GEOTECHNIQUE® PTY LTD

ABN 64 002 841 063

Job No: 13602/2
Our Ref: 13602/2-AA
24 November 2015

[redacted]
c/- CCL Development Pty Ltd
8 Boorea Street
BLAXLAND NSW 2774

Attention: Mr C Lamb

Dear Sir

re: **Proposed Residential Subdivision**
Part Lot 1 DP224861 & Lot 4 DP226490
Glenmore Park Precincts G & H, 2183 The Northern Road, Glenmore Park
Report on Geotechnical and Salinity Assessments

The report details the results of geotechnical and salinity assessments at the above site. The work was commissioned by Mr C Lamb of CCL Development Pty Ltd in a signed confirmation of engagement dated 20 October 2015 and was carried out as per our proposal Q7282-AB dated 12 October 2015.

Proposed Development
We understand that the site, totalling about 23ha, is proposed for a total of 375 lot subdivision in two precincts and nine stages.

In this regard geotechnical and salinity assessments were required to determine existing sub-surface conditions, including depth to bedrock, quality, strength and rippability of the existing bedrock and soil salinity across the site.

Field Work
Field work for the geotechnical and salinity assessments was carried out on 6 and 10 November 2015. This work was carried out in conjunction with contamination assessment.

- OH&S and walkover survey to assess existing site conditions.
- Scanning test pit and boreholes locations for underground services so that excavation would not damage services.
- Excavating a total of eighteen (18) test pits to depths ranging from 0.5m to 1.8m. The test pits were terminated at these depths due to refusal in bedrock.
- Drilling of four (4) boreholes to depths of 2.7m to 5.9m, using a truck mounted drilling rig. These boreholes were located in the deepest cut areas. At V-bit refusal boreholes were advanced by coring technique.
- Groundwater or seepage measurement at the completion of excavation.
- Recovery of soil samples for visual assessment and laboratory further testing.

Field work was carried out by an environmental scientist and a senior geotechnical engineer from this company who was responsible for locating test pits, supervision, in-situ testing, sampling and preparation of logs.

[redacted]

Regional Geology

Based on the Geological Map of Penrith (1:100,000), the bedrock at the site is anticipated to be Bringelly Shale, belonging to the Wianamatta Group of rocks and comprising shale, carbonaceous claystone, laminite, fine to medium grained lithic sandstone and rare coal.

Reference to the Salinity Potential in Western Sydney (2002) map indicates that most portion of the site has Moderate Salinity Potential with High Salinity Potential along the creek lines.

Site Description

The following site observations were made during the field work:

- The proposed development is located to the south of Mulgoa Rise.
- The ground surface consists of rolling hills and mostly covered with grass and isolated trees.
- There is a creek (Surveyors Creek) running in north-south direction through the middle of the site.

Sub-surface Conditions

Sub-surface conditions encountered in the test pits are summarised in Table 1 below and detailed in the attached engineering logs.

TABLE 1

TP/BH	Termination Depth (m)	Topsoil (m)	Natural Soils (m)	Bedrock (m)
TP1	1.6	0.0 – 0.2	0.2 – 1.6	=>1.6
TP2	1.7	0.0 – 0.2	0.2 – 1.7	NE
TP3	1.6	0.0 – 0.2	0.2 –> 1.6	NE
TP4	1.2	0.0 – 0.2	0.2 –> 1.2	NE
TP5	1.5	0.0 – 0.2	0.2 –> 1.5	NE
TP6	1.6	0.0 – 0.2	0.2 –> 1.6	NE
TP7	1.7	0.0 – 0.2	0.2 –> 1.7	NE
TP8	1.4	0.0 – 0.2	0.2 – 1.4	=> 1.4
TP9	1.6	0.0 – 0.2	0.2 –> 1.6	NE
TP10	1.7	0.0 – 0.2	0.2 –> 1.7	NE
TP11	0.5	0.0 – 0.2	0.2 – 0.5	=> 0.5
TP12	1.1	0.0 – 0.2	0.2 – 1.1	=> 1.1
TP13	1.4	0.0 – 0.2	0.2 – 1.4	=> 1.4
TP14	1.8	0.0 – 0.2	0.2 –> 1.8	NE
TP15	1.3	0.0 – 0.2	0.2 –> 1.3	NE
TP16	1.6	0.0 – 0.2	0.2 –> 1.6	NE
TP17	1.1	0.0 – 0.2	0.2 –> 1.1	NE
TP18	1.5	0.0 – 0.2	0.2 –> 1.5	NE
BH18	5.8	0.0 – 0.1	0.1 – 1.9	1.9 –> 5.8
BH19	5.9	0.0 – 0.2	0.2 – 2.5	2.5 –> 5.9
BH20	5.6	0.0 – 0.1	0.1 – 1.7	1.7 –> 5.6
BH21	2.7	0.0 – 0.1	0.1 – 1.9	1.9 –> 2.7

Topsoil	Silty Clay, low plasticity, brown, with roots
Natural	Silty CLAY, medium to high plasticity, orange-grey, brown, with ironstone and shale gravel Clayey sandy SILT, low paslticity, grey and brown, with siltstone gravel
Bedrock	SHALE, dark grey, brown, extremely to distinctly weathered, extremely low to low strength SILTSTONE, grey, distinctly to slightly weathered and medium to high strength

Groundwater Conditions

Groundwater or seepage was not encountered to the terminated depths of the test pits. It should be noted that levels of groundwater or seepage might change due to changes in temperature, rainfall and other factors not evident during the field work.

Laboratory Testing

California Bearing Ratio

Soaked CBR tests were conducted on two subgrade samples collected from the test pits, in the NATA accredited laboratory of Geotech Testing Pty Ltd. The Soaked CBR test was carried out on a specimen compacted to a target dry density ratio of 100% Standard (AS1289 5.4.1) at moisture content close to Standard Optimum. The CBR results are detailed on the attached certificate and summarised below:

TABLE 2

TP	Depth (m)	Summary Description	MDD (t/m^3)	OMC (%)	FMC (%)	Variation from OMC (%)	CBR (%)
1	1.0 – 1.5	(CI) Silty CLAY, medium plasticity, orange-brown, grey	1.82	14.8	13.2	1.6 Dry	4
5	1.0 – 1.5	(CI) Silty CLAY, medium plasticity, orange-brown, grey	1.78	17.4	17.3	0.1 Dry	4
14	1.5 – 1.6	(CI) Silty CLAY, medium plasticity, orange-brown, grey	1.82	16.3	15.4	0.9 Dry	5

MDD: Maximum Dry Density, FMC: Field Moisture Content, OMC: Optimum Moisture Content, CBR: California Bearing Ratio

From the above laboratory test results FMC of the subgrade soil was found to be 1.4% dry of OMC. Depending on the time of construction, moisture conditioning might be required to bring subgrade moisture close to OMC.

