Appendix I

Geotechnical Report

Network Geotechnics Pty Ltd

Central Coast Office
6/6 Morton Close, Tuggerah NSW 2259
Telephone: (02) 4351 6200 Facsimile: (02) 4351 6300
Email centralcoast@netgeo.com.au

RUSTRUM NO 2
C/- STERLINGS PTY LTD

PROPOSED SENIOR LIVING DEVELOPMENT

222 MAIN ROAD
TOUKLEY

GEOTECHNICAL ASSESSMENT

REPORT G08/221-A **NOVEMBER 2008**

Network Geotechnics Pty Ltd

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6/6 Morton Close, Tuggerah NSW 2259
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G08/221-A DS:TC
28th November 2008

Rustrum No 2
c/- Sterling Pty Ltd
PO Box 142
CHATSWOOD NSW 2057

Attention: Terry Roche

Dear Sir

Re: Proposed Senior Living Development 222 Main Road, Toukley: Geotechnical Assessment.

Please find enclosed our report on geotechnical studies undertaken for the above site.

The report presents the results of field and laboratory testing and describes surface and subsurface conditions. Recommendations cover acid sulphate soils, dewatering and footings design parameters including support measures for the excavation.

This report should be read in conjunction with the attached General Notes. Please contact the undersigned if you require further assistance.

For and on behalf of
Network Geotechnics Pty Ltd

V W de Silva *BScEng, MEng, SMIE Aust, CPEng NPER*
Principal Geotechnical Engineer

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1.0 INTRODUCTION

As requested, Network Geotechnics Pty Ltd (NG) has carried out geotechnical studies at 222 Main Road Toukley in order to provide recommendations on acid sulphate soils, dewatering issues and footings design parameters including support measures for the excavation.

The proposed development is understood to comprise a six storey building with two basement levels requiring up to 6m depth of excavation. Support measures considered for the excavation may include contiguous piles and soil/rock batters with or without anchors.

It is also understood that an assessment of acid sulphate soils is required to determine the treatment required for soils to be excavated. In addition groundwater sampling is required to assess disposal of groundwater which may be encountered in the excavation.

A site plan is shown on the attached Drawing No G08/221-1. This report should be read in conjunction with the attached general notes.

2.0 FIELDWORK

Fieldwork was carried out on the 30th September and 1st October, 2008 and comprised seven boreholes (BH1 to BH7). BH1 to BH4 were drilled using a truck mounted Ezi-probe drill rig. Depths of the investigation undertaken on the upper portion of the site are as follows:

- BH1 was drilled fitted with a macro barrel push tube to a refusal depth of 1.5m;
- BH2 was drilled fitted with a Dual push tube barrel to a refusal depth of 4.9m, advanced to a termination depth of 6m using a 100mm diameter solid flight auger fitted with a 'v'-bit;
- BH3 and BH4 were drilled to a termination depth of 5.5m using a 100mm diameter solid flight auger fitted with a 'v'-bit.

On the lower portion of the site, BH5 and BH6 were drilled to a termination depth of 3m using a skid steer small drilling rig fitted with a 100mm diameter solid flight auger drill. BH7 was carried out using portable push tube equipment to a termination depth of 1.8m.

Dynamic Cone Penetrometer (DCP) tests were carried out at regular depth intervals to aid assessment of insitu density/consistency of the soils encountered. Samples were also taken for subsequent laboratory testing.

In addition three stand pipe piezometers were installed into selected boreholes (BH2 TO BH4) at the site to recover groundwater samples for geochemical testing.

The fieldwork was carried out by our geotechnical staff who selected the test locations, carried out in-situ testing and disturbed sampling, and prepared logs of boreholes. The borehole logs are presented in appendix A and approximate test locations are shown on the attached Drawing No. G08/221-1.

3.0 LABORATORY TESTING

Laboratory testing carried out on soil samples obtained during the investigation comprised the following:

- Atterberg Limits on four clay samples to aid in soil classification and assessment of soil reactivity;
- pH tests in H_2O (distilled water) to assess current acidity;
- pH tests in H_2O_2 (hydrogen peroxide) to assess the potential for acid sulphate generation;
- Reduced Inorganic Sulphur (Scr) and Total Actual Acidity (TAA) to assess neutralising lime dosing requirement.

The following analytical tests were carried out on groundwater samples collected:

- Electrical conductivity and resistivity;
- pH;
- Total hardness;
- Benzene, Toluene, Ethyl benzene and Xylene (BTEX) including TPH(C6-C36) and 8 Metals;
- OC/OP/PCB;
- Cations and Anions (Ca, Mg, Na, K, Cl, SO_4 and Alkalinity).

4.0 SITE CONDITIONS

4.1 Surface Conditions

No. 222 Main Road has a frontage of about 50m on the northern side of the road extending north about 70 to 80m to the rear of the site to the Southern shore of Budgewoi Lake. The site has an area of about 1ha, with current surface reduced levels ranging from about RL9m AHD along Main Road to about RL1m AHD fronting the lake shore with majority of site being RL9m-5m. A concrete driveway provides good access to the lower portion of the site from the upper portion of the site which has been retained by a series of retaining walls.

The lower northern portion of the site is well grassed and the southern higher portion of site has grass and shrubbery. Surface soils encountered were Sandy Silt topsoil and Sandy Silty Gravel fill in parts.

4.2 Subsurface Conditions

Soil Landscape maps of the area indicates above proposed site lies within the Gorokan Erosional landscape (gk). The landscape typically comprises of moderately deep Podzols and grey-brown Podzolic soils on slopes with gleyed Podzolic soils along

drainage lines. Geological maps indicate the area to be underlain by Narrabean Group lithic sandstone of the Tuggerah formation.

Limitations in this landscape include very high erosional and foundation hazards, including seasonal waterlogging and strongly acidic, low fertility and plastic impermeable subsoils.

Subsurface profiles encountered in the upper portion of the site (BH1 to BH4) may be summarised as follows:

Layer/Description	***Depth to Base of Layer (m)***			
	BH1	*BH2*	*BH3*	*BH4*
TOPSOIL: Sandy SILT, dark brown, fine to medium sand, trace of rootlets		0.45		0.7
FILL: Sandy Silty GRAVEL/Gravelly Sandy CLAY, fine to medium gravel, pale orange brown becoming pale grey below 1m depth, fine to medium sand, low to medium plasticity	0.35		2.1	2.8
RESIDUAL: Clayey SAND/Sandy CLAY, fine to coarse grained, pale grey becoming orange red at 3.2m depth, low plasticity, trace of fine gravel		3.8	3.8	3.5
CLAY, medium to high plasticity, pale grey, some fine to medium sand	1.2	4.0		
Clayey SAND, fine to coarse grained, pale grey mottled red brown, low plasticity trace of fine gravel		> 6.0	5.0	
CLAY, medium plasticity, pale yellow brown, trace of fine to medium gravel			> 6.0	> 5.5
SANDSTONE, extremely weathered, pale grey, fine to medium grained	> 1.5			

Subsurface profiles encountered in the lower portion of the site (BH5 to BH7) may be summarised as follows:

Layer/Description	***Depth to Base of Layer (m)***		
	BH5	*BH6*	*BH7*
FILL: Clayey SAND, fine to medium grained, pale grey, low to medium plasticity, trace of fine to medium gravel			0.2
ALLUVIUM: Silty SAND, fine to coarse grained, dark grey, trace of fine gravel	0.5		0.7
Silty Clayey SAND, fine to coarse grained, dark			

brown, low plasticity	1.0	0.8	
Gravelly Silty SAND, fine to coarse grained, dark brown, fine gravel	1.3		1.2
CLAY, high plasticity grey mottled orange brown, trace of fine to medium sand, trace of fine to medium gravel	> 3.0	> 3.0	> 1.8

During the investigation of the upper portion of the site, groundwater was encountered in BH2, BH3 and BH4 at depths of 4m, 3.8m and 5.2m respectively.

In the lower portion, groundwater was encountered in BH5, BH6 and BH7 at depths of 1.1m, 1.9m and 0.8m respectively. However, it is pointed out that groundwater levels and seepages may fluctuate with variations in rainfall, site drainage, tidal flows and other factors.

5.0 DISCUSSION & RECOMMENDATIONS

5.1 General

The site proposed for development is located within Gorokan Soil Landscape where underlying geology is Narrabeen Group Tuggerah formation. The northern area of the site is occupied by shallow alluvial/fluvial soils.

Subsurface conditions at BH1, BH2 and BH3 comprised residual Sandy CLAY/Clayey SAND assessed to be dense or hard. Only BH1 encountered SANDSTONE while other boreholes terminated in residual soils. It is likely that the materials encountered at termination depth to be extremely weathered SANDSTONE.

