DEPARTMENT OF MINES AND ENERGY
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

S.A. CO-OP BULK HANDLING - NARACOORTE SILO FOUNDATION INVESTIGATIONS

by

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GEOLOGIST

Rept.Bk.No. 78/72
Eng. No. 1978/38
G.S. No. 6042
D.M. No. 287/78

CONTENTS

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ABSTRACT

Drilling of one cable tool hole has confirmed the conditions encountered in a previous excavation: a series of horizontal sediments approximately 15 m thick overlying limestone bedrock.

Suitable bearing horizons occur at 4 m below ground in a dense sand, or at 1.8 m below ground at the top of a stiff fissured clay which has a safe bearing capacity of 200 kPa based on laboratory tests.

Excavation of the machinery shaft should present no major difficulties, except that groundwater was struck at 7 m and some form of ground support will be required below this depth.

INTRODUCTION

An investigation has been carried out on the site of a proposed new silo by request of Mr. M. Farrent of SACBH.

The purpose of the investigation was to define subsurface conditions and to recommend a safe bearing horizon for the silo; an assessment of ground conditions for a proposed machinery shaft 10 m deep was required.

PREVIOUS WORK

Firman (1963) carried out an investigation of a site located about 400 m to the East (Fig. 1). Five cable tool holes were put down to a depth of 27 m and a safe bearing horizon of from 3 to 4.5 m below ground was recommended.

In view of the good correlation between these early holes, and their proximity to the present site, it was considered that one hole would be sufficient for this present investigation.

TABLE 1

SUMMARY OF GEOLOGY

Depth (m)	Thickness (m)	Formation	Engineering Description
0 - 1.8	1.8	Silt and limy gravel	Variable material, but can be excavated with normal machinery (ML-GM)*
1.8 - 3.6	1.8	Clay	Very stiff, but fissured (CL); laboratory testing indicates safe bearing capacity of 200 kPa
3.6 - 14.5	11	Sand and clayey sand	Generally medium dense and should provide an alternative bearing horizon. NOTE Groundwater struck at 7.0 m. (SP-SC)
14.5+		Sandy Limestone	Dense sandy rock which required drilling

* Unified Soil Classification Symbol.

PRESENT WORK

Continuous driven tube samples were taken to a depth of 10.5 m with Standard Penetration Tests (SPT's) every 1.5 m; the hole was then continued into limestone bedrock by drilling to a total depth of 30 m.

A horizontal series of sediments was encountered down to 14.5 m lying above bedrock; these showed similar characteristics to those encountered in the earlier investigation and their properties have been summarised in Table 1. A detailed log is also attached.

After discussion with the client it was decided to take sealed tube samples from the clay layer struck at 1.8 m, and to have these tested by the E. & W.S. Department Laboratories at Netley. The engineer's report is given in Appendix II.

FOUNDATION CONDITIONS

There appear to be two possible foundation horizons on this site:

(i) the sand encountered at a depth of about 4 m is in the medium dense to dense range, with SPT values averaging N = 18 to 20 when corrected for the effect of concretionary lime bands; this would make an acceptable bearing horizon for piled footings.

(ii) the overlying clay has been assigned a safe bearing capacity of 200 kPa after laboratory testing, but its consistency, thickness, and extent will need proving on each silo site if this horizon is to be used. The possibility of founding the structure at shallower depth, at the base of the silty gravel layer and immediately on top of the clay, could also be considered as an SPT value of 11 at this depth indicates a medium dense condition.

It is recommended that footings be sealed against the possibility of downward penetration by surface runoff.

Excavation of the machinery shaft should present no major resistance to normal equipment, but it should be noted that groundwater was struck at about 7 m below ground and the hole was collapsing below this depth. Depending on the diameter of the shaft therefore, either casing or sheet piling will be necessary below this depth; dewatering of the excavation may also be required.

JS:PDJ:ZV

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REFERENCES

Firman, J.B., (1963). Report on Site Investigation Railway Yards, Naracoorte. S.A. Dept. Mines & Energy Report 57/93 (unpublished).

