Soils.

Laboratory testing included:-

- Shrink/Swell Index (Iss) - to assess the reactivity of the subsurface material.
- Swell Pressure (SP) - to assess the potential uplift forces resulting from moisture variations in the upper level clay soils.
- California Bearing Ratio (CBR) - to assess the subgrade characteristics of the subsurface material under soaked conditions.
- Emerson Class number (ECN), soil pH & Conductivity (EC) - to assess the erosion and sediment control parameters of the upper level soils.

The results of the laboratory testing are given in Appendix C and summarised in Tables 1A and 1B.

TABLE 1A LABORATORY TEST RESULTS (2012)

Borehole No.	Depth (m)	Classification	Test Result
2	0.00-0.20	Fill - Clay	ECN = 4, pH = 6.96, EC = 0.53mS/cm
2	0.20-0.60	Fill - Clay	ECN = 4, pH = 7.93, EC = 0.76mS/cm
3	0.40-1.00	Fill - Clay	ECN = 4, pH = 4.26, EC = 2.96mS/cm
4	0.40-0.70	Fill - Clay	ECN = 2, pH = 6.65, EC = 0.68mS/cm
3	0.60-0.85	Fill - Clay	Iss = 3.8%
3	0.40-1.00	Fill - Clay	CBR = 3.5%

TABLE 1B SUMMARY OF EROSION & SEDIMENT CONTROL TESTING (2007)

Borehole No.	Depth (m)	Emerson Class No.	pH	Conductivity mS/cm
30	0.40-1.00	5	8.63	1.04
31	0.50-0.70	6	7.13	0.91
32	0.06-0.50	5	7.53	0.72
32	0.70-1.00	5	8.14	0.27
33	0.31-0.50	5	8.08	0.14
34	0.06-0.40	5	8.76	0.18
34	0.40-0.70	5	8.63	0.16
35	0.05-0.30	6	4.51	0.59
35	0.30-0.50	6	5.04	0.16

5.0 GEOTECHNICAL MODEL

5.1 Subsurface Profile

Boreholes for the current investigation, together with boreholes and CPT's in the vicinity of this site from the previous broadscale investigation for the Northshore Development have been reviewed for this assessment.

Geological maps of the area of the mouth of the Brisbane River show the expected Quaternary alluvial soil profile (levee banks : sand, gravel, silt, clay), overlying Tertiary sediments of the Tingalpa formation which typically consists of mudstone, siltstone and sandstone, with carbonaceous seams, conglomerate etc..

The upper level alluvial profile varies significantly across the site, with variations in depths and thicknesses of sand and soft to hard clay deposits.

The subsurface profile consisted of the following general strata -

- surface fill consisting of gravels, sands and clays.
- upper level recent alluvial clays and sands.
- lower level older alluvials including clays, sands and gravels.

Fill

Interpretation of fill/natural interface from the CPTU results has proved unreliable. As such, the depth of fill has only been accurately assessed at the location of each borehole drilled in the investigation.

The existing fill must be considered as 'uncontrolled'.

Within the site the fill encountered comprised loose to dense gravels, medium dense sands and very stiff clays to depths of between 0.7m and 1.5m.

At the nearby test locations (BH's 31, 34 and 35) from the 2006/2007 investigation dense gravels, medium dense silty sands and very stiff clays were encountered.

Recent Alluvials

The recent alluvials consisted of sands, clayey sands and marine clays, with the various strata interbedded.

The clays are typically soft in consistency, grading with depth to become firm. Highly plastic and dark grey in colour they are potentially compressible. These clays varied in total thickness in the assessed test locations from 1.2m at BH1 (2012) at the northern end of the site to 3.1m at CPT31 (2007) to the south of the site.

The sandy soils in the upper layers were generally very loose to loose.

Lower Level Older Alluvials

The lower level older alluvials, underlying the recent alluvials, generally tend to be stronger, ie. stiff to hard and medium dense to dense. However, significant deep layers of soft to firm clays and very loose to loose sands were encountered in a number of boreholes for the 2007 investigation of relevance to this site (e.g. BH32A).

A medium dense sand and clayey sand stratum was also encountered. A medium dense to dense sand or gravel stratum was also encountered at depth at a number of the test locations undertaken during the 2007 investigation. The CPT's generally do not distinguish between sand and gravel.

Weathered Rock

In BH1 (2012) very weak to weak, extremely weathered mudstone and siltstone with a coal seam (0.6m thick) were encountered in the upper rock profile from 17.6m to 20.6m depth where a moderately strong, distinctly weathered greywacke rock was encountered.

A summary of the subsurface profile is presented in Table 2.

TABLE 2 SUMMARY OF THE SUBSURFACE PROFILE

Location	Fill (m)	Upper Alluvials (m)			Lower Alluvials (m)		Weathered Rock (m)	Total Depth (m)
		Soft/Firm Clay	Loose Sands / Gravels	Medium Dense Sands	Stiff to Hard Clays	Medium Dense to Dense Sands		
BH1 (2012)	0.00-1.55	3.80-4.70 5.10-5.60	1.55-3.80 4.70-5.10 5.60-8.40	NE	9.25-9.70 10.40-17.60	8.40-9.25 9.70-10.40	17.60-TD	27.00
BH2 (2012)	0.00-1.00	NE	NE	1.00-TD	NE	NE	NE	3.00
BH3 (2012)	0.00-1.30	1.30-TD	NE	NE	NE	NE	NE	3.00
BH4 (2012)	0.00-0.70	0.70-TD ⁽¹⁾	NE	NE	NE	NE	NE	3.00
BH31 (2007)	0.00-0.70	0.70-2.50	NE	2.50-TD	NE	NE	NE	3.00
CPT31 (2007)	NI	13.30-14.00 14.50-15.70 16.50-17.70	0.00-13.30 ⁽²⁾	14.00-14.50 15.70-16.50	20.00-20.50 21.10-28.90	17.70-20.00 20.50-21.10 28.90-TD	NE	29.00
BH34 (2007)	0.00-TD	NE	NE	NE	NE	NE	NE	2.00
BH35 (2007)	0.00-TD	NE	NE	NE	NE	NE	NE	2.00
Notes: - Depth in metres below surface ground level at date of investigation. - NE = Not Encountered; NI - Not identifiable; TD = Termination Depth. (1) Stiff clay crust layer from 0.7m to 1.7m in BH4 (2012). (2) Loose to medium dense zones within general loose strata in CPT31 (2007).								

5.2 Groundwater

Depths at which groundwater was noted are presented in Table 3.

TABLE 3 GROUNDWATER LEVELS

Borehole No.	First Recorded (m)	Termination Depth of Borehole(m)
BH1 (2012)	2.8	27.00
BH2 (2012)	2.7	3.00
BH3 (2012)	2.5	3.00
BH4 (2012)	1.7	3.00
BH31 (2007)	2.5	3.00
BH34 (2007)	NO	2.00
BH35 (2007)	NO	2.00
Note: NO = Not Observed.		

The above depths could be expected to vary with seasonal changes (rainfall) and on a damped cycle with tidal influences, with groundwater levels in the local area adjacent to the Brisbane River typically in the range of RL 0.5m to RL 1.0m AHD.

The potential to encounter pockets of perched/trapped groundwater within the fill stratum is considered to be high.

6.0 GEOTECHNICAL ASSESSMENT (STAGE 1)

This section of the report includes the Stage 1 evaluation of the following:-

- Stage 1 Civil Works, including Traffickability & Earthworks
- Stage 1 Foundations
- Stage 1 Retaining Walls
- Stage 1 Pavements
- Stage 1 Site Management

Working Platforms For Tracked Plant and Heavy Construction Vehicles

The scope of Soil Surveys Engineering's Stage 1 study **DOES NOT** include the design of a working platform for heavy construction vehicles or heavy tracked plant.

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

6.1 Civil Works (Stage 1)

It is understood that the proposed earthworks will consist of cuts of up to 3m or so for the basement construction, with some minor filling also. The anticipated basement excavations will extend into the natural alluvials, possibly ranging from loose to medium dense sands at the northern end (BH's 1 and 2) to soft clays over the remainder of the site (BH's 3 and 4).

The excavation level would also be expected to extend below or near the groundwater table over the majority of the site.

Challenges that will be faced in the developments civil work are considered to include:-

- Stability of excavations; this will need to be carried out inside a sheet piling retention system of similar.
- Control of groundwater; dewatering systems will be required.
- Removal and treatment for ASS of the insitu material.
- Traffickability on the excavated base soils and long term basement slab support; this will require over excavation and provision of a bridging layer.

These comments are made from a geotechnical perspective and do not consider contamination issues; these are to be addressed by other consultants.

Earthwork procedures should be carried out in a responsible manner in accordance with AS.3798-2007 'Guidelines on Earthworks for Commercial and Residential Developments'.

It is recommended that the earthworks contractors make themselves familiar with site conditions.

6.1.1 Traffickability

At the time of the field investigation, trafficking problems were not encountered over the site, with existing ground slabs and pavements covering the majority of the site area.

However, the majority of the fill material and all of the natural soils on site are sensitive to repetitive vehicle traffic/loading and water and will lose strength through repetitive vehicle traffic/loading or if they become overly moist to wet. Further, seepage may also result in a subsequent loss of strength/support. This will limit traffickability and create difficulties for earthworks operations. This situation would be more pronounced following rainfall, particularly subsequent to initial clearing, stripping and grubbing works.

Trafficking problems could also be expected to arise for earthworks and construction machinery from disturbance of the upper level soil fabric with removal of vegetation and underground elements, eg. services, footings and ground covers, eg. slabs, pavements. Depressions could be formed resulting in potential water traps which could cause further softening of adjacent soils.

Depending on the final depth of excavations and seasonal and tidal conditions at the time, dewatering may be required (high probability), in the form of pumping from sumps or by spears. The pumping may include trenching and drains leading to the sumps. The use of spears is most efficient in the cleaner sands and gravels, it is expected to be less successful in silty or clayey soils. The location, depth and spacing of sumps, spears and/or drains will be dependent on prevailing weather conditions, subsurface conditions, proposed earthworks and the degree of risk willing to be accepted by the earthworks contractor.

Allocation and/or construction of dedicated haulage tracks, incorporating appropriate subgrade bridging, will be expected to be required to control site traffic.

To assist, placement of a working platform as a final layer across the basement subgrade is recommended; this approach may be also required outside the basement area depending on site and ground conditions prevailing at the time. This could be achieved by placing a minimum 500mm layer of crushed rock, crushed concrete, coarse gravel, etc., to extend 1.5m laterally beyond the construction area/s, where achievable, across the subgrade as the final layer. The working platform material should be compacted to a density of not less than 95% of maximum dry density in accordance with AS1289 5.2.1 (Modified Compaction).

The 500mm thickness of the working platform material may need to be increased and the incorporation of geotextile, geogrid and specific granular materials may be required for ultimate short and long term support. However, this will need to be more fully assessed with a more detailed geotechnical investigation (Stage 2) and possibly on site testing at the time of civil works.

To improve site traffickability in the upper level existing material where only minor excavation will be carried out, it is recommended that following stripping, clearing and grubbing, the exposed surface be proof rolled under the supervision of Soil Surveys Engineering to assist in identifying weak areas and to improve traffickability.

Areas which demonstrate excessive movement and/or do not improve sufficiently under proof rolling should be removed and replaced as outlined in the following sections.

An important aspect of maintaining traffickability is seepage/drainage control. Maintaining adequate drainage conditions is essential. It should be ensured that runoff is diverted away from the construction area to prevent ponding of water. In addition, the construction area should be "sealed" , by rolling with a smooth drum roller, etc., at the completion of each day and in the event of rain.

Potential traffickability problems with this site should not be underestimated. The site will very quickly become untraffickable if appropriate seepage and drainage control measures, along with construction practices appropriate for site conditions, are not maintained.

The contractors should fully inform themselves of the ground conditions, on site, prior to commencement of earthworks. This requirement should be explicit in any earthworks specifications or contract.

Pre-Construction Meeting Service

Soil Surveys Engineering offer a pre-construction meeting service. The primary objective of this service is to allow the Contractor to demonstrate to the Principal and Project Manager that they have a complete understanding of the earthwork challenges/risks associated with this site (ie. traffickability conditions, treatment of silty/clayey sands, use of insitu soils as structural fill, etc.) and that they have made appropriate cost and time allowances. Excavation of trial pits by the preferred contractor (just prior to commission) should form part of this exercise. Our standard rates will apply for this pre-construction meeting service. **Please note that this pre-construction meeting service is considered essential for this project.**

6.1.2 Erosion & Sediment Control

To allow assessment of erosion potential, the following laboratory testing was undertaken:-

- Emerson Class
- pH
- Conductivity

The results of laboratory testing are presented in Tables 1A (current investigation and 1B (previous investigation).

Emerson Class Number

Selected samples retrieved from the field investigation program were tested for dispersiveness using the Emerson Class Number test method, ie. AS1289.3.8.1.

The test method AS1289.3.8.1 divides soils into seven classes on the basis of their coherence in water, with one further class being distinguished by the presence of calcium - rich minerals, ie:-

- Class 1
 - slaking and complete dispersion of natural soil crumbs in still water
 - very high potential for erosion

-
- Class 2
 - slaking and some dispersion of natural soil crumbs in still water
 - very high potential for erosion
 - Class 3
 - slaking but no dispersion of natural soil crumbs in still water
 - dispersion of moistened, remoulded soil crumbs in still water
 - high potential for erosion
 - Class 4
 - slaking but no dispersion of natural soil crumbs in still water
 - no dispersion of moistened, remoulded soil crumbs in still water
 - calcite or gypsum present
 - medium potential for erosion
 - Class 5
 - slaking but no dispersion of natural soil crumbs in still water
 - no dispersion of moistened, remoulded soil crumbs in still water
 - no calcite or gypsum present
 - dispersion of soil/water suspension after shaking
 - medium potential for erosion
 - Class 6
 - slaking but no dispersion of natural soil crumbs in still water
 - no dispersion of moistened, remoulded soil crumbs in still water
 - no calcite or gypsum present
 - flocculation of soil/water suspension after shaking
 - medium potential for erosion
 - Class 7
 - no slaking and swelling of natural soil crumbs in still water
 - low potential for erosion
 - Class 8
 - no slaking and no swelling of natural soil crumbs in still water

The results of the geotechnical investigation and laboratory test results within the site indicate the following:-

- Hamilton is located in 'All Other Suburbs'.
- The predominant upper level soils encountered comprised fill, gravels, sands and some clays.
- Emerson Class No's for the onsite boreholes of 2 and 4 were recorded indicating medium (4) to high (2) dispersive materials.
- Conductivity (mS/cm) results from the onsite boreholes of between 0.53 and 2.96 were recorded.
- pH of between 4.3 and 7.9 were recorded from the onsite boreholes.

