GEOTECHNIQUE PTY LTD

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ABN 64 002 841 063

Job No: 12337/1
Our Ref: 12337/1-AB
21 October 2010

Service Station Developments
P O Box 365
PENRITH NSW 2751

Attention: Mr J Sgro

Dear Sir

re: **United Service Station**
Londonderry Road, Cranebrook
Geotechnical Investigation – Wastewater Management

This report provides the results of a geotechnical investigation at the above location. The work was carried out as per emails dated 8 and 21 September 2010.

We understand that an on-site wastewater treatment and disposal system is proposed for the above site. It is also understood that the system should be appropriate for wastewater loading of 4000l/day. Therefore, a geotechnical investigation was required for the following:

- To ascertain whether the proposed site is suitable for on-site effluent treatment and disposal systems.
- To provide geotechnical recommendations for design of on-site effluent treatment and disposal systems, if appropriate.

Regional Geology
Based on the Geological Map of Penrith (1:100,000), the site is underlain by Londonderry Clay, comprising clay, patches of ferruginized, consolidated sand.

Reference to the (1:100,000) Penrith Landscape map indicates that the site belongs to the Berkshire Park Group, which is characterised by dissected, gently undulating low rises on Tertiary terraces of the Nepean and Hawkesbury River systems. Soils in this landscape comprise clay and clayey sands, with ironstone nodules and silcrete and impermeable subsoils, which are susceptible to gully, sheet and rill erosion and waterlogging.

Field Work
Field work for geotechnical investigation was conducted on 14 and 27 September 2010 and consisted of the following:

- A walk over survey of the site to assess existing surface conditions.
- Drilling three (3) boreholes using a bobcat equipped with an auger. The boreholes were terminated at about 2.5m on bedrock. The approximate borehole locations are indicated on the attached Drawing No 12337/1-1. The borehole logs are also attached.
- Three (3) Dynamic Cone Penetration (DCP) tests were conducted adjacent to drilled boreholes to assess strength characteristics of sub-surface soils. These results are shown on the borehole logs.
- Recovery of representative soil samples for visual assessment and laboratory testing.
- Measuring depths to groundwater level or seepage in test pits, where encountered.

- Conducting field permeability testing in three boreholes to assess conductivity of sub-surface soils in areas visually assessed to be suitable for disposal of treated wastewater. The test method principally involves the following (Reference 1):
  - Drilling a borehole of known diameter and depth (about 0.5m) using a hand auger.
  - Saturating the sub-surface soils in the vicinity of the borehole by repeatedly refilling the borehole with water until a constant rate of water level drawdown was achieved.
  - Filling the borehole with water and measuring the drop in water level over a period of time.
  - Analysing measurements in water level drawdown for known borehole dimension, to estimate permeability of soils in the vicinity of the borehole.

Field work was supervised by a Field Engineer from this company, responsible for nominating borehole locations, sampling, testing and preparation of borehole logs.

Site Conditions
A wastewater treatment and disposal system will be constructed on the western side of the United Service Station, Londonderry Road, Cranebrook. The ground surface across at the site is generally flat and grass covered.

Sub-surface materials encountered in the three boreholes are detailed in the attached borehole logs and summarised below in Table 1.

TABLE 1

Borehole	Termination Depth (m)	Topsoil / Fill(m)	Natural Soils (m)	Bedrock (m)
1	2.5	0.0 – 1.2	1.2 – 2.5	=>2.5
2	2.5	0.0 – 0.3	0.3 – 2.5	=>2.5
3	2.5	0.0 – 0.1	0.1 – 2.5	=>2.5

In general, sub-surface materials encountered in the boreholes are described as follows:

Topsoil	Sandy Silty Clay, low plasticity, dark brown, traces of roots and ironstone
Fill	Silty Clay, medium to high plasticity, yellow-brown, with inclusions of siltstone and rounded ironstone
	Silty Clay, low plasticity, dark brown, with inclusion of rounded ironstone
Natural Soils (Alluvial & Residual)	Sandy Clayey Silt, low plasticity, dark brown, yellow, with inclusion of rounded ironstone
	Silty Clay, high plasticity, yellow brown, trace of ironstone

DCP tests generally indicated the fill to be variably compacted and the natural soils to be stiff to very stiff in consistency.

Groundwater or seepage was not encountered within the drilled depth of the boreholes. It should be noted that fluctuations in the level of groundwater might occur due to variations in rainfall and/or other factors.

Permeability Testing
Estimates of soil permeability based on field tests are presented below in Table 2.

TABLE 2

BH	Permeability (m/s)	Permeability (m/day)
1	2.0×10^{-7}	0.0173
2	3.6×10^{-7}	0.0259
3	4.3×10^{-7}	0.0346

The above values are consistent with the type of material encountered in the drilled boreholes

Laboratory Testing
Representative soil samples recovered from the boreholes were tested to assess chemical properties. The samples for chemical tests were collected from different types of soils encountered across the site. Tests were carried out in the NATA accredited laboratory of SGS Australia Pty Ltd, in accordance with relevant Australian Standards. Detailed laboratory test results are attached and summaries are presented in Table 3.

