coffey geotechnics
SPECIALISTS MANAGING THE EARTH

25 October 2010

Health Infrastructure NSW Health
c/- Coffey Projects
213 Darby St
Cooks Hill NSW 2300

Attention: Josh Fullerton

Dear Sir/Madam

RE: Initial Geotechnical Assessment, Proposed Cancer Clinic, Gosford Hospital.

1 INTRODUCTION

This letter report has been prepared to provide initial geotechnical advice for the preparation of a Part 3A Environmental Assessment Submission for the proposed new Central Coast Integrated Regional Cancer Care Clinic to be constructed within the grounds of Gosford Hospital, Holden St, Gosford, NSW.

This initial assessment was based on a desktop study review of previous geotechnical investigations carried out at Gosford Hospital as a basis for provision of preliminary comment and recommendations on geotechnical aspects of the proposed new development.

The study was commissioned by Mr James Fullerton from Coffey Projects on behalf of Health Infrastructure (NSW) on the basis of our proposal Ref No. ENAUWARA04052AA-P02, dated 12 October 2010.

2 PROPOSED DEVELOPMENT

We understand that the proposed clinic will comprise a single level extension to the existing three storey brick and masonry Stage 3 building and a portion of the lower floor of the Stage 3 building.

The majority of the proposed new structure will be of steel frame construction with lightweight cladding and accommodate a waiting area, consulting rooms, offices, and utility rooms. The northern part the new structure will include three radiation treatment bunkers, which will be heavy structural elements, with thick reinforced concrete walls, roof, and floor for radiation shielding. Working line loads along each bunker wall will be in the order of 200-300 kN/m.

3 AVAILABLE GEOTECHNICAL INFORMATION

For this desktop review the following Coffey site investigations and study reports for previous developments at Gosford Hospital were reviewed.

- Coffey Geosciences Pty Ltd (2001), Geotechnical Assessment – Gosford Hospital Redevelopment, Holden Street, Gosford. Ref. GO1236/1-AB dated 3 September 2001.
- Coffey Geosciences Pty Ltd (2006), Review of Geotechnical Assessment – Gosford Hospital Redevelopment, Parking Area Regrade, Holden Street, Gosford. Ref. GO01236/01-BC dated 26 June 2006.

In addition, the following regional geology maps were also consulted;

- 1:250,000 Geological Series Sheets S1 56-5 Sydney – 3rd Edition, New South Wales Department of Mines, 1965.
- NSW Dept. of Mineral Resources (1983) Gosford 9131 1:100 000 Geological Map, Geological Series Sheet 9130, Ed 1, 1983.

4 SITE CONDITIONS

4.1 Site Description

Gosford Hospital is located with the block bounded by Ward, Holden, Cape and Stephen Streets, Gosford on the crest and flanking slopes of a low, north trending, spur from Presidents. Natural hill slopes in the immediate vicinity vary from 3° to 10 ° with a gently convex curving consistent with ridg e crest forms.

The proposed development site within the grounds of Gosford Hospital, is located on a south facing slope, between the existing Stage 3 Building and Holden Street. The site itself is triangular in plan, relatively level and existing ground surface levels are between approximately 26.8m AHD to 27.8m AHD. The development site is bounded to the east by Holden Street, to the west/south west by the Stage 3A building, and to the north by a 3-4m high Criblock wall with the site at the base of the wall and the Stage 4 Hospital building (including Paediatrics Wards) on top of the wall.

The site is presently occupied by; the Stage 3 building Main Entry driveway providing drive through access to the main door from Holden Street, a small car parking area for approximately 10 cars, and the vehicular access route from Holden Street to the main hospital car park.

Holden Street along the eastern site boundary slopes down to the south and to retain current site surface levels there is a Criblock retaining wall along this boundary up to 4m high. Heading further south along Holden Street, the ground surface begins to gently slope upwards again.

4.2 Site Geology

The 1:100,000 scale geology map of Gosford indicates that the site and surrounds are underlain by Terrigal Formation sandstone bedrock of the Triassic aged Narrabeen Group. This formation typically comprises Lithic Quartz to Quartz Sandstone, interbedded Siltstone, and minor sedimentary claystone and conglomerate breccia of a meandering alluvial origin.

The Terrigal Formation typically has a deeply weathered profile, and zones of extremely weathered material may also be encountered within slightly weathered rock.

