

ENG. GEOLOGY SECTION

Rep. Bk. No. 74/4



BALTIC WHARF SILO SITE - PORT PIRIE

Hundred of Pirie

REPORT ON FOUNDATION INVESTIGATION

Client: S.A. Co-op Bulk Handling Ltd.

R.S. ROBERTSON

Department of Mines
South Australia —

73-34 74/4

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept. Bk. No. 74/4
GS. No. 5320
Eng. Geol. No. 1973/34
DM. No. 144/73

GEOLOGICAL SURVEY
ENGINEERING DIVISION

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Hundred of Pirie

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Client: S.A. Co-op Bulk Handling Ltd.

by

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7th January, 1974

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Hd. Pirie

REPORT ON FOUNDATION INVESTIGATION

SUMMARY AND CONCLUSIONS

Seven cable tool holes have been drilled to investigate foundation conditions for new silos at the Port Pirie Grain Terminal.

The drilling penetrated a succession of unconsolidated sediments which showed some lateral variation.

From 0 to 12 metres artificial fill and sands, silts and clays of generally very low bearing capacity were found. Saline groundwater was encountered at shallow depths.

Below 12 metres the Hindmarsh Clay Formation was penetrated. This is a stiff to very stiff clay with some sandy lenses. The Hindmarsh Clay should have adequate bearing capacity for the founding of end bearing piles for the silo foundation.

INTRODUCTION

Drilling to determine foundation conditions for extensions to the Port Pirie Grain Terminal was requested by Mr. M. Farrent of the S.A. Co-op. Bulk Handling Ltd. The grain terminal is located at the Baltic Wharf, Port Pirie.

Seven cable tool holes were drilled to depths ranging from 21.6 to 24.6 metres. The drilling was carried out using the standard techniques of continuous open tube sampling, with a sealed tube and standard penetration test taken every two metres. The drilling commenced on 10th September, 1973, and was completed on 29th September, 1973. All holes were backfilled. The site is flat.

Previous reports on silo sites at the terminal have been done by R.D. Steel (1962) and M.N. Hiern (1963).

Geological logs of the holes are given in the Appendix. A site plan showing hole locations (Fig. 1) and a geological section (Fig. 2) are included.

SITE GEOLOGY

The seven cable tool holes penetrated a horizontal succession of unconsolidated sediments of Pleistocene and Recent age. The succession is summarised in Table 1 and confirms that encountered during the earlier drilling programmes.

The sediments are of shallow water marine, estuarine and lacustrine nature. There is slight variation between holes due to the lenticular nature of the sediments. However, the Hindmarsh Clay is encountered at a relatively constant depth.

Correlation between the boreholes is good, indicating uniform geological conditions beneath the site.

GROUNDWATER

Saline groundwater was generally cut at two levels within the top 10 metres of the hole. The water rose to within two metres of the top of the hole. Variation of water level due to tides was noted.

FOUNDATION CONDITIONS

The fill and the silts, sands and clays of the upper 12 metres would provide suitable foundations for light structures only. They are wet and mostly have a very low bearing capacity (Standard Penetration Test values, $N=0$ to $N=3$). There are some stiffer clay layers ($N=5$ to $N=15$) but these are underlain by clayey and sandy silts of very low strength. The presence of saline groundwater should be noted.

Below about 12 metres the stiff to very stiff Hindmarsh Clay is encountered. The standard penetration tests indicated material of moderate strength ($N=11$ to $N=38$); the lower values correspond with sandier layers within the clay. The Hindmarsh Clay should have adequate bearing capacity for the location of end bearing piles for the structure. A softening of the Hindmarsh Clay down to 15 m in CH.1, caused by the presence of a local perched water body, should be noted.

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RSR:FdeA
7/1/74

REFERENCES

- Hiern, M.N., 1963. Silo Site - Baltic Wharf - Port Pirie. Report on Foundation Conditions. S. Aust. Dept. Mines unpublished report No. 57/54.
- Steel, R.D., 1962. Report on Site Investigation. Proposed S.A. Co-op Bulk Handling Ltd. Silo Site. Baltic Wharf, Port Pirie, S. Aust. Dept. Mines unpublished report. Rept. Bk. No. 54/7.

TABLE 1
SUMMARY OF GEOLOGICAL SEQUENCE

AVERAGE DEPTH (m)	AVERAGE THICKNESS (m)	GEOLOGICAL UNIT AND AGE	ENGINEERING PROPERTIES	
			DESCRIPTION	CONSISTENCY AND MOISTURE CONTENT
	1.5 m	Artificial Fill	Variable low plasticity SILT (ML) and SAND with excess clayey or silty fines (SC/SM). Contains angular gravel fragments of rock, cement and cinders.	Silts are <u>moderately compact</u> . Sands are <u>loose to medium dense</u> . Moisture content mostly humid to damp.
1.5 to 4.0	2.5 m	St. Kilda Formation (Recent)	Variable, shelly low plasticity CLAY (CL) and clayey SAND (SC).	Clay varies from <u>very soft</u> to <u>stiff</u> . Moisture content <u>above plastic limit</u> . Sand is <u>loose</u> and moist to wet.
4.0 to 6.0	1.5 m	Pooraka Formation? (upper Pleistocene)	Callabonna CLAY, high plasticity (CH) with distinctive red-brown colour. Absent in CH.4.	Clay is <u>stiff</u> with moisture content around plastic limit.
6.0 to 9.0	3.0 m		Yellow to grey CLAY, low plasticity (CL) with lime nodules.	Clay is <u>stiff</u> to very <u>stiff</u> .
9.0 to 12.0	3.0 m		Mottled brown to grey SILT, low plasticity (ML) sandy and clayey in patches. Grades to clayey SAND (SC) in CH.4.	Silt is <u>loose</u> and wet to saturated.
over 12.0 m	over 10 m	Hindmarsh Clay Formation (Lower Pleistocene)	Mottled red brown and grey CLAY, high plasticity (CH) with lime concretions. A 1.0 m lens of CLAYEY SAND (SC) occurs at 21.0 m depth.	Clay is <u>stiff</u> to <u>very stiff</u> with moisture content <u>less than plastic limit</u> . Perched water softens clay at 15 m in CH1.

APPENDIX I

Logs of Boreholes

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.1

SERIAL NO 312 / 74

PROJECT S.A.C.B.H. PORT. PIRIE Grain Silos

FEATURE Foundations

SEC HD Pirie

LOCATION Baltic Wharf

CO-ORDS

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1961	WATER LEVEL	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	RELATIVE DENSITY	TYPE OF SAMPLE	FIELD TEST DATA	
												Blows PER 30 cm	SC. TEST PENETROMETER
Fill		0		ML	Silt soil (ML), low plasticity. Brown with sand & gravel.	H	MC						
Bitumen & shell fragments		0		CL	clay soil (CL), low plasticity, with abundant coarse sand grains. Red brown colour. Some gravel.	D	MC						
Sand & gravel grains are quartz and feldspar.		1		SC	Sand with clay matrix and gravel size fragments. Grey-brown colour.	M	L					A 192	
sand & gravel is shell fragments. Few quartz grains.		2		SC	Gravel and sand with excess clay (CL) fines grey brown colour.	W	L					3 (1.1.1)	
		3		ML	silt soil (ML), low plasticity with clay and some sand & gravel. Brown. Some plant remains.	W	LS					0	
Fine quartz sand. Gravel is shell fragments.		4		CH	clay soil (CH) high plasticity. Some silt. Red brown colour. Grey patches with shells. Black organic material.	W	St					A 108	
		5		CL	clay soil, low plasticity, (CL). Some silt & sand. Yellow & grey mottled.	W	F					10 (3.3.4)	
Some lime lumps.		6		CH	clay soil, high plasticity, (CH). Red brown colour with some grey patches.	M	St					A 179	
		7		ML	silt soil (ML), low plasticity, considerable sand & clay content. Mottled brown & grey.	S	LS					13 (4.5.4)	
Some lime lumps.		8											
		9											