TABLE 3

BH	Depth (m)	EC (dS/m)	pH	Phosphorous Absorption (mg P sorped /kg)	Cation Exchange Capacity (meq%)	Exchangeable Sodium Percentage (%)
1	0.0 – 0.5	0.25	9.1	280	19	10
2	0.5 – 1.0	0.11	7.7	720	9.5	4
3	1.0 – 1.5	0.14	6.5	500	11	2

Scope of Geotechnical Investigation
The scope of the present investigation was aimed at assessing the suitability of the site for on-site disposal of treated wastewater and estimating the disposal area required. This involved the following:

- Analysis of site and soil conditions
- Estimating effluent load
- Analysis of climatic conditions
- Water and nutrient balance calculation

Site and Soil Assessments
The Environmental and Health Protection Guidelines (Reference 2) provide site and soil assessment ratings for on-site wastewater disposal systems with irrigation and/or absorption. The site features relevant for site assessment and assessed limitations imposed by each feature in the site are presented in Table 4.

TABLE 4

Site Features	Assessed Conditions	Assessed Limitation for Irrigation	Assessed Limitation for Absorption
Flood Potential	Rare, above 1 in 20 year flood contour	Minor to Major	Minor to Major
Exposure	High sun exposure	Minor	Minor
Slope	1-2%	Minor	Minor
Landform	Plain	Minor	Minor
Run-on and upslope seepage	None	Minor	Minor
Erosion potential	No sign of erosion	Minor	Minor
Site drainage	No surface dampness except in flood plain	Minor to Major	Minor to Major
Fill	Fill Present	Moderate	Moderate
Rock outcrops	<10%	Minor	Minor

The soil features relevant for soil assessment and assessed limitations imposed by each soil feature are presented in Table 5.

TABLE 5

Soil Features	Assessed Conditions	Assessed Limitation for Irrigation	Assessed Limitation for Absorption
Depth to bedrock	2.5m	Minor	Minor
Depth to groundwater	>2.5m	Minor	Minor
Soil permeability	0.017 – 0.035 m/day	Minor to Major	Minor to Major
Coarse fragments	About 0-10%	Minor	Minor
Bulk density	About 17.5t/m^3	Minor	Minor
pH	6.5-9.1	Minor	Minor
Electrical conductivity	0.11-0.25 dS/m	Minor	Minor
Exchangeable Sodium Percentage (ESP)	2-10%	Moderate	Minor to Moderate
Cation Exchange Capacity (CEC)	9.5-19.0meq/%	Minor to Moderate	Minor to Moderate
Phosphorus sorption	280-720mg/kg	Minor	Minor

Information presented in Tables 4 and 5 indicates the following:

- Site features listed in Table 4 are unlikely to impose major limitations for on-site disposal of effluent by both irrigation and absorption systems, provided areas in the vicinity of drainage lines or creeks and flood plains (area below 1 in 100 years flood level) are avoided.
- Depths to bedrock and groundwater level are unlikely to impose major limitations for on-site disposal of effluent by both irrigation and absorption systems.
- Physical properties of soils, in terms of coarse fragments and density, are unlikely to impose major limitations for on-site disposal of effluent by both irrigation and absorption systems.
- Clayey soils across the site are assessed to have low permeability and are generally poorly drained. However structural defects like shrinkage cracks might result in relatively high permeability locally.
- Chemical properties of soils listed in Table 5 do not impose major limitations for both irrigation and absorption systems.

In summary, site and soil features listed in Tables 4 and 5 do not impose major limitations for on-site effluent disposal by both irrigation and absorption systems, provided the disposal areas are above the 1 in 100 years flood level.

It should be noted that the site should have a suitable effluent disposal area of adequate size after allowing for adequate buffer distances. Recommended buffer distances for disposal areas, from site features such as boundaries, waterbodies, buildings, etc., are provided in Reference 2 and reproduced in Table 6.

TABLE 6

Disposal System	Feature	Recommended Buffer Distance (m)
All Land Application Systems	Permanent surface waters, (e.g. rivers, streams, lakes etc)	100
	Domestic groundwater well	250
	Other waters (e.g. farm dams, intermittent waterways, drainage channels etc)	40
Surface Spray Irrigation	Up-gradient of driveways and property boundaries	6
	Down-gradient of driveways and property boundaries	3
	Dwellings	15
	Paths and walkways	3
	Swimming pools	6
Surface Drip or Trickle Irrigation and Sub-surface Irrigation	Up-gradient of swimming pools, property boundaries, driveways and buildings	6
	Down-gradient of swimming pools, property boundaries, driveways and buildings	3

Climatic Conditions
A climatic survey was carried out from available data compiled by the Bureau of Meteorology publication "Sydney Climatic Survey 1991" (Reference 3), which included median (50 percentile) monthly rainfall and evaporation. As climatic data is not available for Cranebrook, published climatic data for the nearest monitoring station (Richmond) are presented below in Table 7.

TABLE 7

Month	Median Rainfall (mm)	Evaporation (mm/day)
January	73	6.5
February	65	5.6
March	65	4.6
April	52	3.6
May	28	2.2
June	41	1.8
July	32	2.2
August	24	3.1
September	34	4.3
October	44	5.3
November	60	6.1
December	54	7.6

On-site Effluent (Wastewater) Treatment and Disposal Alternatives
The options available for treatment and disposal of domestic wastewater/effluent are as follows:

- Septic tank and absorption/evapotranspiration trench
- Septic tank and Amended Soil Mould (Ecomax type) System
- Mechanically aerated system and irrigation area or evapotranspiration trench
- Composting wet or dry type toilet with absorption trench and/or further treatment for grey water

However, we understand that an Ecomax Type of wastewater treatment system will be used. Such systems utilise an amended soil mound that absorbs and chemically reacts with contaminants in the wastewater, producing treated water with very low levels of contaminants. Consequently, a nutrient balance is not required. Vegetation cover then takes up the treated water over the amended soil mound.

