Guideline

Geotechnical Borehole Logging

November 2016

Queensland Government

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Amendment Register

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List of Associated Forms

A – Geotechnical Terms and Symbols Form (F:GEOT017/8)

B – Borehole Drilling Data Sheet (F:GEOT026/4)

C – Core Logging Data Input Sheet (F:GEOT199/9)

D – Detailed Discontinuity Description Log (F:GEOT533/9)

E – Core Photo Log (F:GEOT043/3)

F – Field Geotechnical Borehole Log

G – Geotechnical Borehole Log (Example)

1 Introduction

Boreholes are widely used in geotechnical site investigation as a cost effective method of sampling materials from greater depths than is possible with test pits, with minimal environmental impact. Boreholes also provide downhole access for geotechnical testing equipment, enabling the measurement and monitoring of groundwater levels, pore pressures, permeability, ground movements, material strengths, *insitu* stresses and so on.

Together with data gained by other methods, the subsurface geological and geotechnical data obtained by drilling boreholes is used to develop a geotechnical model. This model evolves as information becomes available, providing a basis for the geotechnical design of engineering projects.

A clear and consistent approach to the description of materials obtained from boreholes, (soil and rock) and to the production of Geotechnical Borehole Logs, (referred herein as borehole logs) is required.

This document provides technical guidance for the compilation of borehole logs, by departmental engineering geologists or by external geologists engaged by Department of Transport and Main Roads (TMR) – Geotechnical Section, (referred herein as “geologists”). It outlines the types of information that must be recorded, the standards, terms and symbols that must be adhered to and stipulates the order in which this information should be presented.

The information presented on the borehole logs will, as a minimum, include:

- Project details and dates of drilling
- Borehole location details, including accurate Easting, Northing and Reduced Level
- Drilling contractor and geologist details
- Drilling methods, sampling techniques and depth intervals
- In situ and laboratory test methods and results
- Material descriptions and boundaries, and
- Groundwater depths and Reduced Levels.

The level of detail and specific technical content of the borehole logs will vary to some extent, depending on the nature and purpose of the investigation, and/or proposed structure.

Material descriptions and information presented on the borehole logs will be in general accordance with Australian Standard AS 1726-1993 Geotechnical site investigations and with the *TMR Geotechnical Terms and Symbols Form*, (F:GEOT017).

2 Borehole logging procedure

Borehole logging should ideally be carried out in the field at the time of drilling, in order to take advantage of interactions with the drillers and to ensure that the soil and rock core samples are recovered, bagged and boxed in an appropriate manner.

The logging area should be well lit and ventilated and have sufficient bench or work space for the laying out of multiple core trays. If the logging area is fully enclosed, the facility should be equipped with a dust extraction system.

2.1 Materials and equipment

The following basic items are required by the geologist for logging:

- *TMR Geotechnical Terms and Symbols Form* (F:GEOT017)
- *Blank Geotechnical Borehole Log Sheets*
- *TMR Borehole Drilling Data Sheet* (F:GEOT026)
- *TMR Core Logging Data Input Sheet* (F:GEOT199)
- *TMR Detailed Defect Log Form* (F:GEOT533)
- Plastic snap-lock bags (resealable)
- Permanent marker pens
- Bucket of water and water spray bottle
- Plastic sieve
- Tape measure, ruler, protractor
- Spatula/knife
- Geological hammer
- Pocket Penetrometer, and
- Hand lens.

This list does not include items of Personal Protective Equipment (PPE) or other items required for field or laboratory work.

2.2 General project/Location information

Whist the drillers are setting up over the test location, general project/borehole location information should be recorded on the draft borehole log. This information should be cross-referenced against, (and consistent with) information recorded on the *TMR Borehole Drilling Data Sheet* (F:GEOT026).

General project/borehole location information should include:

- Project Name
- Project Location, e.g. Chainage and Offset
- Project No., e.g. FG9000
- Job No., e.g. 242/530/1
- Height Datum, e.g. AHD
- Surface R.L.
- Grid Datum, e.g. MGA94 Zone 56
- Easting and Northing (please note these will be replaced by the “as-drilled”, surveyed coordinates of the completed borehole when made available)
- Plunge, (90˚ if the borehole is drilled vertically)
- Plunge and Bearing (if the borehole is not drilled vertically)

- Date Started and Date Completed
- Drilling Company, e.g. Boring Contractors Pty Ltd
- Logged by, (initials of geologist), and
- Reviewed by (initials of reviewer – required prior to release of preliminary logs).

2.3 General drilling data

The drilling methods, drill bit types, run lengths, sample types and intervals, core-loss and core recovery and rock quality designation (RQD) percentages should be recorded on the draft borehole log during the drilling. These items should also be cross-referenced against the *TMR Borehole Drilling Data Sheet* (F:GEOT026) upon completion of the borehole.

Samples will be labelled alphabetically, (A to Z, followed by AA to AZ and so on as required) and be recorded at the appropriate depth interval in the “Sample” column on the draft borehole log.

Specific sample or *insitu* test types, (for example Bulk, U50 or SPT) will be shown in the “Samples/ Tests” column, at the appropriate depth interval.

The depth at which groundwater is encountered should also be recorded on the draft borehole log at the time of drilling, noting if the measurement represents standing drilling water or the natural groundwater table. Subsequent readings of groundwater level will be shown on the finalised borehole log, with the date of measurement.

2.4 Logging of soil samples

Logging of soil samples includes the description, naming and classification of soils. Interpretation of the origin of particular stratum is also required, as informed by inherent features and structural evidence.

2.4.1 Description and naming of soils

Soil description is based on visual and tactile assessment of drill cuttings, (spoil) as well as disturbed and undisturbed samples obtained from the drilling.

In order to avoid misrepresentation it is important to cross-check sample information recorded on the draft borehole log and the *TMR Borehole Drilling Data Sheet* (F:GEOT026) with the labels on the soil samples.

Disturbed (SPT) samples should be examined and described prior to sealing them in labelled plastic containers or bags for storage in a cool place out of the sun.

