1980/1. Notes on engineering logging of soils and rocks

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Abstract

This report presents a standard system for all soil and rock descriptions made for engineering purposes. The basic approach to engineering description is discussed and tables of descriptive terms and definitions are included. New engineering log forms are presented.

INTRODUCTION

This report presents a standard system for all soil and rock descriptions made for engineering purposes. Examples of the Departments new engineering logs and an explanation sheet are presented in Appendix 1. The standard and new forms are similar to those used by other engineering organisations in Australia and the writer acknowledges the work and ideas of former work colleagues, D.H. Stapledon, R.A. Rallings and J.R.L. Read.

This report is not an all embracing standard. It presents the basic approach to engineering descriptions, together with commonly used standard terms. There is some discussion on philosophy and topics with which Departmental geologists may be less familiar. For more detailed standards the reader is referred to the standards produced by the Department of Main Roads and the Melbourne and Metropolitan Board of Works. The Australian Mineral Foundation course notes on engineering site investigation provide an invaluable account of the basic approach to soil and rock descriptions (see REFERENCES).

The only way to assess the worth of an engineering log is to use it. It is hoped that the new logs and explanation sheet will appear in all reports produced by the Department in which soil and rock are described for engineering purposes. The writer will be satisfied the system is working when other geologists become critical through experience and seek revision and improvement of the logs presented here.

BASIC APPROACH

An engineering log can be regarded as a report of a test. It should give details of what was carried out, what happened, what was obtained, and what interpretations were made. It should be complete and clearly presented. Repetitions and non-standard abbreviations should be avoided.

Each log includes descriptions of relevant engineering properties of the materials encountered. This part of the description does not depend on knowledge of the geology and can be made of both natural and man made materials. A basic concept in the description is to distinguish between *substance, defects* and *mass*. These terms may be defined as follows:

substance - effectively homogeneous material, may be isotropic or anisotropic

defects - discontinuities or breaks in the continuity of a substance or substances

mass - any body of material which is not effectively homogeneous. It can comprise two or more substances without defects, or one or more substances with one or more defects.

Underlying this concept and these definitions is an attempt to distinguish between those properties defining the soil or rock substance (*i.e.* the unit building blocks) and the additional properties necessary to define the soil or rock mass as a whole. The properties of the mass are controlled partly by the properties of the substance (unit building blocks) and partly by the existence of defects (joints, fissures, *etc.*) within the soil or rock mass and the continuity, attitude and frictional properties *etc.* The importance of the defects in controlling the properties of the mass increases as the ratio of substance strength to defect strength increases. Thus defects in a rock mass are much more important in defining the properties of the mass than defects in a soil mass.

All materials are also described geologically; in fact some of the terms defined in this report are based on both geological origin and engineering properties. For example, a *crushed seam* by definition is a fault (geological) which has the property of being a seam of soil substance separating one or more rock substances. The geological description is very important as it gives information on the origin of a material and the history of the site. Knowledge of the geology can allow inferences to be made about the distribution of the materials and the geometry of the mass. Recognition of the effect of past processes may allow future processes to be predicted. For example, a sandy silt occurring at the surface may be recognised geologically as recent river alluvium. Thus it is likely to occur in thin planar sheets and the site may be liable to flooding.

SOIL DESCRIPTION

Order of description

* Composition	:	Unified Soil Classification system symbol Name Plasticity or particle characteristics Colour Secondary components Other minor components
* Condition	:	Moisture (disturbed or undisturbed) Consistency or relative density (undisturbed only)
* Structure	:	Zoning Defects Cementing
* Additional	:	Soil origin (*e.g.* FILL) Geological and pedological notes Odour

Classification system and soil name

The Unified Soil Classification system (USBR Earth Manual) provides the starting point for the description of soil substance (see fig. 1). Every person logging soils for engineering purposes should be familiar with this system. Apart from natural soils, other materials (*e.g.* weathered rock which breaks down or can be remoulded in water, or some fill such as crushed house bricks) can be usefully described by this system. It should be noted that the system applies to disturbed and remoulded soils with no reference to the *in situ* condition. In order to classify a natural soil it is necessary to disturb it and often to add water. The natural condition of the soil is recorded elsewhere in the description.

Apart from its value as a universal classification system, its basis on the physical properties of materials enable judgments to be made on the suitability of different materials for different engineering purposes. For example, a clayey gravel (GC) may be ideal as a core material for an earth dam whereas a well graded gravel (GW) may be required as a filter. The Unified Soil Classification system symbol alone indicates possible engineering uses.

Single component names

Names for single component soils are based on AS 1726 as follows:-

Name	*Subdivision*	*Particle size (mm)*
Clay and Silt		<0.06
		0.06
Sand	Fine	
		0.2
	Medium	
		0.6
	Coarse	
		2.0
Gravel	Fine	
		6.0
	Medium	
		20
	Coarse	
		60
Cobbles		
		200
Boulders		

Multi-component names

Modifying adjectives and dual symbols should be used as follows:

(i) Fine (>50% clay or silt), CL, CH, ML, MH

Lesser components

0 to 5%:	Just detectable by feel or eye	: Use term "with a trace of" *e.g.* CLAY with a trace of sand
5% to 12%:	Easily detectable by feel or eye	: Use term "with some" *e.g.* CLAY with some sand
>12%:	Requires dual name	: *e.g.* Sandy CLAY

(ii) Coarse (>50% sand or gravel)

Fines content

0 to 5% <0.06 mm	: Well graded or poorly graded GRAVEL and SAND; GW, GP, SW, SP
5% to 12% <0.06 mm	: Requires dual symbols, *e.g.* GP-GC, GW-GM, or SW-SC
>12% <0.06 mm	: Silty or clayey GRAVEL and SAND; GM, GC, SM, SC

Notes

(i) Modifying adjectives (Silty CLAY, Clayey GRAVEL) used *only* when a secondary component is present in a proportion greater than 12%.