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Sils)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only, and provide an indication of their consistency	
H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A' Shoe D Shoe SEALED TUBE WITH NUMBER STANDARD PENETRATION TESTS 2 (2.3.4)	ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE Ruston DRILLER A. Sturak START 10.9.73 FINISH 12.9.73 SHEET 1 OF 3		
LOGGED BY R.S. Robertson DATE 2.10.73 TRACED J.H.W. CHECKED A.F. DRG. NO. S10543 Gal							

SERIAL NO 312/74

EI Surface m

Dotum

PF No S6676 b MB

LOG OF CABLE TOOL HOLE

HOLE NO. C.H. 1

SERIAL NO 312/74

PROJECT S.A.C.B.H. - PORT PIRIE Grain Silos

FEATURE Foundations

LOCATION Baltic Wharf

SEC HD Pirie

CO-ORDS

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		DEPTH (m)	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	RELATIVE DENSITY	TYPE OF SAMPLE	FIELD TEST DATA	
												BLOWS PER 30 cm	SOIL TEST
PLEISTOCENE Hindmarsh Clay.	Sand is rounded quartz grains	19		CH	Clay soil, high plasticity. (CH). Small amount of sand and silt. Mottled red brown and grey colour.	M	VS						
		20											
		21		SC	Sand excess clayey fines (SC). Colour - mottled red brown and grey.	W	MD						
		22		CH	clay soil (CH) with sand.	M	St						
		23			End of hole 22.35 m.								

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Sands)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.	
Water level (date) 7 Dec '66 WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A 12345 STANDARD PENETRATION TESTS 2 (2,3,4) Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION DRILL NO. B TYPE RUSTON DRILLER A. STURROK START 10.9.73 FINISH 12.9.73 SHEET 3 OF 3 DRG NO S10543b Gal	
LOGGED BY R.S. Robertson DATE 2.10.73 TRACED D.W.W. CHECKED R.F.							

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.2.

SERIAL NO 313/74

PROJECT S.A.C.B.H. Port Pirie Grain Silos

FEATURE Foundation

SEC HD Pirie

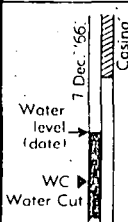
El. Collar m

LOCATION Baltic Wharf

CO-ORDS

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, USBR Earth Manual 2nd Edition 1966	WATER LEVEL	CASING	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	RELATIVE DENSITY	TYPE OF SAMPLE	FIELD TEST DATA	
		El.											BLOWS PER 30 cm	SOIL TEST PENETROMETER UNITS
													4 8 16 32 64	1 2 3
RECENT FILL	Fill.			ML	Silt soil, low plasticity (ML) with sand and some gravel. Brown colour.									
	Gravel is shell and cement fragments			SM	Sand with excess silty fines. Grey brown colour.									
	Sand quartz, mica some organic material			GP	Gravel with some sand and silt. Black.								5 (1.2.2)	
	Fill - Cinders													
PLEISTOCENE - RECENT Marine and Estuarine Sediments				CL/CH	Clay soil, medium plasticity (CL/CH). Grey with many shells.									
				CH	Clay soil, high plasticity (CH). Brown colour.									
	Gravel is shells and shell fragments.			CL	Clay soil, low plasticity, (CL). Considerable silt and gravel content. Yellow brown colour.								A224	
	Some harder lime lumps - shell and lime concentrations.				Yellow to grey colour.								1 (0.0.1)	
	Some lime lumps			CH	Clay soil, high plasticity (CH). Brown colour								A182	
													15 (4.1.2)	
	Quartz grains - well rounded			ML	Silt soil, low plasticity (ML) Some sand and considerable clay matrix. Light red brown colour.									
WATER LEVELS		MOISTURE CONTENT		CONSISTENCY (Clays)		COMPACTNESS (Silt)		RELATIVE DENSITY (Sands)		TYPE OF SAMPLE		* These values refer to clay soils only and provide an indication of their consistency.		
		H -- Humid D -- Damp M -- Moist W -- Wet S -- Saturated LL -- Liquid Limit PL -- Plastic Limit		VS -- Very Soft S -- Soft F -- Firm St -- Stiff V.St -- Very Stiff H -- Hard		Ls -- Loose MC -- Moderately Compact C -- Compact VC -- Very Compact		VL -- Very Loose L -- Loose MD -- Medium Dense D -- Dense VD -- Very Dense		OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER [A 1 2 3 4 5] STANDARD PENETRATION TESTS 9 (2.3.1) Total blows for 0.3m (in 0.1m increments)		ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE RUSTON DRILLER A. Sturank START 13.9.73 FINISH 15.9.73 SHEET 1 OF 3 DRG. NO. S10560 Gal		
												LOGGED BY: R.S. Robertson DATE 4.10.73 TRACED CHECKED		

SERIAL NO 313/74

LOCATION, Baltic Wharf

CC-05.D3

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		SOIL DESCRIPTION GROUP NAME Unified Soil Classification U.S.S. Earth Manual 2nd Edition 1966		FIELD TEST DATA				
WATER LEVEL	Casing	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	RELATIVE DENSITY	TYPE OF SAMPLE	ENGINEERING GEOLOGY SECTION	
							DRILL NO.	LOGGED BY
PLEISTOCENE - RECENT Marine and Estuarine Sediments		Sand is well rounded quartz grains		Silts (ML) with some fine sand and clay matrix.		S Ls		
PLEISTOCENE Hindmarsh Clay		Sand is quartz grains Hard lime lumps present.		Clay soil medium plasticity (CL/CH). Some silt and fine sand. Red brown to grey mottled white lumps.		M St. A237		
		Some lime patches present		Clay soil, high plasticity (CH). Some silt and fine sand. Mottled red brown to grey. Hard white lumps.		D V St. A207		
		More sand and silt present				M V St. A270		
WATER LEVELS		MOISTURE CONTENT		CONSISTENCY (Clays)		COMPACTNESS (Sands)		
H - Humid D - Damp M - Moist W - Wet S - Saturated LL - Liquid Limit PL - Plastic Limit		VS - Very Shiff S - Shiff F - Firm St - Shiff V St - Very Shiff H - Hard		LS - Loose ML - Moderately Compact C - Compact VC - Very Compact		VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense		
7 Dec. '66 Water level (date) WC Water Cut						OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER STANDARD PENETRATION TESTS Total blows for 0.3m (in 0.1m increments)		
SHEET 2 OF 3		DRG. NO. S10560a		DRILL NO. 8 TYPE RUSTON DRILLER A. Sturak START 13.9.73 FINISH 15.9.73		LOGGED BY R.S. Robertson DATE 4.10.73 TRACED CHECKED		

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.2

SERIAL NO. 3/3/74

PROJECT S.A.C.B.H. Port Pirie Grain Silos

FEATURE Foundations

LOCATION Baltic Wharf

SEC HD Pirie

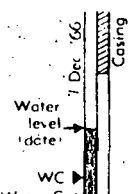
CO-ORDS

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION	EL DEPTH GRAPHIC LOG GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	Casing MOISTURE CONTENT Consistency Compact Density	FIELD TEST DATA	
					BLOWS PER 30 cm	SOIL TEST PENETROMETER Units
					4 8 16 32 64	2 3 4
PLEISTOCENE Hindmarsh Clay	19	CH				
		CH			A 213	
	20	CH			29 (7.11.11)	
		CH			A 236	
Fewer lime patches	21	SC			18 (5.6.7)	
		SC				
	22					
Quartz sand	23	CH			A 15	
		CH			33 (10.13.10)	
		End of hole 23.85m.				