Construction activities and erosion/sediment control measures should be implemented in a manner consistent with good building practices and Authority requirements.

It is essential that batters be suitably protected from erosion and scour by installation of surface drains, placement of rock protection, placement of gravel capping, etc. Runoff should not be allowed to discharge directly across unsupported batters.

Reference to the Institution of Engineers Australia, Queensland Division's publication 'soil Erosion and Sediment Control - Engineering Guidelines for Queensland Construction Sites' should also be referenced in earthworks planning.

6.1.3 Acid Sulfate Soils (Stage 1)

Published Information

A review of the site information and published data has indicated the following :-

- Excavations on the site will extend below RL 5.0m
- On the Brisbane City Council map entitled "*A Guide to the Likely Locations of Acid Sulfate Soils in Brisbane*" dated November, 1998 (Scale 1:50,000) the site of the proposed construction has a Hazard Rating **high**
- On the Department of Natural Resources Acid Sulfate Soils Map 1, Tweed Heads to Redcliffe, dated 2002 (Scale 1:100,000) the site is described as:-
 - S_{DL} - *Disturbed land, eg. Canal estate, Marina, Aquaculture, Quarry, Urban, Industrial likely to contain ASS.*

ASSMP Objective

The objectives of the ASSMP are to ensure the control of any potential acid generation from the insitu soils during excavation operations.

Acid Neutralisation

Laboratory test results indicate that the fill material and natural clays and sands on site have actual and potential acidity exceeding acceptable limits. Therefore the excavated soils will need to be treated either on this site or at a suitable deposition site.

To prevent the adverse consequences of excavation of the ASS material , agricultural lime (aglime) will be applied.

Lime Application

The application of aglime to the soil requires thorough mixing and incorporation into the soil. The distribution of actual acid production is inconsistent across the site. However, for the current preliminary data a practical approach is considered to allow for lime dosing that is based on the depth of excavation.

Strict sampling and testing of the material will be carried out during excavation.

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

- Only aglime (calcium carbonate) will be used.
- Based on the assessment of the investigation results and in accordance with QASSIT guidelines, the recommended lime dosing rates are presented in Table 1, using the minimum industry safety factor of 1.5. The actual liming rates will need to be factored according to the product's quoted neutralising value in order to reach the ideal neutralising capacity.
- Thorough mixing of the aglime is critical. Following excavation of the material, it will 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.

Table 4 presents the estimated lime dosages per cubic metre of soil, based on the results of the field investigation and laboratory testing programs.

TABLE 4 RECOMMENDED DESIGN LIMING RATES

Material Type (AS1726)	Maximum Net Acidity (mole H ⁺ /t)	Factored Lime Rate (kg/m ³ of soil)
Existing Sand/Gravel Fill	<17	0
Existing Clay Fill	890	100
Natural Alluvial Soils to 2.0m depth	229	26
Natural Alluvial Soils below 2.0m depth	637	72
Notes: i) Bulk density 1.50t/m³ assumed. ii) Lime dosing rates include a factor of safety of 1.5 and based on upper bound results. iii) 100% purity (neutralising value) is assumed for the aglime (any variation from 100% in the product actually used must be factored accordingly).		

Dosing rate calculations were carried out in general accordance with the method set out in the QASSIT guidelines.

The estimated liming rates shown will need to be quantified with a more detailed investigation (Stage 2) and will also need to be monitored by on-site sampling and further testing during excavation at the rate of one test per 250m³ of excavated material. This will help safeguard against errors in identifying material types and potential unknown 'hot spots' of acid sulfate material.

Excavations & Dewatering

On reaching the design excavation levels, the underlying ASS will be exposed to the atmosphere resulting in oxidisation. There is the potential for acid leachate runoff in these areas. Treatment by tyning aglime into the underlying soils for a depth of 0.3m is recommended to the base of the excavation, liming rates to be confirmed at time of excavation.

Dewatering will also be required as part of the site excavation with groundwater intersected at depths of 2.0m to 3.0m approximately below ground level. Water should be pumped to holding tanks for treatment prior to discharge.

Basement construction will require the use of a boundary support system. This can be utilised to minimise the drawdown of groundwater beyond the site during construction dewatering, by providing a perimeter cut off into a layer of low permeability material.

The temporary or permanent support system may consist of sheet piles or contiguous piles.

Notwithstanding the use of a cut off system to prevent drawdown beyond the site, the actual extent of dewatering influence will be limited due to the limited depth of drawdown and the soils lower permeability.

Holding Tanks

Given the size of the site, it is considered that catchponds may not be suitable for treatment of water. Temporary holding tanks may be considered for containment and treatment.

It is critical that all construction drains, water table lowering drains and site runoffs be directed towards holding tanks prior to release into the environment.

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.

pH levels and other water quality criteria must be maintained to those presented as baseline conditions prior to discharge. It should be the contractor's intention to ensure the holding tank pH levels are between 6.5 and 8.5 at all times prior to discharge.

Construction Techniques - ASS Treatment

While it is expected that treatment of soils is to be carried out off site, please note that for any stockpiling or treatment on site, the following actions for treatment requirements should be carried out:-

- The excavated material will be placed in a suitable space within the existing site to create a temporary stockpile and treatment area. All excavated material (fill and natural clays) may be conditioned and lime treated on site in accordance with the above liming rates prior to disposal to landfill.
- If insufficient space is available for treatment of the excavated soil, then the material will be lime treated in 250mm layers prior to excavation or the soil will be excavated and treated off-site at a properly designed treatment area.
- ASS must not be stockpiled for a period greater than 18 hours unless it is neutralised first or unless in appropriately prepared stockpile area.
- All stockpiles will 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/m²) will be tynd into the underlying soil for a depth of 0.3m below surface level. As each stockpile of soil is removed for treatment, additional aglime will be added should any of the leachate neutralise the original lime placed in the bunds (to be verified through testing).
- ASS material excavated from the excavation will be placed in nominated areas for immediate treatment. The ASS 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 will add lime at the prescribed rate and mix thoroughly using agricultural spreaders and ploughs as appropriate to ensure a homogeneous mix.

ASS Treatment Off-site

It is expected that ASS is required to be treated off-site, then the actions as presented above will be carried out at the off-site treatment pad, or alternatively, to an approved ASS treatment facility.

Site Monitoring

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

Neutralised soils (soils post liming) should be monitored during construction.

Stockpiled & Neutralised Soil

Testing and monitoring of stockpiled and neutralised soils should be performed throughout the construction period. Chromium test methods should be carried out at a rate of at least one sample per 250m³, 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:-

- i. The neutralising capacity of the treated soil must exceed the existing plus potential acidity of the soil.
- ii. Post neutralisation, the soil pH is to be greater than 6.5.
- iii. 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.

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.

6.1.4 Excavation Characteristics

Excavations would be expected to consist of:-

- Bulk Cuts For excavation to create the basement platform and subgrade levels.
- Trenching - For underground services and high level footings, as appropriate.

Excavations on site should be within the capabilities of relatively light plant, small dozer (Cat D4C or similar) in bulk cuts and a medium sized backhoe (Case 580 or similar) or small to medium excavator (15t - 22t) in detailed and trenching, based on the investigation findings.

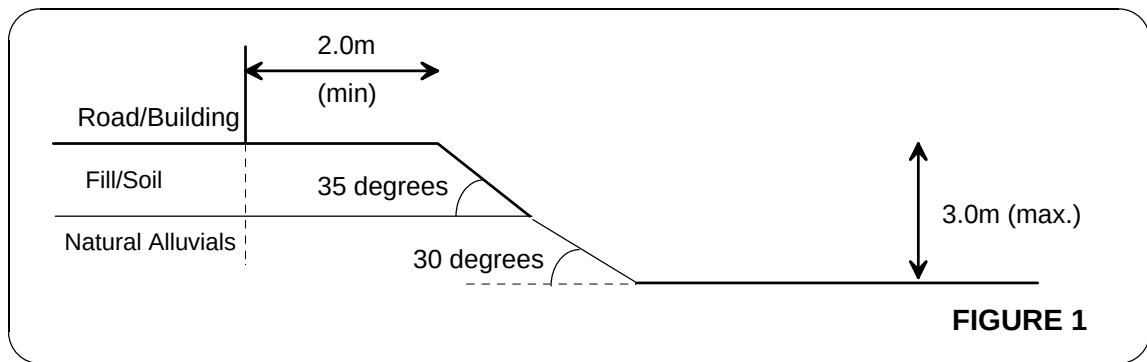
However, traffickability in some areas may limit the type of plant and equipment which can be utilised, to tracked equipment, or low ground pressure equipment.

Also, the material won from on site excavations will need to be considered for treatment of acid sulfates.

6.1.5 Bulk Excavation

The following general recommendations are made for short term stability of batters for bulk excavation of the site.

- Batter angles not greater than 30 degrees to 35 degrees (from horizontal) as outlined in Table 5 of this report.
- Top of batter minimum of 2.0 metres inside site boundaries/buildings.



Inspection of cut batters should be carried out by an Engineering Geologist from Soil Surveys Engineering, during bulk excavation works, to confirm the stability of temporary cut batters. Suitable precautions to satisfy Health & Safety requirements must be adopted. Construction procedures (ie. operation of plant, storage of materials, etc.) should also consider all safety aspects of trenching works and other excavations.

6.1.6 Subgrade/Platform/Site Preparation Procedures

Earthworks preparation procedures should include:-

- Clearing should be carried out in areas subject to earthworks. Also, all soils containing organic and deleterious matter should be stripped from the construction area. This material is not considered suitable for reuse as structural fill. Existing gravels could be considered for use as general fill on site, as required.
- Proof roll building and pavement construction areas (if appropriate) using a vehicle with a tare of at least 3 tonnes, under the supervision of Soil Surveys Engineering. Areas demonstrating excessive movement under proof rolling should be treated (dried/watered and recompacted) if possible, or removed to competent material and replaced with compacted select fill, as detailed in the following sections. Treatment should be to a standard sufficient so that the subgrade passes proof rolling and that the project's compaction specifications can be achieved.
In areas of cut, the proof rolling may be deferred to after the cut operation.
Proof rolling is not expected to be appropriate on the basement excavation, where weak alluvial sands and clays are expected to be exposed.

- In areas where weak soils form the subgrade, as expected to be the situation at the basement subgrade level, it is envisaged that a working layer to support construction equipment and to allow fill placement will be required. The following is offered for consideration:-
 - Overexcavation below design subgrade level by 500mm minimum. As previously noted this overexcavation depth will need to be quantified with a more detailed investigation and possibly confirmed on site at the time of excavation.
 - Place geotextile (say 'G' rating of 2400); the geotextile will act as a separator as well as providing some tensile strength.
 - Place bridging layer (say rocky material, i.e. crushed rock/concrete, coarse gravel - maximum 75mm), lightly compact and proof roll to check platform stability (i.e. that no excessive movements occur).

6.1.7 Material Usage and Fill

- Due to the acid sulfate, water sensitive and reactive nature of the insitu fill and natural alluvial clays and sands, **it is recommended that these soils NOT be used as structural fill.**
- From a geotechnical perspective, the existing gravelly and sandy fill soils, where free of organic and deleterious material, may be used for structural fill provided the moisture content of the soils on placement approximates the optimum moisture content required for compaction.
- **Imported general select fill** (if required) should be cohesive in nature and conform to the following specifications.

Imported select fill, if required for filling in structural areas/if needed to make up earthworks deficiencies, should conform to the following specifications

Soaked CBR	Minimum of 7%
Liquid Limit	40%, maximum
Aggregate Size	100mm, maximum
Shrink/Swell Index	Maximum of 1.0%

Typical material that would conform to the above quality limits would be a good to fair quality overburden type material; such material would have a soaked CBR value of approximately 7 to 10%.

The requirement to specify a minimum soaked CBR value is dependent on slab and pavement design issues; this matter should be referred to the Civil Engineer.

- Quality testing to confirm imported fill quality should be carried out prior to delivery to site; frequency of testing is subject to assessment by Soil Surveys Engineering, however, a sufficient number of tests should be carried out so that all parties are confident of material characteristics. Quality test results should be reviewed by Soil Surveys Engineering prior to construction.
Contractors should submit details of their proposed fill source (with quality certificates) with their tender submission. The proposed fill source should be reviewed by Soil Surveys Engineering prior to awarding the earthworks contract.
- Pavement gravels should comply with the D.O.T. quality specifications for base, sub-base and blanket materials.

6.1.8 *Compaction Procedures and Specifications*

- Provided the placement moisture content of the select insitu material or imported fill approximates the appropriate optimum moisture content, suitable compaction should be achievable using appropriate compaction machinery, such as a 5t-10t vibrating sheepsfoot roller or 25t-30t sheepsfoot compactor.
The select fill material should be compacted in layers not exceeding 250mm, loose thickness.
Layer thicknesses will be dependent on compaction plant type and size, use of vibration, material type and condition. However, cohesive materials should not be placed in layers exceeding 250mm, loose thickness. For cohesionless soils (clean sands), a maximum loose layer thickness of 400mm is recommended. Final maximum placement layer thicknesses will need to be determined when material type and condition as well as compaction plant are known.
- Fill batters should be overfilled and cut back to the required design batter angles to maximise compaction of the material in the batter faces.
- It is recommended that where filling is to be carried out over sloping ground the slope be benched to allow the fill to become 'keyed' into the existing batters. This procedure will provide greater stability of the fill and allow for adequate compaction to be achieved throughout the full depth of the fill.

- The following minimum compaction values are recommended for the building and pavement areas.

<u>Location</u>	Cohesive Soils	Cohesionless Soils
<u>Building areas</u>	98%	75%
<u>Pavements areas</u>		
- Top 300mm below subgrade level	98%	80%
- Below the top 300mm	95%	75%

Where the above values are:

The density ratios as determined by AS.1289 Test 5.1.1 (Standard compaction) for cohesive soils.

The density indices as determined by AS.1289 Test 5.6.1 (Standard method) for cohesionless soils.

- Crushed rock, etc. fill placed in the area of the buildings should be compacted in layers (approximately 250mm loose thickness) to a density not less than 95% of maximum dry density in accordance with AS1289 5.2.1 (Modified Compaction).
- Note that where the majority of particles are greater than 20mm, density testing is not generally feasible and performance testing (proof rolling) should be carried out under appropriate supervision to indicate adequate compaction has been achieved.**
- Pavement gravels should be compacted to the following minimum density ratios as determined by AS.1289 Test 5.2.1 (Modified compaction).