Point Load Strength Index

Rock cores recovered from the boreholes were photographed and tested for determination of point load strength index (I_{s50}). The point load strength indices for the rock cores and the assessed rock strength classes for axially loaded samples, in accordance with AS1726 “Geotechnical Site Investigations”, are summarised in the following Table 3.

Table 3

Borehole No	Depth (m)	Diametral, $I_{s(50)}$ (MPa)	Axial $I_{s(50)}$ (MPa)	Axial Strength* (AS1726)
18	2.7-2.8	0.64	0.52	Medium
	3.7-3.8	0.68	1.58	High
	4.7-4.8	0.47	2.06	High
	5.7-5.8	0.78	3.11	Very High

Borehole No	Depth (m)	Diametral, $I_{s(50)}$ (MPa)	Axial $I_{s(50)}$ (MPa)	Axial Strength* (AS1726)
19	4.1-4.2	0.29	0.18	Low
	5.1-5.2	0.39	0.21	Low
20	2.8-2.9	0.09	0.06	Very Low
	3.6-3.7	0.03	0.06	Very Low
	4.2-4.3	0.03	0.14	Low
	5.5-5.6	0.04	0.09	Very Low

** Estimated strength, $I_{s(50)}$: 0.03-0.1: Very Low , 0.1-0.3: Low, 0.3-1.0: Medium, 1.0-3.0: High, 3.0-10.0: Very High*

Salinity Testing

Soil samples collected from the test pits and boreholes were tested in the NATA accredited laboratory of SGS to determine Electrical Conductivity (EC), pH and Exchangeable Sodium Percentage (ESP). The tests results are summarised below and detailed in the attached certificates.

TABLE 4

Test Pit	Depth (m)	pH	EC (µS/cm)	MF	EC_e (dS/m)	ESP		
						mg/kg	meq/100g	%
TP1	0.1-0.2	6.3	26	7	0.18	160	0.68	4.2
TP1	1.0-1.1	9	450	7	3.15	-	-	-
TP2	0.5-0.6	4.7	690	7	4.83	-	-	-
TP2	1.5-1.6	4.5	790	7	5.53	810	3.5	24.8
TP3	0.5-0.6	5.7	600	7	4.20	-	-	-
TP3	1.5-1.6	5.6	590	7	4.13	670	2.9	24.5
TP4	0.1-0.2	5.7	23	7	0.16	-	-	-
TP4	1.0-1.1	8.6	680	7	4.76	770	3.4	17.2
TP5	0.1-0.2	5.8	12	7	0.08	-	-	-
TP5	1.0-1.1	7.8	1000	7	7.00	610	2.6	22.1
TP6	0.5-0.6	9.1	700	7	4.90	-	-	-
TP6	1.5-1.6	9.3	580	7	4.06	680	2.9	10.2
TP7	0.5-0.6	7.3	93	7	0.65	-	-	-
TP7	1.5-1.6	5.6	520	7	3.64	630	2.7	23.1
TP8	0.1-0.2	6.4	29	7	0.20	-	-	-
TP8	1.0-1.1	6.1	230	7	1.61	600	2.6	19.5
TP9	0.5-0.6	6.2	150	7	1.05	-	-	-
TP9	1.5-1.6	5	410	7	2.87	590	2.6	22.8
TP10	0.5-0.6	6.1	24	7	0.17	-	-	-
TP10	1.5-1.6	5.7	570	7	3.99	370	1.6	11.2
TP11	0.1-0.2	5.9	16	7	0.11	-	-	-
TP11	0.4-0.5	6.2	55	7	0.39	410	1.8	15.1
TP12	0.5-0.6	5.2	440	7	3.08	-	-	-
TP12	1.5-1.6	5.2	380	7	2.66	310	1.4	12.7
TP13	0.1-0.2	6.3	14	7	0.10	95	0.41	6.1
TP13	1.0-1.1	6.7	80	7	0.56	-	-	-
TP14	0.5-0.6	4.8	390	7	2.73	500	2.2	19.6
TP14	1.5-1.6	4.8	480	7	3.36	-	-	-

Test Pit	Depth (m)	pH	EC (µS/cm)	MF	EC_e (dS/m)	ESP		
						mg/kg	meq/100g	%
TP15	0.1-0.2	7	63	7	0.44	-	-	-
TP15	1.0-1.1	8.4	220	7	1.54	590	2.6	13.1
TP16	0.5-0.6	9.4	450	7	3.15	-	-	-
TP16	1.5-1.6	9.4	440	7	3.08	890	3.9	11.3
TP17	0.1-0.2	6.2	28	7	0.20	-	-	-
TP17	1.0-1.1	4.9	460	7	3.22	570	2.5	26.3

EC : Electrical Conductivity; EC_e = Equivalent Electrical Conductivity; ESP : Exchangeable Sodium Percentage

Please note that EC_e is calculated assuming Multiplication Factor (MF) of 7. This value is based on the type of subsurface soils encountered at the site.

Discussion & Recommendations

Geotechnical Model

The eighteen (18) test pits and four (4) boreholes done at the site generally revealed 100mm to 200mm thick topsoil, overlying natural residual silty clays, overlying shale/siltstone bedrock. Depths to bedrock ranged from 0.5m to 2.5m.

Based on the test pits and boreholes, the following geotechnical model was developed:

TABLE 5

Depth Range	Material Description
0.0 to 0.2	Topsoil
0.2m to 2.5	Silty CLAY, medium to high plasticity
0.5m to terminated depths	Shale Bedrock

Groundwater was not encountered up to the terminated depths of the test pits and to auger refusal depths of the boreholes.

Excavation Conditions

Based on the boreholes depths to various strengths of shale bedrock are shown below:

TABLE 6

BH	Depth to Extremely Low to Low Strength Shale/Siltstone	Depth to Medium to High Strength Shale/Siltstone
18	1.6	2.7
19	2.5	NE
20	1.7	5.2
21	2.7	NE

We consider that overburden soils (topsoil, fill and natural soils) and extremely low to low strength shale bedrock could be excavated using conventional earthmoving equipment such as excavators and dozers. For excavation in low strength bedrock 20t to 25t excavator with tiger teeth might be required.

If excavation extends into medium to high strength shale bedrock then large equipment such as Caterpillar D9 or D10 attached with rippers, rock hammer or saw cutter will be required.

Selection of excavation equipment should be based on site access, strength of sub-surface materials and the likely impact of vibration to structures in the vicinity of the excavation. Contractors should make their own judgement when tendering for excavation works, using the engineering logs and core photographs attached to this report and experience in such circumstances.

Acceptable vibration is based on the nature and state of neighbouring structures, which will have to be established by a dilapidation survey. As a general guide, the acceptable maximum peak particle velocity (PPV) in a residential area would range from about 5mm/s to 10mm/s.