Four residual soil samples tested recorded Plasticity Index values in the range 24% to 28% and Liquid Limit of 37% to 47% indicating medium plasticity and possible medium reactivity.

5.2 Footings

It is understood that the proposed basement would be at about RL2.9m making the footings to be 3m to 7m below the existing ground level. Footings in most of the site would be within residual clay or extremely weathered SANDSTONE.

For preliminary footing design the parameters indicated in the table below may be used:

Table 5.2 – Geotechnical Parameters for Preliminary Design of Footing

Footing Type	**Residual Soils**		**Extremely Weathered Sandstone**	
	Allowable	**Ultimate**	**Allowable**	**Ultimate**
Spread Footing kPa	150	450	500	1500
Strip	100	300	400	1200

Footings kPa				
Bored Piers – end bearing kPa	250	750	600	1800
Bored piers – shaft friction kPa	20	40	60	120
Elastic modulus MPa	20	-	50	-

It may be noted that parameters given for extremely weathered Sandstone would likely be available at depths below auger refusal level. It is likely that rock quality would improve with depth. Deeper drilling with coring may be carried out to refine the parameters for economical footing design.

5.3 Basement and Retaining Walls

It is understood that the proposed basement finished level would be up to about 2.0m to 6.0m below the existing ground surface level. Existing ground surface levels range from RL 9m to RL 4m.

All temporary excavations deeper than 1m would require ground support or should be battered no steeper than 1H:1V. No excavation should be carried out within the line of influence (ie a line drawn at 2H:1V from the base of the footing) of any footing. If space restrictions do not allow the above safe distances, excavation should be supported using contiguous bored piles. Retaining walls may be designed based on the following parameters:

Unit weight of sand	20kN/m^3
Depth to water table	4m
Coefficient of active earth pressure	0.30
Coefficient of passive earth pressure	3.25
Angle of friction (drained)	27°
Cohesion (drained)	10 kPa

5.4 Site Maintenance & Footing Performance

The site classification and other recommendations given in this report assumes that the performance expectations given in AS2870-1996 are acceptable and future site maintenance is carried out as described in CSIRO Sheet BTF-18, a copy of which is attached.

5.5 Further Investigation

It is recommended that detailed structural drawings for basements be reviewed by an experienced geotechnical consultant prior to construction in order to confirm that the recommendations made in this report are satisfied.

Deeper drilling investigations would be required to facilitate design of high capacity piles.

6.0 BASEMENT EXCAVATION AND GROUNDWATER

6.1 General

It is unlikely that the proposed up to 6m deep excavation would generate environmental effects which need management to reduce risk of damage. Matters to be concerned with include stability of temporary batters, possibility of groundwater and issues associated with dewatering.

6.2 Stability of Excavation

Subsurface soils found in the boreholes were assessed to be dense residual clayey SAND or hard residual Sandy CLAY. Excavations should be battered to no steeper than 1H: 1V above the groundwater table for short term stability or fully supported if space restrictions do not permit the above batter. Any excavation below the groundwater table, if required, should be battered to no steeper than 2H: 1V. It is expected that permanent ground support would comprise engineered retaining walls.

Provided that excavation batters are designed and constructed under engineering guidance, it is expected that the excavations would not destabilise adjacent properties.

6.3 Dewatering

Three stand pipe piezometers were installed on site for monitoring groundwater levels. Monitoring should be carried out once in two months or after heavy rainfall periods if they occur.

Assessment of dewatering rates would require an assessment of soil permeability, depth of excavation, depth to groundwater table at the time and the geometry of the excavation. Based on soil profile identification, a permeability coefficient of $1x10^{-7}$ m/s may be assumed for the subsurface soils for estimation of flow rates.

6.4 Water Quality

Two groundwater samples collection from BH2 and BH3 were tested to establish the groundwater quality in case there is a need to discharge groundwater to stormwater system. The test results are summarised below:

Parameter		BH2	BH3
pH	units	5.56	5.6
Electrical Conductivity	µS/cm	496	482
Total Alkalinity	mg/L	<1	1
Total hardness	mg/L	36	22
Sulphate	mg/L	53	65
Chloride	mg/L	98	93
Arsenic	mg/L	0.004	0.0.25
Cadmium	mg/L	0.0058	0.0332
Chromium	mg/L	0.076	0.400
Copper	mg/L	0.068	0.055
Lead	mg/L	0.171	0.252
Nickel	mg/L	0.020	0.030

Zinc	mg/L	0.223	0.154
Mercury	mg/L	0.0001	<0.0001
OC/OP (Pesticides)	mg/L	<LOR	<LOR
TPH	mg/L	<LOR	<LOR
BTEX	mg/L	<LOR	<LOR

Based on the above, it is assessed that groundwater is not acidic and does not contain pesticide or hydrocarbon contamination. The water quality test results were compared against ANZECC-2000 Guidelines for Recreational Purposes. It is assessed that chromium and lead are slightly above the criteria for recreational water guidelines. However water quality at this site is assessed to be similar to that of other sites in similar landscapes.

Council approval may be required prior to discharge of groundwater to stormwater system.

7.0 Acid Sulphate Soils Assessment

Fifteen soil samples were obtained from BH5, BH6 and BH7 for pH tests in water (H_2O) and hydrogen peroxide (H_2O_2) to assess for existing acidity and the potential for acid sulphate generation. Sampling depths ranged up to 3.0m below existing surface levels.

Current guidelines from the Acid Sulphate Soil Management Advisory Committee (ASSMAC 1998) list indicators of pH in water of less than 4 for actual acidity and pH in hydrogen peroxide of less than 3 for potential acidity.

None of the fifteen soil samples recorded pH <4. Four soil samples tested recorded pH <3 in H_2O_2 indicating a potential for producing acidity upon oxidation.

In view of the above, Sand and a Clay samples from BH5 at depths of 0.8m to 1m and 2.8m to 3m respectively, were forwarded to Environmental Analysis Laboratory of Southern Cross University Lismore to carry out Total Actual Acidity and Chromium Reducible sulphur tests. Test results are included in the attached table.

The reduced inorganic sulphur tests indicate that the medium textured alluvium has a Scr of less than 0.06% (0.003% to 0.007%) or 37molesH^+/t and the fine textured CLAY has a Scr of less than 0.03% (0.003%) or 62molesH^+/t.

It is therefore considered that no associated acid sulphate interventions are required during earthworks for the above proposed site improvement works if the volume of excavation in the area containing BH5, BH6 and BH7 is less than 1000t. If it is likely that more than 1000t of soil in the low lying area (area below RL 5.0m contour) is to be excavated the following management practices should be incorporated:

- Prior to excavation, facilities for stockpiling and treatment of acid sulphate soils should be established. Acid sulphate soil should be prevented from leaching prior to treatment.
- Excavated soil should be mixed with hydrated lime (neutralising capacity more than 95%) at a rate of 5kg/m^3. Treated soil may be used as fill on site or disposed off site. If off site disposal is required, waste classification may be required.

- Lime treated soil should be tested for pH in water to assess that neutralisation is achieved. The treated soil should record pH>6.5 in water. Most of the measured acidity of site soil is existing actual acidity. Therefore, pH test in water would be sufficient to assess the effectiveness of treatment.

- An environmental consultant should be appointed to oversee the excavation treatment and testing. A validation report may be required by the Council after treatment.

The above recommendations should be the basis of an Acid Sulphate Soil Management Plan (ASSMP) if such a plan is required by the Council. If the volume of soil to be excavated is limited to those from the proposed footing excavations and not more than $150m^3$ the above recommendations contained herein meet the requirements of ASSMP. The recommended works should be carried out under the direction of an environmental consultant and a validation report submitted at the completion of site works stating that acid sulphate soils have been treated and have undergone remediation treatment.

The above recommendations are based on NSW Acid Sulphate Soil management Advisory Committee (ASSMAC) Guidelines 1998.

Review of project drawings supplied indicates the proposed basement to be located where ground surface levels above RL 4.0m. Our assessment is that acid sulphate soils may not be found within the basement excavation. However it is recommended that an environmental/geotechnical consultant review the materials exposed during excavation and assess any treatment requirements.

For and on behalf of
Network Geotechnics Pty Ltd

David Smith
Student Engineer

Reviewed by

V W de Silva *BScEng, MEng, SMIE Aust, CPEng NPER*
Principal Geotechnical Engineer

Network Geotechnics Pty Ltd

GENERAL NOTES

GENERAL

Geotechnical reports present the results of investigations carried out for a specific project and usually for a specific phase of the project (e.g. preliminary design). The report may not be relevant for other phases of the project (e.g. construction), or where project details change.

SOIL AND ROCK DESCRIPTIONS

Soil and rock descriptions are based on AS 1726 – 1993, using visual and tactile assessment except at discrete locations where field and / or laboratory tests have been carried out. Refer to the terms and symbols sheet for definitions.