Allowance is made in the design of such systems for internal storage of effluent, with potential discharge of treated effluent during periods of wet weather, to be taken up in the soils adjacent to the mound. Consequently, it is considered that additional wet weather storage is not required. Due to the high quality of the treated effluent, it is considered that buffer zones are not required. Therefore, it is our assessment that the site and soil conditions are suitable for treatment and disposal of wastewater with an Ecomax System. Specifications and design of this system, appropriate for wastewater loading of 4000L/day, should be provided by the supplier of the system.

If you have any questions, please do not hesitate to contact the undersigned.

Yours faithfully
GEOTECHNIQUE PTY LTD

ZIAUDDIN AHMED
Senior Geotechnical Engineer

Attached — Drawing No 12337/1-1 Borehole Location
Borehole Logs
Explanatory Notes
Laboratory Test Results

References
1. Australian Standard AS/NZS1547 – 2000 "On-site Domestic Waste Water Management".
2. The Environmental and Health Protection Guidelines "On-site Wastewater Management System for Single Households".
3. The Bureau of Meteorology Publication "Sydney Climatic Survey – 1991"

LEGEND

● Borehole

0 8 16 24 32 40m

Scale 1:800

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NOTES

1. Site features are indicative and are not to scale.
2. This drawing has been produced using a base plan provided by others to which additional information e.g test pits, borehole locations or notes have been added. Some or all of the plan may not be relevant at the time of producing this drawing

Service Station Developments Pty Ltd
United Service Station
Londonderry Road
Cranebrook

Borehole Location Plan

Drawing No: 12337/1-AA1
Job No: 12337/1
Drawn By: MH
Date: 14 September 2010
Checked By: AN

File No: Drawing 12337-1
Layers: 0, AA1

GEOTECHNIQUE
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engineering log - borehole

Client : Service Station Development
Project : United Service Station
Location : Londonderry Road, Cranebrook

Job No. : 12337/1
Borehole No. : 1
Date : 27/09/2010
Logged/Checked by: AN/ZA

drill model and mounting : Bobcat with Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Hand Auger	Dry	DS	CONE 7, 5, 4, 3, 6	0			FILL; Silty Clay, medium to high plasticity, yellow brown, with inclusion of siltstone and rounded ironstone	M≤PL			
		DS	8, 17, 8, 5, 5	0.5							
			7, 12, 6, 7, 9	1							
		DS	10, 14	1.5		CI-CH	Silty CLAY, medium to high plasticity, brown, with inclusion of ironstones	M<PL			Residual
				2							
				2.5			Borehole No 1 terminated at 2.5m on bedrock				
				3							
				3.5							
				4							
				4.5							

GEOTECHNIQUE
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engineering log - borehole

Client : Service Station Development
Project : United Service Station
Location : Londonderry Road, Cranebrook

Job No. : 12337/1
Borehole No. : 2
Date : 27/09/2010
Logged/Checked by: AN/ZA

drill model and mounting : Bobcat with Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Hand Auger	Dry		CONE 2 2 3	0			FILL/TOPSOIL; Silty Clay, low plasticity, dark brown, with inclusion of rounded ironstone	M=PL			
			7 6			ML	FILL; Silty Clay, medium to high plasticity, yellow brown, with inclusion of siltstone and rounded ironstone	M>PL			
			4 5	0.5		CH	Sandy Clayey SILT, low plasticity, dark brown, yellow, with inclusion of rounded ironstone	M≥PL			
		DS	9 8 9				Silty CLAY, high plasticity, orange, with inclusion of ironstone				
			8 7 9	1							
			13 12 11			CH	Silty CLAY, high plasticity, grey, orange, with inclusion of ironstone	M≤PL			
		DS	12	1.5							
		DS		2		CI	Shaley Silty CLAY, medium to high plasticity, grey, brown, traces of ironstone	M<PL			
				2.5			Borehole No 2 terminated at 2.5m on bedrock				
				3							
				3.5							
				4							
				4.5							

GEOTECHNIQUE
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engineering log - borehole

Client : Service Station Development
Project : United Service Station
Location : Londonderry Road, Cranebrook

Job No. : 12337/1
Borehole No. : 3
Date : 27/09/2010
Logged/Checked by: AN/ZA

drill model and mounting : Bobcat with Auger **slope :** **deg.** **R.L. surface :**

hole diameter : 250 **mm** **bearing :** **deg.** **datum :**

method	groundwater	samples	field test	depth or R.L. in meters	graphic log	classification symbol	MATERIAL DESCRIPTION soil type, plasticity or particle characteristic, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa	Remarks and additional observations
Hand Auger	Dry	DS	CONE 1, 3, 4	0			TOPSOIL; Sandy Silty Clay, low plasticity, dark brown, traces of roots and ironstone				
						ML	Sandy Clayey SILT, low plasticity, dark brown, yellow, with inclusion of rounded ironstone	M≤PL			
			CONE 2, 3, 4, 6, 7, 5, 6	0.5		CH	Silty CLAY, high plasticity, yellow brown, trace of ironstone	M=PL			
		DS	CONE 4, 6, 6, 7, 9, 12, 15	1		CH	Silty CLAY, high plasticity, grey, with inclusion of ironstone	M≤PL			
				1.5							
		DS		2		CI-CH	Shaley Silty CLAY, medium to high plasticity, grey, brown, traces of ironstone	M<PL			
				2.5			Borehole No 3 terminated at 2.5m on bedrock				
				3							
				3.5							
				4							
				4.5							