Groundwater was not encountered to the termination depths of the test pits. We do not anticipate significant groundwater inflow during excavation. Groundwater inflow during excavation, if any, could be adequately managed using a conventional pump and sump system. However, trafficability problems might arise locally during wet weather or if water is allowed to pond at the site. A layer of recycled gravel can be used to provide good working platform.

Site Preparation

The proposed development works might require fill placement to achieve designed grades. The following procedures are recommended for placement of controlled fill, where required.

- Strip existing topsoil and stockpile separately for possible future use.
- Undertake proof rolling (using an 8 to 10 tonnes roller) of the exposed natural soils to detect potentially weak spots (ground heave). Excavate areas of localised heaving to a depth of about 300mm and replace with granular fill, compacted as described below.
- Undertake proof rolling of the soft spots backfilled with granular fill, as described above. If the backfilled area shows movement during proof rolling, this office should be contacted for further recommendations.
- Place suitable fill materials on proof rolled areas. The fill should be placed in horizontal layers of 200mm to 250mm maximum loose thickness (depending on the size of equipment) and compacted to a Minimum Dry Density Ratio (MDDR) of 98% Standard, at moisture content within 2% of Standard Optimum Moisture Content (SOMC). The top 300mm of fill forming pavement subgrade should be compacted to at least 100% Standard.
- Controlled fill should preferably comprise non-reactive fill (e.g. crushed sandstone) with a maximum particle size not exceeding 75mm, or low plasticity clay. Natural soils and bedrock obtained from excavations within the site may be used in controlled fill after removal of unsuitable materials, if any, crushing to sizes finer than 75mm, proper mixing and moisture conditioning.
- Fill placement should be supervised to ensure that material quality, layer thickness, testing frequency and compaction criteria conform to the specifications. We recommend "Level 2" or better supervision, in accordance with AS3798-2007 (Reference 1). It should be noted that a Geotechnical Inspection and Testing Authority will generally provide certification on the quality of entire compacted fill only if Level 1 supervision and testing is carried out.

Safe Batters & Retaining Structures

Cut and fill during and after site excavation should be battered for stability or retained by engineered retaining structures. Where battered slopes in overburden soils and shale bedrock are possible, we recommend the following safe batters.

TABLE 7

Material Description	Temporary	Permanent
Fill and Natural Clays	1V:1H	1V:2.5H
Low strength shale bedrock	1V:1H	1V:2.0H

The above batter slopes are recommended, providing:

- Cut and fill slopes are at sufficient distance (at least 2m) from structures in the vicinity of the site.
- The excavation faces are protected appropriately from erosion.
- Adequate surface and sub-surface drainage is provided.
- Excavation faces are monitored regularly to observe any signs of movements so that appropriate remedial actions can be taken immediately.
- Collapse of excavation faces, if it occurs is unlikely to pose a threat to the safety of people and structures in the vicinity.

Earth pressure for design for retaining wall, if required, could be calculated as recommended below.

Earth pressure distribution for non-anchored (cantilever) retaining walls is assumed triangular and estimated as follows:

$$p_h = \gamma k H$$

Where,

p_h = Horizontal active pressure (kN/m^2)
γ = Unit weight of materials to be retained (kN/m^3)
k = Coefficient of earth pressure (k_a or k_0)
H = Retained height (m)

For anchored retaining walls earth pressure can be assumed trapezoidal and estimated as 5H kPa, where H is the retained height in metres. The pressure distribution should be nil at the surface, increasing to 5H at a depth of 0.25H and remaining constant to 0.75H, then decreasing to nil at the base of the excavation.

For design of flexible retaining structures where some lateral movement is acceptable, an active earth pressure coefficient is recommended. If it is critical to limit the horizontal deformation of a retaining structure, use of an earth pressure coefficient at rest should be considered. Recommended parameters for the design of retaining structures are provided in the following Table 8.

TABLE 8

Founding Material	Unit Weight (kN/m^3), γ	Active Earth Pressure Coefficient, k_a	Passive Earth Pressure Coefficient*, k_p	At-Rest Earth Pressure Coefficient, k_0
Fill and Natural Clays	18	0.35	2.8	0.52
Extremely Low to Low Strength Shale/Siltstone bedrock	20	0.3	350kPa	0.45
Medium to High Strength Shale/Siltstone bedrock	23	0.1	1000kPa	0.2

** Appropriate safety factors should be applied for the recommended passive pressure values*

These coefficients are based on the assumption that ground level behind the retaining structure is horizontal and the retained material is effectively drained. If retained materials are subjected to groundwater pressure and other surcharge loads (structures and traffic in the vicinity of the site), additional earth pressures resulting from groundwater and surcharge loads should also be allowed for in design of retaining structures.

The design of any retaining structure should also be checked for bearing capacity, overturning, sliding and overall stability of the slope.

Site Classification

It is our assessment that the site is suitable for construction of residential buildings after completion of site preparation works.

At completion of site preparation (cut and fill) for the proposed development works, when building platforms and footing subgrade are ready for construction of residences, sub-surface profiles within the residential lots are anticipated to comprise either of the following:

- Controlled fill overlying, natural clays overlying shale bedrock; or
- Natural clays overlying shale bedrock; or
- Shale bedrock.

The magnitude of ground surface movement due to moisture variation, which is required for site classification, depends on shrink-swell index values and thickness of soils underlying a building slab. Based on the results of the investigation, natural clayey soils are generally medium to high plasticity. Hence, the natural soils and controlled fill are likely to be moderately to highly reactive. Shale bedrock would generally be non-reactive to slightly reactive.

Based on type of clayey soils encountered at the site, site classifications for future residential lots across the site are expected to be Class “M” (Moderately reactive) or “H1” (Highly reactive), in accordance with AS2870-2011 “Residential Slabs and Footings”. In areas where shale bedrock will be exposed the residential lots would generally be classified as “S” (Slightly reactive) as per AS2870-2011 (Reference 2).

Floor Slabs & Footings

Floor slabs for future residential buildings may be designed as ground bearing or suspended slabs supported by footings. If ground bearing floor slabs are preferred, slabs appropriate for site classes may be designed in accordance with AS2870-2011.

Site classification in accordance with AS2870-2011 is only applicable for the design of footing systems for a single dwelling, house, townhouse or similar structure that would be detached or separated by a party wall or common wall. AS2870 is not suitable for dwellings that are situated vertically above or below another dwelling, including buildings classified as Class 1 and Class 10a in the Building Code of Australia (BCA). Therefore, a geotechnical investigation will be required for other dwellings that would be classified in accordance with the BCA.