The ends of undisturbed (U50 or U100) tube samples should be inspected and tested with a pocket penetrometer before sealing. After extrusion and selection of material for laboratory testing, the remainder of the undisturbed sample should be split, examined, described and then stored in a sealed, labelled plastic container.

Preliminary naming of soils can be carried out with the assistance of simple field tests. A preliminary USCS group symbol can be entered (in brackets) in the “UCCS/Weathering” column. Soils are assigned a USCS Group Symbol, in accordance with the major divisions shown on the *TMR Geotechnical Terms and Symbols Form* (F:GEOT017).

Final soil names and USCS classification are determined according to laboratory test results for particle size distribution and plasticity tests. The USCS Group Symbol is recorded on the finalised borehole log without brackets.

2.4.2 Organisation of soil data on the borehole log

On the draft borehole log, soil descriptors should be entered into the “Material Description” column, ordered in rows as shown in Table 2.4.2a

Table 2.4.2a – Description of soil on the geotechnical borehole log

Material Description
Minor Fraction MAJOR FRACTION (Origin) Colour, moisture, consistency. Grainsize, particle shape, sorting or grading, plasticity, organic content, zoning, defects, cementation.

Each row of the material description is detailed as follows:

Row 1 - Soil name

Soils comprising a single fraction can be named accordingly, e.g. SAND. However in most instances soils are composite, consisting of more than one fraction.

On the borehole log, the name of the minor fraction is written as the prefix in lower case, and the major fraction as the suffix in upper case, followed by the origin/depositional environment in brackets (lower case).

For composite soils, the modifiers ‘trace’ or ‘with’ can be used, as appropriate according to the relative proportions of compositional fractions. The appropriate use of modifiers is outlined in Table 2.4.2b below:

Table 2.4.2b – Soil naming convention and use of modifiers according to fractional composition

Coarse Grained Soils		Fine Grained Soils	
%Fines	**Modifier**	**%Coarse**	**Modifier**
≤ 5	‘trace’ clay or silt, (as applicable)	≤ 15	‘trace’ sand or gravel, (as applicable)
> 5 ≤ 12	‘with’ clay or silt, (as applicable)	> 15 ≤ 30	‘with’ sand or gravel, (as applicable)
> 12	clayey or silty SAND or GRAVEL (as applicable)	> 30	sandy or gravelly CLAY or SILT (as applicable)

After AS 1726-1993 Table A2

Row 2 – Primary descriptors

The primary descriptors are to be entered consecutively across the row in lower case according to the following order: Colour, moisture condition, consistency.

The following points provide further detail. Refer to *TMR Geotechnical Terms and Symbols Form* (F:GEOT017).

- Colour should be described in the moist condition, using black, white, grey, red, brown, orange, yellow, green or blue. Borderline cases can be described as a combination of two, with weaker colour followed by stronger colour. Colour can be modified as necessary with pale, dark or mottled (primary colour mottled secondary colour)
- Moisture condition is described as dry, moist or wet, and
- Consistency is described in terms of density for coarse grained, essentially non-cohesive soils, or stiffness for fine grained, essentially cohesive soils.

Row 3 – Secondary descriptors

The secondary descriptors are to be entered consecutively across the row in lower case in the order of the following points:

- Grainsize, and grading/sorting (of the coarse grained fractions)
- Particle shape (of the coarse grained fractions), either rounded, sub-rounded, sub-angular or angular)
- Plasticity (of the fine grained fractions), and
- Organic content, secondary minerals, zoning, defects, cementation.

Table 2.4.2c provides some examples of material descriptions for soils.

Table 2.4.2c – Example geotechnical borehole log material descriptions (soil)

Material Description
Gravelly SAND (Alluvium) Pale grey brown, wet, medium dense. Fine grained sand, rounded grains, medium to coarse grained gravel, sub-rounded grains, poorly graded, weakly cemented.
CLAY with sand (Residual) Orange mottled brown, moist, firm to stiff. Fine grained sand, sub-angular grains, high plasticity, trace organic matter.
Silty CLAY trace sand (Residual) Dark red brown, moist, hard. Coarse grained sand, sub-angular grains, medium plasticity.

2.5 Logging of rock samples (drill core)

Logging of rock samples (as per soil samples) includes the description, naming and classification of materials based on the characteristics of the intact rock and the discontinuities inherent in the rock mass.

2.5.1 Description and naming of rocks

Rock description relies upon visual and tactile assessment of cored rock samples. It is best practice to inspect and describe the core samples as soon as they are sampled and boxed, in natural light and in the ‘wet’ condition. In order to achieve this, the geologist must ensure that the core is clean. A spray bottle is useful for keeping the core wet whilst carrying out inspection and description.

The rock name, should be assigned in accordance with the Australian Standard AS 1726-1993, Table A6 - An Aid to the Identification of Rocks for Engineering Purposes.

2.5.2 Organisation of rock data on the borehole log

On the draft borehole logs, the descriptive rock data should be entered into the “Material Description” column, ordered in rows as shown in Table 2.5.2.

Table 2.5.2a – Description of rock on geotechnical borehole log

Material Description
NAME (Map Unit)
Weathering Degree: Colour, grain size, texture, fabric and rock strength.
Secondary minerals, alteration zones, any distinctive features, generalisations etc.
Discontinuity type, angle to the horizontal, frequency (No./m), roughness class, aperture, infilling.

Each row of the material description is detailed as follows:

Row 1 - Rock name

The rock type (name) is recorded first, in upper case, followed in brackets by the abbreviated name for the lithological unit as published on the appropriate geological map.

Row 2 – Degree of weathering and primary descriptors

The prevalent degree of weathering for each rock layer will appear in upper case followed by a colon, followed across the row by the primary rock descriptors in lower case.

Overlapping weathering terms such as HW/MW are not to be used.

Minor zones of weathering within a layer, (of thickness less than 1 m) will be detailed in the weathering column, (refer to Section 2.6). Intra-layer weathering variability will also be described in Row 3.

In the case of extremely weathered (XW) rock, where the material is weathered to such an extent that it has “soil” properties but the inherent rock structure/ fabric/ texture is still recognisable, the material description will read “recovered as”, followed by the relevant soil description, ordered as per Table 2.4.2a, (Section 2.4.2).