5 INFERRED GEOTECHNICAL MODEL

5.1 Available Site Information

Figure 1 shows the location of Coffey boreholes in the vicinity of the site from the previous reports listed in Section 3.

Augered boreholes CG-15 and CG-16 located in the north west half of the site encountered a subsurface profile comprising shallow fill between 0.5-0.6m deep over highly weathered sandstone inferred to be of low strength.

Augered borehole CG18, located to the north of the site approximately 10m behind the crest of the Criblock wall along this site boundary, encountered a profile comprising 1.6m of fill and residual sandy clay over highly weathered sandstone.

Other boreholes further to the north, i.e. uphill from the subject site, encountered subsurface profiles typically comprising 0.5m to 1.0m of fill and/or residual soils over highly weathered sandstone.

We note that there is no borehole coverage in the southern half of the proposed development site or to the south.

Rock cored boreholes further to the west and north of the site, i.e, across, or uphill from the site, encountered bedrock profiles typically comprising 2m to 3m of highly weathered sandstone over less weathered sandstone of medium to high strength between elevations 24-30m AHD. Below this approximate level the strength and weathering of the sandstone was more variable and beds or bands of siltstone were also present.

5.2 Inferred Geotechnical Model

With reference to the discussed borehole information, presence of retaining walls along the northern and eastern site boundaries, and topography along Holden Street, it may be inferred that the present development site could have once comprised a shallow gully or topographical depression, which was subsequently levelled for current site structures using cut/fill earthworks. Cuttings along the north part of the site may have been up to 2-3m high, and filling in the south east half of the site may have been up to 3-4m deep, requiring the use of Criblock retaining walls along these site boundaries for support. On this basis, a preliminary geotechnical model is presented below in Table 1, Preliminary Geotechnical Model.

Table 1 - Preliminary Geotechnical Model

Unit	Expected Materials	Comments
1. Fill	Silty and Clayey sands, fine to medium grained, dark grey and brown with some gravels. Possibly sourced from cuttings elsewhere within the hospital grounds. The nature, compaction and strength of fill may be variable across the site.	Potentially of variable thickness across the site grading from approximately 0.5m at the toe of the Criblock wall along the northern site boundary to potentially up to 3m to 4m depth in the south eastern site corner, adjacent Holden St.
2. Residual Soils	Sandy Clay, medium plasticity, grey and yellow brown. Typically very stiff to hard.	Thickness typically from 0.5m to 2.5m, present as a layer between fill and bedrock where cutting earthworks have not been carried out.
3. Highly Weathered Sandstone.	Medium to coarse grained sandstone of very low to low strength	Expected beneath fill and residual soils across the site, expected to be 1m to 3m thickness.
4. Less Weathered Sandstone	Distinctly to Slightly Weathered, medium to coarse grained sandstone, of medium to high strength.	Present below Unit 3 across the site. Below approximately RL 22-24m this unit may also contain bands/beds of siltstone or highly weathered, very low to low strength sandstone.

Limited groundwater inflow observations were noted on the available borehole logs. In absence of site specific groundwater monitoring data it is expected that groundwater may be encountered as follows;

- As perched water of limited extent and volume within fill layers.
- At the soil/rock interface as either; perched water of limited extent, as transient seepage associated with local rainfall events, or as more sustained seepage associated with the local groundwater environment.
- Within the rock mass defects as either transient seepage associated with local rainfall events, or as more sustained seepage associated with the local groundwater environment.

It is expected that groundwater presence/levels beneath the site may vary in response to climatic events and over time.

6 DISCUSSION AND RECOMMEDATIONS

6.1 Perceived Geotechnical Considerations for the Proposed Site Development

With reference to the proposed development and preliminary geotechnical model it is expected the following geotechnical aspects should be considered further during project planning and detailed design;

- Foundation design.
- Site prepatory earthworks.
- Interaction with surrounding structures.
- Groundwater.
- Need for further site investigation.

A general discussion on the geotechnical aspects of each of the above items is presented in the following Sections 6.2 to 6.6.

6.2 Foundations

With reference to the proposed development, anticipated loads, and expected subsurface conditions, it is expected that the following two foundation solutions may be suitable for the proposed development;

- The use of a combination of shallow pad footings, and deeper pile foundations, to uniformly support the proposed new building on bedrock.
- Use of a stiffened raft slab on the fill subgrade, with design and detailing to accommodate potential differential settlement between building elements and variability in subsurface conditions.