(ii) Dual names (Clayey GRAVEL - Gravelly CLAY, GC-CH, as distinct from dual symbols, GRAVEL, GP-GC) are used *only* when primary and secondary components are present in almost equal proportions.

(iii) In visual classifications performed without the benefit of a laboratory test, proportions are visually estimated. In borderline cases the symbol or name allotted may not be precise. Always note on the borelog, geological plan, *etc.*, whether the classification was made visually or on the basis of laboratory tests.

Plasticity and particle characteristics

High plasticity	:	Liquid limit >50 (CH, MH and OH)
Medium plasticity	:	Liquid limit >35 <50 (CL-CH etc)
Low plasticity	:	Liquid limit <35 (CL, ML and OL)
Well graded	:	Good representation of all particle sizes from largest to smallest (GW, SW)
Poorly graded	:	One or more intermediate sizes poorly represented (GP, SP)

Note: Clay of high plasticity is best recognised in the field by the properties of high dry strength, toughness and non-dilatancy. Also smeared surfaces tend to be shiny.

Moisture

Dry (D)	:	Looks and feels dry
Moist (M)	:	No free water on hands when remoulding
Wet (W)	:	Free water on hands when remoulding

Consistency

For silt, clay and clayey sand

Range		Unconfined compressive strength (kPa) - pocket penetrometer	N* value	Rough field test
Very soft	(VS)	<25	<1	Exudes in fingers when squeezed
Soft	(S)	25 to 50	1 to 3	Easily penetrated by fist
Firm	(F)	50 to 100	3 to 6	Easily penetrated by thumb
Stiff	(St)	100 to 200	6 to 12	Indented by thumb, penetrated with difficulty
Very stiff	(VSt)	200 to 400	12 to 25	Easily indented by thumbnail
Hard	(H)	>400	>25	Indented by thumbnail with difficulty
Friable	(Fb)	-	-	Crumbles or powders when scraped with thumbnail

*N = standard penetrometer blow count per 300 mm.

Density index

For sand and gravel

Range		%	N value	Rough field test
Very loose	(VL)	0 to 15	0 to 4	Ravelling
Loose	(L)	15 to 35	4 to 10	Easy shovelling
Medium dense	(MD)	35 to 65	10 to 30	Hard shovelling
Dense	(D)	65 to 85	30 to 50	Picking
Very dense	(VD)	85 to 100	>50	Hard picking

Structures

Separate zones of soils differing in colour, grain size or other properties are described as:

Layer	:	Continuous across exposure or borehole core
Lens	:	Discontinuous layer with lenticular shape across exposure
Pocket	:	Irregular inclusion across exposure

Fissures should be described in terms of shape, continuity, texture (rough, polished) and/or coatings.

Cementing. Soils or defects within soils may be cemented by various agencies. The type of cement and degree of cementation should be noted.

EXAMPLE OF SOIL DESCRIPTION

Laboratory results

Sieve aperture (mm)	19.0	13.2	9.5	6.7	2.36	1.18	0.425	0.300	0.150	0.075
% passing				100	90	65	59	56	53	52

Atterberg limits on - 0.425 mm fraction are:

Liquid limit	(LL)	42
Plastic limit	(PL)	22
Plasticity Index	(PI)	20

Description

From grading, soil consists of 52% clay/silt, 38% sand and 10% fine gravel. Soil is therefore fine-grained (clay/silt >50%).

LL and PI plot above 'A' line on plasticity chart (fig. 1) so soil is CLAY. LL is between 35 and 50, so plasticity is medium and symbol is CL-CH.

The soil contains 38% sand and 10% fine gravel, therefore it is a sandy CLAY with some fine gravel.

The soil is pale grey and brown with no particular pattern.

The soil looks and feels dry, and darkens on moistening.

The pocket penetrometer value is 450 kPa which is 'hard'.

The sample contains numerous root holes up to 10 mm in diameter. Therefore the full description is:

CL-CH Sandy CLAY, medium plasticity, pale grey and brown, sand coarse, some medium with a trace of fine, some fine gravel. Dry, hard, with numerous root holes to 10 mm.

ROCK MASS DESCRIPTION

Order of description

Rock substance	:	Name
	:	Grain characteristics
	:	Colour
	:	Structure
	:	Minor components
Condition	:	Weathering or alteration
	:	Strength and hardness
Defects	:	Significant defects
	:	General defects

Rock type name

Clear, simple, general rock names should be used. The object is to ensure a reasonable engineering description rather than a petrologically precise geological classification.