GROUNDWATER

The water levels indicated on the logs are taken at the time of measurement and depending on material permeability may not reflect the actual groundwater level at those specific locations. Also, groundwater levels can vary with time due to seasonal or tidal fluctuations and construction activities.

INTERPRETATION OF RESULTS

The discussion and recommendations in the accompanying report are based on extrapolation / interpolation from data obtained at discrete locations. The actual interface between the materials may be far more gradual or abrupt than indicated. Also, actual conditions in areas not sampled may differ from those predicted.

CHANGE IN CONDITIONS

Subsurface conditions can change with time and can vary between test locations. Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations can also affect subsurface conditions.

REPRODUCTION OF REPORTS

 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimise the likelihood of misinterpretation from logs.

FURTHER ADVICE

Network Geotechnics would be pleased to further discuss how any of the above issues could affect your specific project. We would also be pleased to provide further advice or assistance including:

- assessment of suitability of designs and construction techniques;
- contract documentation and specification;
- construction control testing (earthworks, pavement materials, concrete);
- construction advice (foundation assessments, excavation support).

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the interior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the interior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symptoms may include:

- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

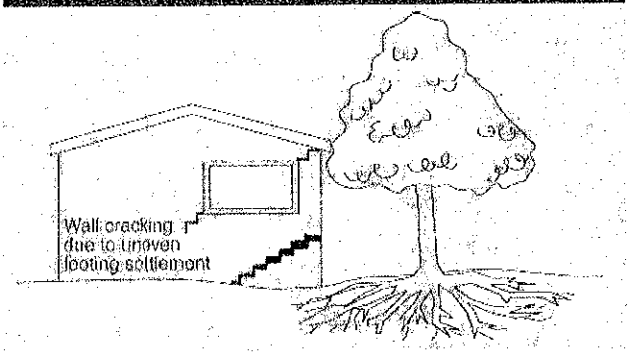
Isolated piers affected by erosion or saturation of foundations will eventually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mitres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the internal footings will rise. If the spread of moisture is roughly even, it may be that the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.

Trees can cause shrinkage and damage



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces that the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return to its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it to its original position. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeated cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexibility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should be noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

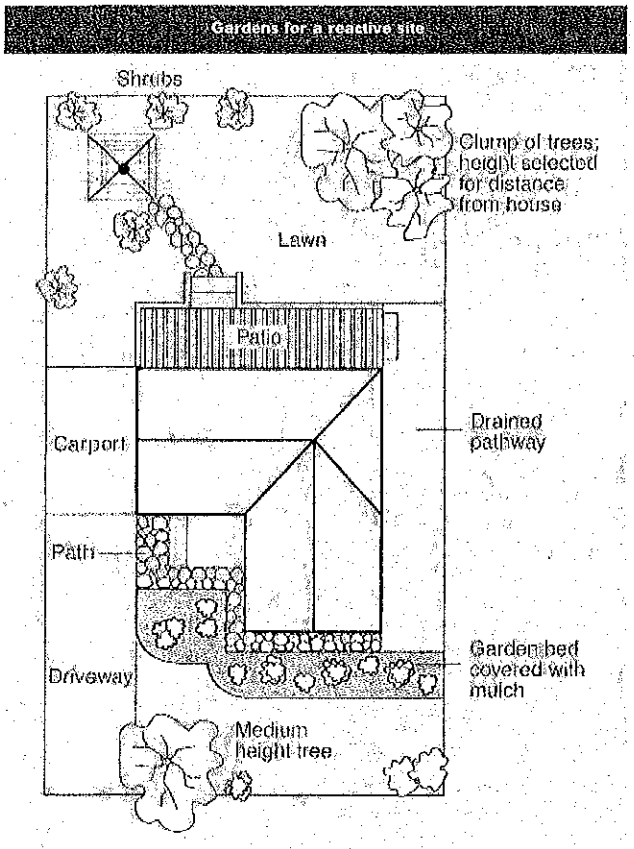
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensation, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where high moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a health hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or threat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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APPENDIX A

Borehole Logs

BOREHOLE LOG

Network Geotechnics Pty Ltd
ACN 069 211 561
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH1
Sheet:	PAGE 1 / 1
Started:	01/10/08
Finished:	01/10/08
Logged:	TR
Checked:	RJK
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: TRUCK MOUNTED EZI PROBE

Borehole Diameter: -mm (I.D.)60mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments, notes, structure, and additional observations
Macro	None Encountered					ML	Sandy SILT, dark brown, fine to medium sand, trace of rootlets	D-M	-	TOPSOIL
						GP-GM/CL/CH	Sandy Silty GRAVEL, fine to medium gravel, dark brown, fine to medium sand			
							Silty Sandy CLAY, medium to high plasticity, pale grey mottled orange brown, fine to medium sand	>Wp	-	RESIDUAL
				1.0						
Macro						-	SANDSTONE, extremely weathered, pale grey, fine to medium grained	D-M	-	
							BH1 Terminated at 1.5 m			Macro refusal at 1.5m depth
				2.0						
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/10/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics Pty Ltd

ACN 069 211 561
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH2
Sheet:	PAGE 1 / 1
Started:	30/09/08
Finished:	30/09/08
Logged:	TR
Checked:	RJK
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: TRUCK MOUNTED EZI PROBE

Borehole Diameter: -mm (I.D.)60mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments, notes, structure, and additional observations
DT						ML	Sandy SILT, dark brown, fine to medium grained, some fine to medium gravel	M	-	TOPSOIL/FILL
						CL	Sandy CLAY, medium plasticity, pale grey mottled orange brown, fine to medium sand	>Wp		RESIDUAL
DT			15+	1.0		SC	Clayey SAND, fine to coarse grained, pale grey mottled orange/red, low plasticity, trace of fine gravel	M	VD	15/75mm
			15+	2.0						15/100mm
DT						CL-CH	Sandy CLAY, medium to high plasticity, pale grey, fine to medium sand	>Wp	-	
						CH	Clayey SAND, fine to coarse grained, pale grey becoming orange/red at 3.2m depth, low plasticity, trace of fine gravel	M	D	
DT			9	3.0						15/50mm
			11							
			16+							
DT	▽		20	4.0		CL-CH	CLAY medium to high plasticity, pale grey, some fine to medium sand	>Wp	VSt	
						SC	Clayey SAND, fine to coarse grained, pale grey mottled red brown, low plasticity, trace of fine gravel	M	S	15/50mm
ADV				5.0						15/75mm
				6.0			BH2 Terminated at 6 m			

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Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics Pty Ltd
ACN 089 211 561
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH3
Sheet:	PAGE 1 / 1
Started:	30/09/08
Finished:	30/09/08
Logged:	DS
Checked:	TR
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: TRUCK MOUNTED EZI PROBE

Borehole Diameter: -mm (I.D.)100mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments notes, structure, and additional observations
ADV	▽					GP-GM	Sandy Silty GRAVEL, fine to medium gravel, grey, fine to medium sand	D-M	-	FILL
						ML	Sandy SILT, brown, fine to medium sand, some fine to medium gravel, traces of low to medium plastic fines	M		
						CL	Gravelly Sandy CLAY, low to medium plasticity, pale orange brown becoming pale grey at 1.2m depth, fine to medium gravel, fine to medium sand	>Wp	St	
			8	1.0						
		D	5							
			15							
				2.0						
		D				CL/SC	Sandy CLAY/Clayey SAND, medium plasticity, pale grey, fine to medium sand	>Wp to (M)	VSt	RESIDUAL
			11							
			15							
			15	3.0						
						SC	Clayey SAND, fine to coarse gravel, pale grey, low to medium plasticity, trace of fine to medium gravel	W-S	D-VD	
			30	4.0						
		D								
				5.0		CL	CLAY, medium plasticity, pale yellow brown, trace of fine to medium gravel	>Wp	(VSt/H)	
		D								
			22				BH3 Terminated at 5.5 m			
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/10/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics Pty Ltd
ACN 089 211 561
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH4
Sheet:	PAGE 1 / 1
Started:	30/09/08
Finished:	30/09/08
Logged:	DS
Checked:	TR
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: TRUCK MOUNTED EZI PROBE