6.2.1 Pad/Pile Foundations

In absence of information on the depth, composition, and compaction of site filling it is expected that this unit will not be suitable for the support of conventional shallow pad and strip footings as any variability in this material could lead to unacceptable total and differential settlements between shallow footings. On this basis it is recommended that for the use of conventional foundations, the new structure be uniformly supported on the highly weathered bedrock using a combination of pad footing and/or piles where the depth to bedrock is greater.

As a guide for concept design, limit state design parameters for strip/pad footings or bored piles foundations on the highly weathered sandstone are presented in Table 2 below.

Table 3: Limit State Design Parameters for Footing Design (Compression loading)

Geotechnical Unit	Ultimate End Bearing Pressure (MPa)	Ultimate Shaft Adhesion for Piles (kPa) [a,b]	Suggested Geotechnical Strength Reduction Factor, ϕ_g	Elastic Modulus (MPa)
Highly weathered Sandstone	3.0	70	0.7	70

Notes

(a) For piles, shaft adhesion should only be assumed where piles have a minimum socket length of 3 pile diameters into highly weathered rock.

(b) For ultimate shaft adhesion in piles a clean rough socket is required. Values may have to be reduced if smear is present.

If foundations are to resist uplift, the ultimate shaft adhesion should be reduced by a factor of 0.7 and a geotechnical strength reduction factor ϕ_g of 0.6 should be adopted.

If a working stress design approach is to be adopted, the maximum working stress may be assessed by dividing the ultimate values by a minimum factor of safety of 3.0. Regardless of the design method, foundation settlement should also be assessed.

For detailed design and construction we recommend that further site investigation and/or foundation construction inspections be carried out to confirm that a suitable foundation stratum has been reached and assess any further variability in subsurface conditions across the site.

If higher bearing pressures on the sandstone are required, we recommend that further site investigations include at least two cored boreholes into the sandstone to investigation the strength, presence, and nature of defects in the upper layers of sandstone.

6.2.2 Raft Foundation

As an alternative to conventional pad, strip and pile foundations to bedrock the use of a stiffened raft slab on the existing site fill subgrade may be considered. As a guide for concept design a maximum allowable bearing pressure of 100kPa for the existing fill may be provisionally adopted. However we recommend that for detailed design additional site investigations be carried out to confirm allowable bearing pressures on the fill.

The suitability, and design thickness, for a stiffened raft slab as a foundation for this proposed development will be depended on the degree of compaction and uniformity in the fill subgrade. To assess whether a stiffened raft slab would be suitable for use we recommend that further site investigation to assess any variability in fill and subsurface conditions across the site be carried out. Variability in fill conditions such as depth or compaction/strength (i.e. weak spots) could lead to unacceptable settlements or load sharing with the raft slab.

6.3 Site Prepatory Earthworks

Following the clearing of existing site structures and any required excavation to construction subgrade or foundation levels we expect that the expose subgrade would comprise existing site fill. If it is intended that this subgrade be used to support a stiffened raft, or ground floor slab, then we recommend that the exposed subgrade be proof rolled with a 5 tonne static (i.e. no vibrations) smooth drum roller to detect any soft or poorly compacted areas in the fill subgrade. If there are no soft areas detected then placement and compaction of base course materials could then commence. Where there are soft or heaving areas of subgrade then further treatment will be required. The specific treatment will need to be assessed on the basis of site conditions but may include the excavation of soft fill material to a sound base and replacement with engineered fill.

6.4 Potential Interaction with Surrounding Structures

It is expected that the following aspect of the proposed development may impact surrounding structures;

- Loads and construction activities from the new development may place additional surcharge loads on the Criblock retaining wall along Holden Street.
- Any excavations adjacent to existing building foundations, buried services, or Criblock retaining walls may reduce the capacity/stability of these existing structures. For planning purposes the zone of such influence for excavations may be nominally defined by a line extending at 1 Horizontal:1 Vertical up from the excavation base.
- Vibrations from excavations into bedrock, compaction of fill materials, or other construction activities may be transmitted into neighbouring structures or buried services.
- Structural connections between new and existing structures should not transfer additional load to existing structures unless appropriate checks have been carried out to assess the capacity of existing structures and foundations. Additionally any connections should also allow for any differential settlement that may occur between structures.