Foundation materials across the site will vary from controlled fill to natural clayey soils to bedrock, depending on the location of a building with regard to cut and fill profile. Therefore, assessment of foundation materials and allowable bearing pressure for a specific building should be reassessed after

completion of site preparation works and during footing construction. For preliminary design, the following is recommended:

TABLE 9

Founding Material	Allowable End Bearing Capacity (kPa)	Shaft Adhesion (kPa)
Controlled fill	100	-
Stiff to very stiff natural clays	150	-
Extremely low to low strength shale/siltstone bedrock	700	50*
Medium to high strength shale/siltstone bedrock	3000	300*

** Bored Piers only*

Erodibility Assessment

Erosion is the detachment and movement of soil materials. Depending on the local landscape and weather conditions, erosion could be very slow or very rapid. Susceptibility of soils to erosion depends on dispersivity (and sodicity) of soils. Soil dispersivity is generally assessed by conducting chemical tests such as Exchangeable Sodium Percentage (ESP) and Sodium Absorption Ratio (SAR) and physical tests such as Emerson Class and Pinhole Dispersion. It should however be noted that assessment of soil dispersibility based on these methods might differ from each other.

For the proposed work only ESP for representative soil samples were determined. Soils with ESP values of 5% or more are considered sodic and those with ESP more than 15% are considered highly sodic (Reference 3). Sodic soils are susceptible to excessive erosion.

ESP values for the seventeen (17) tested samples are presented in Table 4 and indicate ESP values of 4.2% to 26.3%. One sample showed ESP less than 5%, six samples showed ECP between 5% and 15% and the remaining ten (10) showed ESP values of more than 15%. Therefore, it is our assessment that the soils across the site are dispersive and susceptible to excessive erosion.

Salinity Assessment

Salinity refers to the presence of excess salt in the environment, either in soil or water. Salinity is a serious problem for any development due to the many environmental, economic and social impacts. Soil salinity is generally assessed by measuring Electrical Conductivity (EC) of a soil sample made up of 1:5 soil water suspension. Thus, determined Electrical Conductivity (EC) is multiplied by a factor varying from 6 to 10, based on the texture of the soil sample, to obtain Corrected Electrical Conductivity designated as EC_e (Reference 4). Alternatively, EC_e may be directly measured in soil saturation extracts. Soils are classified as saline if EC_e of the saturated extracts exceed 4.0dS/m. The criteria for assessment of soil salinity classes are shown in the following Table 10 (Reference 4).

TABLE 10

Classification	EC_e (dS/m)	Comments
Non-saline	<2	Salinity effects mostly negligible
Slightly saline	2 – 4	Yields of very sensitive crops may be affected
Moderately saline	4 – 8	Yields of many crops affected
Very saline	8 – 16	Only tolerant crops yield satisfactorily
Highly saline	>16	Only a few tolerant crops yield satisfactorily

Electrical Conductivity (EC) values for the thirty-four (34) representative soil samples recovered from across the site are summarised in Table 4. For the nature of soils encountered across the site, a multiplying factor of 7 is considered to be appropriate. Therefore, Corrected Electrical Conductivity (ECe) for the soils across the site is anticipated to vary from 0.08 to 7dS/m.

Based on the above results, it is our assessment that the soils likely to be disturbed or excavated during the proposed development works are generally non-saline to moderately saline. Therefore, soil management plan will be required to address soil erodibility issue at the site.

This salinity assessment was carried out in accordance with the Environment Protection Authority (EPA) guidelines on investigation and management of salinity. These guidelines are detailed in "Site Investigations for Urban Salinity" and were prepared by the then Department of Land & Water Conservation in 2002. The publication refers to the following:

- AS3600: Concrete Structures.
- AS2159: Piling – Design and Installation.
- AS2870: Residential slabs and footings.

Concrete structures constructed in saline soils will require increased concrete strength, which is proportioned to the increase in soil salinity (Reference 2). In addition, the concrete cover and curing period should be increased depending on the degree of salinity of the soil.

Aggressivity Assessment

Aqueous solution of chlorides causes corrosion of iron and steel, including steel reinforcement in concrete. Corrosion damage by chlorides is only relevant to iron and steel. High acidity and soils with high sulphates and magnesium affect the integrity of concrete structures buried in the soil. Concrete structures constructed in aggressive soils will require increased concrete strength proportional to the increased in soil aggressivity (Reference 2). In addition, the concrete cover and curing period should be increased depending on the degree of aggressivity of the soil.

For the present investigation a total of thirty-four (34) samples were tested to determine pH values. The tests indicated pH values ranging from 4.5 to 9.4.

Based on the above results, subsurface materials encountered at the site and as per AS2159-2009 (Reference 5) the soils at the site are generally non-aggressive to mildly aggressive to concrete. Therefore, we recommend use of construction materials, such as concrete that are appropriate to assessed aggressivity.

Soil Management Plan

Laboratory tests generally indicated the soils at the site to be generally non-saline to slightly saline and highly erodible. Therefore, we recommend that the Saline Soil Management Plan should be primarily aimed at minimising impacts of erosion while ensuring that the salinity level is maintained at about existing level. The following should be considered in developing a Saline Soil Management Plan.

- Minimise erosion and sediment loss before, during and after construction.
- Minimise water pollution due to erosion, siltation and sedimentation.

- Reduce and manage salinity within the site so that impacts on future structures (including buildings, roads etc.) are minimised and acceptable.

We recommended the following as part of the Saline Soil Management Plan during earthworks to manage impacts from erodible and saline soils.

- Develop the best use of the existing topography in order to minimise cut and fill operations.
- Construct a V-drain behind the crest of all slopes to divert water away from the slope face.
- Ensure that earthworks and construction activities do not affect the natural flow of groundwater. Where groundwater is intercepted during development works/excavation, the flow should be diverted to stormwater drains or creeks by providing appropriate surface and sub-surface drainage.
- Retaining walls for cut and fill slopes, where required, should be provided with adequate and appropriate drainage.
- Finished ground surface in each of future lot should be provided with adequate fall to the street or stormwater system to allow water run-off and prevent water ponding, waterlogging and infiltration of rainwater.
- Reduce groundwater recharge through appropriate land use and land management practices. This can be achieved by minimising deep infiltration by providing well compacted impermeable liners along surfaces of waterways (drains, channels, creeks etc.) and maximising vegetation cover, planting of deep rooted trees and use of salt tolerant plants.
- Erosion and Sediment Control Plans must be developed and implemented by the earthworks contractors, in accordance with recommendations provided by the NSW Department of Housing (Reference 6). All sediment and erosion controls proposed by the Erosion and Sediment Control Plan are to be installed prior to commencement of any construction works.
- Cut and fill batters should be provided with a secured turf overlay or shotcreting to guard against erosion.
- Utilise native and deep-rooted plants to minimise soil erosion. Where vegetation cover is not adequate to control erosion, improve soil resistance to erosion by stabilising dispersive soils with hydrated lime and gypsum. Exact proportions of lime and gypsum to be used can be determined on the basis of laboratory testing, but for preliminary planning purposes we suggest about 3% to 5% of lime and gypsum.
- Select construction materials like concrete and steel that are appropriate for a non-aggressive site.

Pavement Design CBR

Three CBR test conducted on the sample recovered from the proposed road on the southern boundary of the site showed CBR values of 4% and 5%.