For highly weathered (HW), moderately weathered (MW), slightly weathered (SW) and fresh (FR) rock, the primary descriptors will be ordered across the row in the order: Colour, grain size, texture, fabric and rock strength.

- Colour should be described (as per soils) in the moist condition, using black, white, grey, red, brown, orange, yellow, green or blue. Borderline cases can be described as a combination of two, with weaker colour followed by stronger colour. Colour can be modified as necessary with pale, dark or mottled, (primary colour mottled secondary colour).
- Grain size refers to the average dimension of the mineral or rock fragments comprising the rock. An estimate by eye is generally sufficient.
- The texture of the rock refers to the nature of individual grains. Textural terms may include crystalline, cryptocrystalline, porphyritic, amorphous, glassy, granular/clastic, matrix or clast supported.
- The fabric of the rock refers to the arrangement (or preferred orientation) of the grains. Rock fabric descriptors may include bedding terms (from thinly laminated through to very thickly

bedded) and other terms describing inherent anisotropic fabrics such as foliation, mineral lineation or elongation, refer to *TMR Geotechnical Terms & Symbols Form* (F:GEOT017). The term massive is used to describe a homogeneous and isotropic rock mass.

- Preliminary estimates of intact rock strength can be achieved by use of simple field tests. For a guide to field strengths, refer to *TMR Geotechnical Terms & Symbols Form* (F:GEOT017) or Australian Standards AS 1726-1993, Table A8 – Strength of Rock Materials. Preliminary "field" strength estimates are to be later confirmed or adjusted according to the results of Point Load Strength Index (PL) tests and Uniaxial Compressive Strength (UCS) tests.

Row 3 – Secondary descriptors

The secondary descriptors are to be entered consecutively across the row in lower case in the following order:

- Secondary minerals or alterations, such as silicification, albitisation, pyrite, sericite or clay alteration
- Any minor weathering zones (within a rock layer), noting any structural controls and typical thickness, and
- Any other distinctive banding (such as liesegang banding), discoloration, pervasive staining or other notable features.

Row 4 – Discontinuity sets

Discontinuity sets are listed in order of prevalence down the column and described across the row in the following order: Discontinuity type, angle of incidence, frequency, roughness class, aperture, infilling:

- Discontinuity type, (bedding partings, joints, broken zones and so on), thickness (where applicable)
- Angle of incidence (relative to the horizontal)
- Frequency (number per metre of core)
- Roughness Class, Shape/Smoothness, e.g. Planar/Slickensided
- Aperture (closed, open, filled or tight), and
- Infilling (clean, stain, veneer or coating).

Table 2.5.2b below provides some example material descriptions for rock.

Table 2.5.2b – Example geotechnical borehole log material descriptions (rock)

Material Description
GRANITE (Rg) XW: Recovered as grey brown, moist, hard, clayey gravel.
GRANITE (Pg) MW: Pale white red, grey and black, coarse grained, crystalline, massive, medium strength. Pervasive, week iron staining, weak sub horizontal mineral lineation. LIN: 05° to 15°, Js: 20° to 40°, (4/m), Un/Ro, TI, Fe St Js: 50° to 70°, (2/m), Un/Ro, OP, Fe Vr
METAGREYWACKE (Dcf) SW: Pale brown grey, fine to medium grained, recrystallised, thinly bedded, weakly foliated, high to very high strength. Strongly silicified throughout, some HW bands < 50 mm thick, (3/m). BP / FP:15°, (8/m), Pl/Sm – Ro, TI, Cn DI: 0°-5°, (3/m), along BED SZ: 45°, (< 1/m), Pl/Sm, FL, Cly Ct, 5 mm -10 mm

Notes relating to discontinuities:

1. “Zones” and “coatings must be described in terms of both composition and thickness (in millimetres).
2. Drilling-induced defects must be distinguished from inherent discontinuities in the rock mass.
3. Healed defects and other lineaments or anisotropic fabrics within a solid/unbroken rock mass must be described as such.
4. Note that discontinuity persistence can only be measured in the field.

2.6 Detailed weathering grade

Localised variation in weathering grade within a broader weathering zone is shown in the “USCS/ Weathering” column, for intervals of width greater than 100 mm. (Significant intervals of less than 100 mm width may be mentioned in the “Additional Data and Test Results” column, (refer to Section 2.9). Data entry for the detailed weathering is facilitated by use of the *TMR Core Logging Data Input Sheet* (F:GEOT199).

2.7 Detailed intact strength histogram

A detailed down-hole histogram representation of intact strength is provided by the “Intact Strength” column. Data entry for this histogram is also facilitated by use of the *TMR Core Logging Data Input Sheet* (F:GEOT199). The more detailed presentation provided by the intact strength histogram is designed to highlight the degree of strength variation, within the broader layer context.

The intact strength histogram should be reconciled against (PL) and (UCS) test results, which are entered upon receipt into the “Additional Data and Test Results” column.

2.8 Detailed defect spacing histogram

The defect spacing histogram provides a visualisation of discontinuity distribution down the hole, considering all discontinuities aside from those defects that are drilling induced. This histogram should be reconcilable against RQD and reflective of the discontinuity sets listed in the “Materials Description” column.

Data entry for the defect spacing histogram is also facilitated by use of the *TMR Core Logging Data Input Sheet* (F:GEOT199). Refer to *TMR Geotechnical Terms and Symbols Form* (F:GEOT017) for definition of the defect spacing descriptors.

Note that for some projects where kinematic analysis is required, a separate detailed defect log should be completed, using the *TMR Detailed Discontinuity Description Log Form* (F:GEOT533).

2.9 Additional data and test results

The "Additional Data and Test Results" column is populated with *insitu* and laboratory test results and any data obtained from the monitoring of installed instruments.

Other significant features within a layer, for example shear zones, broken zones, clay bands and distinctive joints should also be described in this column.

2.10 Additional remarks

At the bottom of the borehole log sheet, there is a "Remarks" section, where any footnotes can be entered. These may include definitions of terms or symbols that are not included on the *TMR Geotechnical Terms and Symbols Form* (F:GEOT017). Definitions of abbreviated Map Unit names can also be entered here.