It is recommend that further assessment of each of the above be carried out as part of detailed project planning and design.

6.5 Groundwater

As discussed in Section 5 above, there is the potential for groundwater to be encountered at a number of locations with the subsurface profile at this site.

While it is not considered that the present proposed development would have significant impacts on local or regional groundwater flows there is still a potential for groundwater seepage to impact on various project design elements and construction operations such as; inflows to foundation and bored pile holes during construction, durability to buried structures, or contribution to loadings on existing retain walls at the site.

6.6 Need for Further Geotechnical Site Investigation

The presented preliminary Geotechnical Model and discussion of perceived geotechnical issues associated with the proposed development is intended to only be indicative of expected site conditions and geotechnical issues, as based on currently available information on subsurface conditions at the site. As ground conditions, and in particular fill depths, are expected to vary across the site it is recommended that for detailed planning and design further targeted geotechnical investigation be carried out and further geotechnical advice be sought for the final design solution.

As a guide it is expected that any additional investigation would include a number of boreholes drilled to bedrock across the site with the aim of assessing fill depths, variability and relative density.

7 CLOSURE

The discussion presented in this report was intended as preliminary in scope based on a review of existing available site information only.

Variations in ground conditions can occur over relatively short distances and a geotechnical engineer should be engaged to carry out further targeted site investigations and provide additional detailed geotechnical design advice with reference to the final designs and construction planning.

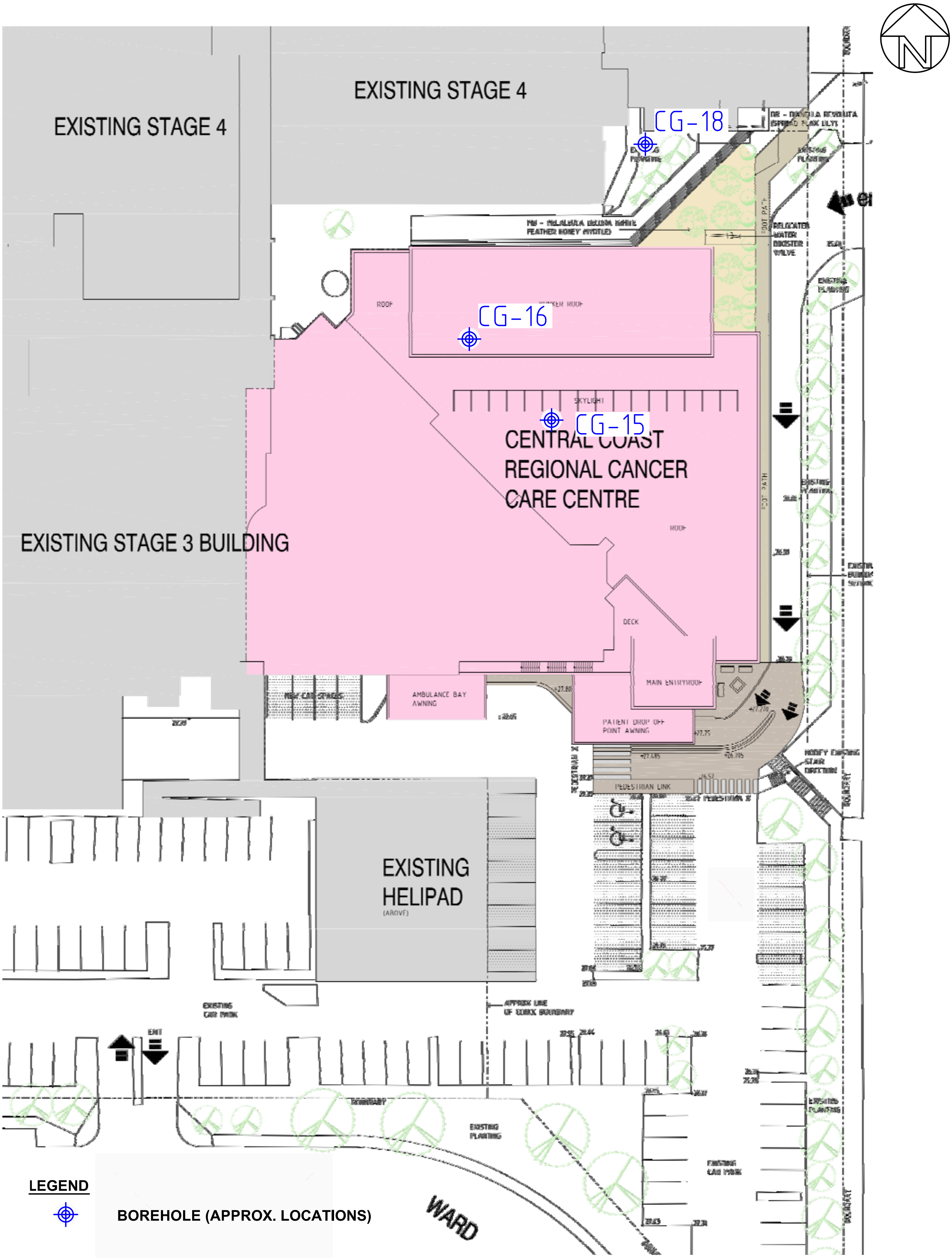
The attached sheet titled “Important Information about your Coffey Report” should be read in conjunction with this report.