Particle characteristics

For sedimentary rocks the size of particles can be described in the same way as soils. For crystalline rocks, terms such as fine-grained, coarse-grained *etc.* with a size range specified, can be used. Particle shape, *e.g.* rounded, sub-angular, spherical, platy *etc.* should also be noted.

Rock substance structure

This refers to features observable in hand specimen. The fabric of the substance can be described; it may be massive (homogeneous and isotropic), layered (bedding or cleavage) or lineated. If the substance is not massive it will have a strength anisotropy which may be measured and noted. There may be zones differentiated by grain size, colour or other properties. The presence of voids should be noted and comment on the porosity may be useful. The spacing of the structures should be noted *e.g.* graded bedding, from coarse to fine sandstone upwards, spacing 100 to 300 mm.

Degree of weathering

Weathering is progressive and hence to categorise weathering it is necessary to define arbitrary limits. Degree of weathering means the observed 'condition' of the rock substance *now* as caused by *past* weathering. It should be noted that the definitions suggested here apply to rock substance only. Other classifications exist which include references to defects, the rock mass as a whole, and the strength of the substance. These classifications may be useful as general grade classification in some situations but are inadequate for detailed engineering purposes. Rock substances do not necessarily become weaker during the weathering processes. For example some weathered Hawkesbury Sandstone (cemented with limonite) is stronger than the fresh rock (cemented with clay).

WEATHERING PRODUCTS CLASSIFICATION

Term	*Abbreviation*	*Definition*
Fresh	Fr	Rock substance unaffected by weathering
Slightly weathered	SW	Rock substance affected by weathering to the extent that partial staining of the rock substance usually by limonite has taken place. The colour and texture of the fresh rock is recognisable.
Highly weathered	HW	Rock substance affected by weathering to the extent that limonite staining or bleaching affects the whole of the rock substance and other signs of chemical or physical decomposition are evident. Porosity and strength may be increased or decreased compared to the fresh rock. The colour and strength of the original fresh rock substance is no longer recognisable.
Extremely weathered	EW	Rock substance affected by weathering to the extent that the rock exhibits soil properties - *i.e.* it can be remoulded and classified according to the Unified Soil Classification system, but the texture of the original rock is still evident.

Note: No criteria are given for "Moderately weathered". It is difficult to devise a universal definition that does not overlap with either 'Slightly weathered" or "Highly weathered". It can be defined on particular sites for particular rock substances if required.

Strength

The strength of rock is based on the point load strength index corrected to 50 mm, known as $Is_{(50)}$. This is a measure of the strength of rock substance. The equivalent Unconfined Compressive Strength (U.C.S.) values are based on the assumed but very approximate relationship, $U.C.S. = Is_{(50)} \times 24$

Rock strength class	*Symbol*	*Point load strength index $Is_{(50)}$ (MPa)*	*Approximate equivalent U.C.S. Qu (MPa)*
Extremely low	EL	<0.03	<0.7
Very low	VL	0.03 to 0.1	0.7 to 2.4
Low	L	0.1 to 0.3	2.4 to 7
Medium	M	0.3 to 1	7 to 24
High	H	1 to 3	24 to 70
Very high	VH	3 to 10	70 to 240
Extremely high	EH	>10	>240

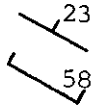
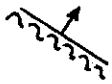
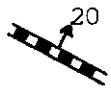
Hardness

The hardness of the rock substance may be described according to Mohs scale of hardness. It should not be confused with strength. For example, a medium strength siltstone may have a Moh's hardness of 5 whereas a very high strength limestone may have a Moh's hardness of 3.

Defects

Rock mass behaviour in most situations is dominantly controlled by the nature and configurations of defects in the mass. It is considered that many soil masses also contain defects which greatly influence their engineering behaviour, but there is inadequate appreciation generally of the nature and influence of soil defects. This report only gives definitions for rock defects because no widely used definitions for soil defects exist. However, it is important for all involved in site investigations in soils to be aware of their existence and adequately report and describe soil defects which occur. As with soil and rock substances understanding the origin of each type of defect is invaluable as it allows the extent (continuity) and shape of most defects to be predicted. For example, both *crushed seams* and *infill seams* consist of soil substance but a crushed seam is a geological fault and may be expected to continue for hundreds of metres, whereas an infill seam results from the mechanical loosening of a rock mass and will be confined to slightly disturbed near surface zones.

Definitions of rock defects

Name	*Map symbol*	*Log symbol*	*Description*
Bedding, Cleavage		Incline graphic symbol *e.g.* 	Layered or parallel arrangement of mineral grains or micro fractures, giving rise to planar anisotropy in the substance. *Not true defect* unless continuous observable parting occurs can then be described as *Joint* parallel to bedding (or cleavage)
Joint		Not usually shown unless considered significant 	Discontinuity or crack across which rock has little or no tensile strength. May be open or closed. May be planar, curved or irregular. Joint surfaces may be rough, smooth or slickensided.
Sheared zone			Zone of rock substance, with roughly parallel almost planar boundaries, cut by closely spaced joints. The joints are usually smooth or slickensided and curved, intersecting to divide the mass into lenticular or wedge-shaped blocks
These are faults in the geological sense			
Crushed seam			Seam with roughly parallel, almost planar boundaries, composed of disoriented, usually angular fragments of host rock substance. The fragments may be of clay, silt, sand or gravel sizes or mixtures of these. Soil properties
Infill seam			Seam of soil substance, usually with very distinct parallel boundaries. Formed by migration of soil into open cavity or joint
Extremely weathered seam			Seam of soil substance, usually with gradational boundaries. Formed by weathering of the rock substance.