Base material	98%
Sub-base material	95%
Blanket material	95%

Backfill to service trenches should be placed in uniform layers over the full width of the excavations, with the layers not exceeding 200mm loose thickness using wheeled plant and 100mm loose thickness using vibrating plates.

The backfill material should be compacted to the above specifications for cohesive and/or cohesionless materials.

- Other comparable compaction specifications may be adopted for earthwork procedures; however, Soil Surveys Engineering Pty Limited should be consulted to confirm these.

6.1.9 Batters

Maximum cut batter angles for different material types are outlined in Table 5 for unsurcharged batters less than 3m high on the site. Where surcharges (eg. footings, live loads, etc.) are located within H (height of batter) of the top of the batter, then some reduction in design angle will occur. Steeper batters are possible by use of retaining structures (temporary and permanent).

TABLE 5 BATTER ANGLES (Slopes less than 3m high)

Material	Short Term (°)	Long Term (°)
Existing "Uncontrolled" Fill	35 (1V:1.45H)	18 (1V:3H)
Sandy Soils - loose to medium dense	35 (1V:1.45H)	18 (1V:3H)
Clay Soils - Soft to Firm - Very Stiff to Hard	30 (1V:1.75H) 45 (1V:1H)	18 (1V:3H) 26 (1V:2H)
Notes: • Subject to inspection by experienced geotechnical engineer/engineering geologist during initial earthworks operations. • These values assume no seepage. If seepage is present the recommended angles would need to be significantly reduced or the use of dewatering considered.		

Inspection of cut batters should be carried out by a Geotechnical Engineer/Engineering Geologist from Soil Surveys Engineering, at the COMMENCEMENT OF BULK EXCAVATION WORKS, to confirm the stability of temporary cut batters.

It is essential that permanent batters/embankments be suitably protected from erosion and scour by appropriate drainage and the establishment of ground cover and shrubs, etc. Runoff should not be allowed to discharge directly across the batters without suitable scour protection.

6.2 Temporary Excavation Support (Stage 1)

Suitable temporary support systems must be determined to allow the temporary excavation for the proposed basement and the construction of the proposed basement wall. Also it is common for the incorporation of a water proof finish on the back of basement wall prior to backfilling. The temporary cut face must be stabilised to allow for this to occur.

The following options could be considered:-

- Contiguous or Secant Pile Walls
- Sheet Pile Walls

The determination of a suitable method will depend upon boundary conditions i.e. existing permanent and transient surcharges, location of existing services, need for water proofing and final wall requirements.

6.2.1 Contiguous or Secant Pile Walls

Contiguous pile wall systems are constructed with piers drilled at nominated spacing and joined at the surface using a capping beam. Excavation is then carried out in stages with the first excavation stage including placement and stressing of any anchors. Pier spacings can be close (say 50mm) or more widely spaced (up to four diameters, centre to centre) in conjunction with infilled panels (mesh and shotcrete).

The advantage of a piled wall system is that it could be incorporated into the final structure.

Due to the subsurface conditions encountered, the piers will need to be drilled either by grout injected methods or with the use of casing.

A secant pile system is formed from overlapping piers installed next to each other. This may be achieved by a hard to soft pile system, with every second pile being formed from a weaker grout mix to ease installation.

As groundwater is expected to be encountered just above or below the basement excavation level, the secant pile wall should prevent excessive ground loss and water ingress. However, water retention is for temporary situations only, and the use of hard to hard pile systems or the use of secondary waterproofed wall will be required for any long term acceptable level of water retention.

It is recommended that a capping beam be poured along the top of all piers. This has the advantage of:-

- Supporting the top section of the profile prior to removal of the first excavation layer which generally reduces fall-in in the early part of the excavation.
- Provides a convenient location for the row of anchors, allowing an increase in anchor spacing and not restricting the anchor points to the post positions only.

-
- Provides a larger bearing surface for the top row of anchors and allows the adoption of larger anchors in the top row.
 - Joins the tops of the posts together thereby reducing the possibility of excessive movement of the top of a single post which could increase the potential for toe “kick out” before the placement of the lower anchor. This movement would also reduce the tension within the anchor thereby downgrading its effectiveness at minimising movement within the wall of the excavation.

6.2.2 Sheet Pile Walls

Cantilevered or anchored sheet pile walls may be considered. A staged excavation process would be required.

Sheet piles can either be installed as a cantilever or be anchored. The installation of an anchored system will reduce deflection and may result in the use of lighter sheet section, however, due to the alluvial soils encountered, the anchors will be expected to extend over large portion of neighbouring properties to obtain the required loading. This may impact on adjacent piled footing systems, services, or future construction during adjacent property redevelopment.

Sheet piles could be designed using the parameters provided in Section 6.3.

6.3 Retaining Wall (Stage 1)

6.3.1 General

Walls should be designed in accordance with Australian Standard 4678-2002 earth-retaining structures.

Retaining walls could be used to restrain cut/fill in the general construction areas and/or incorporated into the building structures.

It is understood that retaining walls may be required for the sections of the proposed basement, if constructed. The expected maximum retained height will be up to 3 metres.

The lateral earth pressure distribution that affects the retaining walls on the site will depend upon the following parameters :-

- Insitu and backfill material properties
- Design water regime at the rear of the wall
- Wall and cut geometry
- Surcharges affecting the wall
- Wall type
- The structural bracing of the wall and the timing of backfilling behind the wall.

6.3.2 Pressure Distribution

The following situations should be considered :

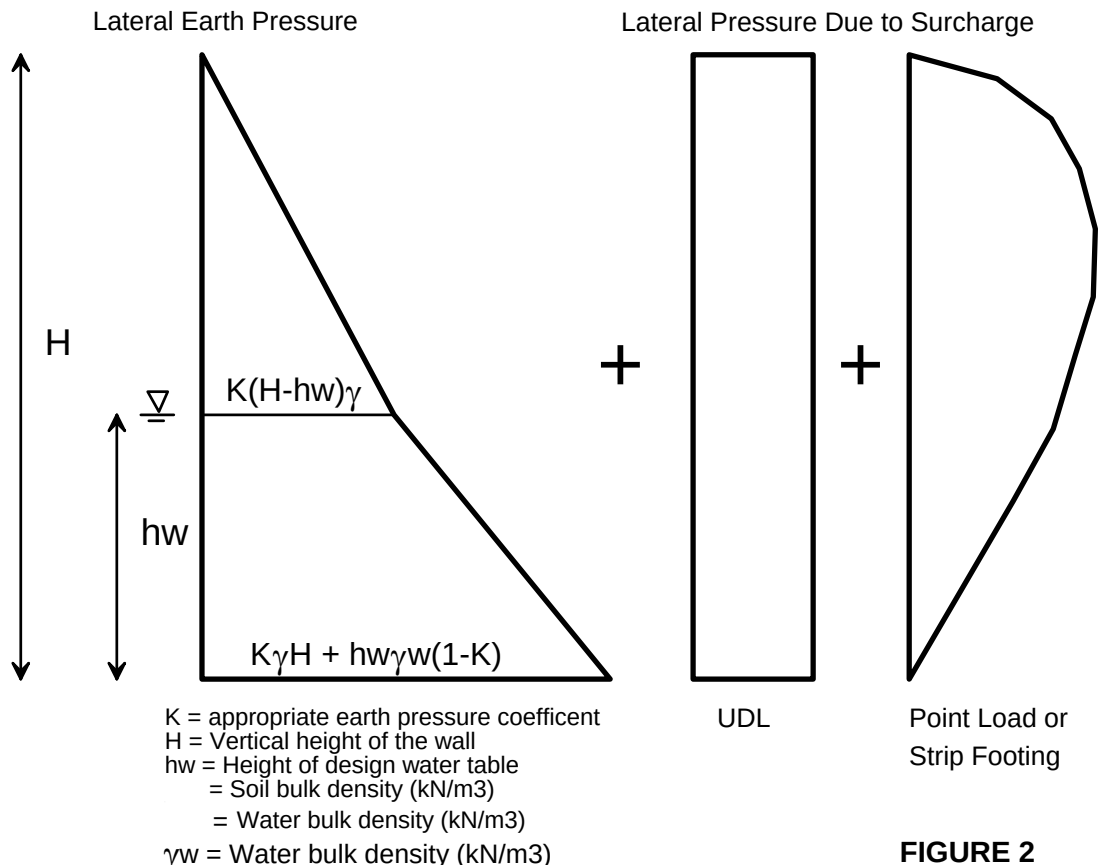
- For cantilever walls, which allow some movement at the top, (ie. at least $0.005H$ in clays) the active case (K_a) applies with a triangular distribution in both the short and long term situations.
- For cantilever walls which cannot tolerate this movement, the at rest case (K_o) applies with a triangular distribution in both the short and long term situations.
- For structurally braced walls(eg. by floor slabs) the wall design should be checked for both a trapezoidal (clay soils - short term conditions) and triangular distribution with K_o values (long term conditions).

The lateral pressure distributions shown in Figures 2 and 3 include hydrostatic pressure and show typical pressure distributions due to surcharge loadings. It is recommended that where the retaining walls are expected to be surcharged (eg. by footings, traffic loads, sloping ground surface, etc.) Soil Surveys Engineering should be contacted to provide a recommended lateral earth pressure distribution.

The parameters selected for use in the figures are dependent on the preconstruction geometry of the face being retained. Where the material has been cut using the recommendations (or flatter) as outlined in Section 6.1.9, the backfill parameters will control. Where a steeper angle is used, the earth parameters will control.

As a general guide (using an elastic model) line loads located $2.5H$ away from the wall (where H is the wall height) results in lateral forces of less than 10% of the line load. Parameters for assessment of lateral earth pressures are outlined in Table 6.

TRIANGULAR DISTRIBUTION



TRAPEZOIDAL DISTRIBUTION

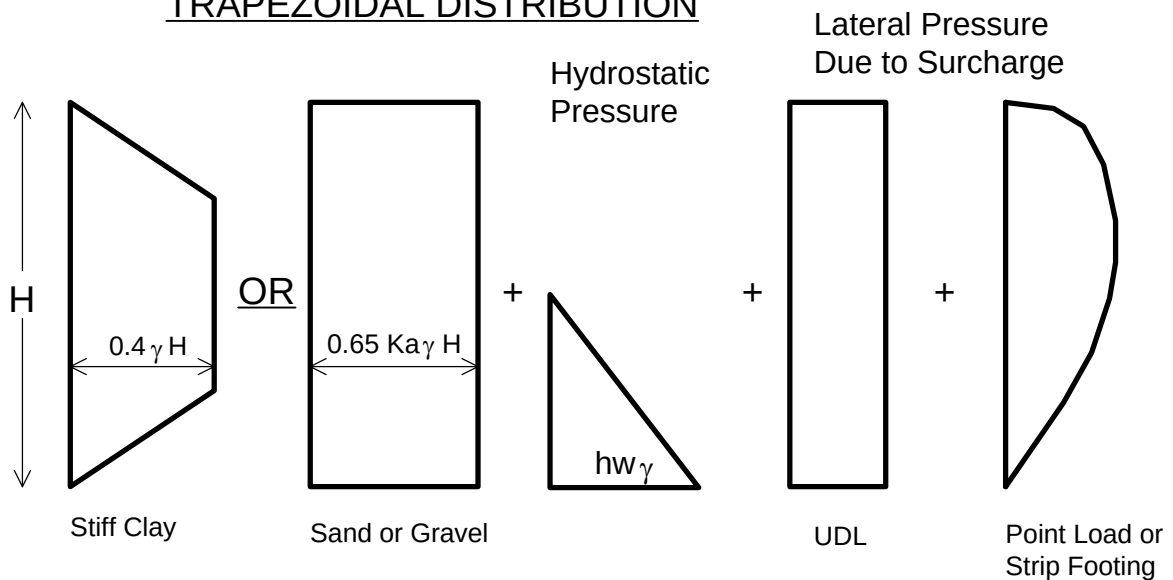


Table 6 presents design parameters (unfactored) for retaining walls.

TABLE 6 RETAINING WALL DESIGN PARAMETERS (Unfactored)

Material	Density (kN/m ³)	Effective Stress Parameters		Shear Strength Cu (kPa)	Earth Pressure Coefficient ⁽¹⁾		
		c' (kPa)	ϕ' (degrees)		Ka	Ko	Kp
Existing Fill	20	2	30	-	0.33	0.50	3.00
Alluvial Clays							
- Stiff	18	5	26	50	0.39	0.56	2.56
- Soft to Firm	17	2	24	25	0.42	0.59	2.37
Alluvial Sands							
- Loose	18	0	30	-	0.33	0.50	3.00
- Medium Dense	18	0	33	-	0.29	0.46	3.39
Notes: (1) these values of earth pressure co-efficient ignore the effects of wall friction. (2) infers granular free draining material placed behind the retaining wall as a drainage layer - If fill is compacted against the retaining wall, the actual earth pressure could exceed the vertical pressure, (ie. Ka >1.0) - These values do not account for a backslope							

Resisting forces to sliding and rotation are provided by the shear resistance at the concrete footing/soil or rock interface and the passive soil resistance in front of the footing or shear key, for which the following design parameters are presented:-

- i) Base friction for walls without a key may be taken as $\tan (2/3 \phi)$. If the wall has a shallow base key the shearing resistance may be based on $\tan \phi$.
Refer to Table 6 for shear angle.
- ii) Soil density as in Table 6.
- iii) The passive pressure coefficient Kp as in Table 6.

6.3.3 Resistance to Lateral Forces

Retaining walls can be designed to resist lateral pressure distribution in several ways ie.

- passive resistance at the toe of the wall
- passive resistance at the key of the wall
- frictional resistance due to the weight of the wall
- propping off existing structures

Further investigation will need to be undertaken together with detailed construction design to better assess this.

6.3.4 Construction Considerations

With all retaining walls, it is essential that adequate drainage be provided behind the wall. Any backfill placed behind the wall should be loose granular material. The backfill should not be heavily compacted since research has shown that compaction can raise the earth pressure to above the 'at rest' pressure.

The placement of a filter fabric between the retained soil and the drainage material (eg. granular backfill) for protection against silting of the drainage material is recommended. The outlets to subsoil pipe drains must be located beyond the ends of the walls and connected to a proper drainage system. It is suggested the pipes be wrapped in filter fabric to minimise silting.

Adequate surface and subsoil drainage should be provided for all retaining walls on the site. Cut-off / interceptor drains should also be provided around the high side of the wall to ensure stormwater runoff from the area above the wall is suitably diverted.