EXPLANATORY NOTES

Introduction
These notes have been provided to simplify the geotechnical report with regard to investigation procedures, classification methods and certain matters relating to the Discussion and Comments section. Not all notes are necessarily relevant to all reports.

Geotechnical reports are based on information gained from finite sub-surface probing, excavation, boring, sampling or other means of investigation, supplemented by experience and knowledge of local geology. For this reason they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods
The methods of description and classification of soils and rocks used in this report are based on AS1726 - 1993 "Geotechnical Site Investigations". In general, descriptions cover the following properties; strength or density, colour, structure, soil or rock type, and inclusions. Identification and classification of soil and rock involves, to a large extent, judgement within the acceptable level commonly adopted by current geotechnical practices.

Soil types are described according to the predominating particle size, qualified by the grading or other particles present (e.g. sandy clay) on the following basis:

Soil Classification	Particle Size
Clay	Less than 0.002mm
Silt	0.002 to 0.06mm
Sand	0.06 to 2.00mm
Gravel	2.00mm to 60.00mm

Cohesive soils are classified on the basis of strength, either by laboratory testing or engineering examination. The strength terms are defined as follows:

Classification	Undrained Shear Strength kPa
Very Soft	Less than 12
Soft	12 – 25
Firm	25 – 50
Stiff	50 – 100
Very Stiff	100 – 200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT), as below:

Relative Density	SPT 'N' Value (blows/300mm)	CPT Cone Value (q_c-MPQ)
Very Loose	Less than 5	Less than 2
Loose	5 – 10	2 – 5
Medium Dense	10 – 30	5 – 15
Dense	30 – 50	15 – 25
Very Dense	>50	>25

Rock types are classified by their geological names, together with descriptive terms on degrees of weathering, strength, defects and other minor components. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling
Sampling is carried out during drilling 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, type, moisture content, inclusions and depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin walled sample tube (normally known as U_{50}) into the soil and withdrawing a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils. Details of the type and method of sampling are given in the report.

Field Investigation Methods
The following is a brief summary of investigation methods currently carried out by this Company and comments on their use and application.

Hand Auger Drilling
The borehole is advanced by manually operated equipment. The diameter of the borehole ranges from 50mm to 100mm. Penetration depth of hand augered boreholes may be limited by premature refusal on a variety of materials, such as hard clay, gravels or ironstone.

Test Pits
These are excavated with a tractor-mounted 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 3.0m for a backhoe and up to 6.0m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Care must be taken if construction is to be carried out near, or within the test pit locations, to either adequately recompact the backfill during construction, or to design the structure to accommodate the poorly compacted backfill.

Large Diameter Auger (e.g. Pengo)
The hole is advanced by a rotating plate or short spiral auger, generally 300mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5m) and are disturbed, but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers and is usually supplemented by occasional undisturbed tube sampling.

Continuous Spiral Flight Augers
The hole is advanced by using 90mm-115mm 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, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be highly mixed with soil of other stratum.

Information from the drilling (as distinct from specific sampling by SPT or undisturbed samples) is of relatively lower reliability due to remoulding, mixing or softening of samples by groundwater, resulting in uncertainties of the original sample depth.

The spiral augers are usually advanced by using a V-bit through the soil profile to refusal, followed by Tungsten Carbide (TC) bit, to penetrate into bedrock. The quality and continuity of the bedrock may be assessed by examination of recovered rock fragments and through observation of the drilling penetration resistance.

Non-core Rotary Drilling (Wash Boring)
The hole is advanced by a rotary bit, with water being pumped down the drill rod and returned up the annulus carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the feel and rate of penetration.

Rotary Mud Stabilised Drilling
This is similar to rotary drilling, but uses drilling mud as a circulating fluid, which may consist of a range of products from bentonite to polymers such as Revert or Biogel. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (e.g. SPT and U_{50}) samples).

Continuous Core Drilling
A continuous core sample is obtained using a diamond tipped core barrel. Providing full core recovery is achieved (which is not always possible in very low strength rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation. In rocks, an NMLC triple tube core barrel, which gives a core of about 50mm diameter, is usually used with water flush.

Portable Proline Drilling
This is manually operated equipment and is only used in sites which require bedrock core sampling and there is restricted site access to truck mounted drill rigs. The boreholes are usually advanced initially using a tricone roller bit and water circulation to penetrate the upper soil profile. In some instances, a hand auger may be used to penetrate the soil profile. Subsequent drilling into bedrock involves the use of NMLC triple tube equipment, using water as a lubricant.

Standard Penetration Tests
Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils, as a means of determining density or strength and of obtaining a relatively undisturbed sample. The test procedure is described in AS1289 6.3.1.