Notes: Often it is not possible in cores to deduce the origin type of a seam. In these cases the extremely weathered symbol should be used, together with an engineering description of the soil in the seam. The origin terms are applied only when there is good evidence to support their use. Other terms such as "gouge", "crush breccia", "mylonite", "shear" *etc.* are not used as they are open to various definitions not specific enough for engineering purposes. In special cases a term not defined above may be preferred by some people. If any other terms, or alternative terms are used they should be clearly defined in simple descriptive terms.

Logging of defects

The most important defects are shown graphically on the borehole log and described individually under the heading "significant defects". For example, infill seams on a dam abutment, open limonite stained joints close to a pressure tunnel, and all crushed seams will usually be judged as significant. Under the general description heading the overall defect pattern in the rock mass is described.

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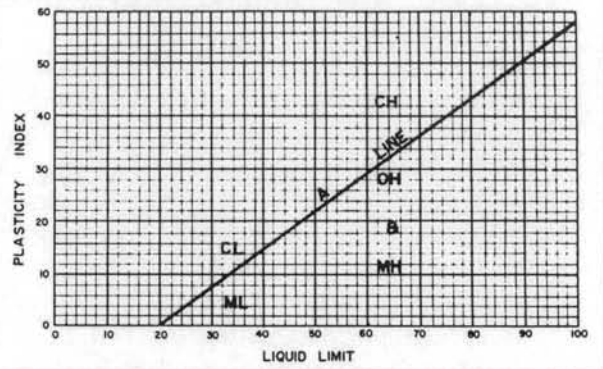
[17 January 1980]

SAA CODE OF PRACTICE FOR SITE INVESTIGATION

UNIFIED SOIL CLASSIFICATION SYSTEM

Major Divisions			Group Symbols	Typical Names	Field Identification Procedures (Excluding particles larger than 15 mm [3"] and basing fractions on estimated weights)	Laboratory Classification Criteria	Information Required for Describing Soils
COARSE GRAINED SOILS More than half of material is larger than 0.075 mm (BS No. 200 Sieve)	GRAVELS More than half of coarse fraction larger than 5 mm (BS ¼" Sieve)	CLEAN GRAVELS Little or no fines	GW	Well-graded gravels, gravel-sand mixtures, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	GW, GP, SW, SP, GM, GC, SM, SC Borderline cases requiring use of dual symbols. Less than 5% smaller than 0.075 mm. More than 12% smaller than 0.075 mm. 5% to 12% smaller than 0.075 mm. $C_U = \frac{D_{60}}{D_{10}}$ Greater than 6. $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3.	Give typical name; indicate approximate percentages of sand and gravel, max. size, angularity, surface condition and hardness of the coarse grains, local or geological name and pertinent descriptive information, and symbol in parentheses. For undisturbed soils add information on stratification, degree of compactness, cementation and moisture conditions. Example: Silty sand, gravelly, about 20% hard, angular gravel particles 12 mm max. size, rounded and subangular sand grains coarse to fine, about 15% nonplastic fines with low dry strength, well compacted and moist in place, alluvial sand (SM).
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.	Not meeting all gradation requirements for GW.	
		GRAVEL WITH FINES Appreciable amount of fines	GM	Silty gravels, gravel-sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (For identification procedures see ML below.)	Atterberg limits below "A" line or PI less than 4. / Atterberg limits above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols. / Atterberg limits above "A" line with PI greater than 7.	
			GC	Clayey gravels, gravel-sand-clay mixtures.	Plastic fines. (For identification procedures see CL below.)		
	SANDS More than half of coarse fraction smaller than 5 mm (BS ¼" Sieve)	CLEAN SANDS Little or no fines	SW	Well-graded sands, gravelly sands, little or no fines.	Wide range in grain sizes and substantial amounts of all intermediate particle sizes.	$C_U = \frac{D_{60}}{D_{10}}$ Greater than 4. $C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3.	
			SP	Poorly-graded sands, gravelly sands, little or no fines.	Predominantly one size or a range of sizes with some intermediate sizes missing.	Not meeting all gradation requirements for SW.	
		SANDS WITH FINES Appreciable amount of fines	SM	Silty sands, sand-silt mixtures.	Nonplastic fines or fines with low plasticity. (For identification procedures see ML below.)	Atterberg limits below "A" line or PI less than 4. / Atterberg limits above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols. / Atterberg limits above "A" line with PI greater than 7.	
			SC	Clayey sands, sand-clay mixtures.	Plastic fines. (For identification procedures see CL below.)		
					Identification Procedure on Fraction Smaller than 0.4 mm (BS No. 36 sieve) size.		
					Dry Strength (Crushing characteristics) / Dilatancy (Reaction to shaking) / Toughness (Consistency near PL)		
FINE GRAINED SOILS More than half of material is smaller than 0.075 mm (BS No. 200 Sieve)	SILTS AND CLAYS Liquid limit less than 50		ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.	None to slight / Quick to slow / None		Give typical name, indicate degree and character of plasticity, amount and maximum size of coarse grains, colour in wet condition, odour if any, local or geological name, and other pertinent descriptive information and symbol in parentheses. For undisturbed soils add information on structure, stratification, consistency in undisturbed and remoulded states, and moisture condition. Example: Clayey silt, brown, slightly plastic, small percentage of fine sand, numerous vertical root holes, firm and dry in place, loess (ML).
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty.	Medium to high / None to very slow / Medium		
			OL	Organic silts and organic silty clays of low plasticity.	Slight to medium / Slow / Slight		
	SILTS AND CLAYS Liquid limit greater than 50		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.	Slight to medium / Slow to none / Slight to Medium		
			CH	Inorganic clays of high plasticity, fat clays.	High to very high / None / High		
			OH	Organic clays of medium to high plasticity, organic silts.	Medium to high / None to very slow / Slight to medium		
Highly Organic Soils			Pt	Peat and other highly organic soils.	Readily identified by colour, odour, spongy feel and frequently by fibrous texture.		