In weather exposed locations, to reduce infiltration by surface runoff, the surface of the backfill should be sealed. This can be achieved by either compacting a material of low permeability or concrete, etc. with a slope towards an open drain.

It is essential that backfill be properly placed to avoid drains being blocked by fines washed out of the fill. However, within 0.5m behind the wall the backfill should be loose as research has shown that compaction directly behind the wall can significantly raise the earth pressure against the wall to above the 'at rest' case.

During installation of any retaining walls, the insitu soils should be battered back to minimise fall-in and subsequent disruption of works. Temporary batter angles are given in Section 6.1.9. Suitable precautions to satisfy Health & Safety requirements must also be adhered to.

6.4 Building Foundation System (Stage 1)

6.4.1 Design Considerations

It is understood that the proposed residential development may consist of an eight to twelve storey building with a single level basement beneath the building extending to depths of 3.0m below surface level.

Given the proposed building type and subsurface conditions comprising uncontrolled fill overlying significant depths of weak alluvial soils, a deep foundation system is recommended.

As an alternative, it may be possible to consider a fully compensated raft foundation system. Provided the weight of the soil removed in excavating the basement is equivalent to the building/raft load, resulting in nil net loading, theoretically, the building can be supported without any additional settlement occurring. If the loadings cannot be balanced a raft foundation system is not recommended, as any positive net loadings may result in settlements and significant differential settlement (given the variation in clay thickness encountered).

Reconsolidation of the soil which has swelled as a result of the removal of overburden pressure during basement construction must also be taken into account as loading is applied.

A floating basement slab system, detailed to allow for possible differential settlement could be considered. However, with basement floors hydrostatic uplift forces will need to be considered, also taking into account anticipated rises in groundwater.

6.4.2 Deep Foundations

Given the anticipated building loads and subsurface profile encountered, a deep foundation system with piles founding in the underlying distinctly weathered rock is recommended for this development.

Deep foundation systems that could be considered include:-

- Driven precast concrete piles
- CFA - continuous flight auger piles (grout injected piles)

Bored cast insitu piles are technically feasible, however, will present construction difficulties associated with the presence of soft alluvial deposits and potential high groundwater flows. The use of casing or bentonite mixture will be required to extend the piles to recommended founding levels.

Driven precast concrete piles are a suitable deep foundation system for this site.

Ground vibrations and noise associated with the installation of driven pile systems should be taken into consideration with assessment from specialist piling contractors.

It is however, recommended that specialist piling contractors be consulted as to the most suitable and economical piling system for this project.

Deep foundations used on this project should be designed in accordance with AS2159-2009 'Piling - Design and Installation'. For the limit state design, as outlined in the Code, both the geotechnical strength $R_{d,g}$ and the structural strength $R_{d,s}$ for a single pile and pile group must be greater or equal to the design action effect (E_d), i.e. $R_{d,g} \geq E_d$ and $R_{d,s} \geq E_d$.

Grout Injected Piles

The grout injected pile is vibration free but is a non-displacement pile. The pile is formed by drilling with a continuous flight auger to the desired level with concrete injected through the hollow stem of the auger as it is withdrawn.

Grout injected pile sizes of 500mm and 600mm are commonly available, however, piles up to 800mm are also available.

It should be noted that where weak layers are encountered, some difficulty with loss of grout, etc., may occur.

Driven Piles

Conventional driven precast piles, with piles founding in the underlying weathered rock are likely to be the most cost effective solution and are recommended.

To accommodate potential loads, piles may need to be driven into the underlying weathered phyllite stratum. The allowable working load on a pile driven to near refusal, by normal driving equipment, is given by the allowable capacity of the pile considered as a structural member, rather than by consideration of failure of the supporting materials.

Typical pile capacities are as follows:-

TABLE 7 PILE CAPACITIES

Pile Type	Section Dimensions (mm)	Working Load (kN)
Precast	275 x 275	1150
Concrete	350 x 350 400 x 400	2400

Design

For design of piles, founded in the lower lying clays, dense gravels and weathered phyllite, the following equations may be used based on the limit state design method. However, piling contractors should be requested to provide their own calculations supported by construction experience and typical pile load results.

$$R_g^* = R_{ug} \times \phi_g$$

$$R_{ug} = Q_b + Q_s$$

Where for cohesive soils (clays and weathered phyllite)

$$Q_b = A_b \times S \times N_c$$

and, $Q_s = A_s \times S \times \alpha$

For cohesionless soils (sands and gravels)

$$Q_b = A_b P_d (N_q - 1)$$

and, $Q_s = K_s P_d' \tan \delta A_s$

Where	R_{ug}	=	ultimate geotechnical strength of pile
	Q_b	=	ultimate bearing capacity of pile base
	Q_s	=	ultimate capacity of pile skin friction
	R_g^*	=	allowable capacity of pile
	ϕ_g	=	geotechnical strength reduction factor, adopt 0.4; refer also Table 4.1 in AS2159-2009, Piling - Design and Installation
	N_c	=	bearing capacity factor which varies between 5.6 and 9 depending on depth of penetration of the pile ($N_c = 9$ for at least 4 pile diameters penetration).
	A_b	=	area of pile base
	A_s	=	circumferential area of pile

S	=	shear strength in the clay
		- Soft to Firm 25kPa
		- Stiff 75kPa
		- Very Stiff 100kPa
α	=	adhesion factor, (will depend upon the method of installation of the pile and the shear strength of the soils being penetrated)
N_q	=	bearing capacity factor
		- Loose = 15
		- Medium Dense = 40
		- Dense = 80
P_d	=	effective overburden pressure
P_d'	=	effective overburden pressure at mid layer
K_s	=	earth pressure coefficient
δ	=	angle of wall friction

A preliminary value of 4500kPa may be adopted for ultimate base bearing capacity in the distinctly weathered rock (minimum embedment depth of four pile diameters, based on a conservatively estimated shear strength of 500kPa). Higher capacities (both bearing and skin friction) may be available, but this would be subject to a more detailed investigation.

Broms has related the values of K_s and δ , effective angle of shearing resistance of cohesionless soils, and various pile materials, as shown in Table 8.

TABLE 8

Pile Material	δ Degrees	K_s	
		Low relative Density	High Relative Density
Steel	20	0.5	1.0
Concrete	$\frac{3}{4}\phi$	1.0	2.0

Negative Skin Friction (NSF)

Negative skin friction must be taken into account - pile capacities will need to be downgraded to allow for negative skin friction effects. It is considered that maximum negative skin friction will be mobilised if the surrounding soil moves relative to the pile by the order of 5mm to 10mm.

The negative skin friction may be calculated from:-

$$c = 0.25\rho'$$

Where c = NSF (kPa)

ρ' = average effective overburden pressure on the length of pile shaft to the base of the compressible soils.

Negative skin friction will potentially affect the pile to the base of the firm clay strata.

Pile Groups

If high column loads are involved, pile groups may need to be used to achieve the required load bearing capacities.

Where pile groups are required, a pile spacing of not less than 2.5 times the pile diameter is recommended. Larger pile spacings can be used if the efficiency of the pile group needs to be increased. Table 9 indicates the relationship between pile spacing and group efficiency (after Tomlinson 1969).

TABLE 9 **PILE GROUP EFFICIENCY**

Pile Spacing	Group Efficiency Ratio
2 x pile diameter	0.7
4 x pile diameter	0.8
6 x pile diameter	0.9
8 x pile diameter, or more	1.0

Actual pile capacities (down-load and uplift) will depend on the adopted pile size and actual pile capacities should be evaluated by specialist piling contractors taking all relevant factors into account.

Compliance Testing

It is recommended that a minimum of 5% of the piles be tested using dynamic pile testing methods (e.g. PDA testing with a suitable number of CAPWAP analyses to confirm field results).

Differential Settlements

Differential settlements will occur between piled and non-piled areas.

Flexible connections between piled and non-piled areas, particularly service connections, must be provided.

6.4.3 Basement Slab

With basement floor slabs being at levels below groundwater levels, floor slabs would need to be designed for hydrostatic uplift forces. Pile foundations for column loads could be used to anchor floor slabs, however, additional anchors possibly in the form of short intermediate piles may be required. The use of short screw piles may also be considered for this purpose. Suitable basement waterproofing would be required.

A fully tanked basement floor to above the highest expected groundwater levels is recommended. Design provision should be made for a 'perched' groundwater level substantially above the present standing water table, possibly to near surface level for short periods. Alternatively, a system of hydrostatic relief valves could be adopted for a lower design water level.

If the structure is not fully waterproofed, a permanent dewatering system would be required. However, this system would be subject to permanent maintenance throughout the life time of the structure and the environmental issues (i.e. ASS) associated with maintaining water quality prior to discharge would need to be considered.

The basement slab system, subject to construction and structural issues, could be designed as:-

- Suspended
- Floating
- Raft

The system adopted will be dependent on the loading conditions and final basement level of the structure. As indicated in Section 6.4.1, the use of raft system could only be suitable for a balanced loading resulting in limited stress applied to the compressible clays.

Subgrade conditions for pavement design of a floating basement slab (if appropriate) will depend upon the thickness of the bridging layer placed over the alluvial clay.

For design purposes, it is recommended that the slab on ground floor be designed adopting principals contained in the Cement & Concrete Association of Australia, Industrial Floors & Pavements, Guidelines for Design, Construction and Specification. A design CBR of 1% has been selected for the soft alluvial clay, increasing to 3% for the upper stiff sandy clay material encountered.

6.4.4 Settlement Characteristics

The settlement behaviour of the proposed structure will be related to the net load applied, taking into account structural loading and stress reduction due to basement excavation.

Laboratory test and CPT results indicate that the marine clay deposits are generally normally to slightly overconsolidated by up to 35kPa.

For presentation purposes, preliminary calculations have been carried out to investigate the likely order of magnitude of total settlement for a raft founding on the soft alluvial clays at the basement level. This is based on an initial building figuration of nine storeys with a single level basement.

The calculation results indicate the following:-

- 150mm to 200mm settlement at the centre of the raft
- 25% to 50% settlement as differential settlement
- 30mm to 50mm to be allowed for long term creep over a period of 30 years.

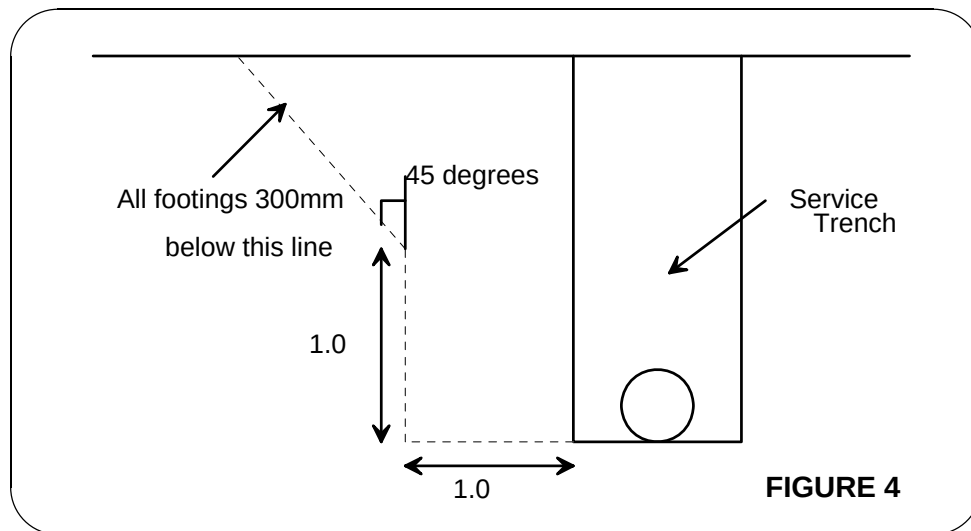
6.4.5 Base Heave

Removal of the overburden when excavating to the basement level will cause swelling or heave of the soil below the excavation. Preliminary estimates indicate that for a 2.5m basement excavation total stress relief of approximately 45kPa will result. Estimate of base heave due to the relief of overburden pressure is expected to be in the order of 25mm to 50mm, increasing with increased depth of soft alluvial clay. This movement will occur predominantly immediately during construction and is expected to be removed during final detailed excavation.

6.4.6 Construction Recommendations

Footings Adjacent to Underground Services

Where footings are located adjacent to underground services, the footings should extend to base a minimum of 300mm below the trench base level for a distance of 1.0m out from the trench. Beyond 1.0m the footings should be taken a minimum of 300mm below an imaginary plane drawn up at 45° from the trench base level, (Figure 4).



These requirements do not override minimum footing levels.

High Level Footings

Given the properties of the founding materials it is recommended that the footings be poured as soon as possible following excavation, to minimise the potential for desiccation/wetting up of the founding material. Where the footings cannot be poured within a short period of time it is recommended that a blinding layer of concrete, at least 50mm thick, be placed immediately following excavation, cleaning and inspection of the footing bases.

It is recommended that inspections be undertaken by an experienced and qualified geotechnical engineer from Soil Surveys Engineering following footing excavations to confirm the adequacy of the founding soils. Inspections should be carried out prior to placement of reinforcing steel and ordering of concrete.

Piers/Piles

As discussed previously, bored piers are not the recommended deep foundation option. Full casing and/or use of drilling fluid to support the pier hole would be required.

Given the nature and strength of the subsurface material encountered, it is recommended that inspections be undertaken by an experienced geotechnical engineer/engineering geologist from Soil Surveys Engineering Pty Limited during pier excavations to confirm the adequacy of the founding material.

Driven piles should only be used if vibration will not cause problems to surrounding structures. Adequate vibration monitoring and control should be carried out.

For the driven pile options, specialist piling contractors should make their own assessment of pile founding levels/pile lengths considering pile loads requirements and subsurface conditions.

6.5 Site Management (Stage 1)

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

Particular reference to site management matters is set out in AS2870-2012. It should be noted that where proper site management, particularly with respect to change in moisture conditions, is not followed, the foundation recommendations contained in this report could be considered void.

7.0 CONSTRUCTION INSPECTION

It is recommended that placement of all structural fill, footing excavations, and cut batter slopes in soil together with building and pavement subgrades should be inspected by Soil Surveys Engineering Pty. Limited. or a duly qualified Geotechnical Engineer. Also, assessment of the basement following excavation, dewatering measures and base fill placement should be inspected by Soil Surveys Engineering Pty Limited or a duly qualified geotechnical engineer. Should subsurface conditions other than those described in this report be encountered, Soil Surveys Engineering Pty. Limited. should be consulted immediately and appropriate modifications developed and implemented if necessary.