The test is carried out in a borehole by driving a 50mm diameter split sample tube under the impact of a 63kg hammer with a free fall of 769mm. It is normal for the tube to be driven in three successive 150mm increments and the 'N' value is taken as the number of blows for the last 300mm. In dense sands, very hard clays or weak rock, the full 450mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form:

- In a case where full penetration is obtained with successive blow counts for each 150mm of, say 4, 6 and 7 blows as;

  N = 13
  4,6,7

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

  15, 30/40mm

The results of the tests can be related empirically to the engineering properties of the soil. Occasionally the test method is used to obtain samples in 50mm diameter thin walled sample tubes in clays. In these circumstances, the test results are shown on the bore logs in brackets.

Cone Penetrometer Testing and Interpretation
Cone penetrometer testing (sometimes referred to as Dutch Cone-CPT) described in this report, has been carried out using an electrical friction cone penetrometer and the test is described in AS1289 6.5.1.

In the test, a 35mm diameter rod with cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig, which is fitted with a hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records. The information provided on the charts comprises:

- Cone resistance - the actual end bearing force divided by the cross sectional area of the cone, expressed in MPa *
- Sleeve friction - the frictional force on the sleeve divided by the surface area, expressed in kPa

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1% to 2% are commonly encountered in sands and very soft clays, rising to 4% to 10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows per 300mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:

$$q_c=(12 \text{ to } 18)C_u$$

Interpretation of CPT values can also be made to allow estimate of modulus or compressibility values, to allow calculation of foundation settlements. Inferred stratification, as shown on the attached report, is assessed from the cone and friction traces, from experience and information from nearby boreholes etc.

This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties and where precise information or soil classification is required, direct drilling and sampling may be preferable.

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

There are two similar tests, Cone Penetrometer (commonly known as Scala Penetrometer) AS1289 6.3.2 and the Perth Sand Penetrometer AS1289 6.3.3. Scala Penetrometer is commonly adopted by this company and consists of a 16mm rod with a 20mm diameter cone end, driven with a 9kg hammer, dropping 510mm (AS1289 Test P3.2).

Laboratory Testing
Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedures are given on the individual report forms.

Engineering Logs
The engineering logs presented herein are an engineering and/or geological interpretation of the sub-surface conditions and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, however, this is not always practicable or possible to justify economically. As it is, the boreholes represent only a small sample of the total sub-surface profile. Interpretation of the information and its application to design and construction should take into account the spacing of boreholes, frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

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

- in low permeability soils groundwater, although present, may enter the hole slowly or perhaps not at all during the investigation period
- a localised perched water table may lead to an erroneous indication of the true water table
- water table levels will vary from time to time due to the seasons or recent weather changes. They may not be the same at the time of construction as indicated in the report
- the use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must be washed out of the hole if water observations are to be made

More reliable measurements can be achieved by installing standpipes that are read at intervals over several days, or 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 a perched water table or surface water.

Engineering Reports
Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, perhaps a three-storey building, the information and interpretation may not be relevant if the design proposal is changed, say to a twenty-storey building. If this occurs, the Company will be pleased to review the report and sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussions of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on bore spacing and sampling frequency.
- Changes in policy or interpretation of policy by statutory authorities.
- The actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies
In the event that conditions encountered on-site during construction appear to vary from those that were expected from the information contained in the report, the Company requests immediate notification. Most problems are much more easily resolved when conditions are exposed rather than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes
Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institute 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 make additional copies of the report available for contract purposes, at a nominal charge.

Site Inspection
The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that the conditions exposed are as expected, to full time engineering presence on site.

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 are complex, it is prudent to have the design reviewed by a Senior Geotechnical Engineer.

SAMPLE RECEIPT ADVICE (SRA)

29 September 2010

Client Details			Laboratory Details		
Requested By	:	**Ziauddin Ahmed**			
Client	:	Geotechnique	Laboratory	:	SGS Environmental Services
Contact	:	Frances Kuipers	Manager	:	Edward Ibrahim
Address	:	P.O. Box 880 PENRITH NSW 2751	Address	:	Unit 16, 33 Maddox Street Alexandria NSW 2015
Email	:	[redacted]	Email	:	[redacted]
Telephone	:	02 4722 2700	Telephone	:	61 2 8594 0400
Facsimile	:	02 4722 6161	Facsimile	:	61 2 8594 0499
Project	:	12337-1-United Serv Stn-Londonderry Rd-Cranebrook	Report No	:	**SE81824**
Order Number	:		No. of Samples	:	3
Samples	:	3 Soils	Due Date	:	11/10/2010

Date Instructions Received	:	28/09/2010
Sample Receipt Date	:	29/9/10

Samples received in good order	:	YES	Samples received in correct containers	:	YES
Samples received without headspace	:	NO	Sufficient quantity supplied	:	YES
Upon receipt sample temperature	:	Ambient	Cooling Method	:	None
Sample containers provided by	:	Customer	Samples clearly Labelled	:	YES
Turnaround time requested	:	Standard	Completed documentation received	:	YES

Samples will be held for 1 month for water samples and 3 months for soil samples from date of receipt of samples, unless otherwise instructed.

Comments

CEC, ESP and Phosphorous Sorption subcontracted to SGS Cairns

The signed chain of custody will be returned to you with the original report.