2.11 Borehole log finalisation

After completion of the initial draft borehole log, an overview should be carried out to ensure that any identified geological boundaries make sense in the context of a developing geological model. This is best achieved by laying out adjacent boreholes for comparison and by drafting geological sections.

The "PRELIMINARY" borehole logs should then be passed on to a Senior Engineering Geologist for review and comment.

Once all necessary corrections have been made and no laboratory test results are outstanding, the "FINAL" borehole logs can be approved for release by the reviewer.

Only finalised borehole logs can be included in the finalised Geotechnical Report, which is appropriately reviewed and approved by departmental Geotechnical Section.

TMR Geotechnical Terms & Symbols Form (F:GEOT017/8) can be accessed via:

http://www.tmr.qld.gov.au/business-industry/Technical-standards-publications/Geotechnical-Design-Standard.aspx

Associated Forms

Geotechnical Terms and Symbols

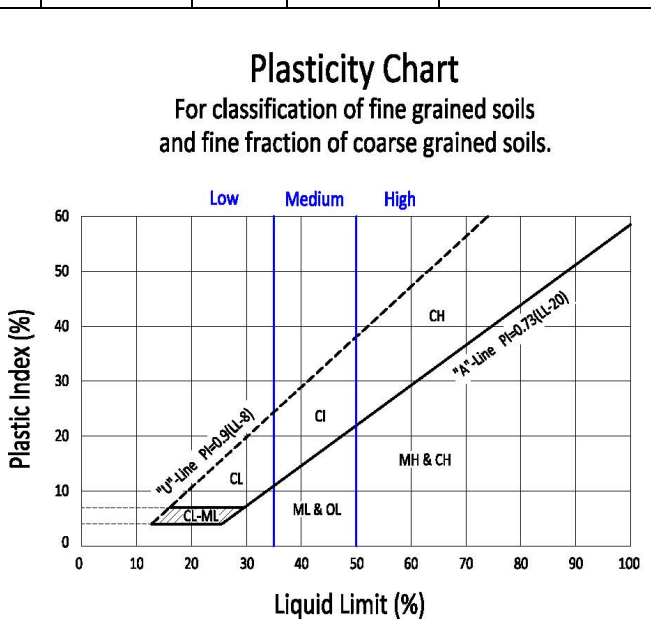
The following information is intended to assist in the interpretation of terms and symbols used in geotechnical borehole logs, test pit logs and reports issued by or for the Queensland Department of Transport and Main Roads (TMR). More detailed information relating to specific test methods is available in the TMR Materials Testing Manual (MTM) and the relevant Australian Standards.

Soil Descriptions

Description and Classification of Soils for Geotechnical Purposes: Refer to AS1726-1993 (Appendix A).
The following chart (adapted from AS1726-1993, Appendix A, Table A1) is based on the Unified Soil Classification System (USCS).

Major Divisions		Particle size mm	USCS Group Symbol	Typical Names	Laboratory Classification				
					% < 0.075mm (2)	Plasticity of fine fraction	$C_u = \frac{D_{60}}{D_{10}}$	$C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})}$	NOTES
COARSE GRAINED SOILS (more than half of material less than 63 mm is larger than 0.075 mm)	BOULDERS	____200							
	COBBLES	_____63							
	GRAVELS (more than half of coarse fraction is larger than 2.36mm)	coarse _____20	GW	Well graded gravels and gravel-sand mixtures, little or no fines	0-5	—	>4	Between 1 and 3	(1) Identify fines by the method given for fine-grained soils.
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines, uniform gravels	0-5	—	Fails to comply with above		
		medium _____6	GM	Silty gravels, gravel-sand-silt mixtures (1)	12-50	Below 'A' line or PI<4	—	—	
		fine ___2.36	GC	Clayey gravels, gravel-sand-clay mixtures (1)	12-50	Above 'A' line and PI>7	—	—	
	SANDS (more than half of coarse fraction is smaller than 2.36mm)		SW	Well graded sands and gravelly sands, little or no fines	0-5	—	>6	Between 1 and 3	(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 SP-SM, GW-GC.
		coarse ____0.6	SP	Poorly graded sands and gravelly sands, little or no fines	0-5	—	Fails to comply with above		
		medium ____0.2	SM	Silty sands, sand silt mixtures (1)	12-50	Below 'A' line or PI<4	—	—	
		fine 0.075	SC	Clayey sands, sand-clay mixtures (1)	12-50	Above 'A' line and PI>7	—	—	
FINE GRAINED SOILS (more than half of material less than 63 mm is smaller than 0.075 mm)	SILTS & CLAYS (Liquid Limit ≤50%)		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity					
			CL CI	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays					
			OL	Organic silts and clays of low plasticity					
	SILTS & CLAYS (Liquid Limit >50%)		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts					
			CH	Inorganic clays of high plasticity, fat clays					
			OH	Organic silts and clays of high plasticity					
	HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils					

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



Soil Colour: Is described in the moist condition using black, white, grey, red, brown, orange, yellow, green or blue. Borderline cases can be described as a combination of two colours, with the weaker followed by the stronger. Modifiers such as pale, dark or mottled, can be used as necessary. Where colour consists of a primary colour with secondary mottling, it should be described as follows:
(Primary) mottled (Secondary). Refer to AS1726-1993, A2.4 and A3.3.

Soil Moisture Condition: Is based on the appearance and feel of soil. Refer to AS1726-1993, A2.5.

Term	Description
Dry	Cohesive soils; hard and friable or powdery, well dry of plastic limit. Granular soils; cohesionless and free-running.
Moist	Soil feels cool, darkened in colour. Cohesive soils can be moulded. Granular soils tend to cohere.
Wet	Soil feels cool, darkened in colour. Cohesive soils usually weakened and free water forms on hands when handling. Granular soils tend to cohere and free water forms on hands when handling.

Consistency of Cohesive Soils: May be estimated using simple field tests, or described in terms of a strength scale. In the field, the undrained shear strength (s_u) can be assessed using a simple field tool appropriate for cohesive soils, in conjunction with the relevant calibration. Refer to AS1726-1993, Table A4.