Borehole Diameter: -mm (I.D.)100mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments, notes, structure, and additional observations
ADV	▽					SM	Silty SAND, fine to medium grained, dark brown	D-M	-	TOPSOIL/FILL
				1.0		SP	Gravelly Clayey SAND, fine to coarse grained, pale grey, fine to medium gravel, low to medium plasticity	M		FILL
			15/50			GP	Sandy GRAVEL, fine to medium, pale orange brown, fine to medium sand, trace of low to medium plastic fines	M	MD-D	(+15/50mm @1.0m)
				2.0						
			+20			SP	Gravelly SAND, fine to medium grained, pale grey, fine to medium gravel, slightly low to medium plastic fines	M	D-VD	(+20/100mm)
				3.0		SP	Gravelly Clayey SAND, low to medium plasticity, fine to medium grained, yellow brown, fine to medium gravel	M-W		RESIDUAL
						CL	Sandy CLAY, low to medium plasticity, yellow brown, fine to medium sand, some fine to medium gravel	>Wp to (Sat)	VSt-H	
				4.0						
			24							
				5.0						
			+35				BH4 Terminated at 5.5 m			(35+/100mm)
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 13/10/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics Pty Ltd

ACN 069 211 561
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH5
Sheet:	PAGE 1 / 1
Started:	01/10/08
Finished:	01/10/08
Logged:	TR
Checked:	RJK
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: SKID STEER DINGO

Borehole Diameter: -mm (I.D.)100mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments: notes, structure, and additional observations
ADV	▽	D		0.0		SM	Silty SAND, fine to coarse grained, dark brown, trace of fine gravel	D-M	(L)	ALLUVIAL
						SM/SC	Silty Clayey SAND, fine to coarse grained, dark brown, low plasticity	M-W		
		D		1.0		SP/SM	Gravelly Silty SAND, fine tto coarse grained, dark brown, fine gravel	W-S		
		D				CH	CLAY, high plasticity, grey mottled orange brown, trace of fine to medium sand, trace of fine to medium gravel	»Wp to W	(St-VSt)	RESIDUAL
		D		2.0						
		D		3.0			BH5 Terminated at 3 m			
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 1/12/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

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6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH6
Sheet:	PAGE 1 / 1
Started:	01/10/08
Finished:	01/10/08
Logged:	TR
Checked:	RJK
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: SKID STEER DINGO

Borehole Diameter: -mm (I.D.)100mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments notes, structure, and additional observations
ADV	▽	D				SM/SC	Silty Clayey SAND, fine to coarse grained, dark brown, low plasticity, trace of fine to medium gravel	M	(L)	ALLUVIAL
		D		1.0		CL	Sandy CLAY, medium plasticity, grey mottled orange brown, fine to coarse sand, trace of fine to medium gravel	>Wp	F	
			3			SC	Clayey SAND, fine to coarse grained, grey, low to medium plasticity	M-W	F-St	
		D	3							
			4							
			6			CL/CH	CLAY, medium to high plasticity, grey mottled red brown, some fine to medium sand	~Wp	VSt	RESIDUAL
		D		2.0						
			11							
			12							
			15+							15/100mm
		D								
				3.0		CH	CLAY, high plasticity, grey mottled brown	>Wp	H	
		D								
			23				BH6 Terminated at 3 m			Near V Bit refusal at 3.0m depth
			25							
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 1/12/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

BOREHOLE LOG

Network Geotechnics Pty Ltd
ACN 069 211 661
6/6 Morton Close
TUGGERAH NSW 2259
02 4351 6200
02 4351 6300

Job No:	G08/221
Hole No:	BH7
Sheet:	PAGE 1 / 1
Started:	01/10/08
Finished:	01/10/08
Logged:	TR
Checked:	RJK
RL Surface:	-
Datum:	-

Client: STERLINGS PTY LTD

Project: PROPOSED SENIORS LIVING

Location: 222 MAIN ROAD, TOUKLEY
GPS (-)

Equipment Type: SKID STEER DINGO

Borehole Diameter: -mm (I.D.)100mm(O.D.) Inclination: Bearing:

method	water	samples, tests etc	DCP Blows per 150 mm	depth (m)	graphic log	USCS symbol	Material Description	Moisture condition	Consistency/ relative density	comments (notes, structure, and additional observations)
LB		D				SC	Clayey SAND, fine to medium grained, pale grey, low to medium plasticity, trace of fine to medium gravel	M	-	FILL
						SM	Silty SAND, fine to coarse grained, dark grey, trace of fine gravel	M-W	(L)	ALLUVIAL
						SP	SAND, fine to coarse grained, pale grey, trace of fine gravel	W		
LB	▽	D		1.0		SP	Gravelly SAND, fine to coarse grained, pale grey, fine gravel		-	
LB		D				CH	CLAY, high plasticity, pale grey	»Wp	(Vst)	RESIDUAL
				2.0			BH7 Terminated at 1.8 m			
				3.0						
				4.0						
				5.0						
				6.0						

BOREHOLE LOG G08221.GPJ NETWORK GEOTECHNICS PTY LTD.GDT 1/12/08

Refer To Explanation Sheets For Description Of Terms And Symbols Used.

APPENDIX B

Laboratory Test Results

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
6/6 Morton Close
Tuggerah,NSW,2259,AUSTRALIA
61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client: Sterlings Pty Ltd
Client Address : 153 Morgan Street Mereweather NSW 2291
Principal:
Project: Proposed Senior Living Development
Location: 222 Main Road , Toukley

Job No: G08/221
Report No: 1
Tested By: MG

Sheet: 1 of 4
Test Date: 21/10/2008

Sample Description:	Clayey SAND,grey-red-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3805	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 2 (4.5m-4.9m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	47
Plastic Limit (W_P) AS1289.3.2.1	%	19
Plasticity Index (I_P) AS1289.3.3.1	%	28
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

DATE 28/10/2008

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
6/6 Morton Close
Tuggerah,NSW,2259,AUSTRALIA
61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client:	Sterlings Pty Ltd	**Job No:**	G08/221	**Sheet:**	2 of 4
Client Address :	153 Morgan Street Mereweather NSW 2291	**Report No:**	1		
Principal:					
Project:	Proposed Senior Living Development	**Tested By:**	MG	**Test Date**	21/10/2008
Location:	222 Main Road , Toukley				

Sample Description:	Sandy CLAY/Clayey SAND, grey	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3806	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 3 (2.2m-2.4m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	43
Plastic Limit (W_P) AS1289.3.2.1	%	17
Plasticity Index (I_P) AS1289.3.3.1	%	26
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

DATE 28/10/2008

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
6/6 Morton Close
Tuggerah,NSW,2259,AUSTRALIA
61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client: Sterlings Pty Ltd
Client Address : 153 Morgan Street Mereweather NSW 2291
Principal:
Project: Proposed Senior Living Development
Location: 222 Main Road , Toukley

Job No: G08/221
Report No: 1
Tested By: MG

Test Date: 21/10/2008

Sample Description:	Gravelly Clayey SAND, yellow-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3807	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 4 (2.9m-3.3m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	40
Plastic Limit (W_P) AS1289.3.2.1	%	16
Plasticity Index (I_P) AS1289.3.3.1	%	24
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

DATE 28/10/2008

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
6/6 Morton Close
Tuggerah,NSW,2259,AUSTRALIA
61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client: Sterlings Pty Ltd
Client Address : 153 Morgan Street Mereweather NSW 2291
Principal:
Project: Proposed Senior Living Development
Location: 222 Main Road , Toukley

Job No: G08/221
Report No: 1
Tested By: MG

Sheet: 4 of 4
Test Date: 21/10/2008

Sample Description:	Sandy CLAY, yellow-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3808	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 4 (5.1m-5.3m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	37
Plastic Limit (W_P) AS1289.3.2.1	%	13
Plasticity Index (I_P) AS1289.3.3.1	%	24
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

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61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client: Sterlings Pty Ltd
Client Address : 153 Morgan Street Mereweather NSW 2291
Principal:
Project: Proposed Senior Living Development
Location: 222 Main Road , Toukley

Job No: G08/221
Report No: 1
Tested By: MG

Sheet: 1 of 4
Test Date: 21/10/2008

Sample Description:	Clayey SAND,grey-red-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3805	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 2 (4.5m-4.9m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	47
Plastic Limit (W_P) AS1289.3.2.1	%	19
Plasticity Index (I_P) AS1289.3.3.1	%	28
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

APPROVED SIGNATORY

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ACN 069 211 561
6/6 Morton Close
Tuggerah,NSW,2259,AUSTRALIA
61 2 43 616200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client:	Sterlings Pty Ltd	**Job No:**	G08/221	**Sheet:**	2 of 4
Client Address :	153 Morgan Street Mereweather NSW 2291	**Report No:**	1		
Principal:					
Project:	Proposed Senior Living Development	**Tested By:**	MG	**Test Date:**	21/10/2008
Location:	222 Main Road , Toukley				

Sample Description:	Sandy CLAY/Clayey SAND, grey	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3806	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 3 (2.2m-2.4m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	43
Plastic Limit (W_P) AS1289.3.2.1	%	17
Plasticity Index (I_P) AS1289.3.3.1	%	26
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