For and on behalf of Coffey Geotechnics Pty Ltd

Sven Padina

Senior Geotechnical Engineer

Attached	Figure 1 Borehole Location Plan
	Important Information about your Coffey Report
	Soil and Rock Description Explanation Sheets



SOURCE: HEALTH INFRASTRUCTURE NSW HEALTH – DoP06-01

drawn	MV	client:	HEALTH INFRASTRUCTURE
approved		project:	PROPOSED CENTRAL COAST REGIONAL CANCER CARE CLINIC, GOSFORD HOSPITAL, NSW
date	22/10/10	title:	BOREHOLE LOCATION PLAN
scale	NTS	project no: ENAUWARA04052AA	figure no: FIGURE 1
original size	A4		

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

coffey

Soil Description Explanation Sheet (1 of 2)

DEFINITION:

In engineering terms soil includes every type of uncemented or partially cemented inorganic or organic material found in the ground. In practice, if the material can be remoulded or disintegrated by hand in its field condition or in water it is described as a soil. Other materials are described using rock description terms.

CLASSIFICATION SYMBOL & SOIL NAME

Soils are described in accordance with the Unified Soil Classification (UCS) as shown in the table on Sheet 2.

PARTICLE SIZE DESCRIPTIVE TERMS

NAME	SUBDIVISION	SIZE
Boulders		>200 mm
Cobbles		63 mm to 200 mm
Gravel	coarse	20 mm to 63 mm
	medium	6 mm to 20 mm
	fine	2.36 mm to 6 mm
Sand	coarse	600 µm to 2.36 mm
	medium	200 µm to 600 µm
	fine	75 µm to 200 µm

MOISTURE CONDITION

Dry Looks and feels dry. Cohesive and cemented soils are hard, friable or powdery. Uncemented granular soils run freely through hands.

Moist Soil feels cool and darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.

Wet As for moist but with free water forming on hands when handled.

CONSISTENCY OF COHESIVE SOILS

TERM	UNDRAINED STRENGTH s_u (kPa)	FIELD GUIDE
Very Soft	<12	A finger can be pushed well into the soil with little effort.
Soft	12 - 25	A finger can be pushed into the soil to about 25mm depth.
Firm	25 - 50	The soil can be indented about 5mm with the thumb, but not penetrated.
Stiff	50 - 100	The surface of the soil can be indented with the thumb, but not penetrated.
Very Stiff	100 - 200	The surface of the soil can be marked, but not indented with thumb pressure.
Hard	>200	The surface of the soil can be marked only with the thumbnail.
Friable	–	Crumbles or powders when scraped by thumbnail.

DENSITY OF GRANULAR SOILS

TERM	DENSITY INDEX (%)
Very loose	Less than 15
Loose	15 - 35
Medium Dense	35 - 65
Dense	65 - 85
Very Dense	Greater than 85

MINOR COMPONENTS

TERM	ASSESSMENT GUIDE	PROPORTION OF MINOR COMPONENT IN:
Trace of	Presence just detectable by feel or eye, but soil properties little or no different to general properties of primary component.	Coarse grained soils: <5% Fine grained soils: <15%
With some	Presence easily detected by feel or eye, soil properties little different to general properties of primary component.	Coarse grained soils: 5 - 12% Fine grained soils: 15 - 30%

SOIL STRUCTURE

ZONING		CEMENTING	
Layers	Continuous across exposure or sample.	Weakly cemented	Easily broken up by hand in air or water.
Lenses	Discontinuous layers of lenticular shape.	Moderately cemented	Effort is required to break up the soil by hand in air or water.
Pockets	Irregular inclusions of different material.		