BOUNDARY CLASSIFICATIONS: Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand with clay binder.

LATERITIC SOILS: These soils may be classified texturally in accordance with the above system, but their properties may be inconsistent with accepted usage because of their tendency to harden on exposure to atmospheric conditions.

FIELD IDENTIFICATION PROCEDURES FOR FINE GRAINED SOILS OR FRACTIONS

These procedures are to be performed on the minus 0.4 mm (BS No. 36 Sieve) size particles.

DILATANCY (Reaction to shaking)
Prepare a pat of moist soil with a volume of about 10 mm³. Add enough water, if necessary, to make the soil soft but not sticky. Place the pat in the open palm of one hand and shake horizontally, striking vigorously against the other hand several times. A positive reaction consists of the appearance of water on the surface of the pat which changes to a livery consistency and becomes glossy. When the sample is squeezed between the fingers, the water and gloss disappear from the surface, the pat stiffens and finally it cracks or crumbles. The rapidity of appearance of water during shaking and of its disappearance during squeezing is a measure of the dilatancy. Very fine clean sands give the quickest and most distinct reaction whereas clays have no reaction. Inorganic silts, such as a typical rock flour, show a moderately quick reaction.

DRY STRENGTH (Crushing characteristics)
Mould a pat of soil to the consistency of putty, adding water if necessary. Allow the pat to dry completely by oven, sun or air drying and then test its strength by breaking and crumbling between the fingers. Fine sand feels gritty whereas typical silt has the smooth feel of flour.

TOUGHNESS (Consistency near plastic limit)
A specimen of soil about 10 mm³ in size is moulded to the consistency of putty. If too dry, water must be added and if sticky, the specimen should be spread out in a thin layer and allowed to lose some moisture by evaporation. Then the specimen is rolled out by hand on a smooth surface or between the palms into a thread about 3 mm in diameter. The thread is then folded and rerolled repeatedly. During this manipulation the moisture content is gradually reduced and the specimen stiffens, finally loses its plasticity and crumbles when the plastic limit is reached. After the thread crumbles, the pieces should be lumped together and a slight kneading action continued until the lump crumbles.
The toughness of the thread near the plastic limit and the stiffness of the lump when it finally crumbles is indicative of the clay content of the soil.

5 cm

Figure 1.

APPENDIX 1

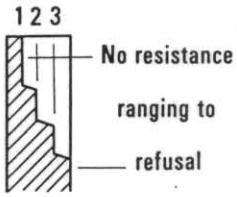
Explanation sheet for engineering logs and sample logs for a borehole, excavation, and cored borehole.

TASMANIA DEPARTMENT OF MINES

EXPLANATION SHEET FOR ENGINEERING LOGS

Borehole and excavation log

Penetration



Water

22 Jan, 80 Water level on date shown.

Water inflow.

Water outflow.

Notes - samples and tests

U50	Undisturbed sample 50mm diameter.
D	Disturbed sample.
N	Standard penetrometer blow count for 300mm.
N*	SPT + sample.

Material classification

Based on Unified Soil Classification System.

In Graphic Log materials are represented by clear contrasting symbols consistent for each project.

Moisture content

D	Dry, looks and feel dry.
M	Moist, no free water on hand when remoulding.
W	Wet, free water on hand when remoulding.
LL	Liquid limit.
PL	Plastic limit.
PI	Plasticity Index.

eg. M > PL – Moist, moisture content greater than the plastic limit.

Consistency

		hand penetrometer (kPa)
VS	Very soft.	< 25
S	Soft.	25 - 50
F	Firm.	50 - 100
St	Stiff.	100 - 200
VSt	Very stiff.	200 - 400
H	Hard.	> 400
Fb	Friable.	

Notes: X on log is test result

— is range of results.

Density index

		%
VL	Very loose.	0 - 15
L	Loose.	15 - 35
MD	Medium dense.	35 - 65
D	Dense.	65 - 85
VD	Very Dense	85 - 100

Cored borehole log

Case - lift

Casing used.

Barrel withdrawn.

Fluid loss

No loss

50% loss

100% loss.

Lugeons

Lugeon units (μL) are a measure of rock mass permeability. For a 46 to 74mm diameter borehole 1 Lugeon is defined as a rate of loss of 1 litre per metre per minute. 1 Lugeon is roughly equivalent to a permeability of 1×10^{-4} mm/sec.