DATE 28/10/2008

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Tuggerah,NSW,2259,AUSTRALIA
61 2 43 516200
61 2 43 516300
centralcoast@netgeo.com.au

TEST REPORT

Client:	Sterlings Pty Ltd	**Job No:**	G08/221	**Sheet:**	3 of 4
Client Address :	153 Morgan Street Mereweather NSW 2291	**Report No:**	1		
Principal:					
Project:	Proposed Senior Living Development	**Tested By:**	MG	**Test Date:**	21/10/2008
Location:	222 Main Road , Toukley				

Sample Description:	Gravelly Clayey SAND, yellow-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3807	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 4 (2.9m-3.3m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	40
Plastic Limit (W_P) AS1289.3.2.1	%	16
Plasticity Index (I_P) AS1289.3.3.1	%	24
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

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TEST REPORT

Client:	Sterlings Pty Ltd	**Job No:**	G08/221	**Sheet:**	4 of 4
Client Address :	153 Morgan Street Mereweather NSW 2291	**Report No:**	1		
Principal:					
Project:	Proposed Senior Living Development	**Tested By:**	MG	**Test Date**	21/10/2008
Location:	222 Main Road , Toukley				

Sample Description:	Sandy CLAY, yellow-brown	Sample Procedure:	AS1289.1.2.1(6.5.3)
Lab Number:	G3808	Sample History:	Oven Dried
Date Sampled:	21/10/2008	Preparation Method:	Dry Sieved
Sample Number	BH 4 (5.1m-5.3m)	Shrinkage Mould Length (mm)	

ATTERBERG LIMITS & LINEAR SHRINKAGE

TEST PROCEDURE		TEST RESULTS
Liquid Limit (W_L) AS1289.3.1.1 1995	%	37
Plastic Limit (W_P) AS1289.3.2.1	%	13
Plasticity Index (I_P) AS1289.3.3.1	%	24
Linear Shrinkage(L_S) AS1289.3.4.1	%	-

REMARKS: Sample locations shown on drawing G08/221-1

Tuggerah Laboratory 1318

APPROVED SIGNATORY

DATE 28/10/2008

pH & ACID SULPHATE SCREENING TEST RESULTS SUMMARY

Sterlings Pty Ltd

Proposed Seniors Living
222 Main Road, Toukley

Location	Depth (m)	Abbrev. Description	pH		Reduced Inorganic Sulphur (%Scr)	Net Acidity mole H+/tonne	Texture	Assessed Actual or Potential Acid Sulphate Soils
			(H_20)	(H_2O_2)				
BH5	0.3-0.5	ALLUVIAL: Silty SAND	6.1	3.0				
BH5	0.8-1.0	ALLUVIAL: Clayey SAND	6.4	**2.6**	**0.008**	**22**	**medium**	**No**
BH5	1.3-1.5	ALLUVIAL: CLAY	7.1	3.6				
BH5	1.8-2.0	ALLUVIAL: CLAY	5.8	3.1				
BH5	2.3-2.5	ALLUVIAL: CLAY	5.4	2.7				
BH5	2.8-3.0	ALLUVIAL: CLAY	5.4	**2.5**	**0.052**	**53**	**fine**	**No**
BH6	0.3-0.5	ALLUVIAL: Silty clayey SAND	5.4	2.8				
BH6	0.8-1.0	ALLUVIAL: Sandy CLAY	5.1	3.2				
BH6	1.3-1.5	ALLUVIAL: Clayey SAND	5.4	3.4				
BH6	1.8-2.0	ALLUVIAL: CLAY	5.4	3.7				
BH6	2.3-2.5	ALLUVIAL: CLAY	5.2	4.4				
BH6	2.8-3.0	ALLUVIAL: CLAY	5.3	4.7				
BH7	0.35-0.7	ALLUVIAL: SAND	6.2	3.7				
BH7	0.8-1.1	ALLUVIAL: Gravelly SAND	6.0	4.1				
BH7	1.3-1.8	ALLUVIAL: CLAY	6.9	7.7				

Notes:

1. %Scr denotes Reduced Inorganic Sulphur (% chromium reducible sulphur) analysed by POCAS method and Chromium Reducible Sulphur technique.
2. Net acidity of chromium suite = potential sulphidic acidity + actual acidity + retained acidity.
3. Bolded values above indicate soils are considered to have the potential to produce acid sulphate upon further oxidation based on ASSMAC guidelines.
4. pH readings were carried out using a pH SCAN2 metre (accuracy ±0.1 pH) calibrated with two buffer solutions (pH4 and 7).
5. The pH of potential acid sulphate soils (PASS) is measured in a mixture of 5g of soil to 25ml of 30% hydrogen peroxide buffered to a pH between 4.5 and 5.5. This is a qualitative method only and gives an indication of the intensity of acidification (pH).
6. AAS refers to assessed Actual Acid Sulphate Soil.

RESULTS OF ACID SULFATE SOIL ANALYSIS (Page 1 of 1)

2 samples supplied by Network Geotechnics Pty Ltd on 10th October, 2008 - Lab. Job No. A0561
Analysis requested by Steve Thorley. - **Your Project: G08/221**

Sample Site	Depth (m)	EAL lab code	Texture (note 6)	Moisture Content (% moisture)	Lab. Bulk Density tonne DW/m^3	TAA pH_{KCl}	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)	Reduced Inorganic Sulfur (% chromium reducible S) (%Scr) (note 2)	Reduced Inorganic Sulfur (Scr) mole H^+/tonne	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3/m^3$ (includes 1.5 safety Factor)
Method No.						*23A*	*23F*	*22B*	*a. 22B*	*note 5*	*note 5*
BH 5	0.8-1.0	*A0561/1*	Medium	20.3	1.6	5.02	17	0.008	5	22	3
BH 5	2.8-3.0	*A0561/2*	Fine	21.3	1.6	4.58	21	0.052	32	53	7

NOTE:

1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines.*** QLD DNRME.
4 - Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)
5 - **ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - .. denotes not requested or required
9 - SCREENING, CRS, TAA and ANC are NATA certified but other SPOCAS segments are currently not NATA certification
10- Results at or below detection limits are replaced with '0' for calculation purposes.
11 - **Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).**

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t)

NATA
Lab Accred No: 14960
This Document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025

checked: .....

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: ES0814597	Page	: 1 of 6
Client	: NETWORK GEOTECHNICS PTY LTD	Laboratory	: Environmental Division Sydney
Contact	: MR VIPUL DE SILVA	Contact	: Charlie Pierce
Address	: UNIT 14, 25 STODDART ROAD PROSPECT NSW, AUSTRALIA 2148	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: sydeng@netgeo.com.au	E-mail	: charlie.pierce@alsenviro.com
Telephone	: +61 96881764	Telephone	: +61-2-8784 8555
Facsimile	: +61 02 96881765	Facsimile	: +61-2-8784 8500
Project	: G081221	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: 2148		
C-O-C number	: —	Date Samples Received	: 03-OCT-2008
Sampler	: T.R.& R.S.	Issue Date	: 14-OCT-2008
Site	: MAIN ROAD TOUKELY		
		No. of samples received	: 2
Quote number	: SY/079/08	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Celine Conceicao	Spectroscopist	Inorganics
Edwandy Fadjar	Senior Organic Chemist	Organics
Sarah Millington	Senior Inorganic Chemist	Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been preformed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = Chemistry Abstract Services number
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **EP068 : Insufficient sample has been provided for standard analysis. Where applicable LOR values have been adjusted accordingly.**
- **EP080: Level of Reporting raised for toluene due to ambient background levels in the laboratory.**

Analytical Results

Sub-Matrix: WATER			Client sample ID	BH 2	BH 3	—	—	—
			Client sampling date / time	02-OCT-2008 11:55	02-OCT-2008 11:55	—	—	—
Compound	CAS Number	LOR	Unit	ES0814597-001	ES0814597-002	—	—	—
EA005: pH								
pH Value	—	0.01	pH Unit	5.55	5.62	—	—	—
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	—	1	µS/cm	496	482	—	—	—
EA065: Total Hardness as CaCO3								
^ Total Hardness as CaCO3	—	1	mg/L	36	22	—	—	—
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	<1	—	—	—
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	<1	—	—	—
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	<1	1	—	—	—
Total Alkalinity as CaCO3	—	1	mg/L	<1	1	—	—	—
ED041: Sulfate (Turbidimetric) as SO4 2-								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	53	65	—	—	—
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	98	93	—	—	—
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	4	<1	—	—	—
Magnesium	7439-95-4	1	mg/L	7	5	—	—	—
Sodium	7440-23-5	1	mg/L	71	78	—	—	—
Potassium	7440-09-7	1	mg/L	2	2	—	—	—
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	0.004	0.025	—	—	—
Cadmium	7440-43-9	0.0001	mg/L	0.0058	0.0332	—	—	—
Chromium	7440-47-3	0.001	mg/L	0.076	0.400	—	—	—
Copper	7440-50-8	0.001	mg/L	0.068	0.055	—	—	—
Lead	7439-92-1	0.001	mg/L	0.171	0.252	—	—	—
Nickel	7440-02-0	0.001	mg/L	0.020	0.030	—	—	—
Zinc	7440-66-6	0.005	mg/L	0.223	0.154	—	—	—
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	0.0001	<0.0001	—	—	—
EN055: Ionic Balance								
^ Total Anions	—	0.01	meq/L	3.87	4.00	—	—	—
^ Total Cations	—	0.01	meq/L	3.86	3.90	—	—	—
^ Ionic Balance	—	0.01	%	0.22	1.30	—	—	—
EP066: Polychlorinated Biphenyls (PCB)								
Total Polychlorinated biphenyls	—	1	µg/L	<1	—	—	—	—
EP068A: Organochlorine Pesticides (OC)								