GEOLOGICAL ORIGIN

WEATHERED IN PLACE SOILS

Extremely weathered material	Structure and fabric of parent rock visible.
Residual soil	Structure and fabric of parent rock not visible.

TRANSPORTED SOILS

Aeolian soil	Deposited by wind.
Alluvial soil	Deposited by streams and rivers.
Colluvial soil	Deposited on slopes (transported downslope by gravity).
Fill	Man made deposit. Fill may be significantly more variable between tested locations than naturally occurring soils.
Lacustrine soil	Deposited by lakes.
Marine soil	Deposited in ocean basins, bays, beaches and estuaries.

coffey

Soil Description Explanation Sheet (2 of 2)

SOIL CLASSIFICATION INCLUDING IDENTIFICATION AND DESCRIPTION

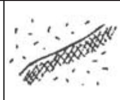
FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 60 mm and basing fractions on estimated mass)					USC	PRIMARY NAME
COARSE GRAINED SOILS More than 50% of materials less than 63 mm is larger than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than 2.36 mm	CLEAN GRAVELS (Little or no fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes.	GW	GRAVEL
				Predominantly one size or a range of sizes with more intermediate sizes missing.	GP	GRAVEL
			GRAVELS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	GM	SILTY GRAVEL
				Plastic fines (for identification procedures see CL below)	GC	CLAYEY GRAVEL
		SANDS More than half of coarse fraction is smaller than 2.36 mm	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate sizes	SW	SAND
				Predominantly one size or a range of sizes with some intermediate sizes missing.	SP	SAND
			SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below).	SM	SILTY SAND
				Plastic fines (for identification procedures see CL below).	SC	CLAYEY SAND

			IDENTIFICATION PROCEDURES ON FRACTIONS <0.2 mm.				
			DRY STRENGTH	**DILATANCY**	**TOUGHNESS**		
FINE GRAINED SOILS More than 50% of material less than 63 mm is smaller than 0.075 mm	(A 0.075 mm particle is about the smallest particle visible to the naked eye)	SILTS & CLAYS Liquid limit less than 50	None to Low	Quick to slow	None	ML	SILT
			Medium to High	None	Medium	CL	CLAY
			Low to medium	Slow to very slow	Low	OL	ORGANIC SILT
		SILTS & CLAYS Liquid limit greater than 50	Low to medium	Slow to very slow	Low to medium	MH	SILT
			High	None	High	CH	CLAY
			Medium to High	None	Low to medium	OH	ORGANIC CLAY
HIGHLY ORGANIC SOILS			Readily identified by colour, odour, spongy feel and frequently by fibrous texture.			Pt	PEAT

• Low plasticity – Liquid Limit w_L less than 35%. • Medium plasticity – w_L between 35% and 50%. • High plasticity – w_L greater than 50%.

COMMON DEFECTS IN SOIL

TERM	DEFINITION	DIAGRAM
PARTING	A surface or crack across which the soil has little or no tensile strength. Parallel or sub parallel to layering (eg bedding). May be open or closed.	
JOINT	A surface or crack across which the soil has little or no tensile strength but which is not parallel or sub parallel to layering. May be open or closed. The term 'fissure' may be used for irregular joints <0.2 m in length.	
SHEARED ZONE	Zone in clayey soil with roughly parallel near planar, curved or undulating boundaries containing closely spaced, smooth or slickensided, curved intersecting joints which divide the mass into lenticular or wedge shaped blocks.	
SHEARED SURFACE	A near planar curved or undulating, smooth, polished or slickensided surface in clayey soil. The polished or slickensided surface indicates that movement (in many cases very little) has occurred along the defect.	

TERM	DEFINITION	DIAGRAM
SOFTENED ZONE	A zone in clayey soil, usually adjacent to a defect in which the soil has a higher moisture content than elsewhere.	
TUBE	Tubular cavity. May occur singly or as one of a large number of separate or inter-connected tubes. Walls often coated with clay or strengthened by denser packing of grains. May contain organic matter	
TUBE CAST	Roughly cylindrical elongated body of soil different from the soil mass in which it occurs. In some cases the soil which makes up the tube cast is cemented.	
INFILLED SEAM	Sheet or wall like body of soil substance or mass with roughly planar to irregular near parallel boundaries which cuts through a soil mass. Formed by infilling of open joints.	

coffey

Rock Description Explanation Sheet (1 of 2)

The descriptive terms used by Coffey are given below. They are broadly consistent with Australian Standard AS1726-1993.