Graphic log

No core.

Rock substances represented by clear, contrasting symbols consistent for each project.

Weathering

Fr	Fresh.
SW	Slightly weathered.
HW	Highly weathered.
EW	Extremely weathered.

Strength

		point load strength index $I_{s\,(50)}$ (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

Note: X on log is test result.

Significant defects

Significant defects shown graphically.

Joint.

Sheared zone.

Crushed seam.

Infill seam.

Extremely weathered seam.

16/21

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – BOREHOLE

borehole no. 1
sheet 1 of 1

project GOVERNMENT OFFICES location HILL STREET, NEWTOWN

co-ordinates 478639m E
5736892m N
R.L. 42·6m
inclination vertical
bearing —

drill type Gemco 210B
drill method Auger, "V" bit 0 to 5m, TC bit 5 to 8m
drill fluid None

hole commenced 22 Jan, 80
hole completed 22 Jan, 80
drilled by JRS
logged by WMB
checked by SCD

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	NONE						SC	Clayey SAND, fine to medium, brown, clay of low plasticity, some bottles and cans	M	F to St		FILL
			7 11 14 N* 25		1		SM	Silty SAND, fine to medium, grey brown, trace of medium gravel, many fine roots	D	MD		TOPSOIL
			9 16 23 N* 39	140	2			As above, grey, trace of clay		D		
		25 Jan 80 ▼	U50		3		CH	CLAY, high plasticity, pale grey and light brown mottled, some fine sand, trace of limonite nodules to 10mm across	M < PL	St to VSt		'B' HORIZON Fissures, near-vertical irregular spaced 30 to 100mm
			U50		4							
			CHANGE "V" bit to TC bit		5		GC	Clayey GRAVEL, fine to coarse, grey and yellow brown, clay low to medium plasticity, some fine to medium sand. gravel consists of subrounded fragments of weathered fine sandstone	M > PL	VD		'C' HORIZON
			D		6				W			
			D	135	7		GP – GM	GRAVEL, fine to coarse, yellow brown, sand fine to coarse, trace of clay	D			HIGHLY TO EXTREMELY WEATHERED SANDSTONE (TRIASSIC)
					8			HOLE STOPPED AT REQUIRED DEPTH 8.00m				
					9							
					10							

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – CORED BOREHOLE

borehole no. 3
sheet 1 of 5

project RED RIVER location SEATOWN

co-ordinates 398 471m E
6402 713m N
R.L. 177·5m
inclination vertical
bearing –

drill type Minidrill F30
drill method NMLC
triple tube barrel 1·53m
drill fluid water

hole commenced 18 Jan '80
hole completed 25 Jan '80
drilled by B Brown
logged by RKM
checked by JEP

drilling information

case-lift	fluid loss	water	notes	lugeons (0.3 1 3 10 30 100)	R.L.	depth
					177·5	0
						1
						2
				0·5	175	3
						4
				12		5
			19 Jan '80			6
			21 Jan '80			7
			2 Feb '80	1·5	170	8
						9
			WATER INFLOW	5		10

rock substance

graphic log	substance description (rock type: grain characteristics, colour, structure, minor components.)	weathering	strength (EL VL L M H VH EH)
	NO CORE, tricone roller bit. Cuttings of HW SILTSTONE		
	SILTSTONE, coarse grained, yellow brown, slightly friable, bedding dips at 40 to 60° as shown	HW	
	SILTSTONE (90%) coarse grained, grey brown and grey, dips 30 to 40° as shown interbedded with SANDSTONE (10%) fine grained, pale grey, in beds up to 50mm thick	SW	
	SANDSTONE medium to coarse grained, yellow brown, slightly friable.	HW	
	SILTSTONE (90%) and SANDSTONE (10%) as above	SW	
		Fr	
	GRANITE, coarse grained, speckled pale grey and pink, massive, trace of pyrite		
		SW	
		Fr	

rock mass defects

defect spacing mm (30 100 300 1000 3000)	defect description (thickness, type, inclination, planarity, roughness, coating.) significant	general
	← 60mm, dips 60°	Most defects are EW seams parallel to bedding as shown, GC or CL, moist, stiff
	← 40mm, dips 50°	
	← 20mm dips 45°	
	← irregular	
	← INFILL Seam CLAY (CH) grey moist, 40mm dips 55°	Most defects are joints parallel to bedding. Steeply dipping joints in sets 2 and 3 also occur (sets defined in report). Joints irregular, surfaces rough and stained with limonite. Some joints in SANDSTONE do not continue into SILTSTONE
	← EW Seam CLAY (CL) brown 20mm dips 30°	
	← SHEARED Zone 10mm dips 30°	
	← CRUSHED Seam 20mm dips 40° (GM)	
	← SHEARED Zone 20mm dips 45°	Defects are joints, steeply dipping, irregular, rough and stained with limonite
	← JOINT, rough irregular limonite stained	