Analytical Results

Sub-Matrix: **WATER**

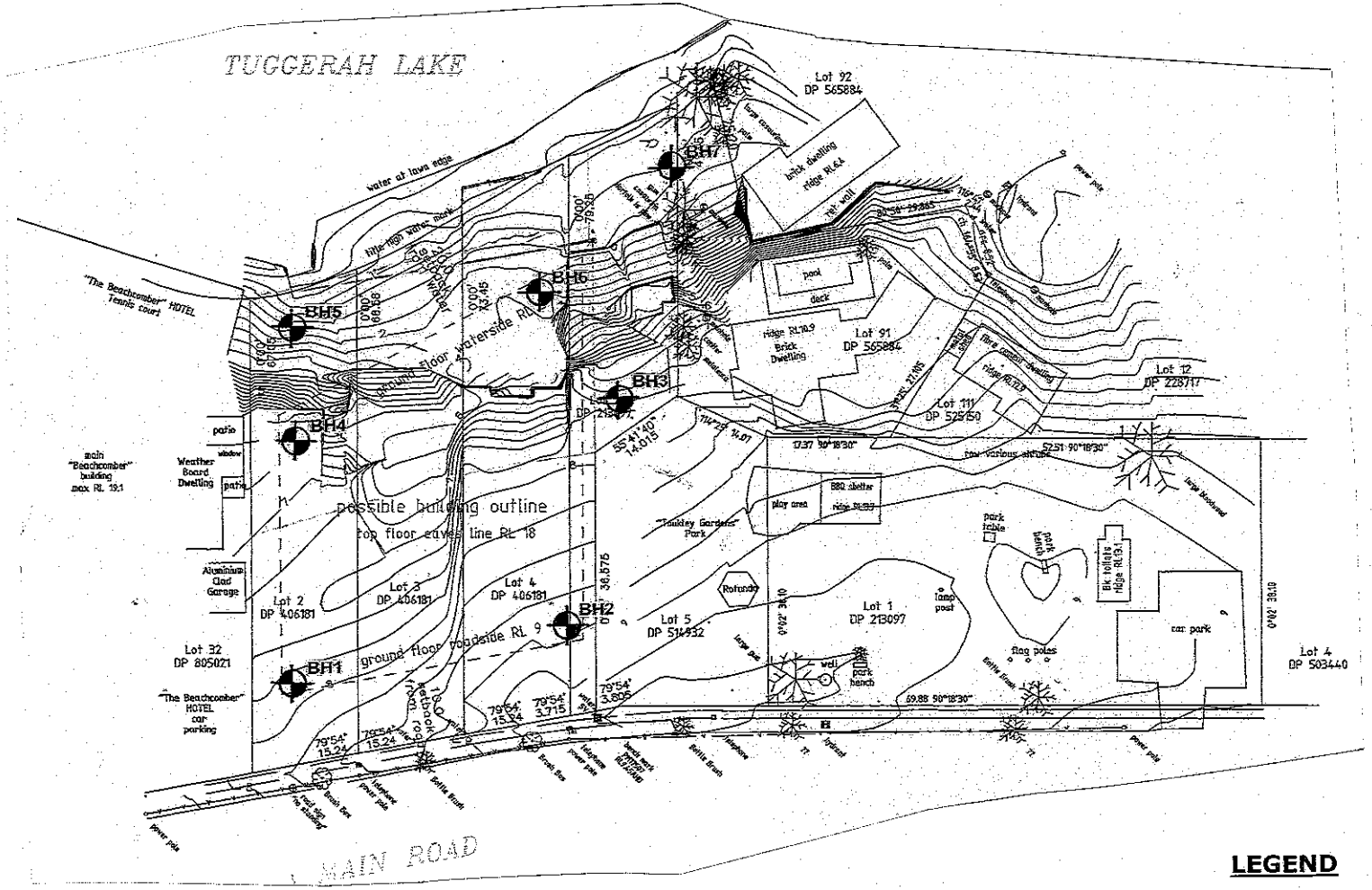
Compound	CAS Number	LOR	Unit	Client sample ID: BH 2 Client sampling date / time: 02-OCT-2008 11:55 ES0814597-001	BH 3 02-OCT-2008 11:55 ES0814597-002	—	—	—
EP068A: Organochlorine Pesticides (OC) - Continued								
alpha-BHC	319-84-6	0.5	µg/L	<0.9	—	—	—	—
Hexachlorobenzene (HCB)	118-74-1	0.5	µg/L	<0.9	—	—	—	—
beta-BHC	319-85-7	0.5	µg/L	<0.9	—	—	—	—
gamma-BHC	58-89-9	0.5	µg/L	<0.9	—	—	—	—
delta-BHC	319-86-8	0.5	µg/L	<0.9	—	—	—	—
Heptachlor	76-44-8	0.5	µg/L	<0.9	—	—	—	—
Aldrin	309-00-2	0.5	µg/L	<0.9	—	—	—	—
Heptachlor epoxide	1024-57-3	0.5	µg/L	<0.9	—	—	—	—
trans-Chlordane	5103-74-2	0.5	µg/L	<0.9	—	—	—	—
alpha-Endosulfan	959-98-8	0.5	µg/L	<0.9	—	—	—	—
cis-Chlordane	5103-71-9	0.5	µg/L	<0.9	—	—	—	—
Dieldrin	60-57-1	0.5	µg/L	<0.9	—	—	—	—
4.4`-DDE	72-55-9	0.5	µg/L	<0.9	—	—	—	—
Endrin	72-20-8	0.5	µg/L	<0.9	—	—	—	—
beta-Endosulfan	33213-65-9	0.5	µg/L	<0.9	—	—	—	—
4.4`-DDD	72-54-8	0.5	µg/L	<0.9	—	—	—	—
Endrin aldehyde	7421-93-4	0.5	µg/L	<0.9	—	—	—	—
Endosulfan sulfate	1031-07-8	0.5	µg/L	<0.9	—	—	—	—
4.4`-DDT	50-29-3	2	µg/L	<4	—	—	—	—
Endrin ketone	53494-70-5	0.5	µg/L	<0.9	—	—	—	—
Methoxychlor	72-43-5	2	µg/L	<4	—	—	—	—
EP068B: Organophosphorus Pesticides (OP)								
Dichlorvos	62-73-7	0.5	µg/L	<0.9	—	—	—	—
Demeton-S-methyl	919-86-8	0.5	µg/L	<0.9	—	—	—	—
Monocrotophos	6923-22-4	2	µg/L	<4	—	—	—	—
Dimethoate	60-51-5	0.5	µg/L	<0.9	—	—	—	—
Diazinon	333-41-5	0.5	µg/L	<0.9	—	—	—	—
Chlorpyrifos-methyl	5598-13-0	0.5	µg/L	<0.9	—	—	—	—
Parathion-methyl	298-00-0	2	µg/L	<4	—	—	—	—
Malathion	121-75-5	0.5	µg/L	<0.9	—	—	—	—
Fenthion	55-38-9	0.5	µg/L	<0.9	—	—	—	—
Chlorpyrifos	2921-88-2	0.5	µg/L	<0.9	—	—	—	—
Parathion	56-38-2	2	µg/L	<4	—	—	—	—
Pirimphos-ethyl	23505-41-1	0.5	µg/L	<0.9	—	—	—	—
Chlorfenvinphos	470-90-6	0.5	µg/L	<0.9	—	—	—	—
Bromophos-ethyl	4824-78-6	0.5	µg/L	<0.9	—	—	—	—
Fenamiphos	22224-92-6	0.5	µg/L	<0.9	—	—	—	—
Prothiofos	34643-46-4	0.5	µg/L	<0.9	—	—	—	—