SAMPLE RECEIPT ADVICE (SRA) - continued

Client : Geotechnique Report No : SE81824
Project : 12337-1-United Serv Stn-Londonderry Rd-Cranebrook

Summary of Samples and Requested Analysis

The table below represents SGS Environmental Service's understanding and interpretation of the customer supplied sample request.
Please indicate ASAP if your request differs from these details.
Testing shall commence immediately as per this table, unless the customer intervenes with a correction prior to testing.
Note that a small X in the table below indicates some testing has not been requested in the package.

Sample No.	Description	No Prep Required	Inorganics	Exchangeable Sodium Percent	External	Moisture
1	BH1	X	X	X	X	X
2	BH2	X	X	X	X	X
3	BH3	X	X	X	X	X

Sample No.	Description
1	BH1
2	BH2
3	BH3

COC 28/9/2010 @ 5:02pm

SGS
Received 29/9/10
By CP
Time 2
Samples intact ✓
Ice/Cooler Pack ✓
Temperature on Receipt 20
Storage Location 517
SGS REF SE81824

GEOTECHNIQUE PTY LTD

Laboratory Test Request / Chain of Custody Record

Lemko Place
PENRITH NSW 2750

P O Box 880
PENRITH NSW 2751

Tel: (02) 4722 2700
Fax: (02) 4722 6161
email: info@geotech.com.au

Page of

TO:	**SGS ENVIRONMENTAL SERVICES** **UNIT 16** **33 MADDOX STREET** **ALEXANDRIA NSW 2015**	**Sampling By:** AN	**Job No:** 12337/1
			Project: United Service Station
PH:	[redacted] **FAX:** 02 8594 0499	**Project Manager:** ZA	**Location:** Londonderry Road, Cranebrook
ATTN:	**MS ANGELA MAMALICOS**		

Sampling details				Sample type		Results required by:								
Location	Depth (m)	Date	Time	Soil	Water	EC (dS/m)	pH	CEC (cmol⁺/kg)	ESP (%)	Phosphorous Sorption (kg/ha)				KEEP SAMPLE
1 BH1	0.0	0.5		DS		✓	✓	✓	✓	✓				Y
2 BH2	0.5	1.0		DS		✓	✓	✓	✓	✓				Y
3 BH3	1.0	1.5		DS		✓	✓	✓	✓	✓				Y

Relinquished by			Received by		
Name	Signature	Date	Name	Signature	Date
Ziauddin Ahmed	[redacted]	28/09/2010	CP	[redacted]	29/9/10

Legend:

WG	Water sample, glass bottle	USG	Undisturbed soil sample (gl	DSP	Disturbed soil sample (small plastic bag)	* Purge & Trap	@ mole H⁺/tonne
WP	Water sample, plastic bottle	DSG	Disturbed soil sample (glass	✓	Test required	# Geotechnique Screen	

LABORATORY REPORT COVERSHEET

Date: 7 October 2010

To: Geotechnique Pty Ltd
PO Box 880
PENRITH NSW 2015

Attention: Ziaddin Ahmed

Your Reference: SE81824 - 12337/1 United Svc Stn - Geotechnique
Laboratory Report No: CE69056

Samples Received: 30/09/2010
Samples / Quantity: 3 Soils

The above samples were received intact and analysed according to your written instructions. Unless otherwise stated, solid samples are reported on a dry weight basis and liquid samples as received.

[redacted]

Jon Dicker
Manager
CAIRNS

Shey Goddard
Administration Manager
CAIRNS

SGS Australia Pty Ltd
ABN 44 000 964 278
Environmental Services Unit 2, 58 Comport Street, Portsmith 4870 QLD Australia
t +61 (0)7 4035 5111 f +61 (0)7 4035 5122

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechnique **Laboratory Report No:** CE69056

LABORATORY REPORT

Cation Exchange Capacity Suite Our Reference Your Reference Type of Sample Sample Identification	Units	CE69056-1 SE81824-1 Soil BH1 0.0-0.5	CE69056-2 SE81824-2 Soil BH2 0.5-1.0	CE69056-3 SE81824-3 Soil BH3 1.0-1.5
Date Extracted		30/09/2010	30/09/2010	30/09/2010
Date Analysed		5/10/2010	5/10/2010	5/10/2010
Sodium, Na	mg/kg	440	96	53
Sodium (meq%)	meq%	1.9	0.42	0.23
Exchangeable Sodium	%	10	4	2
Potassium, K	mg/kg	100	150	250
Potassium (meq%)	meq%	0.26	0.38	0.64
Exchangeable Potassium	%	1	4	6
Calcium, Ca	mg/kg	2,200	1,100	1,600
Calcium (meq%)	meq%	11	5.5	8.0
Exchangeable Calcium	%	59	58	70
Magnesium, Mg	mg/kg	670	390	320
Magnesium (meq%)	meq%	5.5	3.2	2.6
Exchangeable Magnesium	%	29	34	23
CEC	meq%	19	9.5	11

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechniqu **Laboratory Report No:** CE69056