Consistency - Essentially Cohesive Soils					
Term	**Field Guide**	**Symbol**	**SPT "N" Value**	**Undrained Shear Strength s_u (kPa)**	**Unconfined Compressive Strength q_u (kPa)**
Very soft	Oozes between fingers when squeezed in hand.	VS	0-2	<12	<25
Soft	Easily moulded with fingers.	S	2-4	12-25	25-50
Firm	Can be moulded by strong pressure of fingers.	F	4-8	25-50	50-100
Stiff	Not possible to mould with fingers.	St	8-15	50-100	100-200
Very stiff		VSt	15-30	100-200	200-400
Hard	Can be indented with difficulty by thumb nail.	H	>30	>200	>400

Note: SPT - N to q_u correlation from Terzaghi and Peck, 1967. (General guide only).

Soil Particle Sizes	
Term	**Size Range**
BOULDERS	>200mm
COBBLES	63-200mm
Coarse GRAVEL	20-63mm
Medium GRAVEL	6-20mm
Fine GRAVEL	2.36-6mm
Coarse SAND	0.6-2.36mm
Medium SAND	0.2-0.6mm
Fine SAND	0.075-0.2mm
SILT	0.002-0.075mm
CLAY	<0.002mm

Consistency of Non-Cohesive Soils: Is described in terms of the density index, as defined in AS1289.0-2000. This can be assessed using a field tool appropriate for non-cohesive soils, in conjunction with the relevant calibration. Refer to AS1726-1993, Table A5; BS5930-1999, p117.

Consistency - Essentially Non-Cohesive Soils				
Term	**Symbol**	**SPT N Value**	**Field Guide**	**Density Index (%)**
Very loose	VL	0-4	Foot imprints readily	0-15
Loose	L	4-10	Shovels Easily	15-35
Medium dense	MD	10-30	Shovelling difficult	35-65
Dense	D	30-50	Pick required	65-85
Very dense	VD	>50	Picking difficult	85-100

Standard Penetration Test (SPT): Refer to. AS 1289.6.3.1-2004. Example report formats for SPT results are shown below:

Test Report	Penetration Resistance (N)	Explanation / Comment
4, 7, 11	N=18	Full penetration; N is reported on engineering borehole log
18, 27, 32	N=59	Full penetration; N is reported on engineering borehole log
4, 18, 30/15 mm	N is not reported	30 blows causes less than 100 mm penetration (3rd interval) – test discontinued
30/80 mm	N is not reported	30 blows causes less than 100 mm penetration (1st interval) – test discontinued
rw	N<1	Rod weight only causes full penetration
hw	N<1	Hammer and rod weight only causes full penetration
hb	N is not reported	Hammer bouncing for 5 consecutive blows with no measurable penetration – test discontinued

Rock Descriptions

Refer to AS1726-1993 (Appendix A3.3) for the description and classification of rock material composition, including:

(a) Rock type (Table A6, (a) and (b))
(b) Grain size
(c) Texture and fabric
(d) Colour (describe as per soil)

The condition of a rock material refers to its weathering characteristics, strength characteristics and rock mass properties. Refer to AS1726-1993 (Appendix A3 Tables A8, A9 and A10).

Weathering Condition (Degree of Weathering):

The degree of weathering is a continuum from fresh rock to soil. Boundaries between weathering grades may be abrupt or gradational.

Rock Material Weathering Classification		
Weathering Grade	**Symbol**	**Definition**
Residual Soil	RS	Soil-like material developed on extremely weathered rock; the mass structure and substance fabric are no longer evident; there is a large change in volume but the material has not been significantly transported.
Extremely Weathered Rock	XW	Rock is weathered to such an extent that it has 'soil' properties, i.e. it either disintegrates or can be remoulded in water, but substance fabric and rock structure still recognisable.
Highly Weathered Rock	HW	Strong discolouration is evident throughout the rock mass, often with significant change in the constituent minerals. The intact rock strength is generally much weaker than that of the fresh rock.
Moderately Weathered Rock	MW	Modest discolouration is evident throughout the rock fabric, often with some change in the constituent minerals. The intact rock strength is usually noticeably weaker than that of the fresh rock.
Slightly Weathered Rock	SW	Rock is slightly discoloured but shows little or no change of strength from fresh rock.
Fresh Rock	FR	Rock shows no sign of decomposition or staining.

Notes:
1. Minor variations within broader weathering grade zones will be noted on the engineering borehole logs.
2. Extremely weathered rock is described in terms of soil engineering properties.
3. Weathering may be pervasive throughout the rock mass, or may penetrate inwards from discontinuities to some extent.
4. The 'Distinctly Weathered (DW)' class as defined in AS1726-1993 is divided to incorporate HW and MW in the above table. The symbol DW should not be used.

Strength Condition (Intact Rock Strength):

Strength of Rock Material (Based on Point Load Strength Index, corrected to 50mm diameter – $I_{s(50)}$. Field guide used if no tests available. Refer to AS 4133.4.1-2007.			
Term	**Symbol**	**Point Load Index (MPa)** $I_{s(50)}$	**Field Guide to Strength**
Extremely Low	EL	≤0.03	Easily remoulded by hand to a material with soil properties.
Very Low	VL	>0.03 ≤0.1	Material crumbles under firm blows with sharp end of pick; can be peeled with knife; too hard to cut a triaxial sample by hand. Pieces up to 3cm thick can be broken by finger pressure.
Low	L	>0.1 ≤0.3	Easily scored with a knife; indentations 1mm to 3mm show in the specimen with firm blows of the pick point; has dull sound under hammer. A piece 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 ≤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 ≤3	A piece of core 150mm long by 50mm diameter cannot be broken by hand but can be broken by a pick with a single firm blow; rock rings under hammer.
Very High	VH	>3 ≤10	Hand specimen breaks with pick after more than one blow; rock rings under hammer.
Extremely High	EH	>10	Specimen requires many blows with geological pick to break through intact material; rock rings under hammer.

Notes:
1. These terms refer to the strength of the rock material and not to the strength of the rock mass which may be considerably weaker due to the effect of rock defects.
2. Anisotropy of rock material samples may affect the field assessment of strength.