8.0 LIMITATIONS

We have prepared this report for the use of **Shayher Development Pty Ltd** and **Bornhorst & Ward**, for preliminary design purposes (Stage 1) 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 **Shayher Development Pty Ltd** and **Bornhorst & Ward**. It may not contain sufficient information for purposes of other parties or for other uses.

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.

This statement is 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.

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.

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



P. J. DIXON (RPEQ 4150)

for and on behalf of
SOIL SURVEYS ENGINEERING PTY LIMITED

APPENDICES

APPENDIX A
NOTES RELATING TO THIS REPORT

INTRODUCTION

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

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

DESCRIPTION AND CLASSIFICATION METHODS

Soils - The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726-1993 (Geotechnical Site Investigations), where appropriate. In general, descriptions cover the following properties - soil or rock type, colour, structure, strength or density, and inclusions. Identification and classification of soil and rock involves judgement and the Company infers accuracy only to the extent that is common in current geotechnical practice.

Soil types are described according to the dominant particle size and behaviour as set out in AS 1726-1993.

Cohesive soils are classified on the basis of strength (consistency) either by use of hand penetrometer, shear vane, laboratory testing or engineering examination. The strength terms are defined in AS1726-1993 Table A4.

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

Rocks - Rock types are classified by their geological names (AS1726-1993 Table A6), together with

descriptive terms regarding weathering (AS1726-1993 Table A9), strength (refer Table 1 below), defects (AS1726-1993 Table A10), etc. Where strength testing (ie Point Loads) is carried out, AS1726-1993 Table A8 is used. Where relevant, further information regarding rock classification is attached.

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

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

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

SAMPLING

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

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

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

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

TEST LOCATIONS

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

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

INVESTIGATION METHODS

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

Test Pits - These are normally excavated with a backhoe or a tracked excavator, allowing close examination of the insitu soils if it is safe to descend into the pit. The depth of penetration is limited to about 3m for a backhoe and up to 6m for an excavator. Limitations of test pits are the problems associated with disturbance and difficulty of reinstatement and the consequent effects on close-by structures. Care must be taken if construction is to be carried out near test pit locations to either properly recompact the backfill during construction or to design and construct the structure so as not to be adversely affected by poorly compacted backfill at the test pit location.

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

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

the drilling. The depth of refusal of the different bit types can provide information as to the strength of the material encountered. Generally two different bit types are used. The 'V' bit is a V shaped steel bit and the 'TC' bit is a tungsten carbide tipped screw type bit.

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

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

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

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

exist between static cone and nearby borehole information.

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

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

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

LOGS

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

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

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

GROUNDWATER

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

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

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

FILL

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

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

LABORATORY TESTING

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

ENGINEERING REPORTS

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

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

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

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

SITE ANOMALIES

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

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

REPRODUCTION OF INFORMATION FOR

CONTRACTUAL PURPOSES

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

REVIEW OF DESIGN

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

Otherwise Soil Surveys Engineering reserves the right to refuse to carry out inspections.

SITE INSPECTION

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

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

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

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

RESPONSIBLE USE OF GEOTECHNICAL INFORMATION

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

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

conservatism which is commensurate with the consequences of the risk of error.

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

APPENDIX B
BOREHOLE RECORDS



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Specialist in Applied Geotechnics

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SOIL SURVEYS

Easting: 507015 Northing: 6964966 RL:
Logger: DA Operator: DA Machine: Scout 2

BOREHOLE RECORD SHEET

Location Number: BH 1

Project Number: 112-13901

Project Name: Subprecinct 3A Redevelopment

Location: Remora Rd., Hamilton

Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 1 OF 3

Drilling Method					Depth	Graphic	Description	Samples and Remarks
TC	VB	RR	NMLC	Casing				
					1.0	0.95	FILL Clayey Gravelly SAND (SP) Medium dense, fine to coarse grained, light grey and brown, fine to medium size gravel, high plasticity fines, dry.	SPT 8, 7, 6 N=13
					1.55		FILL CLAY (CH) Very stiff, high plasticity, grey brown, moist.	
					2.0		NATURAL SAND (SP) Loose to medium dense, fine to coarse grained, brown, dry.	U50 PP=Sand
					2.20		SAND (SP) Loose to medium dense, fine to coarse grained, brown, moist.	
					3.0			
					3.30		SAND (SP) Loose, fine to medium grained, dark grey, some shells, wet.	SPT 4, 6, 6 N=12
					3.80		Sandy CLAY (CH) Soft, high plasticity, dark grey, fine grained sand.	
					4.70			
					5.0		SAND (SP) Very loose, fine to coarse grained, grey and brown.	U50 PP=Sand
					5.10		CLAY (CH) Soft, high plasticity, dark grey, some organics.	SPT 1, 0, 1 N=1
					5.60		SAND (SP) Loose to medium dense, fine to coarse grained, grey and brown.	
					6.0			
					7.0			
					7.10		Gravelly SAND (SP) Very loose, fine to coarse grained, dark grey and brown, fine size gravel, some charcoal.	SPT 6, 8, 7 N=15
					8.0			
					8.40		Sandy GRAVEL (GP) Medium dense, fine to medium size, grey and brown, fine to coarse grained sand.	SPT 1, 1, 0 N=1
					9.0			
					9.10		Clayey SAND (SC) Medium dense, fine to medium grained, brown, high plasticity fines.	SPT 7, 12, 7 N=19
					9.25		Sandy CLAY (CH) Very stiff, high plasticity, light grey and brown mottled, some fine grained sand.	
					9.70			
					10.0			

Comments:

1) Groundwater noted at 2.8m.

Water First Noted Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh
Rock Strength
VW - Very weak
W - Weak
MS - Medium strong
S - Strong
VS - Very strong
RS - Extremely strong

Samples
U50
SPT
Disturbed Sample

Approved: JD
Date: 1/3/12



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Specialist in Applied Geotechnics

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BOREHOLE RECORD SHEET

Location Number: BH 1

Project Number: 112-13901

Project Name: Subprecinct 3A Redevelopment

Location: Remora Rd., Hamilton

Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 2 OF 3

SOIL SURVEYS

Easting: 507015 Northing: 6964966 RL:
Logger: DA Operator: DA Machine: Scout 2

Drilling Method		Depth	Graphic	Description	Samples and Remarks
TC	WB				
		10.40		Clayey SAND (SC) Medium dense, fine grained, light grey and orange brown, high plasticity fines. (continued)	
		11.0		Sandy CLAY (CH) Very stiff, high plasticity, grey and orange brown mottled, fine grained sand.	SPT 3, 5, 6 N=11
		11.10		Sandy CLAY (CH) Hard, high plasticity, light grey red and yellow brown mottled, fine grained sand.	
		12.0			U50 PP=450
		13.0			
		14.0			SPT 12, 15, 17 N=32
		14.30		Silty CLAY (CI-CH) Hard, medium to high plasticity, pale yellow brown, trace of silt.	
		14.70		Silty CLAY (CI-CH) Hard, medium to high plasticity, dark brown, trace of silt, lenses of peat.	
		14.75		Silty CLAY (CL) Hard, low plasticity, brown, trace of silt.	U50 PP=600
		15.0		Silty CLAY (CL) Hard, low plasticity, brown, trace of silt; tending to Mudstone.	
		15.10			
		16.0			
		17.0			SPT 14, 16, 23 N=39
		17.60		MUDSTONE (XW) Very weak, brown.	
		18.0			
		18.05		MUDSTONE (XW) Very weak, brown, with lenses of coal seams.	SPT 30/120mm N=R
		18.60		COAL, black.	
		19.0			
		19.30		SILTSTONE (XW) Weak, light grey, fine to medium grained sand.	SPT 30/70mm N=R
		19.90			
		20.0			

Comments:
1) Groundwater noted at 2.8m.

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh
Rock Strength
VW - Very weak
W - Weak
MS - Medium strong
S - Strong
VS - Very strong
ES - Extremely strong

Samples
U50
SPT
Disturbed Sample

Approved: *JP*
Date: *11/3/12*

Water First Noted Water Steady Level



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Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 3 OF 3

Drilling Method					Depth	Graphic	Description	Samples and Remarks
TC	WB	RR	NNLC	Casing				
					20.60		SILTSTONE (XW) Very weak, light grey, fine to medium grained sand, bands of coal throughout. (continued)	
					21.0			
					22.0			
					22.30		GREYWACKE (SW) Moderately strong, dark grey.	SPT 30/30mm N=R
					23.0			
					24.0			
					25.0		SILTSTONE (XW) Weak, dark grey, trace of coal seams.	SPT 30/120mm N=R
					25.50			
					26.0			
					27.0		SILTSTONE (DW) Weak, light grey.	SPT 30/70mm N=R
					27.00			
					28.0		BOREHOLE BH 1 TERMINATED AT 27.00 m	SPT 30/60mm N=R
					29.0			
					30.0			

Comments:

- 1) Groundwater noted at 2.8m.

Water First Noted Water Steady Level

Weathering Grades
RS - Residual Soil
XW - Extremely weathered
DW - Distinctly weathered
SW - Slightly weathered
FR - Fresh
Rock Strength
VW - Very weak
W - Weak
MS - Medium strong
S - Strong
VS - Very strong
ES - Extremely strong

Samples
U50
SPT
Disturbed Sample

Approved:
Date: 1/3/12



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SOIL SURVEYS

Easting: 507003 Northing: 6964968 RL:
Logger: RH Operator: RH Machine: EVH1750

BOREHOLE RECORD SHEET

Location Number: BH 2

Project Number: 112-13901

Project Name: Subprecinct 3A Redevelopment

Location: Remora Rd., Hamilton

Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 1 OF 1

Drilling Method				Depth	Graphic	Description	DCP Test (blows/100mm)						Samples and Remarks	
TC	WB	RR	NNMLC				Casing	0	6	12	18	24		30
					0.20	FILL Clayey GRAVEL (GC) Loose, fine to medium size, light brown, medium to high plasticity fines, with fine to coarse grained sand, moist.								
					0.5	FILL Sandy GRAVEL (GP) Medium dense, fine to medium size, dark brown, fine to coarse grained sand, with low to medium plasticity fines, moist.								
					0.60									
					1.0	FILL Silty CLAY (CH) Very stiff, high plasticity, dark brown, trace of fine to coarse grained sand and fine to medium size gravel, moist.								
					1.00									
					1.20	NATURAL SAND (SP) Dense to medium dense, fine to coarse grained, dark brown, moist.								
					1.5	SAND (SP) Loose to medium dense, fine to coarse grained, dark brown, trace of fine shells, moist.								
					2.0									
					2.5									
					2.70	SAND (SP) Medium dense, fine to coarse grained, dark brown, trace of fine shells, wet.								
					3.0									
					3.00	BOREHOLE BH 2 TERMINATED AT 3.00 m								
					3.5									
					4.0									
					4.5									
					5.0									

Comments:

1) Groundwater noted at 2.7m.

Weathering Grades

RS - Residual Soil

XW - Extremely weathered

DW - Distinctly weathered

SW - Slightly weathered

FR - Fresh

Rock Strength

VW - Very weak

W - Weak

MS - Medium strong

S - Strong

VS - Very strong

ES - Extremely strong

Samples

U50

SPT

Disturbed Sample

Approved: *[Signature]*

Date: 1/3/12

Water First Noted Water Steady Level



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SOIL SURVEYS

Easting: 507055 Northing: 6964904 RL:
Logger: RH Operator: RH Machine: EVH1750

BOREHOLE RECORD SHEET

Location Number: BH 3

Project Number: 112-13901

Project Name: Subprecinct 3A Redevelopment

Location: Remora Rd., Hamilton

Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 1 OF 1

Drilling Method		Depth	Graphic	Description	DCP Test (blows/100mm)						Samples and Remarks		
TC	WB				RR	MMLC	Casing	0	6	12		18	24
		0.04		Bitumen									
		0.12		FILL Sandy GRAVEL (GP) Dense, fine to medium size, dark brown, fine to coarse grained sand, moist.									
		0.40		FILL Sandy GRAVEL (GP) Dense, fine to medium size, light brown, fine to coarse grained sand, moist.									
		0.5		FILL Silty CLAY (CH) Stiff, high plasticity, dark brown mottled dark grey, trace of fine to coarse grained sand, trace of fine to medium size gravel, moist.									
		0.70		FILL Silty CLAY (CH) Stiff, high plasticity, dark brown mottled dark grey, trace of fine to coarse grained sand, trace of fine to medium size gravel and organics, moist.									
		1.0											
		1.30		NATURAL Silty CLAY (CH) Firm, high plasticity, dark grey, trace of fine size gravel, moist.									
		1.5											
		2.0											
		2.10		Silty CLAY (CH) Soft, high plasticity, dark grey, trace of fine size gravel, moist.									
		2.5											
		2.50		Silty CLAY (CH) Very soft, high plasticity, dark grey, trace of fine size gravel, with fine to medium grained sand, wet.									
		3.0											
		3.00		BOREHOLE BH 3 TERMINATED AT 3.00 m									
		3.5											
		4.0											
		4.5											
		5.0											

Comments:

1) Groundwater noted at 2.5m. 2) DCP Refusal at 0.2m.

Weathering Grades

RS - Residual Soil

XW - Extremely weathered

DW - Distinctly weathered

SW - Slightly weathered

FR - Fresh

Rock Strength

VW - Very weak

W - Weak

MS - Medium strong

S - Strong

VS - Very strong

ES - Extremely strong

Samples

U50

SPT

Disturbed Sample

Approved: *JD*

Date: *4/3/12*

Water First Noted Water Steady Level

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Location Number: BH 4

Project Number: 112-13901

Project Name: Subprecinct 3A Redevelopment

Location: Remora Rd., Hamilton

Client: Shayher Developments Pty. Ltd.