DEFINITIONS: Rock substance, defect and mass are defined as follows:

Rock Substance	In engineering terms rock substance is any naturally occurring aggregate of minerals and organic material which cannot be disintegrated or remoulded by hand in air or water. Other material is described using soil descriptive terms. Effectively homogenous material, may be isotropic or anisotropic.
Defect	Discontinuity or break in the continuity of a substance or substances.
Mass	Any body of material which is not effectively homogeneous. It can consist of two or more substances without defects, or one or more substances with one or more defects.

SUBSTANCE DESCRIPTIVE TERMS:

ROCK NAME Simple rock names are used rather than precise geological classification.

PARTICLE SIZE Grain size terms for sandstone are:

Coarse grained	Mainly 0.6mm to 2mm
Medium grained	Mainly 0.2mm to 0.6mm
Fine grained	Mainly 0.06mm (just visible) to 0.2mm

FABRIC Terms for layering of penetrative fabric (eg. bedding, cleavage etc.) are:

Massive	No layering or penetrative fabric.
Indistinct	Layering or fabric just visible. Little effect on properties.
Distinct	Layering or fabric is easily visible. Rock breaks more easily parallel to layering of fabric.

CLASSIFICATION OF WEATHERING PRODUCTS

Term	Abbreviation	Definition
Residual Soil	**RS**	Soil derived from the weathering of rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the soil has not been significantly transported.
Extremely Weathered Material	**XW**	Material is weathered to such an extent that it has soil properties, ie, it either disintegrates or can be remoulded in water. Original rock fabric still visible.
Highly Weathered Rock	**HW**	Rock strength is changed by weathering. The whole of the rock substance is discoloured, usually by iron staining or bleaching to the extent that the colour of the original rock is not recognisable. Some minerals are decomposed to clay minerals. Porosity may be increased by leaching or may be decreased due to the deposition of minerals in pores.
Moderately Weathered Rock	**MW**	The whole of the rock substance is discoloured, usually by iron staining or bleaching , to the extent that the colour of the fresh rock is no longer recognisable.
Slightly Weathered Rock	**SW**	Rock substance affected by weathering to the extent that partial staining or partial discolouration of the rock substance (usually by limonite) has taken place. The colour and texture of the fresh rock is recognisable; strength properties are essentially those of the fresh rock substance.
Fresh Rock	**FR**	Rock substance unaffected by weathering.

Notes on Weathering:

1. AS1726 suggests the term "Distinctly Weathered" (DW) to cover the range of substance weathering conditions between XW and SW. For projects where it is not practical to delineate between HW and MW or it is judged that there is no advantage in making such a distinction. DW may be used with the definition given in AS1726.
2. Where physical and chemical changes were caused by hot gasses and liquids associated with igneous rocks, the term "altered" may be substituted for "weathering" to give the abbreviations XA, HA, MA, SA and DA.

ROCK SUBSTANCE STRENGTH TERMS

Term	Abbrev-iation	Point Load Index, $I_{s(50)}$ (MPa)	Field Guide
Very Low	**VL**	Less than 0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with a knife; pieces up to 30mm thick can be broken by finger pressure.
Low	**L**	0.1 to 0.3	Easily scored with a knife; indentations 1mm to 3mm show with firm bows of a pick point; has a dull sound under hammer. Pieces of core 150mm long by 50mm diameter may be broken by hand. Sharp edges of core may be friable and break during handling.
Medium	**M**	0.3 to 1.0	Readily scored with a knife; a piece of core 150mm long by 50mm diameter can be broken by hand with difficulty.
High	**H**	1 to 3	A piece of core 150mm long by 50mm can not be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	**VH**	3 to 10	Hand specimen breaks after more than one blow of a pick; rock rings under hammer.
Extremely High	**EH**	More than 10	Specimen requires many blows with geological pick to break; rock rings under hammer.