For the purpose of pavement design a design CBR of 4% can be used. Preliminary thicknesses for pavements for various types of roads are shown below :

TABLE 11

Traffic Loading (ESA)	Design CBR (%)	Asphaltic Concrete (AC10)* (mm)	Basecourse (DGB20) (mm)	Sub-basecourse (Sandstone) (mm)	Total Thickness (mm)
5×10^4	4.0	50	100	200	350
2×10^5	4.0	50	150	210	410
5×10^5	4.0	50	150	260	460
1×10^6	4.0	50	150	300	500

** Over single coat flush seal*

Limitations

The conclusions and recommendations of this report are based on results obtained from a total of eighteen (18) test pits and four (4) boreholes conducted across the site and laboratory tests on recovered representative soil samples. Although we believe that the sub-surface profile presented in this report is an indicative of the general profile across the site, it is possible that the sub-surface profile across the site could differ from that encountered in the test pits. We recommend that this company is contacted for further advice if actual site conditions encountered during construction differ from those presented in this report.

Yours faithfully
GEOTECHNIQUE PTY LTD

[redacted]

ZIAUDDIN AHMED
Associate Geotechnical Engineer

Attached *Drawing No 13602/1-AA1*
Test Pit Logs (1 to 18), Borehole Logs (BH18 to 21) & Explanatory Notes
CBR Tests Results & SGS Laboratory Results

References

1. *Australian Standard AS3798-2007 - Guidelines on Earthworks for Commercial and Residential Developments, 2007.*
2. *Australian Standard AS2870-2011 "Residential Slabs and Footings".*
3. *Fell, R., MacGregor, P and Stapledon, D., Geotechnical Engineering of Embankment Dams, 1992.*
4. *Lillicrap, A and McGhie, S., Site Investigation for Urban Salinity, Department of Land and Water Conservation, 2002.*
5. *Standard Australia- AS2159-2009, Piling – Design and Installation, 2009.*
6. *NSW Department of Housing, Managing Urban Stormwater, Soils and Construction, 1998.*

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 1
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS									
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
					0.5							
			DS		1							
			DB									
Dry					1.5							
								Test Pit No. 1 terminated at 1.6m due to refusal				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 2
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
					1							
			DS		1.5							
Dry								Test Pit No. 2 terminated at 1.7m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 3
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
Dry			DS		0.5		CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		1 1.5							
								Test Pit No. 3 terminated at 1.6m				
					2 2.5 3 3.5 4 4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 4
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS									
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
Dry					0.5							
			DS		1							
								Test Pit No. 4 terminated at 1.2m				
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 5
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
Dry			DS		0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
					0.5		CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		1							
			DB		1.5			Test Pit No. 5 terminated at 1.5m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 6
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
Dry			DS		1							
					1.5							
								Test Pit No. 6 terminated at 1.6m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 7
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
Dry			DS		1							
					1.5							
								Test Pit No. 7 terminated at 1.7m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 8
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
dry			DS		0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
					0.5		CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		1							
					1.5			Test Pit No. 8 terminated at 1.4m due to refusal				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 9
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
Dry			DS		1							
					1.5							
								Test Pit No. 9 terminated at 1.6m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 10
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
					1							
Dry			DS		1.5							
								Test Pit No. 10 terminated at 1.7m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
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engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 11
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS									
Dry							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5			Test Pit No. 11 terminated at 0.5m due to refusal				
					1							
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 12
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
					1							
Dry			DS		1.5							
								Test Pit No. 12 terminated at 1.6m due to refusal				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 13
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
dry			DS		0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
					0.5		CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		1							
					1.5			Test Pit No. 13 terminated at 1.4m due to refusal				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 14
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
					1							
Dry			DS		1.5							
								Test Pit No. 14 terminated at 1.8m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 15
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS				CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
Dry			DS		0.5							
					1							
								Test Pit No. 15 terminated at 1.3m				
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 16
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
							CI-CH	Silty CLAY, medium to high plasticity, brown-grey, mixed with weathered shale				
			DS		0.5							
					1							
Dry			DS		1.5							
								Test Pit No. 16 terminated at 1.6m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 17
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS									
							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
DRY					0.5							
			DS		1							
								Test Pit No. 17 terminated at 1.1m				
					1.5							
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

GEOTECHNIQUE
PTY LTD

engineering log - excavation

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Road, Glenmore Park

Job No : 13602/2
Pit No : 18
Date : 06/11/2015
Logged/Checked by: GC/ZA

Equipment type and model: Backhoe
R.L. surface :
Excavation dimensions : 1.5 **m long** 0.4 **m wide** **datum :**

groundwater	env samples	PID reading (ppm)	geo samples	field tests	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
					0			TOPSOIL: Silty Clay, low plasticity, brown, with roots				
			DS									
Dry							CI-CH	Silty CLAY, medium to high plasticity, orange-grey, mixed with weathered shale				
			DS		0.5							
			DB		1							
					1.5			Test Pit No. 18 terminated at 1.5m				
					2							
					2.5							
					3							
					3.5							
					4							
					4.5							

KEY TO SYMBOLS

Symbol Description

Strata symbols

Topsoil

Silty Clay
medium to high plasticity

Descriptions of various line types (solid, dotted, etc.)

Profile change

Gradual profile change

Notes:

1. **Exploratory borings were drilled between 06/11/2015 and 06/11/2015 using a 50, 100 and 125mm diameter continuous flight power auger.**

2. **These logs are subject to the limitations, conclusions and recommendations in this report.**

3. **Results of tests conducted on samples recovered are reported on the logs.**

GEOTECHNIQUE
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engineering log - borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 18
Date : 10/11/2015
Logged/Checked by: AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 84.15

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo 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
V-Bit	Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with root fibres				
								CI	Silty CLAY, medium plasticity, brown	M<PL	St		Residual
				DS	N=9 3,4,5	0.5		CI-CH	Silty CLAY, medium to high plasticity, grey mottled red-brown, traces of ironstone gravel	M<PL	St-VSt		
						1		CI	Silty CLAY, medium plasticity, grey and brown, with ironstone/shale gravel	M<PL	VSt-H		
				DS	N=Ref 28,5/0	1.5							
						2			SHALE, dark grey and brown, extremely low to low strength, extremely weathered, with silty clay band interbedded				Bedrock
									Refer to cored borehole				
						2.5							
						3							
						3.5							
						4							
						4.5							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : CCL Development Pty Ltd
Job No. : 13602/2
Project : Proposed Residential Development
Borehole No. : 18
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park
Date : 10/11/2015
Logged/Checked by : AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 84.15
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Commenced coring at 2.4m					
		2.5		SHALE, dark grey and brown, with silty clay band interbedded	EW	EL-L			
				SILTSTONE, grey and brown	DW-SW	M-H			2.91m: Ds 3.12m: Jo=45°,Pl,Ro,St 3.17m: Jo=0°,Ir,Ro,cg 3.27m: Jo=30°,Pl,Ro,Cu 3.48m: Jo=5°,Cu,Ro,Cu 3.83m: Jo=0°,Pl,Ro,cg 4.15m: Jo=0°,Pl,Ro,Cu 4.33m: Jo=0°,Pl,Ro,Cu 4.44m: Jo=0°,Pl,Ro,cg 4.52m: Jo=5°,Pl,Sm,Cu 4.88m: Jo=0°,Pl,Sm,Cu 5.45m: Jo=0°,Pl,Ro,Sm 5.52m: Jo=0°,Un,Ro,Cu
		3 3.5 4 4.5 5 5.5							
		6 6.5 7		Borehole No. 18 terminated at 5.8m					