Date: 01/02/2012

Page: 1 OF 1

Easting: 507052

Northings: 6964825

RL:

Logger: RH

Operator: RH

Machine: EVH1750

SOIL SURVEYS 00 LIBRARY.GLB Log SOIL SURVEY AUGER LOG 112-13001 GPJ <<DrawingFile>> 02/03/2012 09:55 8.2.856 Developed by Dintzel



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BOREHOLE RECORD SHEET

Borehole Number : 31

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 18/11/2006

Page : 1

Easting : 507009 Northing : 6964810 RL : 2.10
Logger : RH Driller : RH Drilling Rig : Jacro105

Drilling Method					Depth	Graphic	Description	DCP Test (blows/100mm)					Samples and Remarks
V	TC	WB	RR	NALC				5	10	15	20	25	
					0.07		Bitumen						D
					0.50		FILL Silty Sandy GRAVEL (GP) Dense, fine to coarse size, dark brown, fine to coarse grained sand, moist.						
					0.70		FILL Gravelly Sandy CLAY (CI-CH) Very stiff, high plasticity, dark brown, fine to coarse grained sand, fine size gravel, moist.						
					1.0		NATURAL CLAY (CH) Firm to stiff, high plasticity, dark brown, with fine to medium grained sand, trace of fine size gravel, moist.						D
					1.75		CLAY (CH) Very soft to soft, high plasticity, dark grey, with fine grained sand, trace of root fibres, moist.						
					2.0								
					2.50		Silty SAND (SM) Medium dense to dense, fine to medium grained, dark brown, wet.						
					3.0								
					3.00		Borehole Terminated 3.00m						
					4.0								
					5.0								

COMMENTS

1) Groundwater noted at 2.5m. 2) ASS 'D' samples from 0.0m to 3.0m at 0.25m depth intervals.

▼ Water First Noted ▼ Water Steady Level

Approved :

Date : 12/11/07

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BOREHOLE RECORD SHEET

Borehole Number : 32

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client: Bornhorst & Ward

Date : 18/11/2006

Page : 1

Easting : 506910 Northing : 6964691 RL : 1.20

Logger: RH Driller: RH Drilling Rig: Jacro105

Drilling Method						Depth	Graphic	Description	DCP Test (blows/100mm)					Samples and Remarks	
V	TC	WB	RR	NALC	Casing				5	10	15	20	25		
						0.08		<u>Bitumen</u> FILL Silty Sandy GRAVEL (GP) Dense to very dense, fine to coarse size, dark brown, fine to coarse grained sand, moist.							D
						0.70		FILL Silty SAND (SM) Medium dense, fine to coarse grained, light brown, moist.							D
						1.20		FILL Silty SAND (SM) Medium dense, fine to coarse grained, light brown, moist to dry.							D
						2.0									
						2.00		Borehole Terminated	2.00m						

COMMENTS

1) Groundwater not observed. 2) DCP Refusal at 0.5m. 2) ASS 'D' samples from 0.0m to 2.0m at 0.25m depth intervals.

▼ Water First Noted ▽ Water Steady Level

Approved :

Date :

ISSUE No. 1.1 08/10/97 RS007A



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BOREHOLE RECORD SHEET

Borehole Number : **32A**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 22/12/2006

Page : 1

Easting : 506910 Northing : 6964691 RL : 1.20

Logger : DA Driller : DA Drilling Rig : J500

Drilling Method					Depth	Graphic	Description	Samples and Remarks
V	TC	WB	RR	NALC				
					0.02		Bitumen FILL Sandy GRAVEL (GP) Loose to medium dense, fine to coarse size, yellow brown, fine to coarse grained sand, dry.	
					0.90		FILL Sandy GRAVEL (GP) Loose, fine to coarse size, grey, fine to coarse grained sand, dry.	
					1.10		FILL SAND (SP) Medium dense, fine to coarse grained, yellow brown and grey, dry to moist.	
					2.0			SPT 5,6,7 N=13
					2.80		NATURAL SAND (SP) Loose, fine to coarse grained, grey and brown, moist to wet.	SPT 4,3,4 N=7
					5.00		SAND (SP) Loose, fine to coarse grained, grey and brown, trace of charcoal, wet.	
					6.0			SPT 3,3,3 N=6
					6.90		Clayey SAND (SC) Very loose, fine to medium grained, dark grey, high plasticity fines, wet.	
					7.40		SAND (SP) Loose to medium dense, fine to coarse grained, grey and brown, trace of charcoal, with bands of very loose dark grey clayey sand, wet.	
					8.0			
					9.0			SPT 4,5,5 N=10
					10.0			

COMMENTS

1) Groundwater noted at 3.4m.

Approved :

Date : 27/1/07

▼ Water First Noted ▼ Water Steady Level

ISSUE No. 1.1 08/10/97 RS007A



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BOREHOLE RECORD SHEET

Borehole Number : **32A**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 22/12/2006

Page : 2

Easting : 506910 Northing : 6964691 RL : 1.20

Logger : DA Driller : DA Drilling Rig : J500

Drilling Method						Depth	Graphic	Description	Samples and Remarks
V	PC	WB	PK	M&C	Casing				
						11.0			
						11.40		Clayey SAND (SC) Very loose, fine to medium grained, dark grey, high plasticity fines, some shells, wet.	SPT 1,0,0 N=0
						12.0			
						13.0			
						14.0			
						14.70		Sandy CLAY (CH) Soft to firm, high plasticity, dark grey, fine to medium grained sand, very moist.	
						15.0			
						15.20		Gravelly SAND (SC) Loose, fine to coarse grained, dark grey, high plasticity fines, wet.	USO
						16.0			
						17.0			
						17.00		Clayey SAND (SC) Loose, fine to coarse grained, dark grey, high plasticity fines, wet.	SPT 4,3,4 N=7
						18.0			
						19.0			
						20.0			

COMMENTS

1) Groundwater noted at 3.4m.

Approved :

Date : 27/12/07

ISSUE No. 1.1 08/10/97 RS007B



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BOREHOLE RECORD SHEET

Borehole Number : **32A**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 22/12/2006

Page : 3

Easting : 506910 Northing : 6964691 RL : 1.20

Logger : DA Driller : DA Drilling Rig : J500

Drilling Method					Depth	Graphic	Description	Samples and Remarks
V	TC	WB	RR	MLC				
					21.0			
					21.20		SAND (SP) Medium dense, fine to coarse grained, grey and brown, wet.	SPT 1,3,7 N=10
					22.0			
					23.0			
					23.00		Sandy GRAVEL (GP) Medium dense, fine to coarse size, grey, fine to coarse grained sand.	SPT 7,7,7 N=14
					24.0			
					23.90		Sandy GRAVEL (GP) Dense, fine to coarse size, grey, fine to coarse grained sand.	
					25.0			
					25.00		Sandy GRAVEL (GP) Dense, fine to coarse size, grey, fine to coarse grained sand, cobbles throughout.	
					25.30		Sandy GRAVEL (GP) Medium dense, fine to coarse size, grey, fine to coarse grained sand.	SPT 5,5,7 N=12
					26.0			
					26.00		Sandy GRAVEL (GP) Dense, fine to coarse size, grey, fine to coarse grained sand, cobbles throughout.	
					27.0			
					28.0			
					29.0			
					29.40		Sandy GRAVEL (GP) Medium dense, fine to coarse size, grey, fine to coarse grained sand, with bands of medium dense gravelly sand.	SPT 20,22,19 N=41
					30.0			

COMMENTS

- 1) Groundwater noted at 3.4m.

Approved :

Date : 22/12/2006

ISSUE No. 1.1 08/10/97 RS007C



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BOREHOLE RECORD SHEET

Borehole Number : **32A**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 22/12/2006

Page : 4

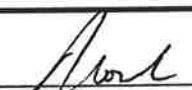
Easting : 506910 Northing : 6964691 RL : 1.20

Logger : DA Driller : DA Drilling Rig : J500

Drilling Method					Depth	Graphic	Description	Samples and Remarks
V	TC	WB	RR	NALC				
					30.80		Sandy GRAVEL (GP) Dense, fine to coarse size, grey, fine to coarse grained sand, cobbles throughout.	7,8,9 SPT N=17
					31.20		Sandy CLAY (CH) Very stiff, high plasticity	
					31.70		Sandy GRAVEL (GP) Dense, fine to coarse size, grey, fine to coarse grained sand, cobbles throughout.	
					32.20		Sandy GRAVEL (GP) Very dense, fine to coarse size, grey and brown, fine to coarse grained sand, cobbles throughout.	
					33.0			SPT 30/130mm
					34.0			
					34.30		MUDSTONE (DW) Weak, grey, some thin coal seams, carbonaceous.	
					35.0			
					35.50		Borehole Terminated 35.50m	SPT 30/80mm
					36.0			
					37.0			
					38.0			
					39.0			
					40.0			

COMMENTS

1) Groundwater noted at 3.4m.

Approved : 

Date : 22/12/07

ISSUE No. 1.1 08/10/97 RS007A



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BOREHOLE RECORD SHEET

Borehole Number : **33**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Easting : 507084

Northing : 6964667

RL :

Location : Eagle Farm

Logger : RH

Driller : RH

Drilling Rig : Jacro105

Client : Bornhorst & Ward

Date : 18/11/2006

Page : 1

Drilling Method					Depth	Graphic	Description	DCP Test (blows/100mm)					Samples and Remarks
V	TC	WB	PR	ANLC				5	10	15	20	25	
					0.05		Binumen						D
					0.31		FILL Silty Sandy GRAVEL (GP) Very dense, fine to coarse size, dark brown, fine to coarse grained sand, moist.						
							FILL SAND (SP) Medium dense, fine to coarse grained, light brown, moist.						
					1.0								
					2.0								
					3.0								
					3.00		Borehole Terminated 3.00m						
					4.0								
					5.0								

COMMENTS

1) Groundwater not observed. 2) ASS 'D' samples from 0.0m to 3.0m at 0.25m depth intervals.

▼ Water First Noted ▼ Water Steady Level

Approved :

Date : 12/12/07

ISSUE No. 1.1 08/10/97 RS007A



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BOREHOLE RECORD SHEET

Borehole Number : **34**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 18/11/2006

Page : 1

Easting : 506930

Northing : 6964804

RL :

Logger : RH

Driller : RH

Drilling Rig : Jacro105

Drilling Method					Depth	Graphic	Description	DCP Test (blows/100mm)					Samples and Remarks
V	TC	WB	RR	ANAL				5	10	15	20	25	
					0.06		Bitumen						D
					0.40		FILL Silty Sandy GRAVEL (GP) Very dense, fine to coarse size, dark brown, fine to coarse grained sand, moist.						
							FILL Silty SAND (SM) Medium dense, fine to coarse grained, light brown, with fine size gravel, moist.						
					1.0								
					2.0								
					2.00		Borehole Terminated						
					3.0								
					4.0								
					5.0								

COMMENTS

1) Groundwater not observed. 2) ASS 'D' samples from 0.0m to 2.0m at 0.25m depth intervals.

▼ Water First Noted ▼ Water Steady Level

Approved :

Date : 12/11/07

ISSUE No. 1.1 08/10/97 RS007A



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BOREHOLE RECORD SHEET

Borehole Number : **35**

Project Number : 106-9336

Project Name : Northshore Hamilton Development

Location : Eagle Farm

Client : Bornhorst & Ward

Date : 18/11/2006

Page : 1

Easting : 507086

Northing : 6964755

RL :

Logger : RH

Driller : RH

Drilling Rig : Jacro105

Drilling Method					Depth	Graphic	Description	DCP Test (blows/100mm)					Samples and Remarks
TD	WB	RR	NALC	Casing				5	10	15	20	25	
					0.05		Bitumen						D
					0.30		FILL Silty Sandy GRAVEL (GP) Very dense, fine to coarse size, dark brown, fine to coarse grained sand, moist.						
							FILL Silty Sandy GRAVEL (GP) Dense to very dense, fine to medium size, light brown, fine to coarse grained sand, with low to medium plasticity fines, moist.						
					1.0								D
					2.0								
					2.00		Borehole Terminated 2.00m						
					3.0								
					4.0								
					5.0								

COMMENTS

1) Groundwater not observed. 2) DCP Refusal at 0.4m and 1.6m. 3) ASS 'D' samples from 0.0m to 2.0m at 0.25m depth intervals.

▼ Water First Noted ▼ Water Steady Level

Approved :

Date : 27/11/07

ISSUE No. 1.1 08/10/97 RS007A



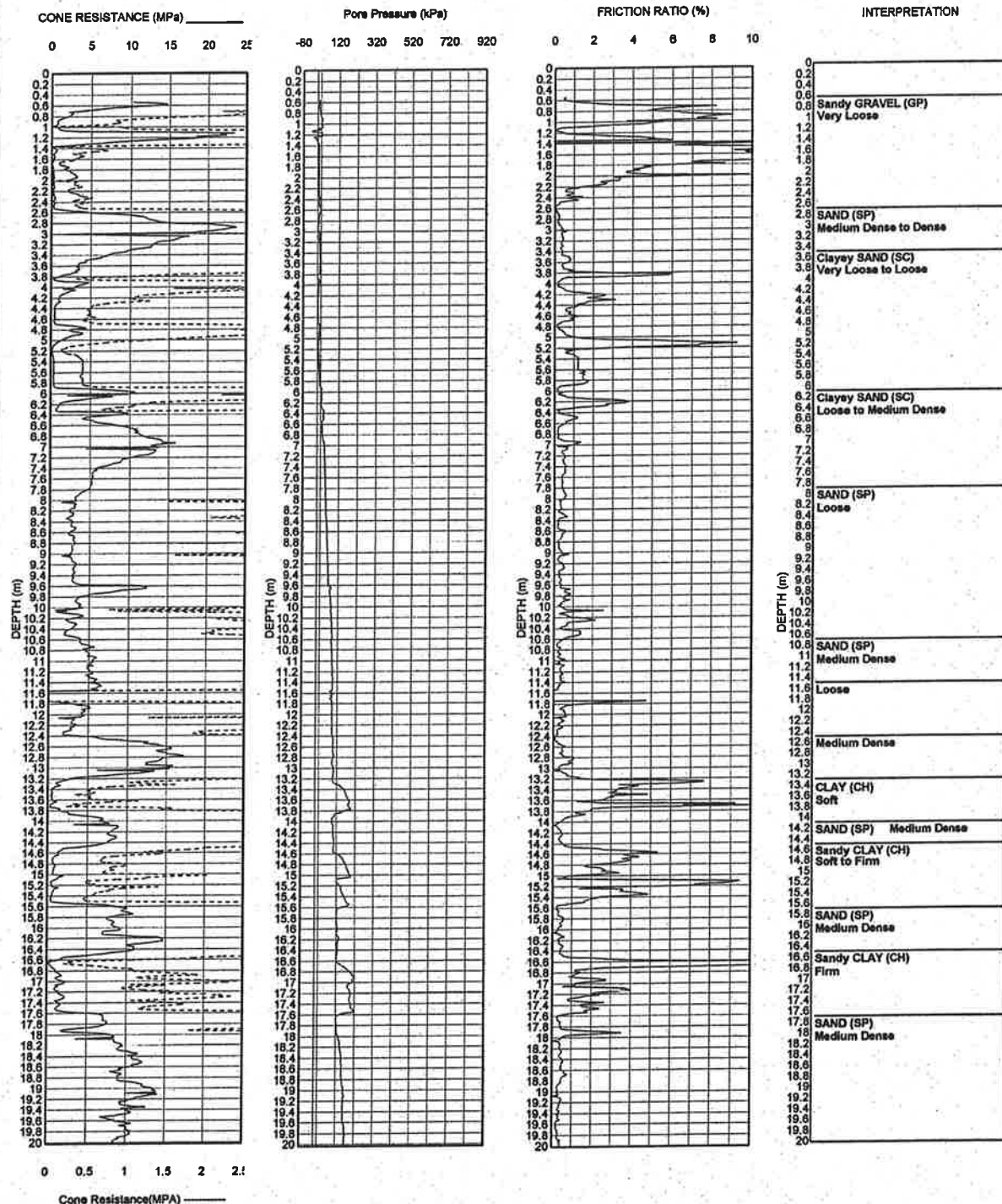
Soll Surveys Engineering Pty Ltd
A.C.N. 054 043 631