Analytical Results

Sub-Matrix: WATER			Client sample ID	BH 2	BH 3	—	—	—
			Client sampling date / time	02-OCT-2008 11:55	02-OCT-2008 11:55	—	—	—
Compound	CAS Number	LOR	Unit	ES0814597-001	ES0814597-002	—	—	—
EP068B: Organophosphorus Pesticides (OP) - Continued								
Ethion	563-12-2	0.5	µg/L	<0.9	—	—	—	—
Carbophenothion	786-19-6	0.5	µg/L	<0.9	—	—	—	—
Azinphos Methyl	86-50-0	0.5	µg/L	<0.9	—	—	—	—
EP080/071: Total Petroleum Hydrocarbons								
C6 - C9 Fraction	—	20	µg/L	<20	<20	—	—	—
C10 - C14 Fraction	—	50	µg/L	<50	<50	—	—	—
C15 - C28 Fraction	—	100	µg/L	<100	<100	—	—	—
C29 - C36 Fraction	—	50	µg/L	<50	<50	—	—	—
EP080: BTEX								
Benzene	71-43-2	1	µg/L	<1	<1	—	—	—
Toluene	108-88-3	2	µg/L	<5	<5	—	—	—
Ethylbenzene	100-41-4	2	µg/L	<2	<2	—	—	—
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	<2	—	—	—
ortho-Xylene	95-47-6	2	µg/L	<2	<2	—	—	—
EP066S: PCB Surrogate								
Decachlorobiphenyl	2051-24-3	0.1	%	88.0	—	—	—	—
EP068S: Organochlorine Pesticide Surrogate								
Dibromo-DDE	21655-73-2	0.1	%	83.9	—	—	—	—
EP068T: Organophosphorus Pesticide Surrogate								
DEF	78-48-8	0.1	%	82.1	—	—	—	—
EP080S: TPH(V)/BTEX Surrogates								
1,2-Dichloroethane-D4	17060-07-0	0.1	%	105	82.1	—	—	—
Toluene-D8	2037-26-5	0.1	%	114	87.3	—	—	—
4-Bromofluorobenzene	460-00-4	0.1	%	102	91.5	—	—	—

Surrogate Control Limits

Sub-Matrix: WATER		Recovery Limits (%)	
Compound	CAS Number	Low	High
EP066S: PCB Surrogate			
Decachlorobiphenyl	2051-24-3	10	164
EP068S: Organochlorine Pesticide Surrogate			
Dibromo-DDE	21655-73-2	10	136
EP068T: Organophosphorus Pesticide Surrogate			
DEF	78-48-8	10	136
EP080S: TPH(V)/BTEX Surrogates			
1,2-Dichloroethane-D4	17060-07-0	80	120
Toluene-D8	2037-26-5	88	110
4-Bromofluorobenzene	460-00-4	86	115



LEGEND

Approximate location of boreholes

Network Geotechnics Pty Ltd
Geotechnical Engineering, Consulting & Testing Services

ACN 069 211 561
Unit 6/6 Morton Close
TUGGERAH NSW 2259 AUSTRALIA
Telephone 61 2 4351 6200
Facsimile 61 2 4351 6300
Email centralcoast@netgeo.com.au

SCALE: As Shown

DRAWING NO: G08/221-1

STERLINGS PTY LTD
PROPOSED SENIOR LIVING
222 MAIN ROAD,
TOUKLEY

SITE PLAN

Appendix J

Acid Sulphate Soils Report

Network Geotechnics Pty Ltd

Central Coast Office
6/6 Morton Close, Tuggerah NSW 2259
Telephone: (02) 4351 6200 Facsimile: (02) 4351 6300
Email centralcoast@netgeo.com.au

G08/221-B VDS:KW
18th November 2008

Rustrum No 2
c/- Sterling Pty Ltd
PO Box 142
CHATSWOOD NSW 2057

Attention: Terry Roche

Dear Sir

Re: Proposed Senior Living Development 222 Main Road, Toukley: Acid Sulphate Assessment, Preliminary Report.

This preliminary report presents the results of acid sulphate assessment carried out along with a geotechnical investigation.

Fieldwork was carried out on the 30th September and 1st October, 2008 and comprised of seven boreholes (BH1 to BH7). BH1 to BH4 was drilled using a truck mounted Ezi-probe drill rig in the upper portion. On the lower portion of the site, BH5 and BH6 were drilled to a termination depth of 3m using a skid steer mini drilling rig fitted with a 100mm diameter solid flight 'V-bit' auger drill. BH7 was carried out using portable push tube equipment to a termination depth of 1.8m.

The fieldwork was carried out by our geotechnical staff who selected the test locations, carried out in-situ testing and disturbed sampling, and prepared logs of boreholes on the soils encountered. The borehole logs are presented in appendix A and approximate test locations are shown on the attached Drawing No. G08/221-1.

Laboratory testing carries out on soil samples obtained during the investigation incldued the following:

- pH tests in H_2O (distilled water) to assess current acidity;
- pH tests in H_2O_2 (hydrogen peroxide) to assess the potential for acid sulphate generation;
- Reduced Inorganic Sulphur (Scr) and Total Actual Acidity (TAA) to assess neutralising lime dosing requirement.

No. 222 Main Rd has a frontage of about 50m on the northern side of the road extending north about 70 to 80m to the rear of the site to the Southern shore of Tuggerah lake. The above proposed site has an area of about 1ha, with current site surface reduced levels ranging from about RL8-9m AHD along Main Rd to about RL1-2m AHD fronting the Lake shore (where localised acid sulphate assessment may be justified) with majority of site being RL9m-5m. A concrete driveway provides good

access to the lower portion of the site from the upper portion of the site which has been retained by a series of decrepit retaining walls.

The lower northern portion of the site is heavily grassed and the southern higher portion of site has grass and shrubbery. Surface soils encountered were Sandy Silt topsoil and Sandy silty Gravel fill in Parts.

Subsurface profiles encountered in the lower portion of the site (BH5 to BH7) comprised shallow (<0.2m) fill overlying clay and clayey sand Alluvium.

Fifteen soil samples were obtained from BH5, BH6 and BH7 for pH tests in water (H_2O) and hydrogen peroxide (H_2O_2) to assess for existing acidity and the potential for acid sulphate generation. Sampling depths ranged up to 3.0m below existing surface levels.

Current guidelines from the Acid Sulphate Soil Management Advisory Committee (ASSMAC 1998) list indicators of pH in water of less than 4 for actual acidity and pH in hydrogen peroxide of less than 3 for potential acidity.

None of the fifteen soil samples recorded pH <4. Four soil samples tested recorded pH <3 in H_2O_2 indicating a potential for producing acidity upon oxidation.

In view of the above, Sand and a Clay samples from BH5 at depths of 0.8m to 1m and 2.8m to 3m respectively, were forwarded to Environmental Analysis Laboratory of Southern Cross University Lismore to carry out Total Actual Acidity and Chromium Reducible sulphur tests. Test results are included in the attached table.

The reduced inorganic sulphur tests indicate that the medium textured alluvium has a Scr of less than 0.06% (0.003% to 0.007%) or 37molesH^+/t and the fine textured CLAY has a Scr of less than 0.03% (0.003%) or 62molesH^+/t.

It is therefore considered that no associated acid sulphate interventions are required during earthworks for the above proposed site improvement works if the volume of excavation in the area containing BH5, BH6 and BH7 is less than 1000t. If it is likely that more than 1000t of soil in the low lying area (area below RL 5.0m contour) is to be excavated the following management practices should be incorporated.

- Prior to excavation, facilities for stockpiling and treatment of acid sulphate soils should be established. Acid sulphate soil should be prevented form leaching prior to treatment.

- Excavated soil should be mixed with hydrated lime (neutralising capacity more than 95%) at a rate of 5kg/m^3. Treated soil may be used as fill on site or disposed off site. If off site disposal is required, waste classification may be required.

- Lime treated soil should be tested for pH in water to assess that neutralisation is achieved. The treated soil should record pH>6.5 in water. Most of the measured acidity of site soil is existing actual acidity. Therefore, pH test in water would be sufficient to assess the effectiveness of treatment.

- An environmental consultant should be appointed to oversee the excavation treatment and testing. A validation report may be required by the Council after treatment.

The above recommendations should be the basis of an Acid Sulphate Soil Management Plan (ASSMP) if such a plan is required by the Council. If the volume of soil to be excavated is limited to those from the proposed footing excavations and not more than 150m^3 the above recommendations contained herein meet the requirements of ASSMP. The recommended works should be carried out under the direction of an environmental consultant and a validation report submitted at the completion of site works stating that acid sulphate soils have been treated and have undergone remediation treatment.

This report should be read in conjunction with the attached General Notes. Please contact the undersigned if you require further assistance.