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency	
 7 Dec '66 Casing Water level (dotted) WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE  A Shoe  D Shoe SEALED TUBE WITH NUMBER  A 1 2 3 4 5 STANDARD PENETRATION TESTS  2-2.3.4 Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION	
DRILL NO. 8 TYPE RUSTON DRILLER A. Sturak START 13.9.73 FINISH 15.9.73						LOGGED BY R.S. Robertson DATE 5.10.73 TRACED CHECKED	
SHEET 3 OF 3						DRG. NO. S10560 b Gal	

SERIAL NO. 314/74

El. Surface : m

Datum

PLEISTOCENE - RECENT Estuarine & Marine Sediments

Water level →
(date)

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.3

SERIAL NO. 314/74

PROJECT S.A.C.B.H. Port Pirie Grain Silos

SECH.B. Bk8 HD Pirie

El. Collar m

FEATURE Foundations

El. Surface m

LOCATION Baltic wharf

CO-ORDS

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	FIELD TEST DATA	
											BLOWS PER 30 cm 4 6 16 32 64	SOIL TEST PENETROMETER UNITS *
PLEISTOCENE RECENT Estuarine & marine sediments	Sand & silt-quartz grains		10		ML	Silt soil, low plasticity, (ML) Considerable clay matrix and sand. Red brown colour some grey patches.	WLS				0	
	Some lime nodules		11			Patch of brown CH within silt					3(1.1.1)	
PLEISTOCENE Hindmarsh Clay	Hard lime nodules present		13		CL	Clay soil, low plasticity, (CL) Contains silt & sand. Mottled red brown to grey colour.	M St				A212	20(5.6.9)
			14									
			15								A149	
			16		CH	Clay soil, high plasticity (CH) Some sand grains Mottled red brown to grey colour.	D V St					25(8.8.9)
	Sand is well rounded quartz grains		17		CL	Clay soil, low plasticity (CL) Considerable fine sand content.	M V St				A26	11(3.4.4)
		18										

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Sils)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.
 Water level (date) 7 Dec '66 WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A Shoe D, Shoe SEALED TUBE WITH NUMBER A 1 2 3 4 5 STANDARD PENETRATION TESTS 9 2 3 4 Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE Ruston DRILLER A. Sturak START 17-9-73 FINISH 18-9-73 SHEET 2 OF 3 DRG. NO. S10594a Gal

SERIAL NO. 314/74

Datum

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.	
7 Dec. '66 Water level (date) WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V St — Very Stiff H — Hard	LS — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A-12345 STANDARD PENETRATION TESTS 9 (25.4) Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE Ruston DRILLER Asturak START 11-9-73 FINISH 18-9-73 LOGGED BY R. S. Robertson DATE 10-10-73 TRACED GM. CHECKED	
					SHEET 3 OF 3 DRG. NO. SI 0594 b Gal		

LOG OF CABLE TOOL HOLE

HOLE NO. CH 4

SERIAL NO. 315/74

PROJECT S.A.C.B.H Port Pirie Grain Silos

FEATURE FOUNDATIONS

SEC H.B.B.K.B.H.D Pirie

LOCATION BALTIC WHARF

CO-ORDS

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	Casing	MOISTURE CONTENT	Consistency	Compact Density	FIELD TEST DATA	
												BLOWS PER 30 cm	SOIL TEST PENETROMETER Units *
												4 8 16 32 64	1 2 3 4
FILL	Fill. Rock fragments in silt.		0		GM	Gravel, excess silty fines. Brown colour.		H					
			0		SM	sand, excess silty fines (SM). Grey green colour.		D L					
PLEISTOCENE - RECENT Estuarine & Marine sediments	Plant remains		1		ML	silt soil, low plasticity, (ML) with clay soil, low plasticity (CL). Variable between two. Yellow brown colour. Some brown clay patches. Black organic patches.		M F or MC				A232	
			2									6(22.2)	
			3										
			4									A170	
			5										
	Gravel is lime nodules		6		ML	Silt soil, low plasticity, (ML). Considerable clay content. Brown colour.		W Ls					
			7			Grey colour. Gravel fragments.							
			8		CL	clay soil, low plasticity (CL) A little sand & silt content. Brown colour. Some grey patches.		M St.				12(35.4)	
	Some lime nodules		9		SM	Sand excess silty and							
	WATER LEVELS		MOISTURE CONTENT		CONSISTENCY (Clays)		COMPACTNESS (Sills)		RELATIVE DENSITY (Sands)		TYPE OF SAMPLE		* These values refer to clay soils only and provide an indication of their consistency.
H - Humid D - Damp M - Moist W - Wet S - Saturated LL - Liquid Limit PL - Plastic Limit		VS - Very Soft S - Soft F - Firm St - Stiff V.St - Very Stiff H - Hard		Ls - Loose MC - Moderately Compact C - Compact VC - Very Compact		VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense		OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A 1 2 3 4 5 STANDARD PENETRATION TESTS 9 (2,3,4) Total blows for 0.3m (in 0.1m increments)		ENGINEERING GEOLOGY SECTION DRILL NO. B TYPE RUSTON DRILLER A. Sturton START 19.9.73 FINISH 21.9.73 LOGGED BY R.S. Robertson DATE 5.11.73 TRACED D.W.W. CHECKED			
SHEET 1 OF 3		DRG. NO. S10583											

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.4

SERIAL NO. 315/74

PROJECT SAC.B.H. PORT PIRIE Grain Silos

FEATURE FOUNDATIONS

LOCATION Baltic Wharf

SEC H.B. Bk. BHD Pirie

CO. ORDS

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	LOGGING MOISTURE CONTENT	CONSISTENCY	FIELD TEST DATA							
										BLOWS PER 30 cm	SOIL TEST PENETROMETER Units *						
										4	8	16	32	64	1	2	3
PLEISTOCENE - RECENT Estuarine & Marine Sands.	sand is well rounded quartz grains. Few lime concretions.				SM/SC	clayey fines Light brown, colour.					6(2.2.2)						
		10															
PLEISTOCENE Hindmarsh Clay	Lime nodules. Hard white lumps. Some lime nodules.	11									13(3.4.6)						
		12					clay soil, low plasticity (CL). considerable sand content. Mottled red brown to grey colour.		M VS								
		13									A22						
		14									9(3.3.3)						
		15							W F								
		16					clay soil, high plasticity (CH) some silt and sand. mottled red brown to grey colour.				A183						
		17									20(7.6.7)						
		18							M VS								
										A109							
										17(5.6.6)							

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.
7 Dec. 66. Water level (date) WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A 1 2 3 4 5 STANDARD PENETRATION TESTS 9 (2,3,4) "	ENGINEERING GEOLOGY SECTION DRILL NO. B TYPE RUSTON DRILLER A. Sturak START 19.9.73 FINISH 21.9.73 SHEET 2 OF 3 DRG. NO. 10583a Gal

LOG OF CABLE TOOL HOLE

SERIAL NO. 315/74

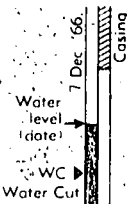
Datum

PF No S6676 b MB

SERIAL NO. 316/74

CO-ORDS

Datum

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency	
	H — Humid	VS — Very Soft	LS — Loose	VL — Very Loose	OPEN TUBE	ENGINEERING GEOLOGY SECTION	
	D — Damp	S — Soft	MC — Moderately Compact	L — Loose	 A Shoe  D Shoe SEALED TUBE WITH NUMBER	LOGGED BY R.S. Roberts	
	M — Moist	F — Firm	C — Compact	MD — Medium Dense		DRILL NO. 8	DATE 16 Oct. 1973
	W — Wet	St — Stiff	VC — Very Compact	D — Dense	 ATTS-5 STANDARD PENETRATION TESTS	TYPE RUSTON	TRACED J.V.
	S — Saturated	V St — Very Stiff	H — Hard	VD — Very Dense	 9 12 3 4 Total blows for 0.3m (in 0.1m increments)	START 22 Sept. 1973	CHECKED
LL — Liquid Limit					FINISH 25 Sept. 1973	SHEET 1 OF 3	DRG NO 510595 Gal
PL — Plastic Limit							