Cone Penetrometer Test Record

JOB No - 106-9336
CLIENT - Bornhorst & Ward
PROJECT - Northshore Hamilton
LOCATION - Eagle Farm

CONE NO. - CPT31
SURFACE R.L. - 2.1
CO-ORDINATES - 507009; 6964810
DATE - 02/01/07

PAGE 1 OF 2



RIG - HE500

SUPERVISOR - Jeff Brecknell
CONE TYPE - 10 sq cm Geotech

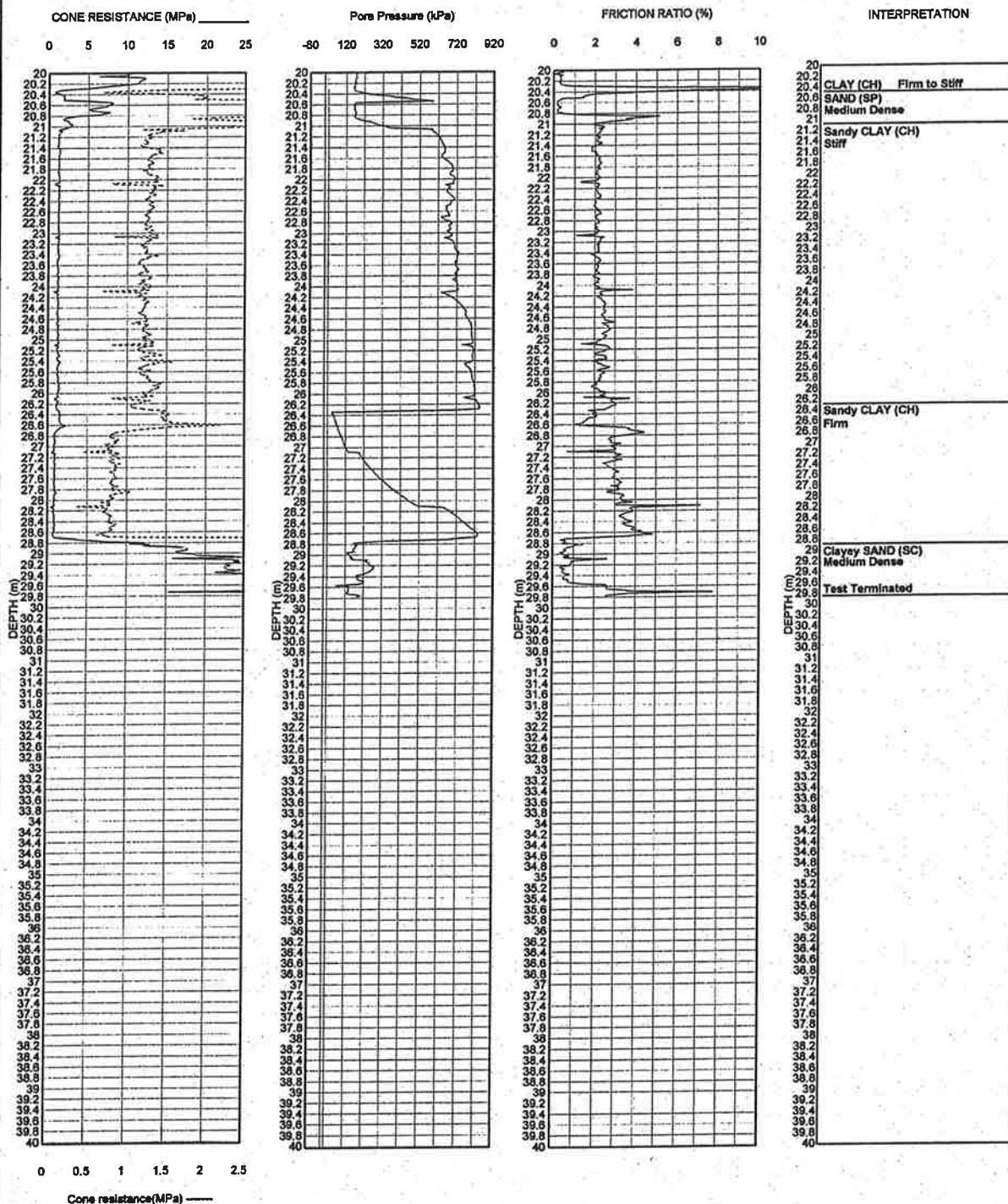


Cone Penetrometer Test Record

JOB No - 106-9336
CLIENT - Bomhorst & Ward
PROJECT - Northshore Hamilton
Soil Surveys Engineering Pty Ltd LOCATION - Eagle Farm
A.C.N. 054 043 631

CONE NO. - CPT31
SURFACE R.L. - 2.1
CO-ORDINATES - 507009; 6964810
DATE - 02/01/07

PAGE 2 OF 2



RIG - HE500

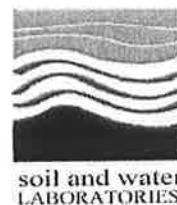
SUPERVISOR - Jeff Brecknell
CONE TYPE - 10 sq cm Geotech

APPENDIX C

LABORATORY TEST RESULTS

SOIL & WATER
LABORATORIES PTY LTD

Unit 8, 140 Millaroo Drive
HELENSVALE QLD 4212
PHONE 07 55026795
FAX 07 55026724



Emerson Class Number & pH Report

Client :	SOIL SURVEYS ENGINEERING PTY LTD - MILTON	Report Number:	SL37553,37554,37557,37558
Client Address :	LEVEL 2, 19 FINCHLEY ST MILTON QLD 4064	Report Date:	09/02/2012
Job Number :	1-13901	Order Number:	
Project :	SUB-PRECINCT 3A	Test Method:	AS1289.3.8.1
Location :	HAMILTON		

Page 1 of 1

Lab No :	SL37553	SL37554	SL37557	SL37558
ID No :	-	-	-	-
Lot No :	-	-	-	-
Item No :	-	-	-	-
Sampling Method :	AS SUPPLIED	AS SUPPLIED	AS SUPPLIED	AS SUPPLIED
Date Sampled :	2/2/2012	2/2/2012	2/2/2012	2/2/2012
Date Tested :	9/2/2012	9/2/2012	9/2/2012	9/2/2012
Material Source :	BORE HOLE	BORE HOLE	BORE HOLE	BORE HOLE
For Use As :	UNKNOWN	UNKNOWN	UNKNOWN	UNKNOWN
Sample Location :	Allotment No : Offset : Location :BOREHOLE 2 Depth:0.0-0.2m	Allotment No : Offset : Location :BOREHOLE 2 Depth:0.2-0.6m	Allotment No : Offset : Location :BOREHOLE 3 Depth:0.4-1.0m	Allotment No : Offset : Location :BOREHOLE 4 Depth:0.4-0.7m
Soil Description :	SILTY SANDY CLAY(CH) BROWN, SOME GRAVEL	SANDY GRAVELLY CLAY(CH) BROWN	SANDY GRAVELLY CLAY(CH) GREY	SILTY SANDY CLAY(CH) BROWN, SOME GRAVEL
Type of Water Used :	Distilled Water	Distilled Water	Distilled Water	Distilled Water
Temperature of Water (°C) :	21	21	21	21
Emerson Class Number :	Class 4	Class 4	Class 4	Class 2
pH:	6.96	7.93	4.26	6.65
Conductivity (mS/cm):	0.53	0.76	2.96	0.68

Remarks :

Conductivity and pH are not covered by this Laboratories current Scope of Registration.



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APPROVED SIGNATORY

Craig Ferguson

CRAIG FERGUSON HANNAH
NATA Accred No:15301

FORM NUMBER

EMC-REP-4

Shrink Swell Index Report

Client:	SOIL SURVEYS ENGINEERING PTY LTD - MILTON	Report Number:	SL37556
Client Address:	LEVEL 2, 19 FINCHLEY ST MILTON QLD 4064	Report Date:	09/02/2012
Job Number:	1-13901	Order Number:	
Project:	SUB-PRECINCT 3A	Test Method :	AS1289.7.1.1
Location	, HAMILTON	Sample Location	
Lab No:	SL37556	Allotment No :	
Date Sampled:	02/02/2012	Offset :	
Date Tested:	06/02/2012	Location :BOREHOLE 3	
Sampled By:	CLIENT	Depth:0.6-0.85m	
Sample Method:	AS SUPPLIED	Lot Number:	-
Material Source:	BORE HOLE	Item Number :	-
For Use As:	UNKNOWN		
Remarks:	-		

Page 1 of 1

Shrinkage Moisture Content (%) :	40.5	Swell MC Before(%):	39.4
Shrinkage (%) :	6.8	Swell MC After(%):	39.5
Unit Weight (t/m ³) :	1.81	PP Before (kPa):	
Swell (%) :	0.2	PP After (kPa):	
Shrink Swell Index (Iss %):	3.8		
Visual Classification :	SILTY CLAY(CH) DARK BROWN		
Inert Material Estimate(%):	-		
Cracking :	MODERATE		
Crumbling :	-		

 WORLD RECOGNISED ACCREDITATION	This document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025. This document shall not be reproduced, except in full.	APPROVED SIGNATORY	FORM NUMBER
		 CRAIG FERGUSON HANNAH NATA Accred No:15301	REP SS-1-28

SOIL & WATER
LABORATORIES PTY LTD

Unit 8, 140 Millaroo Drive
HELENSVALE QLD 4212
PHONE 07 55026795
FAX 07 55026724



soil and water
LABORATORIES

California Bearing Ratio Report (1 Point)

Client:	SOIL SURVEYS ENGINEERING PTY LTD - MILTON	Report Number:	SL37555
Client Address:	LEVEL 2, 19 FINCHLEY ST MILTON QLD 4064	Report Date:	13/02/2012
Job Number:	1-13901	Order Number:	Page 1 of 1
Project:	SUB-PRECINCT 3A		
Location:	, HAMILTON		
Lab No:	SL37555	Sample Location	
Date Sampled:	02/02/2012	Allotment No :	
Date Tested:	11/02/2012	Offset :	
Sampled By:	CLIENT	Location :BOREHOLE 3	
Sample Method:	AS SUPPLIED	Depth:0.4-1.0m	
Material Source:	BORE HOLE	Test Method :	AS1289.6.1.1
For Use As:	UNKNOWN	Lot Number:	-
Remarks:	-	Item Number :	-

Maximum Dry Density - MDD (t/m ³) :	1.454
Optimum Moisture Content - OMC (%) :	28.7
Compactive Effort :	Standard
Nominated % Maximum Dry Density Compaction :	98
Nominated % Optimum Moisture Content Compaction :	100
Achieved Dry Density before Soak (t/m ³) :	1.408
Achieved Percentage of Maximum Dry Density (%) :	97
Achieved Moisture Content (%) :	28.7
Achieved Percentage of Optimum Moisture Content (%) :	100
Test Condition (Soaked/Unsoaked) / Soaking Period (Days) :	Soaked / 4 days
Swell (%) / Surcharge (kg):	2.1 / 4.5 kg
Dry Density after Soak (t/m ³) :	1.379
Moisture Content after Soak (%) :	33.5
Density Ratio after Soak (%) :	95
Field Moisture Content (%) :	39.7
Moisture Content (Top) after Penetration (%) :	35.5
Moisture Content (Total) after Penetration (%) :	30.9
CBR 2.5mm (%) :	3.5
CBR 5.0mm (%) :	3.0
Minimum Specified CBR Value (%) :	-
CBR Value (%) :	3.5

Soil Description : **SANDY CLAY WITH SOME GRAVEL (CH) BROWN**



This Laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its scope of accreditation. This document shall not be reproduced, except in full.

Approved Signatory

RODNEY LUCAS
NATA Accred No:15301

Form Number
CBR_1_3-1-36



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, Level 2, 19 Finchley Street Milton, Brisbane Qld. 4064.

Hamilton
111-13901

Reference Number: 12 - 13901

Certificate Number: 202123

Date Received: 03-Feb-12

Date Tested: 03-Feb-12

Date Issued: 06-Feb-12

Sample Number	Borehole/ Location	Identification		Reaction to		pH (1:5 susp.)	
		From	To	H2O2	HCl	H2O	
						pHf	pHox
1	BH - 2	0.00	0.25	Nil	Nil	6.1	4.7
2	BH - 2	0.25	0.50	Moderate	Nil	7.6	5.9
3	BH - 2	0.50	0.75	Moderate	Nil	7.6	5.9
4	BH - 2	0.75	1.00	Moderate	Nil	6.9	5.7
5	BH - 2	1.00	1.25	Moderate	Nil	7.6	6.3
6	BH - 2	1.25	1.50	Moderate	Nil	7.5	6.4
7	BH - 2	1.50	1.75	High	Nil	8.6	7.0
8	BH - 2	1.75	2.00	Moderate	Low	8.7	7.8
9	BH - 2	2.00	2.25	Moderate	Low	8.7	7.8
10	BH - 2	2.25	2.50	Moderate	Low	8.7	7.8
11	BH - 2	2.50	2.75	Moderate	Low	8.5	7.2
12	BH - 2	2.75	3.00	Low	Nil	8.3	7.4
13	BH - 3	0.04	0.25	Low	High	9.6	8.1
14	BH - 3	0.25	0.50	Low	Moderate	7.1	6.7
15	BH - 3	0.50	0.75	Moderate	Nil	4.3	2.3
16	BH - 3	0.75	1.00	High	Nil	4.3	1.7
17	BH - 3	1.00	1.25	Very High	Nil	5.4	1.8
18	BH - 3	1.25	1.50	Very High	Nil	5.4	1.9
19	BH - 3	1.50	1.75	Very High	Nil	7.0	3.7
20	BH - 3	1.75	2.00	High	Nil	7.2	4.2
21	BH - 3	2.00	2.25	High	Nil	7.9	5.4
22	BH - 3	2.25	2.50	Moderate	Nil	8.0	5.9
23	BH - 3	2.50	2.75	Moderate	Nil	8.2	6.2
24	BH - 3	2.75	3.00	Moderate	Low	8.3	6.5
25	BH - 4	0.00	0.25	Moderate	Moderate	7.8	6.8
26	BH - 4	0.25	0.50	Very High	Nil	7.9	6.5
27	BH - 4	0.50	0.75	Very High	Nil	7.8	6.8
28	BH - 4	0.75	1.00	High	Nil	7.5	6.2
29	BH - 4	1.00	1.25	High	Nil	7.5	5.7
30	BH - 4	1.25	1.50	High	Nil	7.4	5.1
31	BH - 4	1.50	1.75	High	Nil	7.8	6.4
32	BH - 4	1.75	2.00	High	Nil	8.0	5.8
33	BH - 4	2.00	2.25	High	Nil	8.2	6.7
34	BH - 4	2.25	2.50	High	Nil	8.3	6.6
35	BH - 4	2.50	2.75	High	Nil	8.5	6.6
36	BH - 4	2.75	3.00	Moderate	Nil	8.4	6.6

Signed: V. G. R. for and on behalf of Soil and Water Laboratories P/L
Vaughan Pattinson - Senior Laboratory Technician

Page:

1 of 1

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



Soil & Water Laboratories P/L

19 Finchley Street, Milton, QLD, 4064
Phone: (07) 3369 6668; Fax: (07) 3503 9063



Chromium Reducible Sulphur, Titratable Actual Acidity & Retained Acidity Test Results

For Soil Surveys Engineering Pty Ltd, Level 2, 19 Finchley Street Milton, Brisbane Qld, 4064.