APPENDIX I

Log of Borehole

PROJECT: NARACOORTE SILOS.

DEPARTMENT OF MINES — SOUTH AUSTRALIA
ENGINEERING DIVISION

LOG OF CABLE TOOL HOLE

HOLE NO. CH. 6

UNIT/STATE NO:

SERIAL NO. 309/78

FOLDER NO.

LOCATION OR CO-ORDS:

SEC. R WAY RES. HD. NARACOORTE

EL Surface

EL ref. point — Datum

GEOLOGICAL DESCRIPTION OF CORE	HOLE Dia	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 Densy	FIELD TEST DATA: BLOWS PER 30 cm (4 8 16 32 64)	FIELD TEST DATA: SOIL TEST PENETROMETER Units * (1 2 3 4)
SURFACE SILT SOIL with LIME CONCRETIONS.		0		ML	SILT, low plasticity, black, organic material, some gravel.		D	MC		
				GM	LIME concretions, pink.					
				ML	SILT, as above dark grey, minor sand and clay.		H	C		
		1								
				GM-ML	LIME gravel in silt matrix.		D	MC		
				ML	increasing clay content.					
VERY STIFF, MOTTLED, CLAY.		2		CL	CLAY, low plasticity, light grey-green with brown mottles. White powdery lime patches. Some lime concretions.		< PL	VSt.	11 (3,4,4)	
		3			moderate plasticity, slickensided faces.				8 (2,3,3)	
MEDIUM-DENSE, POORLY GRADED, SANDS.		4		SP	SAND, poorly graded, white, fine grained.		W	MD		
					medium grained, becoming coarse.					
		5		SC	SAND, excess clay (15%) white, medium to coarse grained.		M	D	31 (8,11,12)	
				SP	SAND, poorly graded, white, fine.					
				SC	SAND, excess clay (15%), white		W	MD		
		6		SP	SAND, poorly graded, white, fine.					
				SC	SAND, excess clay. medium to coarse grained, minor yellow mottling.	▼ 20-5-78	M	D	30 (6,6,18)	
				GP	LIME, concretionary, in a sand matrix					
				SP	SAND, poorly graded, white. Very fine grained, minor clay.	WS				
		7								
							W	MD	21 (5,7,9)	
		8			Some orange mottling.					
					medium grained.					
				SC	SAND, excess clay. medium grained. orange, yellow and grey mottled.					
		9		SP	SAND, poorly graded, white, coarse grained. rounded.		W	MD	19 (4,7,8)	
					fine to medium grained. some yellow and brown mottling.					
		10								

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silts)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE
7 Dec. '66 Casing; 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) Total blows for 0-3m (in 0-1m increments)

* These values refer to clay soils only and provide an indication of their consistency.

DRILL TYPE CT 2.	LOGGED BY: P.D.J.
CIRCULATION: AIR	DATE: 25/5/78.
START: 10/5/78	TRACED BY: P.D.J.
FINISH: 20/5/78	DATE: 26/5/78

SHEET 1 OF 4

PROJECT: NARACOORTE SILOS.

DEPARTMENT OF MINES — SOUTH AUSTRALIA
ENGINEERING DIVISION

LOG OF CABLE TOOL HOLE

HOLE NO. CH. 6

UNIT/STATE NO:

SERIAL NO:

FOLDER NO.

LOCATION OR CO-ORDS:

SEC. HD.

EL Surface

EL ref. point Datum

GEOLOGICAL DESCRIPTION OF CORE	HOLE Dia	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 Compct Densty	FIELD TEST DATA: BLOWS PER 30 cm (4 8 16 32 64)	SOIL TEST PENETROMETER Units * (1 2 3 4)
MEDIUM DENSE, POORLY GRADED, SANDS.		10		SC	SAND, excess clay. mottled.			W	L/MD		
				SP	SAND, poorly graded, white.						
				SC	SAND, excess clay. orange.						
				SP/SC	SAND, poorly graded, fine to medium grained. off-white to cream-yellow colour. Thin bands of clayey sand throughout sequence. partially lime cemented.					19 (3,7,9) Bit Drilled	
		11									
		12									
		13									
		14									
LIMESTONE, sandy with 20-30% clay. Predominantly fossil fragments up to fine gravel size.		15		SW	SAND, well graded. white, unconsolidated. 20-30% clay.			S	MD	Bit Drilled	
		16									
		17		SW	as above but only 5-10% clay.					Bit Drilled	
		18									
		19									
		20									

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silts)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE
Water level (date) 7 Dec. '65. Casing. 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)

* These values refer to clay soils only and provide an indication of their consistency.