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.5

SERIAL NO 316/74

PROJECT S.A.C.B.H. Port Pirie Grain Silos

FEATURE Foundations

SECH.B. BK8HD Pirie

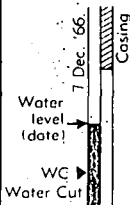
LOCATION Baltic Wharf

CO-ORDS

El Collar m

El Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification USBR. Earth Manual 2nd Edition 1966	WATER LEVEL	LEVEL	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	RELATIVE DENSITY	TYPE OF SAMPLE	FIELD TEST DATA	
														BLOWS PER 30 cm	SOIL TEST PENETROMETER
														4 16 32 64	1 2 3 4
PLEISTOCENE RECENT	Sand is well rounded-quartz grains		10		ML	More sand content								5 (12.2)	
PLEISTOCENE Hidmarsh Clay	Lime nodules present		11											A125	
			12		CL	Clay soil, low plasticity (CL). Some silt and sand Mottled brown to grey								18 (65.7)	
			13											A185	
	Lime concretions		14											17 (24.5)	
			15		CH	Clay soil, high plasticity (CH). Some sand + silt. Mottled red brown to grey								A26	
			16												24 (87.8)
		17											A197		
			18											20 (67.7)	
WATER LEVELS		MOISTURE CONTENT		CONSISTENCY (Clays)		COMPACTNESS (Sils)		RELATIVE DENSITY (Sands)		TYPE OF SAMPLE		* These values refer to clay soils only and provide an indication of their consistency.			
		H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit		VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard		Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact		VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense		OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER [A12345] STANDARD PENETRATION TESTS [9] (2,3,4) Total blows for 0.3m (in 0.1m increments)		ENGINEERING GEOLOGY SECTION			
												DRILL NO. 8 TYPE RUSTON DRILLER R Sturak START 22 Sept. 1973 FINISH 25 Sept 1973 SHEET 2 OF 3			
												LOGGED BY R.S. Robertson DATE 17 Oct. 1973 TRACED J.V. CHECKED S10595a Gal			

LOG OF CABLE TOOL HOLE

PROJECT S.A.C.B.H Port Pirie Grain Silos

FEATURE Foundations

LOCATION Baltic Wharf

SEC H.B.Bk 8 HD Pirie

CO-OPDS

HOLE NO. CH5

SERIAL NO 316/74

El Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION	DEPTH (m)	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.R. Earth Manual 2nd Edition 1966	WATER LEVEL	CURING	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	FIELD TEST DATA	
										BLOWS PER 30 cm	SOIL TEST PENETROMETER
PLEISTOCENE Hindmarsh Clay Quartz sand	19		CH								
	20										
	21		SC	Sand excess clayey fines. Red brown & grey colour.							
	22										
	23		CH								

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Sils)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.
	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE SEEALED TUBE WITH NUMBER STANDARD PENETRATION TESTS 2, 2.3, 4 Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE Ruston DRILLER A. Sturak START 22 Sept. 1973 FINISH 25 Sept. 1973 SHEET 3 OF 3 DRG. NO. 510595b Gal

LOG OF CABLE TOOL HOLE

SERIAL NO 317/74

• Datum

[illegible]

LOG OF CABLE TOOL HOLE

PROJECT *S.A.C.B.H. Port Pirie Grain Silos*
 FEATURE *FOUNDATIONS*
 LOCATION *Baltic Wharf*

SECH. B. 0k. 8HD.
 CO-ORDS.

HOLE NO. *C.H. 6*SERIAL NO. *317/74*

El. Collar m
 El. Surface m
 Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	Casing	LEVEL	MOISTURE CONTENT	Consistency	Compact Density	FIELD TEST DATA															
													BLOWS PER 30 cm								SOIL TEST PENETROMETER Units *							
													4	8	16	32	64	1	2	3	4							
PLEISTOCENE - RECENT Estuarine & Marine sed.					ML																							
			10																									
			11																									
PLEISTOCENE Hindmarsh Clay	Many lime concretions.		12		CH	clay soil, high plasticity (CH). Some sand and silt. Mottled red brown to grey colour.																						
			13																									
			14				White patches. More silt and sand.																					
			15																									
			16																									
			17																									
			18																									

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Sils)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.	
Water level (date) 7 Dec. '66 WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A 1 2 3 4 5 STANDARD PENETRATION TESTS 9 (2,3,4) Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION	
DRILL NO. <i>8</i> TYPE <i>RUSTON</i> DRILLER <i>A. Sturak</i> START <i>25.9.73</i> FINISH <i>26.9.73</i>						LOGGED BY <i>R.S. Robertson</i> DATE <i>7.11.73</i> TRACED <i>D.W.W.</i> CHECKED	
SHEET <i>2</i> OF <i>3</i>						DRG. NO. <i>S10586</i>	

LOG OF CABLE TOOL HOLE

PROJECT *S.A.C.B.H. Port Pirie Grain Silos*
 FEATURE *FOUNDATIONS*
 LOCATION *Baltic Wharf*

SECH.B.Bk8HD *Pirie*
 CO-ORDS

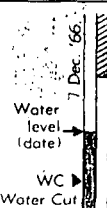
HOLE NO. *C.H.6*SERIAL NO. *317/74*

El. Collar m

El. Surface m

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EI	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition, 1966	WATER LEVEL	Casing	MOISTURE CONTENT	Consistency	Compact Density	FIELD TEST DATA								
												BLOWS PER 30 cm		SOIL TEST PENETROMETER Units *						
												4	3	16	32	64	1	2	3	4
PLEISTOCENE Hindmarsh Clay			19			CH clay soil, high plasticity(CH) some sand and silt Mottled red brown to grey colour.														
			20																	
			21																	
			22			End of hole 21.60														

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.	
 Water level (date) 7 Dec. 66 WC Water Cut	H — Humid D — Damp M — Moist W — Wet S — Saturated LL — Liquid Limit PL — Plastic Limit	VS — Very Soft S — Soft F — Firm St — Stiff V.St — Very Stiff H — Hard	Ls — Loose MC — Moderately Compact C — Compact VC — Very Compact	VL — Very Loose L — Loose MD — Medium Dense D — Dense VD — Very Dense	OPEN TUBE SEEALED TUBE WITH NUMBER STANDARD PENETRATION TESTS 9 12,3,4 Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION	
DRILL NO. <i>B</i> TYPE <i>RUSTON</i> DRILLER <i>A. Sturak</i> START <i>25.9.73</i> FINISH <i>26.9.73</i>						LOGGED BY <i>RS. Robertson</i>	
SHEET <i>3</i> OF <i>3</i>						DATE <i>7.11.73</i>	
DRG. NO. <i>S 10586 b</i>						CHECKED <i>D.W.W.</i>	

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.7

SERIAL NO 318/74

PROJECT: S.A.C.B.H. Port Pirie Grain Silos

FEATURE: Foundations

SECH.B.Bk8HD Pirie

El. Collar m

El. Surface m

LOCATION: Baltic Wharf

CO-ORDS

Datum

GEOLOGICAL NOTES AND CLASSIFICATION		EL.	DEPTH m	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	CASING	MOISTURE CONTENT	CONSISTENCY	COMPACT DENSITY	FIELD TEST DATA				
												BLOWS PER 30 cm		SOIL TEST PENETRATION Units		
												4	8	16	32	64
FILL	Cement + rock fragments. Cinders.					Gravel excess-silty fine (GM)		H								
	Contains some cinders		1			Silt soil, low plasticity, (ML) Some clay. Brown colour		MLs								
PLEISTOCENE - RECENT Estuarine or Marine Sediments	Sand is quartz + lime grains.		2			Clay soil, low plasticity (CL). Some silt and sand Yellow brown colour		MF								
			3													
			4			Clay soil, high plasticity (CH). Darker brown colour.		W St.								
			5													
			6			Clay soil, low plasticity (CL). Yellow grey colour. White patches. Brown + grey colour Some silt content.		M St								
			7													
			8													
			9			Silt soil, low plasticity (ML) Considerable clay matrix		W Ls.								
	Quartz sand															