5 cm

TASMANIA DEPARTMENT OF MINES

ENGINEERING LOG – EXCAVATION

excavation no. 4
sheet 1 of 1

project WATER TREATMENT PLANT location RIVERPORT

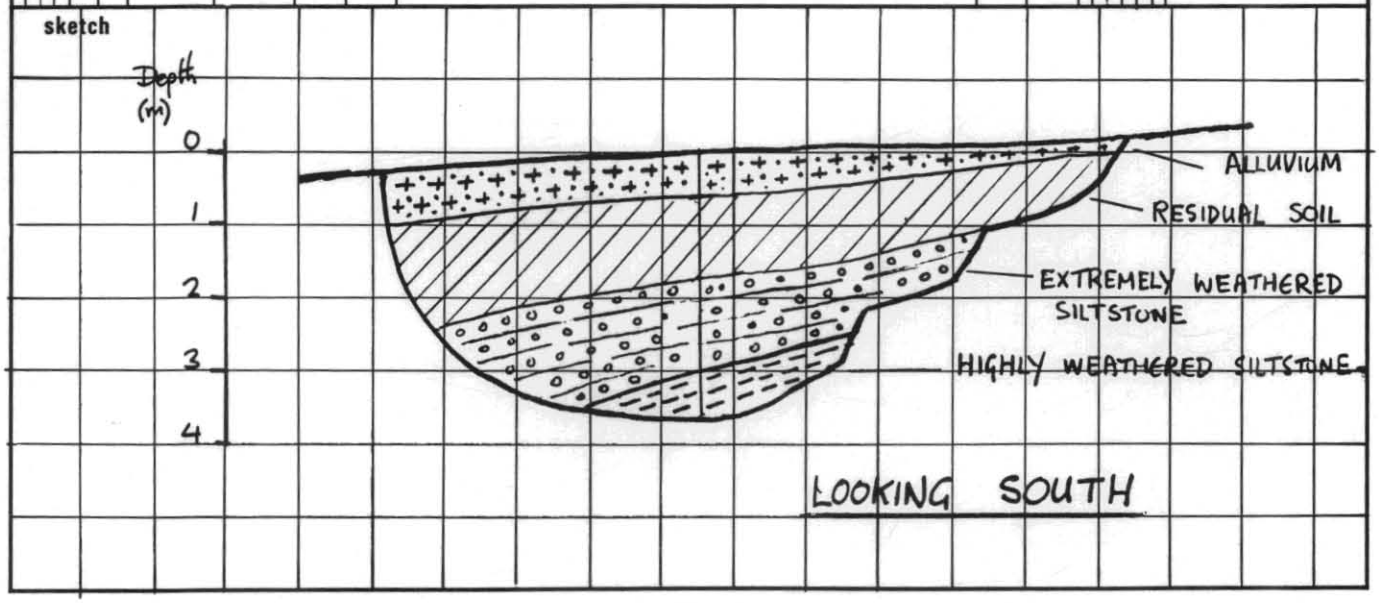
co-ordinates 469731 m E
5736844m N
R.L. 146·8m
excavation dimensions 10m x 0·8m x 3·6m deep

exposure type Backhoe pit
equipment John Deere 400
450mm bucket
operator J. Smith

pit commenced 29 Jan '80
pit completed 29 Jan '80
logged by MBD
checked by LMS

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure geology
	NONE	NOT ENCOUNTERED		145			ML	Sandy SILT, quick dilatancy, grey brown, sand fine to medium, many fine roots	M	F		ALLUVIUM
			U50		1		CL	Silty CLAY, low plasticity, brown, some coarse sand, trace of fine to medium gravel, angular,	M < PL	St to VSt		RESIDUAL SOIL
			D		2		GC	Clayey GRAVEL, fine to coarse, mottled grey and yellow brown, clay low to medium plasticity. Gravel consists of angular fragments of weathered SILTSTONE	D	VSt / H	X >450	EXTREMELY WEATHERED SILTSTONE
					3			SILTSTONE, coarse grained, dark grey, bedding well developed, dips 25°, low strength				HIGHLY WEATHERED SILTSTONE
					4			BACKHOE REFUSAL ON HIGHLY WEATHERED SILTSTONE AT 3·6m				
					5							

sketch



5 cm

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. 1
sheet 1 of 1

19/21

ENGINEERING LOG – BOREHOLE

project GOVERNMENT OFFICES location HILL STREET, NEWTOWN

co-ordinates 478639m E
5736892m N
R.L. 42·6m
inclination vertical
bearing —

drill type Gemco 210B
drill method Auger, "V" bit 0 to 5m
TC bit 5 to 8m
drill fluid None

hole commenced 22 Jan, 80
hole completed 22 Jan, 80
drilled by JRS
logged by WMB
checked by SCD

penetration 1 2 3	support	water	notes samples, tests	metres R.L.	metres depth	graphic log	classification symbol	material: soil type: plasticity or particle characteristics, colour, secondary and minor components.	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	NONE				1		SC	Clayey SAND, fine to medium, brown, clay of low plasticity, some bottles and cans	M	F to St	—	FILL
			7 11 14 N* 25				SM	Silty SAND, fine to medium, grey brown, trace of medium gravel, many fine roots	D	MD		TOPSOIL
			9 16 23 N* 39	140	2			As above, grey, trace of clay		D		
		25 Jan 80	U50		3		CH	CLAY, high plasticity, pale grey and light brown mottled, some fine sand, trace of limonite nodules to 10mm across	M < PL	St to VSt	—	'B' HORIZON Fissures, near-vertical irregular spaced 30 to 100mm
			U50		4						—	
			CHANGE "V" bit to TC bit		5		GC	Clayey GRAVEL, fine to coarse, grey and yellow brown, clay low to medium plasticity, some fine to medium sand. gravel consists of subrounded fragments of weathered fine sandstone	M > PL	VD		'C' HORIZON
			D		6				W			
			D	135	7		GP – GM	GRAVEL, fine to coarse, yellow brown, sand fine to coarse, trace of clay	D			HIGHLY TO EXTREMELY WEATHERED SANDSTONE (TRIASSIC)
					8			HOLE STOPPED AT REQUIRED DEPTH 8.00m				
					9							
					10							