DRILL TYPE CT2	LOGGED BY: P.D.J
CIRCULATION: AIR/WATER	DATE: 25/5/78
START: 10/5/78	TRACED BY: P.D.J.
FINISH: 20/5/78	DATE: 26/5/78.

PROJECT: NARACOORTE SILOS.

DEPARTMENT OF MINES — SOUTH AUSTRALIA
ENGINEERING DIVISION

LOG OF CABLE TOOL HOLE

HOLE NO. CH.6
UNIT/STATE NO:
SERIAL NO:
FOLDER NO.

LOCATION OR CO-ORDS:

SEC. HD.

EL Surface
EL ref. point Datum

GEOLOGICAL DESCRIPTION OF CORE	HOLE Dia	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 Compct Density	FIELD TEST DATA: BLOWS PER 30 cm (4 8 16 32 64)	FIELD TEST DATA: SOIL TEST PENETROMETER Units * (1 2 3 4)
LIMESTONE, sandy with some clay. Predominantly fossil fragments up to fine gravel size. Partially cemented in places.		20		SW	SAND, well graded, white. unconsolidated. 5-10% clay. predominantly fossil fragments, some sand.		W	MD	Bit Drilled	
		21		SW	SAND, well graded, white. unconsolidated. 20-30% clay. predominantly fossil fragments.					
		22		SW	as above but only 5-10% clay.					
		23							Bit Drilled	
		24		GW	GRAVEL, well graded. mostly lime cemented fossil fragments.		W	D		
		25								
		26		SW	SAND, well graded, white. unconsolidated. 5-10% clay. mostly fossil fragments.		W	MD/D	Bit Drilled	
		27		SW/GW	as above, partially cemented.			D		
		28		SW	SAND, well graded, white. unconsolidated. 5-10% clay. predominantly fossil fragments.		W	MD	Bit Drilled	
		29								
		30								

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silts)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE
7 Dec. '66. Casing. 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) Total blows for 0-3m (in 0-1m increments)

* These values refer to clay soils only and provide an indication of their consistency.

DRILL TYPE CT2	LOGGED BY: P.D.J.
CIRCULATION: AIR/WATER	DATE: 25/5/78
START: 10/5/78	TRACED BY: P.D.J.
FINISH: 20/5/78	DATE: 26/5/78

SHEET 3 OF 4

PROJECT: NARACOORTE SILOS

DEPARTMENT OF MINES — SOUTH AUSTRALIA
ENGINEERING DIVISION

LOG OF CABLE TOOL HOLE

HOLE NO. CH 6.

UNIT/STATE NO:

SERIAL NO:

FOLDER NO.

LOCATION OR CO-ORDS:

SEC. HD.

EL Surface

EL ref. point Datum

GEOLOGICAL DESCRIPTION OF CORE	HOLE Dia / 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 Compct Denisy	FIELD TEST DATA: BLOWS PER 30 cm (4 8 16 32 64)	FIELD TEST DATA: SOIL TEST PENETROMETER Units * (1 2 3 4)
LIMESTONE, as above.	30		GW/SW	as above, partially cemented.					
				End of Hole 30.3m.					

WATER LEVELS	MOISTURE CONTENT	CONSISTENCY (Clays)	COMPACTNESS (Silts)	RELATIVE DENSITY (Sands)	TYPE OF SAMPLE
Casing 7 Dec. 166 — 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) A Total blows for 0-3m (in 0-1m increments)

* These values refer to clay soils only and provide an indication of their consistency.