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silt)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.	
	H --- Humid D --- Damp M --- Moist W --- Wet S --- Saturated LL --- Liquid Limit PL --- Plastic Limit	VS --- Very Soft S --- Soft F --- Firm St --- Stiff V St --- Very Stiff H --- Hard	Ls --- Loose MC --- Moderately Compact C --- Compact VC --- Very Compact	VL --- Very Loose L --- Loose MD --- Medium Dense D --- Dense VD --- Very Dense	OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER STANDARD PENETRATION TESTS Total blows for 0.3m (in 0.1m increments)	ENGINEERING GEOLOGY SECTION	
DRILL NO. 8 TYPE Ruston DRILLER A. Sturak START 27 Sept 1973 FINISH 29 Sept 1973						LOGGED BY R.S. Robertson DATE 24 Oct 1973 TRACED J.V. CHECKED	
SHEET 1 OF 3						DRG. NO 510596 Gal	

LOG OF CABLE TOOL HOLE

HOLE NO. C.H.7

SERIAL NO. 318/74

PROJECT S.A.C.B.H. Port Pirie Grain Silos

FEATURE Foundations

SECH.B. 8x8 HD Pirie

El. Collar m

LOCATION Baltic Wharf

CO-ORDS

El. Surface m

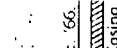
Datum

GEOLOGICAL NOTES AND CLASSIFICATION		DEPTH (m)	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification, U.S.B.R. Earth Manual 2nd Edition 1966	WATER LEVEL	Casing	MOISTURE CONTENT	CONSISTENCY	COMPACTNESS	FIELD TEST DATA				
											BLOWS PER 30 cm	SOIL TEST PENETROMETER Units #			
PLEISTOCENE - RECENT Estuarine or Marine Sediments		10		ML	Some sand. Brown colour						6(22.2)				
		11													
PLEISTOCENE Hindmarsh Clay	Lime nodules	12										17(5.66)			
		13		CL	Clay soil, low plasticity (CL). Some sand and silt. Mottled red brown to grey colour. Hard lumps.							A 222			
		14										11(23.6)			
		15		CH	Clay soil, high plasticity, (CH). Some sand. Mottled red brown to grey colour							A 124			
		16										23(788)			
		17													
		18		CH	More sand						A 4				
											17(46.7)				
WATER LEVELS		MOISTURE CONTENT		CONSISTENCY (Clays)		COMPACTNESS (Silt)		RELATIVE DENSITY (Sands)		TYPE OF SAMPLE		* These values refer to clay soils only and provide an indication of their consistency.			
Water level (date) 1 Dec. '66 WC Water Cut Casing		I - Humid D - Damp M - Moist W - Wet S - Saturated LL - Liquid Limit PL - Plastic Limit		VS - Very Soft S - Soft F - Firm St - Stiff V.St - Very Stiff H - Hard		Ls - Loose MC - Moderately Compact C - Compact VC - Very Compact		VL - Very Loose L - Loose MD - Medium Dense D - Dense VD - Very Dense		OPEN TUBE A Shoe D Shoe SEALED TUBE WITH NUMBER A 1 2 3 4 5 STANDARD PENETRATION TESTS 2 (23.4) Total blows for 0.3m (in 0.1m increments)		ENGINEERING GEOLOGY SECTION DRILL NO. 8 TYPE Ruston DRILLER A. Sturak START 27. Sept. 1973 FINISH 29. Sept. 1973 SHEET 2 OF 3		LOGGED BY R.S. Robertson DATE 24. Oct. 1973 TRACED J.V. CHECKED DRG. NO. S10596 a Gal	

SERIAL NO. 318/74

CO-ORDS

Datum

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silts)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE	* These values refer to clay soils only and provide an indication of their consistency.		
	I — Humid	VS — Very Soft	LS — Loose	VL — Very Loose	OPEN TUBE	ENGINEERING GEOLOGY SECTION		
	D — Damp	S — Soft	MC — Moderately Compact	L — Loose	SEALD TUBE WITH NUMBER  A Shoe  D Shoe	DRILL NO. 8.		LOGGED BY R.S. Robertson
M — Moist	F — Firm	C — Compact	MD — Medium Dense	TYPE Ruston		DATE 24. Oct. 1973		
W — Wet	St — Stiff	VC — Very Compact	D — Dense	STANDARD PENETRATION TESTS  12345 2 12,3,41 Total blows for 0.3m (in 0.1m increments)	DRILLER A. Sturak		TRACED J.V.	
S — Saturated	V.St — Very Stiff	H — Hard	VD — Very Dense		START 27. Sept. 1973			CHECKED
LL — Liquid Limit	PL — Plastic Limit				FINISH 29. Sept. 1973		SHEET 3 of 3	