TASMANIA DEPARTMENT OF MINES

5 cm

borehole no. 3
sheet 1 of 5

ENGINEERING LOG – CORED BOREHOLE

project RED RIVER location SEATOWN

co-ordinates 398 471 m E
6402 713 m N
R.L. 177·5m
inclination vertical
bearing –

drill type Mindrill F30
drill method NMLC
triple tube barrel 1·53m
drill fluid water

hole commenced 18 Jan '80
hole completed 25 Jan '80
drilled by B Brown
logged by RKM
checked by JEP

drilling information | **rock substance** | **rock mass defects**

case-lift	fluid loss	water	notes	lugeons pL (0.3 1 3 10 30 100)	metres R.L.	metres depth	graphic log	substance description (rock type: grain characteristics, colour, structure, minor components.)	weathering	strength (EL VL L M H VH EH)	defect spacing mm. (30 100 300 1000 3000)	defect description (thickness, type, inclination, planarity, roughness, coating.) significant	general
								NO CORE, tricone roller bit. Cuttings of HW SILTSTONE					
						1		SILTSTONE, coarse grained, yellow brown, slightly friable, bedding dips at 40 to 60° as shown	HW			← 60mm, dips 60°	Most defects are EW seams parallel to bedding as shown, GC or CL, moist, stiff
						2						← 40mm, dips 50°	
												← 20mm dips 45°	
												← irregular	
				0·5pL	175	3		SILTSTONE (90%) coarse grained, grey brown and grey, dips 30 to 40° as shown interbedded with SANDSTONE (10%) fine grained, pale grey, in beds up to 50mm thick	SW			← INFILL Seam CLAY (CH) grey moist, 40mm dips 55°	Most defects are joints parallel to bedding. Steeply dipping joints in Sets 2 and 3 also occur (Sets defined in report). Joints irregular, surfaces rough and stained with limonite. Some joints in SANDSTONE do not continue into SILTSTONE
						4						← EW Seam CLAY (CL) brown 20mm dips 30°	
				12pL		5		SANDSTONE medium to coarse grained, yellow brown, slightly friable	HW			← SHEARED Zone 10mm dips 30°	
						6		SILTSTONE (90%) and SANDSTONE (10%) as above	SW				
			19 Jan '80						Fr			← CRUSHED Seam 20mm dips 40° (GM)	
			21 Jan '80			7							
			2 Feb '80	1·5pL	170								
						8		GRANITE, coarse grained, speckled pale grey and pink, massive, trace of pyrite				← SHEARED Zone 20mm dips 45°	Defects are joints, steeply dipping, irregular, rough and stained with limonite
						9			SW				
			WATER INFLOW	5pL					Fr			← JOINT, rough irregular limonite stained	
						10							

TASMANIA DEPARTMENT OF MINES

5 cm

excavation no. 4 (21/21)
sheet 1 of 1

ENGINEERING LOG – EXCAVATION

project WATER TREATMENT PLANT location RIVERPORT

co-ordinates 469731m E
5736844m N
R.L. 146·8m
excavation dimensions 10m x 0·8m x 3·6m deep

exposure type Backhoe pit
equipment John Deere 400
450mm bucket
operator J. Smith

pit commenced 29 Jan '80
pit completed 29 Jan '80
logged by MBD
checked by LMS

penetration 1 2 3	support	water	notes samples, tests	metres R.L. / depth	graphic log	classification symbol[1]	material: soil type: plasticity or particle characteristics, colour secondary and minor components	moisture condition	consistency density index	hand penetrometer kPa (25 50 100 200 400)	structure, geology
	NONE	NOT ENCOUNTERED		146 / 0		ML	Sandy SILT, quick dilatancy, grey brown, sand fine to medium, many fine roots	M	F	–	ALLUVIUM
			U50	1		CL	Silty CLAY, low plasticity, brown, some coarse sand, trace of fine to medium gravel, angular,	M < PL	St to VSt	– –	RESIDUAL SOIL
			D	2		GC	Clayey GRAVEL, fine to coarse, mottled grey and yellow brown, clay low to medium plasticity. Gravel consists of angular fragments of weathered SILTSTONE	D	VSt / H	– X >450	EXTREMELY WEATHERED SILTSTONE
				3			SILTSTONE, coarse grained, dark grey, bedding well developed, dips 25°, low strength				HIGHLY WEATHERED SILTSTONE
				4			BACKHOE REFUSAL ON HIGHLY WEATHERED SILTSTONE AT 3·6m				
				5							

sketch