DRILL TYPE CT 2	LOGGED BY: P.D.J.
CIRCULATION: AIR/WATER	DATE: 25/5/78
START: 10/5/78	TRACED BY: P.D.J.
FINISH: 20/5/78	DATE: 26/5/78.

SHEET 4. OF 4.

APPENDIX II

Results of Laboratory Testing on Soil Samples

REPORT ON LABORATORY TESTING OF SOIL SAMPLES

Two samples of the stiff clay from between 1.8 and 3.6 m depth were sheared in the undrained condition in the triaxial apparatus. Cell pressures of 50 and 100 kPa were used, the lower cell pressure corresponding to the average overburden pressure in the clay layer. The clay was highly fissured which accounts for the lower than expected shear strength - which was found to be 100 kPa for the sample sheared at overburden pressure. A safe bearing capacity of 200 kPa (equivalent to 2 Tons/ft^2) is recommended for a structure founded on the top of the clay layer.

Two things are important if the clay is to be used as a foundation. Firstly, the clay should be proved to be the same as tested (or better) over the area to be loaded. Secondly, should all the overburden above the clay be removed, then care should be taken to ensure the top surface of the clay is not allowed to soften. It must therefore be protected from groundwater and rain until the structure is placed on it.

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SOILS AND FOUNDATIONS

EWS DEPARTMENT

Soils Laboratory
TRIAXIAL COMPRESSION

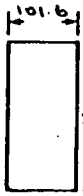
TRIAL HOLE: MC 47

DEPTH: 2.5 - 2.8m, 3.0 - 3.3m

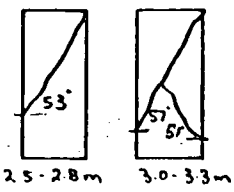
PROJECT NARACOORTE Co.oP. BULK HANDLING. DATE 16-6-78

LOCATION ORDER NO. OPERATOR RB

Description: LIGHT GREY SANDY CLAY. HIGHLY STRUCTURED W/ POCKETS OF ORGANIC SANDY CLAY. CALCAREOUS.



Failure Mode



Test Description: CONSOLIDATED TO SOME QUICK UNDRAINED.

Rate of Strain: 0.06"/min

Sample: Undisturbed / ~~Reconstituted~~

STRESS - DEFORMATION CURVES

DEFORMATION : mm

AXIAL STRESS : kPa

MOHR DIAGRAMS

SHEAR STRESS : kPa

0 100 200 300 400

0 100 200 300 400 500 600 700 800

NORMAL STRESS : kPa

Suggest for use this ~~Quick~~ shear strength (same as 1 ton/sq ft) in shear calculation of Safe bearing capacity. Also plot the persists in the same state over the whole area of the limestone overburden pressure for the centre of the layer of clay.

Soils Laboratory
SUMMARY OF
TRIAXIAL COMPRESSION DATA

LOCATION: NARACOORTE Co. OF
PROJECT: BULK HANDLING.

Sample B.H.	Sample Depth	Description	In Situ M.C. %	In Situ γ_D t/m³	In Situ Sat. %	Stage or Spec. No.	Triaxial Compression: Consd. Press. kPa	Max. Pore Press. kPa	App. Lat. Press. σ_3 kPa	Max. Princ. Stress σ_1 kPa	Shear Str. $\frac{\sigma_1-\sigma_3}{2}$, kPa	Strain at Failure, %	After Test M.C. %	After Test γ_D t/m³	After Test Sat. %
MC 47	2.5 - 2.8m	LIGHT GREY SANDY CLAY HIGHLY STRUCTURED W/- POCKETS OF ORGANIC SANDY CLAY, CALCAREOUS	24.3	1.576	90.3	1	50	-	50	253.0	101.5	0.7	24.8	1.575	91.9
	3.0 - 3.3m	— " —	29.8	1.487	96.9	1	50	-	100	470.8	185.4	3.4	30.4	1.489	99.1
		P.L. 22.0 P.F. = 11.5μV @ 22.5°C = 4.30													
		Note Both Samples are wetter than the plastic limit and should therefore be close to their weakest, their winter wetting-up being well advanced.													