APPENDIX II

Explanatory Notes

ENGINEERING CLASSIFICATION OF SOILS

The Unified Soil Classification System

FIELD INVESTIGATION PROCEDURES										GROUP SYMBOL	GROUP NAME and typical material:	LABORATORY CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 B.S. sieve size	Excluding particles larger than 7.5cm and basing fractions on estimated weights													
	GRAVELS More than 50% of the coarse fraction is larger than 2mm. (retained on B.S.7 sieve)	CLEAN GRAVELS. Little or no fines	Wide range in grain sizes, and substantial amounts of all intermediate particle sizes							GW	GRAVEL, well graded; gravel sand mixtures, little or no fines	C _u = $\frac{D_{60}}{D_{10}}$ Greater than 4 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ Between 1 and 3		
			Predominantly one size or a range of sizes, with some intermediate sizes missing							GP	GRAVEL, poorly graded; gravel sand mixtures, little or no fines	Not meeting all gradation requirements for GW		
		DIRTY GRAVELS Appreciable amount of fines	Non-plastic fines—for identification see ML below							GM	GRAVEL, excess silty fines; poorly graded gravel-sand-silt mixtures	Atterberg limits below "A" line or PI less than 4		
			Plastic fines—for identification see CL below							GC	GRAVEL, excess clayey fines; poorly graded gravel-sand-clay mixtures	Atterberg limits below "A" line or PI greater than 7		
	SANDS More than 50% of the coarse fraction is smaller than 2mm. (passing B.S.7 sieve)	CLEAN SANDS Little or no fines	Wide range in grain sizes, and substantial amounts of all intermediate particle sizes							SW	SAND, well graded; well graded sands, gravelly sands, little or no fines	C _u = $\frac{D_{60}}{D_{10}}$ Greater than 6 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ Between 1 and 3.		
			Predominantly one size or a range of sizes, with some intermediate sizes missing							SP	SAND, poorly graded; poorly graded sands, gravelly sands, little or no fines	Not meeting all gradation requirements for SW		
		DIRTY SANDS Appreciable amount of fines	Non-plastic fines—for identification see ML below							SM	SAND, excess silty fines; poorly graded sand-silt mixtures	Atterberg limits below "A" line or PI less than 4		
Plastic fines—for identification see CL below							SC	SAND, excess clayey fines; poorly graded sand-clay mixtures	Atterberg limits below "A" line or PI greater than 7					
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 B.S. sieve size	FIELD INVESTIGATION PROCEDURES on fraction smaller than 0.4mm. (passing B.S.36 sieve)										GROUP SYMBOL	GROUP NAME and typical materials		
	SILTS AND CLAYS Liquid limit less than 50	SOIL CAST. (soil wet)	SOIL THREAD	SHINE	DILATANCY	ODOUR	DRY STRENGTH	ML	SILT SOIL, low plasticity; inorganic silts and very fine silty or clayey sands, rock flour					
		Forms fragile cast Cracks form when kneaded while moist	Thin strands (thread) easily broken	None to very dull	Distinct	Not significant	None to slight	CL	CLAY SOIL, low plasticity; inorganic clays of low to medium plasticity, gravelly clay, sand, clays, silty clays, lean clays					
		Cast may be handled freely without breaking Can be kneaded moist without cracking Material adheres to the hand	Threads can be pointed as fine as a hair Pinch test is fragile	Moderate	None to short	Not significant	Moderate	OL	ORGANIC SOIL, low plasticity; organic silts and silt clays of low plasticity					
		Cast fragile to cohesive material will adhere somewhat to the hand	Soft, weak thread	None to very dull	Slight to distinct	Decayed organic matter	Low							
	SILTS AND CLAYS Liquid limit more than 50	Moderately plastic and cohesive Material adheres somewhat to the hand	Weak to medium thread May be crumbly	Dull	None to short	Not significant	Moderate Powdered soil feels floury	MH	SILT SOIL, high plasticity; inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts					
		Very plastic and cohesive Material very sticky to the hand Greasy to touch	Very tough thread, can be rolled to a pin point	Very glossy	None	Strong earthy	High to very high Cannot be powdered by finger pressure	CH	CLAY SOIL, high plasticity; inorganic clays of high plasticity, fat clays					
		Plastic and cohesive Feels slightly spongy Greasy to touch	Weak to medium thread Often soft and fibrous	Moderate to very glossy	None	Decayed organic matter	Moderate to high Powdered soil may be fibrous	OH	ORGANIC SOIL, high plasticity; organic clays of medium to high plasticity					
		Readily identified by colour, odour, spongy feel and frequently by fibrous texture							PI	PEATY SOIL; Peat and other highly organic soils				
	GRAIN SIZE CURVES to be used to identify soil fractions													
	Coarse-grained soil classified on basis of percentage of fines, as follows													
	PERCENT OF FINES GRAVELS SANDS													
Less than 5 More than 12 5 to 12 Borderline cases, use 2 symbols														
GW GP SW SP GM GC SM SC														
C _u = $\frac{D_{60}}{D_{10}}$ Greater than 4 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ Between 1 and 3														
Not meeting all gradation requirements for GW														
Atterberg limits below "A" line or PI less than 4														
Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols														
Atterberg limits below "A" line or PI greater than 7														
C _u = $\frac{D_{60}}{D_{10}}$ Greater than 6 C _c = $\frac{(D_{30})^2}{D_{10} \cdot D_{60}}$ Between 1 and 3.														
Not meeting all gradation requirements for SW														
Atterberg limits below "A" line or PI less than 4														
Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols														
Atterberg limits below "A" line or PI greater than 7														
PLASTICITY CHART FOR LABORATORY CLASSIFICATION OF FINE-GRAINED SOILS														
NOTE: BOUNDARY CLASSIFICATIONS: Soil possessing characteristics of two groups are shown as a combination of two group symbols, eg. GW-GC, well graded gravel with clay binder.														
Based on "The Unified Soil Classification System" United States Department of the Interior, Bureau of Reclamation "Earth Manual" First Edition, Denver COLORADO 1960.														

NOTE: BOUNDARY CLASSIFICATIONS: Soil possessing characteristics of two groups are shown as a combination of two group symbols, eg. GW-GC, well graded gravel with clay binder.

Based on "The Unified Soil Classification System" United States Department of the Interior, Bureau of Reclamation "Earth Manual" First Edition, Denver, COLORADO 1960.

DESCRIPTIVE TERMS

1. CLAY SOILS

CONSISTENCY

CONSISTENCY	SYMBOL	UNCONFINED COMPRESSIVE STRENGTH (kg/sq. cm)	FIELD TEST	N
Very soft	V.S.	Less than 0.25	Easily penetrated several centimetres by fist.	2
Soft	S.	0.25 to 0.5	Easily penetrated several centimetres by thumb	2 to 4
Firm	F	0.5 to 1.0	Can be penetrated several centimetres by thumb with moderate effort.	4 to 8
Stiff	St	1.0 to 2.0	Readily indented by the thumb but penetrated only with great effort.	8 to 15
Very Stiff	V.St.	2.0 to 4.0	Readily indented by thumb nail.	15 to 30
Hard (Extremely stiff)	H	over 4.0	Indented with difficulty by thumb nail.	30 and over

Based partly on Terzaghi, K. and Peck, R.B., 1966. Soil Mechanics in Engineering Practice, Wiley - New York.

MOISTURE CONTENT

ABBREVIATION	MEANING
MC = LL	Moisture content near liquid limit.
MC < LL	" " less than liquid limit.
MC > PL	" " greater than plastic limit.
MC = PL	" " near plastic limit.
MC ≤ PL	" " less or equal to plastic limit.
MC < PL	" " less than plastic limit
MC << PL	" " much less than plastic limit.

2. SILT SOILS

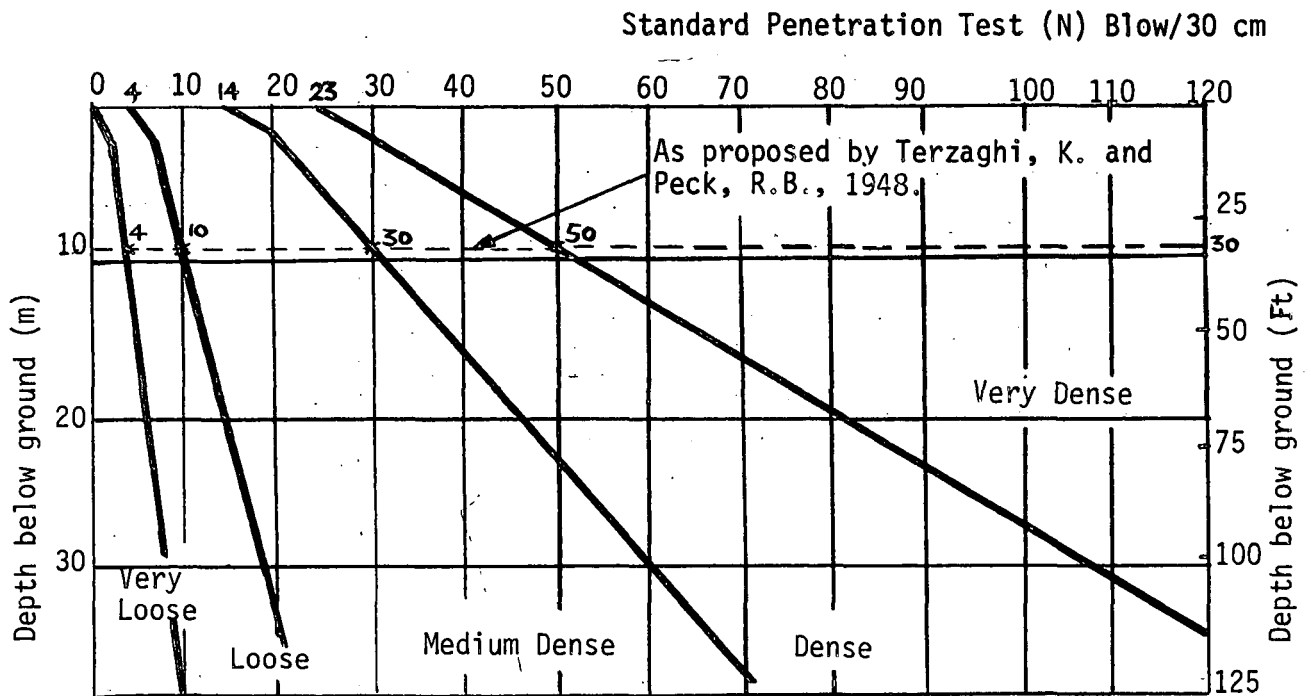
COMPACTNESS	SYMBOL	N
Loose	Ls	0 to 8
Moderately compact	MC	8 to 15
Compact	C	15 to 30
Very Compact	VC	greater than 30

3. SANDS

CLASSIFICATION OF SANDS BY STANDARD PENETRATION TEST

The relative density of granular soils has been judged from the results of Standard Penetration Tests carried out by the procedure described by Terzaghi and Peck (1948) bearing in mind the limitations of the method as discussed by Gibbs and Holtz (1957). At all times the water in the drill hole was kept at the level of surrounding ground-water.