Page: 3 of 5

Certificate Number: 101238

Ref. Number: 12 - 9336

Date: 15-Jan-07

Eagle Farm

Project Number: 106-9336

This Document is issued in accordance with NATA's accreditation requirements

Accredited for compliance with ISO 17025

Sample Number	Borehole/ Testpit	Identification/ from		Excluded Material		Moisture as received (BSOC)	Inlt. pH	a - TAA	TAA	S - HCl	S - KCl	S - NAS	a - S - NAS	SCr	
		to	(m)	Shell	Gravel									a - 20J	a - 22B
				(% S.W.)		252	23A	a - 23F	23F	23B	23C	20J	a - 20J	22B	a - 22B
							(1M KCl)	(% S Eq.)	(mol. H+/l)		(% S)		(mol. H+/l)	(% S)	(mol. H+/l)
151	31	2.50	2.75	0.0	0.0	19.1	7.81	0.00	0	n/r	n/r	n/r	n/r	0.03	22
152	31	2.75	3.00	0.0	0.0	16.2	7.31	0.00	0	n/r	n/r	n/r	n/r	0.02	12
156	32	0.70	1.00	0.0	0.0	2.3	7.20	0.00	0	n/r	n/r	n/r	n/r	0.01	3
162	33	0.50	0.75	0.0	0.0	4.3	7.20	0.00	0	n/r	n/r	n/r	n/r	0.00	1
165	33	1.25	1.50	0.0	0.0	3.0	6.96	0.00	0	n/r	n/r	n/r	n/r	0.00	2
169	33	2.25	2.50	0.0	0.0	4.8	6.79	0.00	0	n/r	n/r	n/r	n/r	0.00	1
178	34	1.50	1.75	0.0	0.0	6.0	7.23	0.00	0	n/r	n/r	n/r	n/r	0.00	0
182	35	0.50	0.75	0.0	0.0	8.0	4.19	0.05	33	0.03	0.02	0.01	4	0.00	0
193	8	1.25	1.50	0.0	0.0	6.3	6.87	0.00	0	n/r	n/r	n/r	n/r	0.01	3
199	4	0.75	1.00	0.0	0.0	12.0	7.02	0.00	0	n/r	n/r	n/r	n/r	0.00	1
202	4	1.50	1.75	0.0	0.0	18.0	4.35	0.03	21	0.03	0.02	0.01	4	0.01	5
205	7	0.20	0.60	0.0	0.0	3.2	6.58	0.00	0	n/r	n/r	n/r	n/r	0.02	10
211	7	1.75	2.00	0.0	0.0	46.8	4.35	0.05	30	0.00	0.00	0.00	0	0.02	15
212	7	2.00	2.25	0.0	0.0	58.9	5.10	0.02	15	n/r	n/r	n/r	n/r	0.89	557
214	7	2.50	2.75	0.0	0.0	62.2	7.85	0.00	0	n/r	n/r	n/r	n/r	1.02	637
218	9	0.50	0.75	0.0	0.0	5.0	7.98	0.00	0	n/r	n/r	n/r	n/r	0.01	3
224	15	0.60	0.75	0.0	0.0	-6.5	5.22	0.01	9	n/r	n/r	n/r	n/r	0.02	13
230	25	1.00	1.20	0.0	0.0	55.9	6.25	0.00	0	n/r	n/r	n/r	n/r	0.39	244
237	25	2.75	3.00	0.0	0.0	64.4	7.92	0.00	0	n/r	n/r	n/r	n/r	0.31	196
239	39	0.12	0.50	0.0	0.0	4.5	8.94	0.00	0	n/r	n/r	n/r	n/r	0.01	7

Tests Completed: 15-Jan-07

Samples Received: 08-Dec-06

Signed:  for and on behalf of Soil and Water Laboratories P/L
Trevor Nelson - Chemical Laboratory Manager - Soils and Waters

- 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 (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'.
- Samples supplied by others
- Samples tested in 'as received' condition
- The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
- NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



Soil & Water Laboratories P/L

19 Finchley Street, Milton, QLD. 4064
Phone: (07) 3369 6668; Fax: (07) 3503 9063



Chromium Reducible Sulphur, Titratable Actual Acidity & Retained Acidity Test Results

For Soil Surveys Engineering Pty Ltd, Level 2, 19 Finchley Street Milton, Brisbane Qld. 4064.

Page: 2 of 5

Certificate Number: 101238

Ref. Number: 12 - 9336

Date: 15-Jan-07

Eagle Farm

Project Number: 106-9336

This Document is issued in accordance with NATA's accreditation requirements

Accredited for compliance with ISO AEC 17025

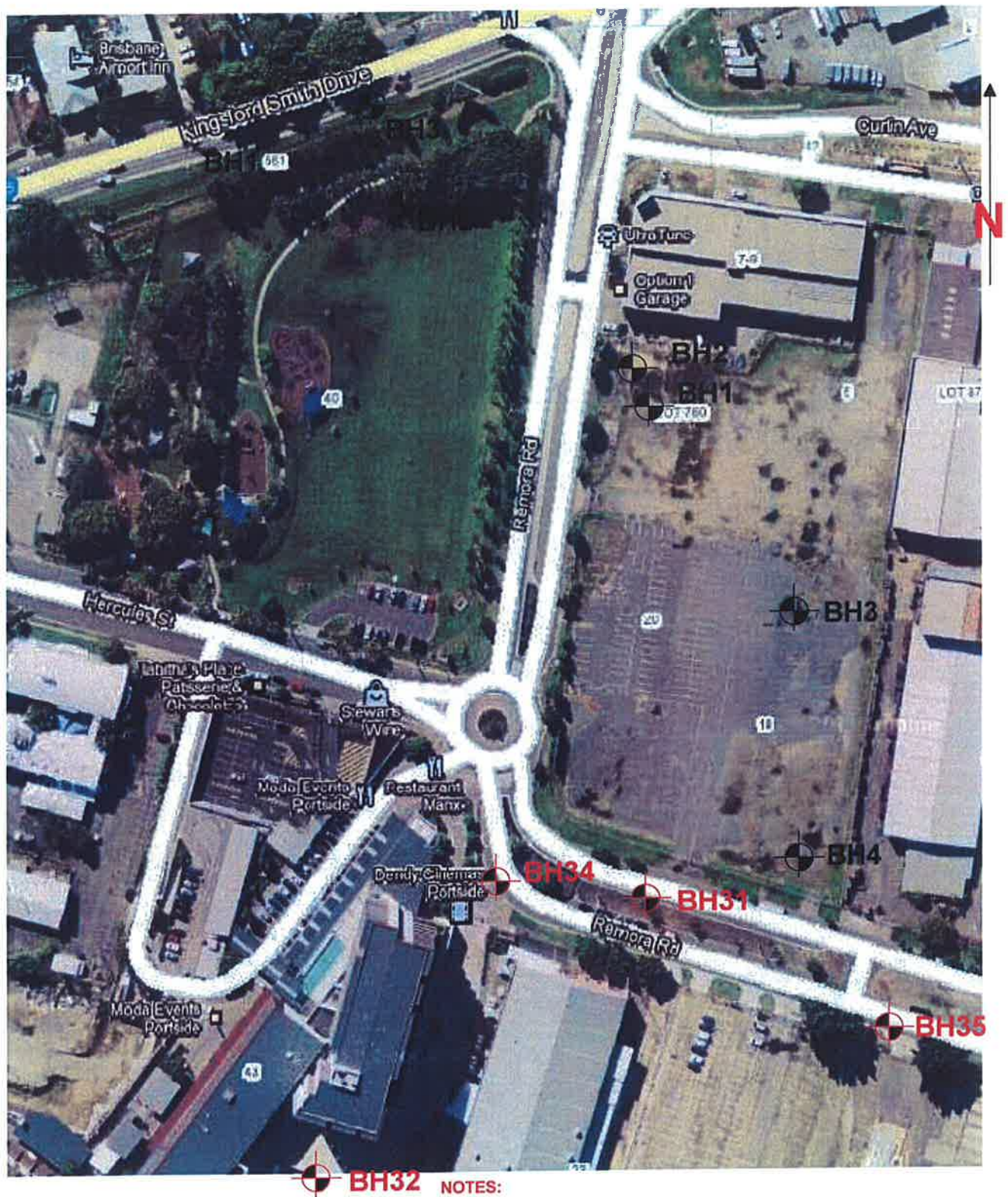
Sample Number	Identification/			Excluded Material		Moisture as received (R50C)	Init. pH	s - TAA	TAA	S - HCl	B - KCl	S - NAS	s - S - NAS	SDr								
	Borehole/ Test pit	from	to	Shell	Gravel									Z3A	s - Z3F	Z3F	Z3B	Z3C	Z3J	s - Z3J	Z3B	s - Z3B
		(m)			(%d.w.)	(1M KCl)	(%S Eq.)	(mol. H+/g)		(% S)		(mol. H+/g)	(% S)	(mol. H+/g)								
75	12	0.75	1.00	0.0	0.0	7.4	8.41	0.00	0	n/r	n/r	n/r	n/r	0.00	3							
78	12	1.50	1.75	0.0	0.0	23.6	7.42	0.00	0	n/r	n/r	n/r	n/r	0.01	3							
82	13	0.50	0.75	0.0	0.0	6.0	6.80	0.00	0	n/r	n/r	n/r	n/r	0.00	1							
84	14	0.50	0.75	0.0	0.0	11.3	6.80	0.00	0	n/r	n/r	n/r	n/r	0.00	2							
96	14	1.00	1.25	0.0	0.0	26.3	7.00	0.00	0	n/r	n/r	n/r	n/r	0.00	2							
99	14	1.75	2.00	0.0	0.0	16.3	8.07	0.00	0	n/r	n/r	n/r	n/r	0.00	0							
105	26	1.20	1.60	0.0	0.0	2.7	7.20	0.00	0	n/r	n/r	n/r	n/r	0.01	4							
108	27	0.50	0.75	0.0	0.0	10.3	4.26	0.04	25	0.03	0.03	0.00	0	0.01	3							
111	27	1.00	1.25	0.0	0.0	8.3	4.59	0.02	15	n/r	n/r	n/r	n/r	0.00	1							
113	27	1.50	1.75	0.0	0.0	11.6	3.76	0.08	52	0.00	0.00	0.00	0	0.00	3							
117	28	0.50	0.75	0.0	0.0	10.4	4.51	0.02	12	n/r	n/r	n/r	n/r	0.01	5							
119	28	1.25	1.50	0.0	0.0	39.0	6.72	0.00	0	n/r	n/r	n/r	n/r	0.02	15							
122	28	2.00	2.25	0.0	0.0	16.2	6.10	0.00	3	n/r	n/r	n/r	n/r	0.01	8							
124	28	2.50	2.75	0.0	0.0	16.7	6.32	0.00	2	n/r	n/r	n/r	n/r	0.01	3							
128	29	0.55	0.75	0.0	0.0	30.7	7.18	0.00	0	n/r	n/r	n/r	n/r	0.04	24							
130	29	1.00	1.25	0.0	0.0	41.7	7.04	0.00	0	n/r	n/r	n/r	n/r	0.02	15							
140	30	1.75	2.00	0.0	0.0	54.7	7.58	0.00	0	n/r	n/r	n/r	n/r	0.20	126							
143	31	0.50	0.70	0.0	0.0	24.6	7.61	0.00	0	n/r	n/r	n/r	n/r	0.05	28							
146	31	1.25	1.50	0.0	0.0	34.5	7.30	0.00	0	n/r	n/r	n/r	n/r	0.01	7							
148	31	1.75	2.00	0.0	0.0	44.6	7.60	0.00	0	n/r	n/r	n/r	n/r	0.06	40							

Tests Completed: 15-Jan-07

Samples Received: 08-Dec-06

Signed:  for and on behalf of Soil and Water Laboratories P/L
Trevor Nelson - Chemical Laboratory Manager - Soils and Waters

- 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 (QASSMAC); Queensland Acid Sulphate Soils Investigation Team (QASST) & Queensland Department of Natural Resources, Mines and Energy; as described in the 'Acid Sulphate Soils Laboratory Methods Guidelines 2004'.
- Samples supplied by others
- Samples tested in 'as received' condition
- The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards
- NATA is a signatory to the APLAC mutual recognition arrangement for the mutual recognition of the equivalence of testing, calibration and inspection reports.



- NOTES:**
-  BH's 1,2,3,4 - drilled for current investigation
 -  BH's 31,32,34,35 - drilled in 2006 as part of 106-9336 investigation
- NOT TO SCALE**

Drawn AA	 SOIL SURVEYS Soil Surveys Engineering Pty Limited A.C.N. 054 043 631 Consulting Geotechnical Engineers		
Date 09.02.2012	REMORA RD., HAMILTON		Drawing No. 112-13901-01
Checked 			A4

APPENDIX D
SITE PLAN