LABORATORY REPORT

-------- Our Reference Your Reference Type of Sample Sample Identification	Units	CE69056-1 SE81824-1 Soil BH1 0.0-0.5	CE69056-2 SE81824-2 Soil BH2 0.5-1.0	CE69056-3 SE81824-3 Soil BH3 1.0-1.5
Date Extracted		30/09/2010	30/09/2010	30/09/2010
Date Analysed		6/10/2010	6/10/2010	6/10/2010
Phosphorus Absorption #	mg P sorbed/kg	280	720	500

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechniqu **Laboratory Report No:** CE69056

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Date Extracted			
Date Analysed			
Sodium, Na	mg/kg	2	AN122 CEI-014
Sodium (meq%)	meq%	0.01	Calculation
Exchangeable Sodium	%	1	Calculation
Potassium, K	mg/kg	2	AN122 CEI-014
Potassium (meq%)	meq%	0.01	Calculation
Exchangeable Potassium	%	1	Calculation
Calcium, Ca	mg/kg	2	AN122 CEI-014
Calcium (meq%)	meq%	0.01	Calculation
Exchangeable Calcium	%	1	Calculation
Magnesium, Mg	mg/kg	2	AN122 CEI-014
Magnesium (meq%)	meq%	0.01	Calculation
Exchangeable Magnesium	%	1	Calculation
CEC	meq%	0.01	R & H ##

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechniqu **Laboratory Report No:** CE69056

LABORATORY REPORT

TEST PARAMETERS	UNITS	LOR	METHOD
Date Extracted			
Date Analysed			
Phosphorus Absorption #	mg P sorbed/kg	1	R & H ##

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechniqu **Laboratory Report No:** CE69056

LABORATORY REPORT

QUALITY CONTROL	UNITS	Blank	Duplicate Sm#	Duplicate SamplelIDuplicate	Spike Sm#	Spike Recovery
Date Extracted		30/09/10	CE69056-1	30/09/2010 || 30/09/2010	Batch Spike	-
Date Analysed		05/10/10	CE69056-1	5/10/2010 || 5/10/2010	Batch Spike	-
Sodium, Na	mg/kg	<2	CE69056-1	440 || 450 || RPD: 2	Batch Spike	92%
Sodium (meq%)	meq%	-	CE69056-1	1.9 || 2.0 || RPD: 5	Batch Spike	-
Exchangeable Sodium	%	-	CE69056-1	10 || 10 || RPD: 0	Batch Spike	-
Potassium, K	mg/kg	<2	CE69056-1	100 || 100 || RPD: 0	Batch Spike	105%
Potassium (meq%)	meq%	-	CE69056-1	0.26 || 0.26 || RPD: 0	Batch Spike	-
Exchangeable Potassium	%	-	CE69056-1	1 || 1 || RPD: 0	Batch Spike	-
Calcium, Ca	mg/kg	<2	CE69056-1	2200 || 2200 || RPD: 0	Batch Spike	96%
Calcium (meq%)	meq%	-	CE69056-1	11 || 11 || RPD: 0	Batch Spike	-
Exchangeable Calcium	%	-	CE69056-1	59 || 59 || RPD: 0	Batch Spike	-
Magnesium, Mg	mg/kg	<2	CE69056-1	670 || 670 || RPD: 0	Batch Spike	90%
Magnesium (meq%)	meq%	-	CE69056-1	5.5 || 5.5 || RPD: 0	Batch Spike	-
Exchangeable Magnesium	%	-	CE69056-1	29 || 29 || RPD: 0	Batch Spike	-
CEC	meq%	-	CE69056-1	19 || 19 || RPD: 0	Batch Spike	-

CLIENT: Geotechnique Pty Ltd

PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechnique **Laboratory Report No:** CE69056

LABORATORY REPORT

QUALITY CONTROL	UNITS	Blank	Duplicate Sm#	Duplicate SamplelIDuplicate	Spike Sm#	Spike Recovery
Date Extracted		-	CE69056-1	30/09/2010 || 30/09/2010	Batch Spike	-
Date Analysed		-	CE69056-1	6/10/2010 || 6/10/2010	Batch Spike	-
Phosphorus Absorption #	mg P sorbed/kg	<1	CE69056-1	280 || 270 || RPD: 4	Batch Spike	-

CLIENT: Geotechnique Pty Ltd
PROJECT: SE81824 - 12337/1 United Svc Stn - Geotechniqu**Laboratory Report No:** CE69056

LABORATORY REPORT

NOTES:
LOR - Limit of Reporting.
This test is not covered by our current NATA accreditation.
Method from Rayment & Higginson - "Australian Laboratory Handbook of Soil and Water Chemical Methods".

Analysis Date: **Between** 30/09/10 **and** 7/10/10

SGS Terms and Conditions are available at www.au.sgs.com

ANALYTICAL REPORT

11 October 2010

Geotechnique
P.O. Box 880
PENRITH
NSW 2751

Attention: **Ziauddin Ahmed**

Your Reference: 12337-1-United Serv Stn-Londonderry Rd-Cranebrook

Our Reference: SE81824 Samples: 3 Soils
Received: 29/9/10

Preliminary Report Sent: Not Issued

These samples were analysed in accordance with your written instructions.