EFFECT OF OVERBURDEN PRESSURE ON STANDARD PENETRATION TEST



REFERENCES

- Terzaghi, K. and Peck, 1948. "Soil Mechanics in Engineering Practice". Wiley, New York.
- Gibbs, H.T. and Holtz, W.G., 1957. Research on Determining the Density of Sands by Spoon Penetration Testing. Proc. 4th Inter. Conf. SM & FE, London, Vol. 9.

APPENDIX

LOGS OF CABLE TOOL HOLES AND EXPLANATORY NOTES

NOTES ON DRILLING PROCEDURES

Equipment

The drilling is carried out with a cable tool drilling plant using sampling tubes attached, through a vacuum head, to the sampling tools (Figs. 1 and 2).

Sampling Procedures

S.A. Samples

To obtain, for logging purposes, an almost continuous series of samples, with a relatively small amount of sample disturbance, SA type samples are taken. These are obtained by driving an "S" tube, fitted with a Mark A shoe (Fig. 2), into the material to be sampled.

The assembly is lowered carefully to the bottom of the hole, and the tube driven exactly 30 cm, and the number of blows required for the 30 cm of penetration recorded.

The sample, or core, is extruded from the sampling tube using an hydraulic ram. The extruded core is sealed in a labelled plastic bag and stored in a core box (Fig. 3).

The hole is reamed with a "D" or "E" shoe (Fig. 2) and then the next sample is taken, using the same procedure as above. Thus the hole proceeds by alternate sampling, reaming (and where required, casing) operations, and the samples form a continuous record of the materials penetrated except for a few centimetres which may be lost between samples during reaming operations.

SA sampling equipment is a composite sampler for simple class sampling. Details are as follows:-

"S" SERIES CUTTING SHOES

MARK	FEATURES	USES
A	Inside clearance 3%. Area Ratio 33%.	Continuous open-tube sampling in strong soils, in which it causes little deformation. Samples extruded and used for logging purposes. Hole is reamed after each sample.
D	Shoe belled out to 12.5 cm (4 29/32 in.) (just greater than outside dia. of vacuum head)	Continuous open tube sampling where considerable deformation of sample is permissible. Essentially self-reaming.

MARK	FEATURES	USES
E	Shoe belled out to 13.8 cm (5 7/16 in.) (just less than internal dia. of 15 cm casing)	Cleaning hole and reaming out hole.

Sealed Tube (LB) Samples

Sealed tube samples, for laboratory testing, are taken at various intervals during drilling. These are obtained by driving an "L" type sampling tube with a Mark B cutting shoe (Fig. 4) a distance of 30 cm into the material to be sampled.

Before the sample is taken the hole is cleared out to the depth specified. The hole is not reamed or cased for at least 30 cm from the bottom, however, because these operations can cause considerable disturbance in the soil below. The sampling assembly is lowered carefully to the bottom of the hole, the sampling tube driven exactly 30 cm, and the number of blows recorded.

The sample is sealed in the tube by inserting in each end, plastic seals with rubber sealing rings, and the tube is then labelled and stored in a Laboratory Sample Box.

LB sampling equipment is a composite sampler for obtaining samples with the least possible disturbance. Details are as follows:

Sampler tube - ASSAB tube cadmium plated
 "L" type 10.2 cm (4.016 in.) I.D.
 10.9 cm (4.282 in.) O.D.

Mark B shoe - ASSAB tube, heat treated, cadmium plated
 Area ratio 15%
 Inside clearance - 0.4%
 Outside clearance - nil
 Cutting edge angle - 7°

Standard Penetration Test

The Standard Penetration Test (Terzaghi et al 1948) is used to test the in-situ density of sands and to give an indication of the consistency of clays, and compactness of silts. However the test results can be affected by several geological factors such as degree of cementation, and size and shape of grains. These factors should be taken into account in interpretation of results.

The equipment is illustrated in Fig. 5 and consists of a 5.1 cm (2 in.) diameter, sampling spoon (tube) and a hammer of standard weight (64 kg (140 lbs)).

With the equipment assembled as in Fig. 5 the hammer is allowed to fall on to the drill rods until the sampling shoe has penetrated 15 cm into the soil. The Standard Penetration Test is the number of blows (N) required to produce the next 30 cm of penetration.

NOTES ON DRILL LOG SHEETS

The logs are plotted on a standard cable-tool log form.

Near the centre of the form a graphic log of the materials encountered is shown.

In the column to the right of the graphic log, the soils are classified and described according to the Unified Soil Classification (U.S. Dept. of Interior, Bureau of Reclamation 1966) as shown on Figure 6.

To the left of the graphic log is a geological description of the materials sampled. This includes:-

.....Geological age	}	Printed vertically
.....Soil unit name		
.....Type of material		
.....Mineral composition		
.....Grain shape		
.....Cementation		
.....Organic materials		

Water levels are indicated by a small arrow with the date at which the observation was made.

In the blows per 30 cm column, a continuous histogram is made of the number of blows required to drive the sampling tube through each 30 cm of material. A hatching code is used to distinguish various types of sample. This code is reproduced at the bottom of each log sheet.

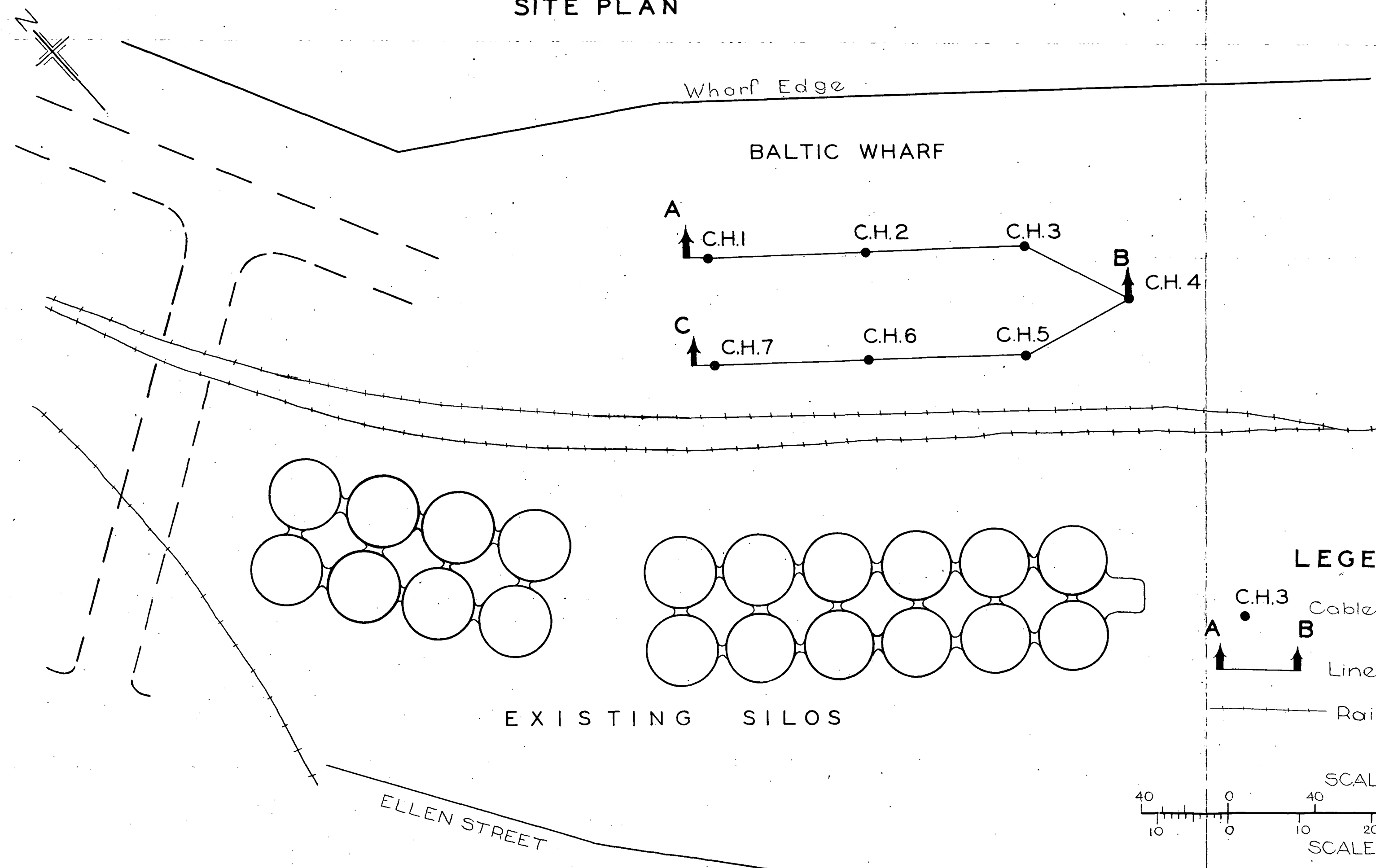
In the column on the far right of the log sheet, readings of unconfined compressive strength (q_u) made with a Soiltest Penetrometer, are recorded. The readings are plotted as a histogram. The Soiltest Penetrometer only gives true values of q_u when used in clays in which $\phi = 0$.