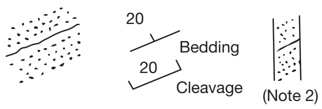
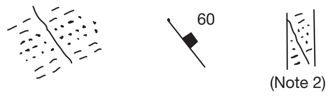
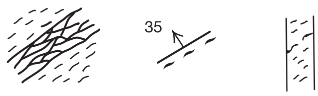
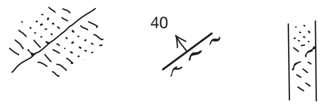
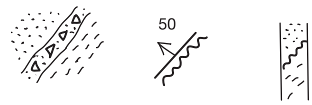
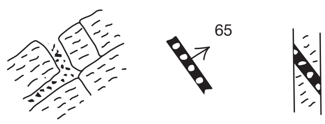
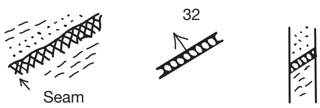
Notes on Rock Substance Strength:

1. In anisotropic rocks the field guide to strength applies to the strength perpendicular to the anisotropy. High strength anisotropic rocks may break readily parallel to the planar anisotropy.
2. The term "extremely low" is not used as a rock substance strength term. While the term is used in AS1726-1993, the field guide therein makes it clear that materials in that strength range are soils in engineering terms.
3. The unconfined compressive strength for isotropic rocks (and anisotropic rocks which fall across the planar anisotropy) is typically 10 to 25 times the point load index $I_{s(50)}$. The ratio may vary for different rock types. Lower strength rocks often have lower ratios than higher strength rocks.

coffey

Rock Description Explanation Sheet (2 of 2)

COMMON DEFECTS IN ROCK MASSES

Term	Definition	Diagram / Map Symbol / Graphic Log (Note 1)
Parting	A surface or crack across which the rock has little or no tensile strength. Parallel or sub parallel to layering (eg bedding) or a planar anisotropy in the rock substance (eg, cleavage). May be open or closed.	
Joint	A surface or crack across which the rock has little or no tensile strength. but which is not parallel or sub parallel to layering or planar anisotropy in the rock substance. May be open or closed.	
Sheared Zone (Note 3)	Zone of rock substance with roughly parallel near planar, curved or undulating boundaries cut by closely spaced joints, sheared surfaces or other defects. Some of the defects are usually curved and intersect to divide the mass into lenticular or wedge shaped blocks.	
Sheared Surface (Note 3)	A near planar, curved or undulating surface which is usually smooth, polished or slickensided.	
Crushed Seam (Note 3)	Seam with roughly parallel almost planar boundaries, composed of disoriented, usually angular fragments of the host rock substance which may be more weathered than the host rock. The seam has soil properties.	
Infilled Seam	Seam of soil substance usually with distinct roughly parallel boundaries formed by the migration of soil into an open cavity or joint, infilled seams less than 1mm thick may be described as veneer or coating on joint surface.	
Extremely Weathered Seam	Seam of soil substance, often with gradational boundaries. Formad by weathering of the rock substance in place.	

DEFECT SHAPE

	TERMS
Planar	The defect does not vary in orientation
Curved	The defect has a gradual change in orientation
Undulating	The defect has a wavy surface
Stepped	The defect has one or more well defined steps
Irregular	The defect has many sharp changes of orientation

Note: The assessment of defect shape is partly influenced by the scale of the observation.

ROUGHNESS TERMS

Slickensided	Grooved or striated surface, usually polished
Polished	Shiny smooth surface
Smooth	Smooth to touch. Few or no surface irregularities
Rough	Many small surface irregularities (amplitude generally less than 1mm). Feels like fine to coarse sand paper.
Very Rough	Many large surface irregularities (amplitude generally more than 1mm). Feels like, or coarser than very coarse sand paper.

COATING TERMS

Clean	No visible coating
Stained	No visible coating but surfaces are discoloured
Veneer	A visible coating of soil or mineral, too thin to measure; may be patchy
Coating	A visible coating up to 1mm thick. Thicker soil material is usually described using appropriate defect terms (eg, infilled seam). Thicker rock strength material is usually described as a vein.

BLOCK SHAPE TERMS

Blocky	Approximately equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greate than cross section

Notes on Defects:

1. Usually borehole logs show the true dip of defects and face sketches and sections the apparent dip.
2. Partings and joints are not usually shown on the graphic log unless considered significant.
3. Sheared zones, sheared surfaces and crushed seams are faults in geological terms.