GEOTECHNIQUE
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engineering log - borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 19
Date : 10/11/2015
Logged/Checked by: AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 91.32

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo 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
V-Bit	Dry					0			TOPSOIL: Silty Clay, low plasticity, dark brown, with gravel and roots				
								ML	Clayey SILT, low plasticity, brown and grey	M<PL	St-VSt		Residual
				DS	N=10 3,3,7	0.5							
						1							
								CL-CI	Silty CLAY, low to medium plasticity, grey and brown, with ironstone/shale gravel	M<PL	VSt-H		
				DS	N=22 6,10,12	1.5							
						2							
						2.5			SHALE, dark grey and brown, extremely low to very low strength, extremely weathered, with silty clay band interbedded				Bedrock (soil property dominate over rock property)
				DS	N=36 9,12,24	3							
						3.5			Refer to cored borehole				
						4							
						4.5							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 19
Date : 10/11/2015
Logged/Checked by : AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 91.32
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	DEFECT DETAILS defect spacing (mm) 2000 1000 500 300 100 50	DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Commenced coring at 3.5m					
		3.5		SHALE, grey and brown, with silty clay band interbedded	EW	EL-VL			
		4		SHALE, dark grey	EW-DW	VL			4.32m: Ds 4.4m: Ds 4.58m: Ds 4.81m: Jo=0°,Ir,Ro,cg 5.06m: Jo=0°,Ir,Ro,cg 5.45m: Jo=5°,Ir,Ro,cg 5.59m: Jo=0°,Ir,Ro,cg 5.6m: Jo=5°,Pl,Ro,Cu 5.8m: Jo=0°,Ir,Ro,cg
		4.5							
		5							
		5.5							
		6		Borehole No. 19 terminated at 5.9m					
		6.5							
		7							
		7.5							
		8							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 20
Date : 10/11/2015
Logged/Checked by: AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 92.46

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo 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
V-Bit	Dry					0			TOPSOIL: Silty Clay, low to medium plasticity, dark brown, with root fibres				
								CI	Silty CLAY, medium plasticity, red-brown,	M<PL	St		
						0.5							
				DS	N=28 7,15,13			ML	Clayey Sandy SILT, low plasticity, grey and brown, with siltstone/ironstone gravel embedded	M<PL	St-VSt		Residual
						1							
						1.5							
				DS	N=24 8,12,12				SILTSTONE/SHALE, grey and brown, extremely low to very low strength, extremely weathered, with clayey silt layers interbedded				Bedrock (soil property dominate over rock property)
						2							
						2.5							
									Refer to cored borehole				
						3							
						3.5							
						4							
						4.5							

GEOTECHNIQUE
PTY LTD

engineering log
cored borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 20
Date : 10/11/2015
Logged/Checked by : AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 92.46
core size: NMLC **bearing :** **deg.** **datum :** AHD

barrel lift	water loss/level	depth of R.L. in meters	graphic log	CORE DESCRIPTION rock type, grain characteristics, colour, structure, minor components.	weathering	strength	point load index strength $I_S(50)$ EL VL L M H VH	defect spacing (mm) 2000 1000 500 300 100 50	DEFECT DETAILS DESCRIPTION type, inclination, thickness, planarity, roughness, coating. Specific / General
				Commenced coring at 2.7m					
		3		SHALE/CLAYSTONE, grey and brown, with clay band	EW	EL-VL			Class - V 2.9m: EW zone 3.22m: Ds
		3.5							3.55m: Jo=0°,Un,Sm,cg 3.58m: Crushed zone=420mm
		4		SHALE/CLAYSTONE, grey and brown	DW	VL-L			Class - IV 4.32m: Crushed zone=380mm
		4.5							
		5							5.08m: Crushed zone=60mm
					DW-SW	M			5.21m: Jo=0°,Un,Sm,cg 5.26m: Jo=0°,Un,Sm,cg 5.37m: Crushed zone=50mm
		5.5							
				Borehole No. 20 terminated at 5.6m					
		6							
		6.5							
		7							

GEOTECHNIQUE
PTY LTD

engineering log - borehole

Client : CCL Development Pty Ltd
Project : Proposed Residential Development
Location : Part Lot 1 DP224861 & Lot 4 DP226490, Precincts G & H, 2183 The Northern Rd, Glenmore Park

Job No. : 13602/2
Borehole No. : 21
Date : 10/11/2015
Logged/Checked by: AI

drill model and mounting : Geo 305, Track Mounted **slope :** **deg.** **R.L. surface :** 87.4

hole diameter : 125 **mm** **bearing :** **deg.** **datum :** AHD

method	groundwater	env samples	PID reading (ppm)	geo 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
V-Bit	Dry					0			TOPSOIL: Silty Clay, low to medium plasticity, dark brown, traces of gravel and roots				
								CI	Silty CLAY, medium plasticity, red-brown	M<PL	St		Residual
				DS		0.5		ML	Clayey Sandy SILT, low plasticity, grey and brown, with siltstone gravel embedded	M<PL	VSt-H		
						1							
						1.5							
				DS		2			SILTSTONE/SHALE, grey and brown, extremely low to very low strength, extremely weathered, with clayey silt layer interbedded				Bedrock
						2.5							
									Borehole No. 21 terminated at 2.7m				
						3							
						3.5							
						4							
						4.5							

KEY TO SYMBOLS

Symbol Description

Strata symbols

Topsoil

Silty Clay
medium plasticity

Silty Clay
medium to high plasticity

Shale

Clayey Silt
low plasticity

Silty Clay
low to medium plasticity

Clayey Sandy Silt
low plasticity

Siltstone / Shale

Descriptions of various line types (solid, dotted, etc.)

Profile change

Gradual profile change

Notes:

1. **Exploratory borings were drilled between 10/11/2015 and 10/11/2015 using a 50, 100 and 125mm diameter continuous flight power auger.**

2. **These logs are subject to the limitations, conclusions and recommendations in this report.**

3. **Results of tests conducted on samples recovered are reported on the logs.**

KEY TO SYMBOLS

Symbol Description

Strata symbols

 **Shale**

 **Siltstone**

 **Shale/Claystone**

Misc. Symbols

× **Point Load Strength**

Descriptions of various line types (solid, dotted, etc.)