For and on Behalf of:
SGS ENVIRONMENTAL SERVICES

Sample Receipt:	Angela Mamalicos	AU.SampleReceipt.Sydney@sgs.com
Production Manager:	Huong Crawford	Huong.Crawford@sgs.com

Results Approved and/or Authorised by:

[redacted]
Edward Ibrahim
Laboratory Manager

[redacted]
Snezana Kostoka
Chemist

SGS Australia Pty Ltd
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Inorganics Our Reference: Your Reference Sample Matrix Depth	UNITS ---------- ----------	SE81824-1 BH1 Soil 0.0-0.5	SE81824-2 BH2 Soil 0.5-1.0	SE81824-3 BH3 Soil 1.0-1.5
Date Extracted (Conductivity)		8/10/2010	8/10/2010	8/10/2010
Date Analysed (Conductivity)		8/10/2010	8/10/2010	8/10/2010
Electrical Conductivity 1:5 soil:water	dS/m	0.25	0.11	0.14
Date Extracted- (pH 1:5 soil: Water)		8/10/2010	8/10/2010	8/10/2010
Date Analysed (pH 1:5 Soil: Water)		8/10/2010	8/10/2010	8/10/2010
pH 1:5 soil:water	pH Units	9.1	7.7	6.5

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Exchangeable Sodium Percent				
Our Reference:	UNITS	SE81824-1	SE81824-2	SE81824-3
Your Reference	----------	BH1	BH2	BH3
Sample Matrix	----------	Soil	Soil	Soil
Depth		0.0-0.5	0.5-1.0	1.0-1.5
Exchangeable Sodium Percent		#	#	#

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Phosphorus Sorption Analysis				
Our Reference:	UNITS	SE81824-1	SE81824-2	SE81824-3
Your Reference	----------	BH1	BH2	BH3
Sample Matrix	----------	Soil	Soil	Soil
Depth		0.0-0.5	0.5-1.0	1.0-1.5
Phosphorus Sorption		#	#	#

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Moisture Our Reference: Your Reference Sample Matrix Depth	UNITS ---------- ---------- 	SE81824-1 BH1 Soil 0.0-0.5	SE81824-2 BH2 Soil 0.5-1.0	SE81824-3 BH3 Soil 1.0-1.5
Date Analysed (moisture)		1/10/2010	1/10/2010	1/10/2010
Moisture	%	12	23	17

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Method ID	Methodology Summary
SEI-037	Ammonia - Determined by salicylate colourimetric method using Discrete Analyser.
AN106	Conductivity and TDS by Calculation (cTDS) - Conductivity is measured using a conductivity cell and dedicated meter, in accordance with APHA 21st Edition, 2510. TDS is calculated by TDS(mg/L)=0.6 x Conductivity(µS/cm).
AN101	pH - Measured using pH meter and electrode based on APHA 21st Edition, 4500-H+. For water analyses the results reported are indicative only as the sample holding time requirement specified in APHA was not met (APHA requires that the pH of the samples are to be measured within 15 minutes after sampling).
Ext-002	Analysis subcontracted to SGS Environmental Services Cairns, NATA Accreditation No. 2562, Site No. 3146.
AN002	Preparation of soils, sediments and sludges undergo analysis by either air drying, compositing, subsampling and 1:5 soil water extraction where required. Moisture content is determined by drying the sample at 105 ± 5°C.

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Document Set ID: 9398804
Version: 1, Version Date: 02/12/2020

Result Codes

[INS] : Insufficient Sample for this test
[NR] : Not Requested
[NT] : Not tested
[LOR] : Limit of reporting
[RPD] : Relative Percentage Difference
* : Not part of NATA Accreditation
[N/A] : Not Applicable

Report Comments

CEC and P Sorption analysed by SGS Cairns, report No. CE69056 (Report Attached).
Samples analysed as received. Solid samples expressed on a dry weight basis.
Date Organics extraction commenced:
NATA Corporate Accreditation No. 2562, Site No 4354
Note: Test results are not corrected for recovery (excluding Air-toxics and Dioxins/Furans*)

Quality Control Protocol

Method Blank: An analyte free matrix to which all reagents are added in the same volume or proportions as used in sample processing. The method blank should be carried through the complete sample preparation and analytical procedure. A method blank is prepared every 20 samples.
Duplicate: A separate portion of a sample being analysed that is treated the same as the other samples in the batch. One duplicate is processed at least every 10 samples.
Surrogate Spike: An organic compound which is similar to the target analyte(s) in chemical composition and behavior in the analytical process, but which is not normally found in environmental samples. Surrogates are added to samples before extraction to monitor extraction efficiency and percent recovery in each sample.
Internal Standard: Added to all samples requiring analysis for organics (where relevant) or metals by ICP after the extraction/digestion process; the compounds/elements serve to give a standard of retention time and/or response, which is invariant from run-to-run with the instruments.
Laboratory Control Sample: A known matrix spiked with compound(s) representative of the target analytes. It is used to document laboratory performance. When the results of the matrix spike analysis indicates a potential problem due to the sample matrix itself, the LCS results are used to verify that the laboratory can perform the analysis in a clean matrix.
Matrix Spike: An aliquot of sample spiked with a known concentration of target analyte(s). The spiking occurs prior to sample preparation and analysis. A matrix spike is used to document the bias of a method in a given sample matrix.

Quality Acceptance Criteria

The QC criteria are subject to internal review according to the SGS QAQC plan and may be provided on request or alternatively can be found here: http://www.au.sgs.com/sgs-mp-au-env-qu-022-qa-qc-plan-en-09.pdf

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