For and on behalf of
Network Geotechnics Pty Ltd

per: V W de Silva *BSc Eng, MEng, SMIE Aust, CPEng, NPER*
Principal Geotechnical Engineer

encl *General Notes*
Results of Acid Sulfate Soil Analysis
Drawing No G08/221-1 Site Plan

Network Geotechnics Pty Ltd

GENERAL NOTES

GENERAL

Geotechnical reports present the results of investigations carried out for a specific project and usually for a specific phase of the project (e.g. preliminary design). The report may not be relevant for other phases of the project (e.g. construction), or where project details change.

SOIL AND ROCK DESCRIPTIONS

Soil and rock descriptions are based on AS 1726 – 1993, using visual and tactile assessment except at discrete locations where field and / or laboratory tests have been carried out. Refer to the terms and symbols sheet for definitions.

GROUNDWATER

The water levels indicated on the logs are taken at the time of measurement and depending on material permeability may not reflect the actual groundwater level at those specific locations. Also, groundwater levels can vary with time due to seasonal or tidal fluctuations and construction activities.

INTERPRETATION OF RESULTS

The discussion and recommendations in the accompanying report are based on extrapolation / interpolation from data obtained at discrete locations. The actual interface between the materials may be far more gradual or abrupt than indicated. Also, actual conditions in areas not sampled may differ from those predicted.

CHANGE IN CONDITIONS

Subsurface conditions can change with time and can vary between test locations. Construction operations at or adjacent to the site and natural events such as floods, earthquakes or groundwater fluctuations can also affect subsurface conditions.

REPRODUCTION OF REPORTS

 Where information from the accompanying report is to be included in contract documents or engineering specification for the project, the entire report should be included in order to minimise the likelihood of misinterpretation from logs.

FURTHER ADVICE

Network Geotechnics would be pleased to further discuss how any of the above issues could affect your specific project. We would also be pleased to provide further advice or assistance including;

- assessment of suitability of designs and construction techniques;
- contract documentation and specification;
- construction control testing (earthworks, pavement materials, concrete);
- construction advice (foundation assessments, excavation support).

RESULTS OF ACID SULFATE SOIL ANALYSIS (Page 1 of 1)

2 samples supplied by Network Geotechnics Pty Ltd on 10th October, 2008 - Lab. Job No. A0561
Analysis requested by Steve Thorley. - **Your Project: G08/221**

Sample Site	Depth (m)	EAL lab code	Texture (note 6)	Moisture Content (% moisture)	Lab. Bulk Density tonne DW/m^3	TAA pH_{kcl}	Titratable Actual Acidity (TAA) mole H^+/tonne (to pH 6.5)	Reduced Inorganic Sulfur (% chromium reducible S) (%Scr) (note 2)	Reduced Inorganic Sulfur (Scr) mole H^+/tonne	NET ACIDITY Chromium Suite mole H^+/tonne (based on %Scrs)	LIME CALCULATION Chromium Suite kg $CaCO_3/m^3$ (includes 1.5 safety Factor)
Method No.						*23A*	*23F*	*22B*	*a- 22B*	*note 5*	*note 5*
BH 5	0.8-1.0	*A0561/1*	Medium	20.3	1.6	5.02	17	0.008	5	22	3
BH 5	2.8-3.0	*A0561/2*	Fine	21.3	1.6	4.58	21	0.052	32	53	7

NOTE:
1 - All analysis is Dry Weight (DW) - samples dried and ground immediately upon arrival (unless supplied dried and ground)
2 - Samples analysed by SPOCAS method 23 (ie Suspension Peroxide Oxidation Combined Acidity & sulfate) and 'Chromium Reducible Sulfur' technique (Scr - Method 22B)
3 - Methods from Ahern, CR, McElnea AE , Sullivan LA (2004). ***Acid Sulfate Soils Laboratory Methods Guidelines.*** QLD DNRME.
4 - Bulk density was determined immediately on arrival to laboratory (insitu bulk density is preferred)
5 - **ABA Equation: Net Acidity = Potential Sulfidic Acidity (ie. Scrs or Sox) + Actual Acidity + Retained Acidity - measured ANC/FF (with FF currently defaulted to 1.5)**
6 - The neutralising requirement, lime calculation, includes a 1.5 safety margin for acid neutralisation (an increased safety factor may be required in some cases)
7 - For Texture: coarse = sands to loamy sands; medium = sandy loams to light clays; fine = medium to heavy clays and silty clays
8 - .. denotes not requested or required
9 - SCREENING, CRS, TAA and ANC are NATA certified but other SPOCAS segments are currently not NATA certification
10- Results at or below detection limits are replaced with '0' for calculation purposes.
11 - Projects that disturb >1000 tonnes of soil, the ≥0.03% S classification guideline would apply (refer to acid sulfate management guidelines).

(Classification of potential acid sulfate material if: coarse Scr≥0.03%S or 19mole H+/t; medium Scr≥0.06%S or 37mole H+/t; fine Scr≥0.1%S or 62mole H+/t)

NATA
Lab.Accred.No.:14960
This Document is issued in accordance with NATA's accreditation requirements. Accredited for compliance with ISO/IEC 17025

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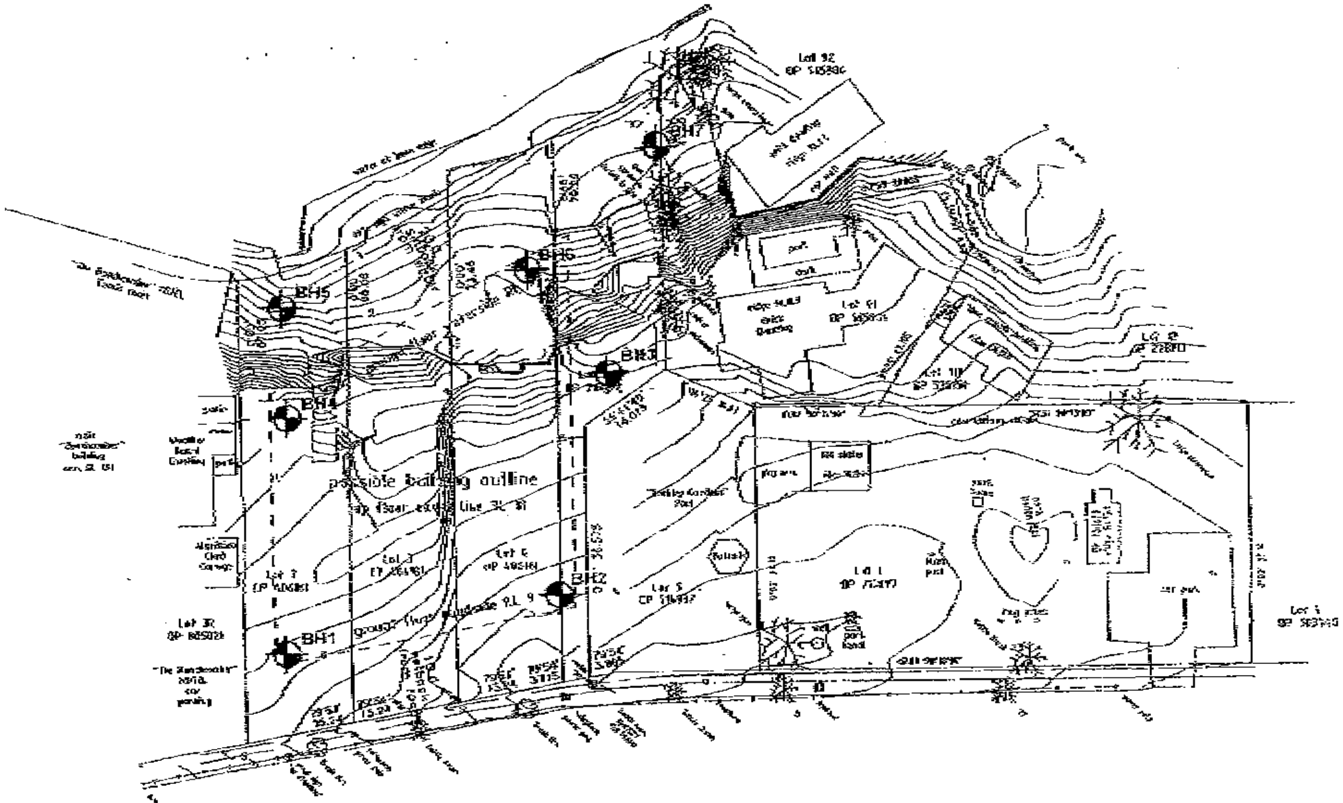

LEGEND

Approximate location of boreholes

Network Geotechnics Pty Ltd

Scale: As Shown

STERLINGS PTY LTD
PROPOSED SENIOR LIVING
222 MAIN ROAD