____ **Profile change**

_ _ _ **Gradual profile change**

Notes:

1. **Exploratory borings were drilled between 10/11/2015 and 10/11/2015 using a 50, 100 and 125mm diameter continuous flight power auger.**

2. **These logs are subject to the limitations, conclusions and recommendations in this report.**

3. **Results of tests conducted on samples recovered are reported on the logs.**

Log Symbols & Abbreviations (Non-cored Borehole Log)

Log Column	Symbol/Value		Description
Drilling Method	V-bit TC-bit RR DB BB		Hardened steel 'V' shaped bit attached to auger Tungsten Carbide bit attached to auger Tricone (Rock Roller) bit Drag bit Blade bit
Groundwater	Dry 		Groundwater not encountered to the drilled or auger refusal depth Groundwater level at depths shown on log Groundwater seepage at depths shown on log
Environment Sample	GP G P		Glass bottle and plastic bag sample over depths shown on log Glass bottle sample over depths shown on log Plastic bag sample over depths shown on log
PID Reading	100		PID reading in ppm
Geotechnical Sample	DS DB U_{50}		Disturbed Small bag sample over depths shown on log Disturbed Bulk sample over depths shown on log Undisturbed 50mm tube sample over depths shown on log
Field Test	N=10 3,5,5 N=R 10,15/100		Standard Penetration Test (SPT) 'N' value. Individual numbers indicate blows per 150mm penetration. 'R' represents refusal to penetration in hard/very dense soils or in cobbles or boulders. The first number represents10 blows for 150mm penetration whereas the second number represents 15 blows for 100mm penetration where SPT met refusal
	DCP/PSP	5 6 R/10	Dynamic Cone Penetration (DCP) or Perth Sand Penetrometer (PSP). Each number represents blows per 100mm penetration. 'R/10' represents refusal after 10mm penetration in hard/very dense soils or in gravels or boulders.
Classification	GP GW GM GC SP SW SM SC ML MI MH CL CI CH		Poorly Graded GRAVEL Well graded GRAVEL Silty GRAVEL Clayey GRAVEL Poorly graded SAND Well graded SAND Silty SAND Clayey SAND SILT / Sandy SILT / clayey SILT, low plasticity SILT / Sandy SILT / clayey SILT, medium plasticity SILT / Sandy SILT / clayey SILT, high plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, low plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, medium plasticity CLAY / Silty CLAY / Sandy CLAY / Gravelly CLAY, high plasticity
Moisture Condition Cohesive soils Cohesionless soils	 M<PL M=PL M>PL D M W		 Moisture content less than Plastic Limit Moisture content equal to Plastic Limit Moisture content to be greater than Plastic Limit Dry - Runs freely through hand Moist - Tends to cohere Wet - Tends to cohere
Consistency Cohesive soils	 VS S F St VSt H		Term / Undrained shear strength, C_u (kPa) / Hand Penetrometer (Qu) Very Soft / ≤12 / <25 Soft / >12 ≤25 / 25 – 50 Firm / >25 ≤50 / 50 – 100 Stiff / >50 ≤100 / 100 – 200 Very Stiff / >100 ≤200 / 200 – 400 Hard / >200 / >400
Density Index Cohesionless soils	 VL L M D VD		Term / Density Index, I_D (%) / SPT 'N' (blows/300mm) Very Loose / ≤15 / ≤5 Loose / >15 ≤35 / >5 ≤10 Medium Dense / >35 ≤65 / >10 ≤30 Dense / >65 ≤85 / >30 ≤50 Very Dense / >85 / >50
Hand Penetrometer	100 200		Unconfined compressive strength (q_u) in kPa determined using pocket penetrometer, at depths shown on log
Remarks	 Residual Alluvium Colluvial Aeolian Marine		Geological origin of soils Residual soils above bedrock River deposited Alluvial soils Gravity deposited Colluvial soils Wind deposited Aeolian soils Marine Soils

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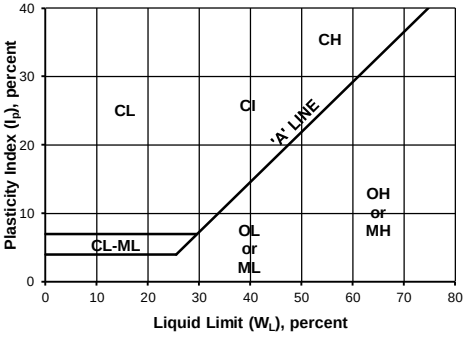
AS1726 – Unified Soil Classification System

Major Divisions		Particle size (mm)	Group Symbol	Typical Names	Field Identifications Sand and Gravels			Laboratory classification				
	BOULDERS	200						% (2) < 0.075mm	Plasticity of Fine Fraction	$C_u = D_{60}/D_{10}$	$C_c = (D_{30})^2/(D_{10}D_{60})$	Notes
	COBBLES	63										
COARSE GRAINED SOILS (more than half of material less 63mm is larger than 0.075mm)	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	Coarse 20	GW	Well-graded gravels, gravel-sand mixtures, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>4	between 1 and 3	1. Identify lines by the method given for fine grained soils 2. Borderline classifications occur when the percentage of fines (fraction smaller than 0.075mm size) is greater than 5% and less than 12%. Borderline classifications require the use of dual symbols e.g. SP-SM, GW-GC
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines, uniform gravels	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
		Medium 6	GM	Silty gravels, gravel-sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 2.36	GC	Clayey gravels, gravel-sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line or I_p>7	-	-	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)	Coarse 0.6	SW	Well-graded sands, gravelly sands, little or no fines	Wide range in grain size and substantial amounts of all intermediate sizes, not enough fines to bind coarse grains, no dry strength			0-5	-	>6	between 1 and 3	
		Medium 0.2	SP	Poorly graded sands and gravelly sands; little or no fines, uniform sands	Predominantly one size or range of sizes with some intermediate sizes missing, not enough fines to bind coarse grains, no dry strength			0-5	-	Fails to comply with above		
			SM	Silty sands, sand-silt mixtures	'Dirty' materials with excess of non-plastic fines, zero to medium dry strength			12-50	Below 'A' line or I_p<4	-	-	
		Fine 0.075	SC	Clayey sand, sand-clay mixtures	'Dirty' materials with excess of plastic fines, medium to high dry strength			12-50	Above 'A' line of I_p>7	-	-	
FINE GRAINED SOILS (more than half of material less than 63mm is smaller than 0.075mm)					**Dry Strength**	**Dilatancy**	**Toughness**					
	SILTS & CLAYS (liquid limit < 50%)		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity	None to low	Quick to slow	None	More than 50% passing 0.075mm	Below 'A' line			
			CL, CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	Medium to high	None to very slow	Medium		Above 'A' line			
			OL	Organic silts and organic silty clays of low plasticity	Low to medium	Slow	Low		Below 'A' line			
	SILTS & CLAYS (liquid limit > 50%)		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	Low to medium	Slow to none	Low to medium		Below 'A' line			
			CH	Inorganic clays of medium to high plasticity, fat clays	High to very high	None	High		Above 'A' line			
			OH	Organic clays of medium to high plasticity, organic silts	Medium to high	None to very slow	Low to medium		Below 'A' line			
	HIGHLY ORGANIC SOILS		Pt	Peat and highly organic soils	Identified by colour, odour, spongy feel and generally by fibrous texture			Effervesces with H_2O_2				