Discontinuity Description: Refer to AS1726-1993, Table A10.

Anisotropic Fabric	
BED	Bedding
FOL	Foliation
LIN	Mineral lineation
Defect Type	
LP	Lamination Parting
BP	Bedding Parting
FP	Cleavage / Foliation Parting
J, Js	Joint, Joints
SZ	Sheared Zone
CZ	Crushed Zone
BZ	Broken Zone
HFZ	Highly Fractured Zone
AZ	Alteration Zone
VN	Vein

Roughness (e.g. Planar, Smooth is abbreviated Pl / Sm)		**Class**
Stepped (Stp)	Rough or irregular (Ro)	I
	Smooth (Sm)	II
	Slickensided (Sl)	III
Undulating (Un)	Rough (Ro)	IV
	Smooth (Sm)	V
	Slickensided (Sl)	VI
Planar (Pl)	Rough (Ro)	VII
	Smooth (Sm)	VIII
	Slickensided (Sl)	IX

Aperture		**Infilling**		
Closed	CD	No visible coating or infill	Clean	Cn
Open	OP	Surfaces discoloured by mineral/s	Stain	St
Filled	FL	Visible mineral or soil infill <1mm	Veneer	Vr
Tight	TI	Visible mineral or soil infill >1mm	Coating	Ct

Other	
Cly	Clay
Fe	Iron
Co	Coal
Carb	Carbonaceous
Sinf	Soil Infill Zone
Qz	Quartz
CA	Calcite
Chl	Chlorite
Py	Pyrite
Int	Intersecting
Inc	Incipient
DI	Drilling Induced
H	Horizontal
V	Vertical

Note: Describe 'Zones' and 'Coatings' in terms of composition and thickness (mm).

Discontinuity Spacing: On the geotechnical borehole log, a graphical representation of defect spacing vs depth is shown. This representation takes into account all the natural rock defects occurring within a given depth interval, excluding breaks induced by the drilling / handling of core. Refer to AS1726-1993, BS5930-1999.

Defect Spacing			**Bedding Thickness (Sedimentary Rock Stratification)**	
Spacing/Width (mm)	Descriptor	Symbol	Descriptor	Spacing/Width (mm)
			Thinly Laminated	< 6
<20	Extremely Close	EC	Thickly Laminated	6 – 20
20 – 60	Very Close	VC	Very Thinly Bedded	20 – 60
60 – 200	Close	C	Thinly Bedded	60 – 200
200 – 600	Medium	M	Medium Bedded	200 – 600
600 – 2000	Wide	W	Thickly Bedded	600 – 2000
2000 – 6000	Very Wide	VW	Very Thickly Bedded	> 2000
>6000	Extremely Wide	EW		

Defect Spacing in 3D	
Term	**Description**
Blocky	Equidimensional
Tabular	Thickness much less than length or width
Columnar	Height much greater than cross section

Defect Persistence
(areal extent)
Trace length of defect given in metres

Symbols: The list below provides an explanation of terms and symbols used on the geotechnical borehole, test pit and penetrometer logs.

Test Results			
PI	Plasticity Index	c'	Effective Cohesion
LL	Liquid Limit	c_u	Undrained Cohesion
LI	Liquidity Index	c'_R	Residual Cohesion
DD	Dry Density	ϕ'	Effective Angle of Internal Friction
WD	Wet Density	ϕ_u	Undrained Angle of Internal Friction
LS	Linear Shrinkage	ϕ'_R	Residual Angle of Internal Friction
MC	Moisture Content	c_v	Coefficient of Consolidation
OC	Organic Content	m_v	Coefficient of Volume Compressibility
WPI	Weighted Plasticity Index	$c_{\alpha\varepsilon}$	Coefficient of Secondary Compression
WLS	Weighted Linear Shrinkage	e	Voids Ratio
DoS	Degree of Saturation	ϕ'_{cv}	Constant Volume Friction Angle
APD	Apparent Particle Density	q_t / q_c	Piezocone Tip Resistance (corrected / uncorrected)
s_u	Undrained Shear Strength	q_d	PANDA Cone Resistance
q_u	Unconfined Compressive Strength	$I_{s(50)}$	Point Load Strength Index
R	Total Core Recovery	*RQD*	Rock Quality Designation

Test Symbols	
DCP	Dynamic Cone Penetrometer
SPT	Standard Penetration Test
CPTu	Cone Penetrometer (Piezocone) Test
PANDA	Variable Energy DCP
PP	Pocket Penetrometer Test
U50	Undisturbed Sample 50 mm (nominal diameter)
U100	Undisturbed Sample 100mm (nominal diameter)
UCS	Uniaxial Compressive Strength
Pm	Pressuremeter
FSV	Field Shear Vane
DST	Direct Shear Test
PR	Penetration Rate
A	Point Load Test (axial)
D	Point Load Test (diametral)
L	Point Load Test (irregular lump)

28/11/13 Groundwater level on the date shown	Water Inflow	Water Outflow

Queensland Government

BOREHOLE DRILLING DATA SHEET

Borehole No.						Page _____ of _____	
Project No.		Project Name		Site Name		Supervisor	
Start Date		Borehole Location		Surface RL		Groundwater RL	
Finish Date		Drilling Contractor		Driller		Drill Rig	
NDD Contractor		Water Truck		Water Load Vol		Security	

Drilling Method / Sample Type	From Depth	To Depth	Run Length	Core Loss			RQD		Sample No.	*In Situ* Testing				Material Description **Soil:** Colour, Moisture, Consistency **Rock:** Colour, Grain Size, Strength,
				From	To	Rec %	>100 mm	%		SPT Blows / PP / FSV			N Value	

TIME LOG *Including set-up, mix mud, cart water, lunch, standby and so on.*

Date	From	To	Activity	Date	From	To	Activity

SUMMARY OF QUANTITIES

Casing (m)		Tubes (No.)		SPTs (No.)		Shear Veins (No.)		Core Trays (No.)	
Soil Drilling (m)		Rock Drilling (m)		Consumed Drill Bits		Bentonite Mud (kg)		Polymer Mud (L)	
Water Truck Loads		Standby Time		Piezo installed					

CORE LOGGING DATA INPUT SHEET

(For Geotechnical Terms & Symbols: Refer Form GEOT017)

Queensland Government

Project No. Project Name

Borehole No. Page _______ of _______ Date

Detailed Weathering Grade			Intact Strength			Defect Spacing		
Depth (m)			Depth (m)			Depth (m)		
From	To	Symbol	From	To	Symbol	From	To	Symbol

Detailed Discontinuity Description Log

This form is intended for the detailed description of discontinuities and defects as measured in outcrop by line mapping, or as they occur downhole in drilled rock core. The descriptions and abbreviations used shall be in accordance with Australian Standard AS1726-1993 Geotechnical site investigations and TMR Geotechnical Terms and Symbols Form F:GEOT017/8.