REFERENCES

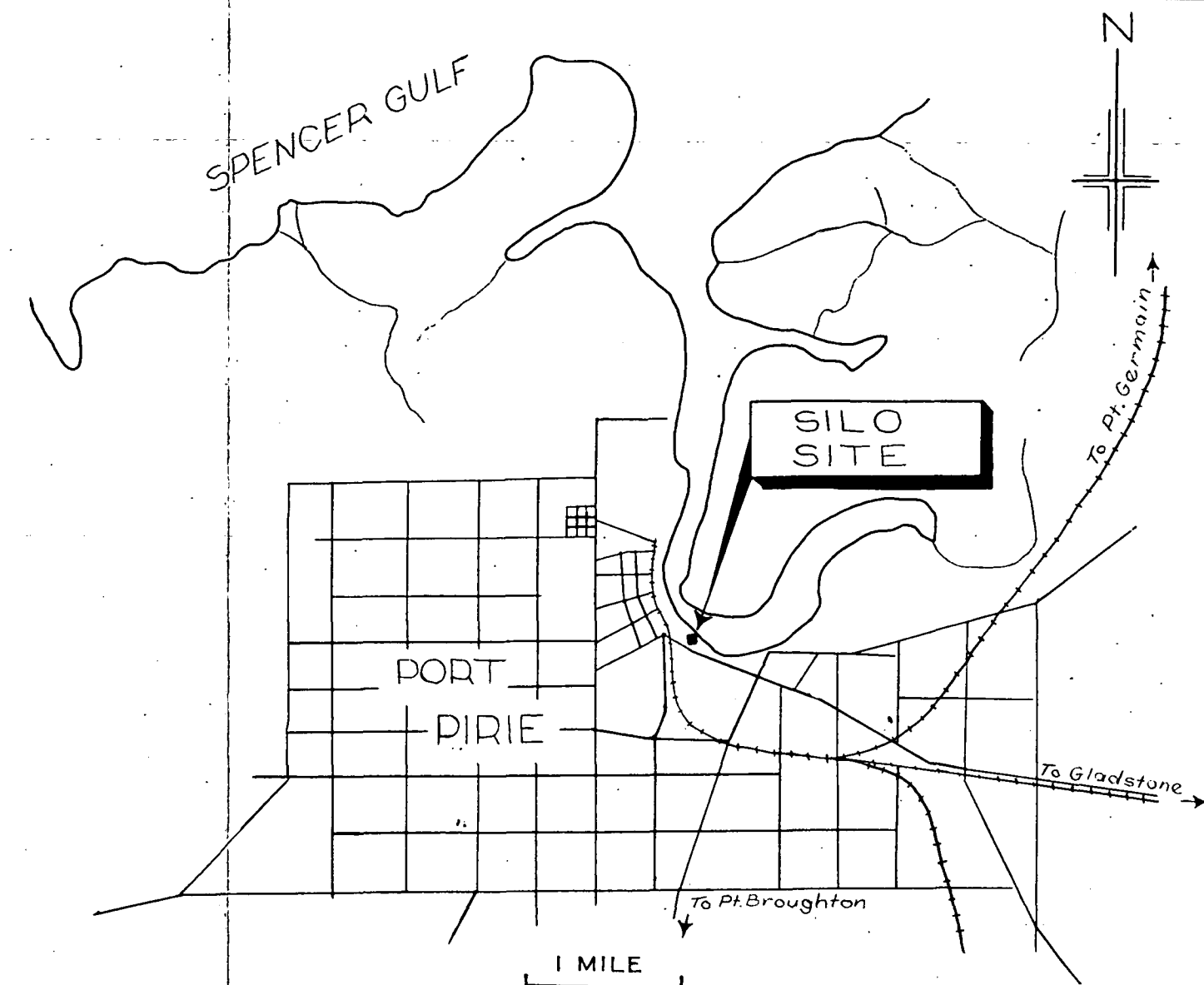
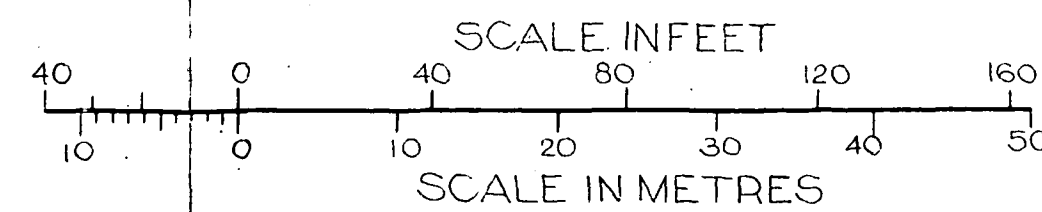
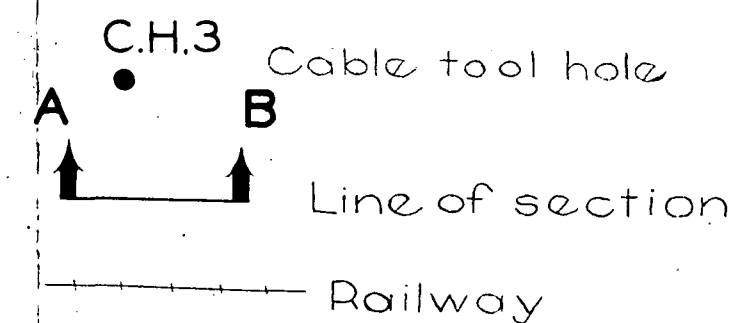
TERZAGHI, K. and PECK, R.B., 1948. Soil Mechanics in Engineering Practice. John Wiley and Sons.

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SITE PLAN



LEGEND



ORIENTATION MAP

FIG.1

DEPARTMENT OF MINES — SOUTH AUSTRALIA

PORT PIRIE SILO SITE SITE PLAN AND ORIENTATION MAP

ENGINEERING GEOLOGY SECTION	<i>R. D. Robertson</i> GEOLOGIST	Drn. R.S.R.	SCALE: 1:480
		Tcd. J.V.	73-931
		Ckd.	Gal
		Exd.	DATE: 17 December 1973
..... Director of Mines	SEN. GEOLOGIST		