Use the gradation of material passing 63mm for classification of fractions according to the criteria given in 'Major Divisions'

Log Symbols & Abbreviations (Cored Borehole Log)

Log Column	Symbol	Description
Core Size		Nominal Core Size (mm)
	NQ	47
	NMLC	52
	HQ	63
Water Loss		Complete water loss Partial water loss
Weathering	FR	Fresh — Rock shows no sign of decomposition or staining
	SW	Slightly Weathered — Rock is slightly discoloured but shows little or no change of strength from fresh rock
	DW	Distinctly Weathered — Rock strength usually changed by weathering. The rock may be highly discoloured, usually by ironstaining. Porosity may be increased by leaching, or may be decreased by deposition of weathering products in pores
	EW	Extremely Weathered — Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrate or can be remoulded, in water
	RS	Residual Soil — Soil developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but soil has not been significantly transported
Strength		Term — Point Load Strength Index (I_{s50}, MPa)
	EL	Extremely Low — ≤0.03
	VL	Very Low — >0.03 ≤0.1
	L	Low — >0.1 ≤0.3
	M	Medium — >0.3 ≤1
	H	High — >1 ≤3
	VH	Very High — >3 ≤10
	EH	Extremely High — >10
Defect Spacing		Description — Spacing (mm)
		Extremely closely spaced — <20
		Very closely spaced — 20 to 60
		Closely spaced — 60 to 200
		Medium spaced — 200 to 600
		Widely spaced — 600 to 2000
		Very widely spaced — 2000 to 6000
		Extremely widely spaced — >6000
Defect Description		
Type	Bp	Bedding parting
	Fp	Foliation parting
	Jo	Joint
	Sh	Sheared zone
	Cs	Crushed seam
	Ds	Decomposed seam
	Is	Infilled seam
Macro-surface geometry	St	Stepped
	Cu	Curved
	Un	Undulating
	Ir	Irregular
	Pl	Planar
Micro-surface geometry	Ro	Rough
	Sm	Smooth
	Sl	Slickensided
Coating or infilling	cn	clean
	sn	stained
	vn	veneer
	cg	coating

AS1726 – Identification of Sedimentary Rocks for Engineering Purposes

Grain Size mm		Bedded rocks (mostly sedimentary)									
More than 20	20	Grain Size Description				At least 50% of grains are of carbonate				At least 50% of grains are of fine-grained volcanic rock	
	6	RUDACEOUS		CONGLOMERATE Rounded boulders, cobbles and gravel cemented in a finer matrix		LIMESTONE and DOLOMITE (undifferentiated)	Calcirudite			Fragments of volcanic ejecta in a finer matrix	SALINE ROCKS
	2			Breccia Irregular rock fragments in a finer matrix						Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	Halite Anhydrite
	0.6	ARENACEOUS	Coarse	SANDSTONE Angular or rounded grains, commonly cemented by clay, calcite or iron minerals			Calcarenite			Cemented volcanic ash	Gypsum
	0.2		Medium	Quartzite Quartz grains and siliceous cement						TUFF	
	0.06		Fine	Arkose Many feldspar grains Greywacke Many rock chips							
	0.002	ARGILLACEOUS		MUDSTONE	SILTSTONE Mostly silt	Calcareous Mudstone		Calcisiltite	CHALK	Fine-grained TUFF	
	Less than 0.002			SHALE Fissile	CLAYSTONE Mostly clay			Calcilutite		Very fine-grained TUFF	
Amorphous or crypto-crystalline				Flint: occurs as hands of nodules in the chalk Chert: occurs as nodules and beds in limestone and calcareous sandstone							COAL LIGNITE
				Granular cemented – except amorphous rocks							
				SILICEOUS		CALCAREOUS				SILICEOUS	CARBONACEOUS
				SEDIMENTARY ROCKS Granular cemented rocks vary greatly in strength, some sandstones are stronger than many Igneous rocks. Bedding may not show in hand specimens and is best seen in outcrop. Only sedimentary rocks, and some metamorphic rocks derived from them, contain fossils Calcareous rocks contain calcite (calcium carbonate) which effervesces with dilute hydrochloric acid							

AS1726 – Identification of Metamorphic and Igneous Rocks for Engineering Purposes

Obviously foliated rocks (mostly metamorphic)			Rocks with massive structure and crystalline texture (mostly igneous)					Grain size (mm)
Grain size description			Grain size description	Pegmatite			Pyrosenite	More than 20
		MARBLE						20
COARSE	GNEISS Well developed but often widely spaced foliation sometimes with schistose bands	QUARTZITE	COARSE	GRANITE	Diorite	GABBRO	Peridorite	6
	Migmatite Irregularly foliated: mixed schists and gneisses	Granulite HORNFELS		These rocks are sometimes phorphyritic and are then described, for example, as porphyritic granite				2
MEDIUM	SCHIST Well developed undulose foliation; generally much mica	Amphibolite	MEDIUM	Micorgranite	Microdiorite	Dolerite		0.6
		Serpentine		These rocks are sometimes phorphyritic and are then described as porphyries				0.2
								0.06
FINE	PHYLLITE Slightly undulose foliation; sometimes 'spotted'		FINE	RHYOLITE	ANDESITE	BASALT		0.002
	SLATE Well developed plane cleavage (foliation)			These rocks are sometimes phorphyritic and are then described as porphyries				Less than 0.002
	Mylonite Found in fault zones, mainly in igneous and metamorphic areas			Obsidian	Volcanic glass			Amorphous or cryptocrystalline
CRYSTALLINE				Pale<----------->Dark				
SILICEOUS		Mainly SILICEOUS		ACID Much quartz	INTERMEDIATE Some quartz	BASIC Little or no quartz	ULTRA BASIC	
METAMORPHIC ROCKS Most metamorphic rocks are distinguished by foliation which may impart fissility. Foliation in gneisses is best observed in outcrop. Non-foliated metamorphics are difficult to recognize except by association. Any rock baked by contact metamorphism is described as 'hornfels' and is generally somewhat stronger than the parent rock Most fresh metamorphic rocks are strong although perhaps fissile			IGNEOUS ROCKS Composed of closely interlocking mineral grains. Strong when fresh; not porous Mode of occurrence : 1 Batholith; 2 Laccoliths; 3 Sills; 4 Dykes; 5 Lava Flows; 6 Veins					