Project Name		**Project No.**	
Site ID / Borehole No.		**Surface RL**	
Geologist		**Date**	
		Page	__ of __

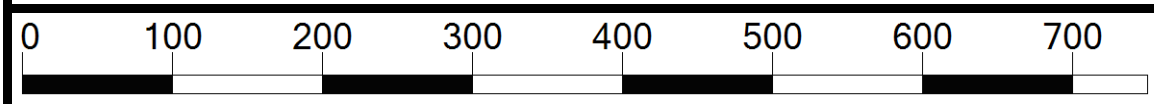
Traverse Chainage; or Down hole depth (rock core)	Type LP / BP / FP / J etc.	Dip ° / Dip Direction °; or Angle ° from horizontal (rock core)	Planarity Stp / Un / Pl	Roughness Ro / Sm / Sl	Roughness Class I to IX	Aperture CD / OP / FL / TI	Infilling Cn / St / Vr / Ct [1]	Zones [1] SZ / CZ / HFZ / AZ	Other

Note: 1. Describe zones and coatings in terms of composition and thickness (mm)

CORE PHOTO LOG
F: GEOT043/3
DEPARTMENT OF TRANSPORT AND MAIN ROADS
Geotechnical Section

Queensland Government

Project Name			
Project No.	FG	Date Completed	
Borehole No.	BH	Reference Number	H
Location		Start Depth (m)	
Submitted By		Finish Depth (m)	
Remarks			

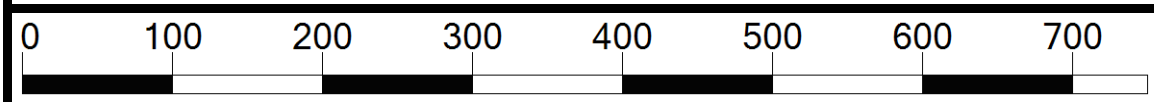


SCALE (mm)

CORE PHOTO LOG
F: GEOT043/3
DEPARTMENT OF TRANSPORT AND MAIN ROADS
Geotechnical Section

Queensland Government

Project Name			
Project No.	FG	Date	
Borehole No.	BH	Reference Number	H
Location		Start Depth (m)	
Submitted By		Finish Depth (m)	
Remarks			

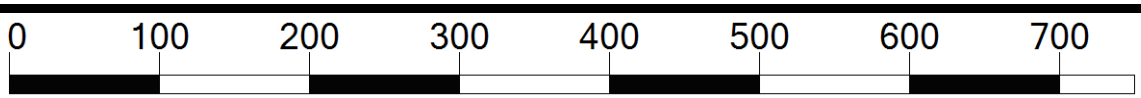


SCALE (mm)

CORE PHOTO LOG
F: GEOT043/3
DEPARTMENT OF TRANSPORT AND MAIN ROADS
Geotechnical Section

Queensland Government

Project Name			
Project No.	FG	Date	
Borehole No.	BH	Reference Number	H
Location		Start Depth (m)	
Submitted By		Finish Depth (m)	
Remarks			

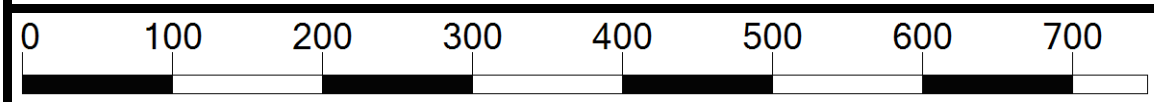


SCALE (mm)

CORE PHOTO LOG
F: GEOT043/3
DEPARTMENT OF TRANSPORT AND MAIN ROADS
Geotechnical Section

Queensland Government

Project Name			
Project No.	FG	Date	
Borehole No.	BH	Reference Number	H
Location		Start Depth (m)	
Submitted By		Finish Depth (m)	
Remarks			



SCALE (mm)

Queensland Government

FIELD GEOTECHNICAL BOREHOLE LOG

FOR GEOTECHNICAL TERMS AND SYMBOLS REFER FORM F:GEOT 017/8-2014

BOREHOLE No

PAGE No

REFERENCE No

PROJECT

LOCATION

COORDINATES

PROJECT No

SURFACE RL

PLUNGE 90°

DATE STARTED

GRID DATUM

JOB No

HEIGHT DATUM AHD

BEARING °

DATE COMPLETED

DRILLER

DEPTH (m)	MATERIAL DESCRIPTION	USCS WEATHERING	ADDITIONAL DATA AND TEST RESULTS	SAMPLES TESTS

REMARKS:

LOGGED BY

Queensland Government

FIELD GEOTECHNICAL BOREHOLE LOG

FOR GEOTECHNICAL TERMS AND SYMBOLS REFER FORM F:GEOT 017/8-2014

BOREHOLE No

PAGE No

REFERENCE No

PROJECT

LOCATION

COORDINATES

PROJECT No

SURFACE RL

PLUNGE 90°

DATE STARTED

GRID DATUM

JOB No

HEIGHT DATUM AHD

BEARING °

DATE COMPLETED

DRILLER

DEPTH (m)	MATERIAL DESCRIPTION	USCS WEATHERING	ADDITIONAL DATA AND TEST RESULTS	SAMPLES TESTS

REMARKS:

LOGGED BY

Queensland Government

FIELD GEOTECHNICAL BOREHOLE LOG

FOR GEOTECHNICAL TERMS AND SYMBOLS REFER FORM F:GEOT 017/8-2014

BOREHOLE No

PAGE No

REFERENCE No

PROJECT

LOCATION

COORDINATES

PROJECT No

SURFACE RL

PLUNGE 90°

DATE STARTED

GRID DATUM

JOB No

HEIGHT DATUM AHD

BEARING °

DATE COMPLETED

DRILLER

DEPTH (m)	MATERIAL DESCRIPTION	USCS WEATHERING	ADDITIONAL DATA AND TEST RESULTS	SAMPLES TESTS

REMARKS:

LOGGED BY

FINAL 09/03/2016

Queensland Government

GEOTECHNICAL BOREHOLE LOG

FOR GEOTECHNICAL TERMS AND SYMBOLS REFER FORM F:GEOT 017/8-2014

BOREHOLE No **BH-CC-01**

Sheet 1 of 2

REFERENCE No **H12327**

PROJECT Gold Coast Light Rail (GCLR) Stage 2

LOCATION Coombabah Creek Abutment

COORDINATES 533654.0 E; 6909338.8 N

PROJECT No FG6280 | SURFACE RL 0.99m | PLUNGE 90° | DATE STARTED 10/09/2015 | GRID DATUM MGA Zone 56

JOB No 498/04375 | HEIGHT DATUM AHD | BEARING ° | DATE COMPLETED 11/09/2015 | DRILLER North Coast Drilling

DEPTH (m)	R.L. (m)	AUGER / CASING / WASH BORING / CORE DRILLING	RQD ( ) % / CORE REC %	SAMPLE	MATERIAL DESCRIPTION	LITHOLOGY	USCS / WEATHERING	INTACT STRENGTH (EH VH H M L VL EL)	DEFECT SPACING (EC VC C M W VW EW)	ADDITIONAL DATA AND TEST RESULTS	SAMPLES / TESTS
	0.89				Silty CLAY (Topsoil) Dark grey, moist.						
					Silty CLAY (Estuarine) Dark grey, moist, soft.		(CI)				
1	-0.21			A	Clayey SAND (Estuarine) Dark grey, wet, very loose. Fine to medium grained. Shell fragments throughout.						U75
2				B						hw, hw, hw N<1	SPT
3				C						3.00m: * hw, hw, hw N<1	SPT
				D			(SC)				U75
4				E						4.00m: * hw, hw, hw N<1	SPT
				F							U75
5				G						1, hw, hw N<1	SPT
6				H						7, 9, 7 N=16	SPT
	-5.41				METAGREYWACKE (DCf) XW: Recovered as orange brown to grey, moist, very stiff, Silty CLAY.		XW	M	VC-C	6.40m-6.80m: Based on drilling observations.	
	-5.81		(37)		METAGREYWACKE (DCf) SW: Dark grey, fine to medium grained, indistinctly foliated, high to very high strength. -BP/FP: 40°-60° (<1/m), Pl/Sm-Ro, Tl, Cn -Js: 10°-30° (4/m), Pl/Sm-Ro, Tl, FeSt or Cn -Js: 40°-50° (2-3/m), Pl/Sm-Ro, Tl, FeSt or Cn -Js: 70°-90° (2/m), Pl/Sm-Ro, Tl, Cn or Qz		MW SW HW			7.14m-7.20m: HW BZ Is(50)=5.50 MPa Is(50)=3.60 MPa	D (7.04m) A (7.08m)
7								H-VH	C		
8			100 (42)				SW	H-VH	C	7.66m-7.68m: BZ	
									C		
								H-VH			
9									M	UCS=142.00 MPa Is(50)=4.10 MPa	(8.80m) D (9.00m)
									C		
									H	9.27m-9.32m: HW Zone Is(50)=0.85 MPa	A (9.31m)
									LM	9.42m-9.66m: BZ along subvertical joint	
			100 (41)				MW SW		M		
	-9.01										

Continued on next sheet

REMARKS: DCf = Neranleigh Fernvale Beds. *Refer to ALS laboratory test report.

LOGGED BY	REVIEWED BY
D.Colborne/ J.Armstrong	S.Foley

FINAL 09/03/2016

Queensland Government

GEOTECHNICAL BOREHOLE LOG

FOR GEOTECHNICAL TERMS AND SYMBOLS REFER FORM F:GEOT 017/8-2014

BOREHOLE No **BH-CC-01**

Sheet 2 of 2

REFERENCE No **H12327**

PROJECT Gold Coast Light Rail (GCLR) Stage 2

LOCATION Coombabah Creek Abutment

COORDINATES 533654.0 E; 6909338.8 N

PROJECT No FG6280 | SURFACE RL 0.99m | PLUNGE 90° | DATE STARTED 10/09/2015 | GRID DATUM MGA Zone 56

JOB No 498/04375 | HEIGHT DATUM AHD | BEARING ° | DATE COMPLETED 11/09/2015 | DRILLER North Coast Drilling

DEPTH (m)	R.L. (m)	AUGER / CASING / WASH BORING / CORE DRILLING	RQD ( ) % / CORE REC %	SAMPLE	MATERIAL DESCRIPTION	LITHOLOGY	USCS WEATHERING	INTACT STRENGTH (EH VH H M L VL EL)	DEFECT SPACING (EC VC C M W VW EW)	ADDITIONAL DATA AND TEST RESULTS	SAMPLES TESTS
11			100 (0)		METAGREYWACKE (DCf) SW: Cont'd.		SW	H-VH	VC, C	Is(50)=2.10 MPa Is(50)=1.40 MPa	D (10.77m) A (10.90m)
							MW	LM		11.09m-11.43m: BZ, MW	
							SW	H-VH	C		
			100 (17)				HW	L	C	11.59m-11.80m: HW BZ	
12							SW	H-VH	C	Is(50)=0.90 MPa Is(50)=2.10 MPa	D (11.82m) A (12.01m)
	-11.71		100					H-VH	VC		
					Borehole completed at 12.70m						
13											
14											
15											
16											
17											
18											
19											

REMARKS: DCf = Neranleigh Fernvale Beds. *Refer to ALS laboratory test report.

LOGGED BY	REVIEWED BY
D.Colborne/ J.Armstrong	S.Foley