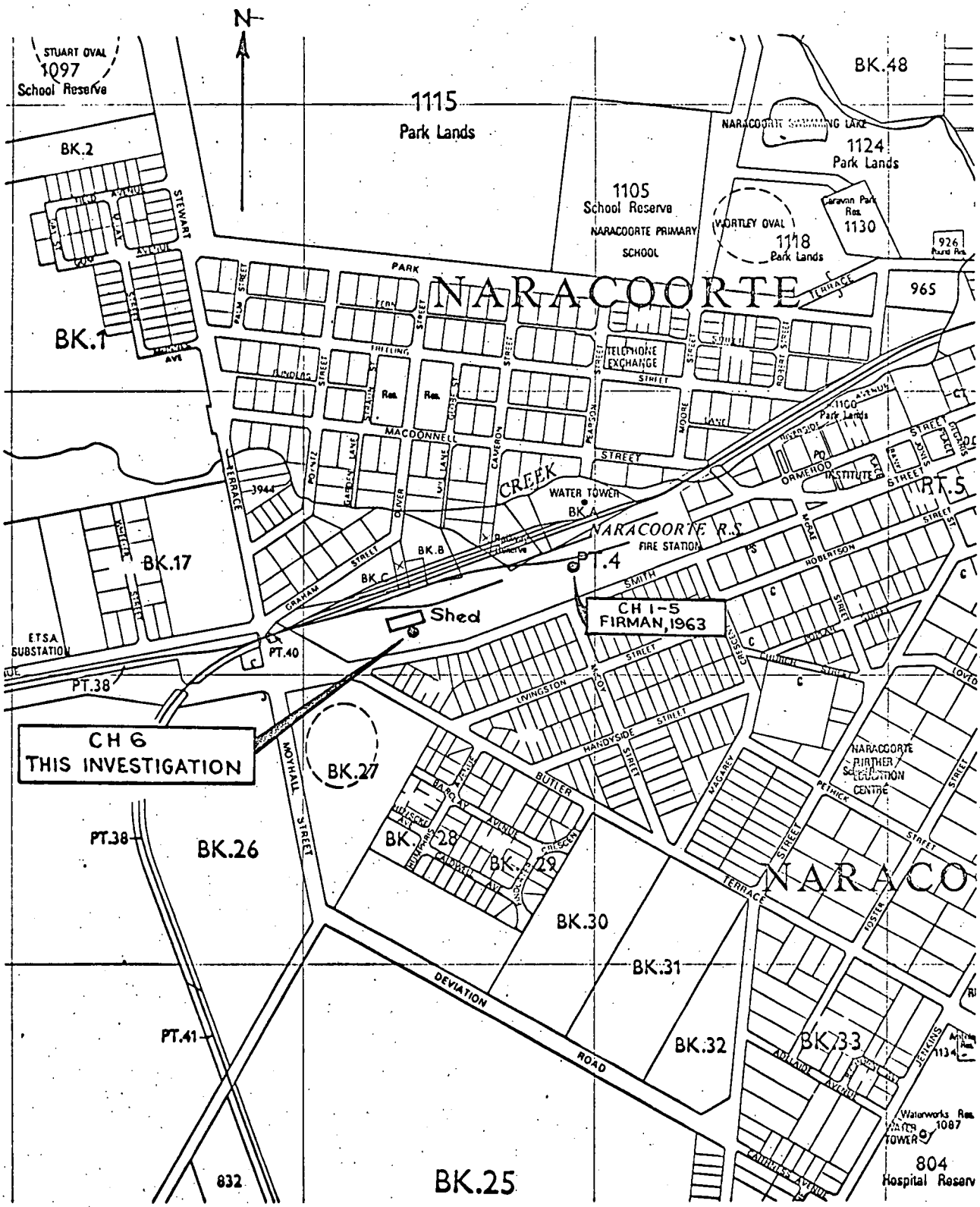


FIG 1

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: 1:10000
Compiled: J. Selby	NARACOORTE SILO	Date: 22-6-78
Drn. A.F. | Ckd.	FOUNDATION INVESTIGATION	Drg. No.
	ORIENTATION PLAN	S13440

500—11.76 H1081 O

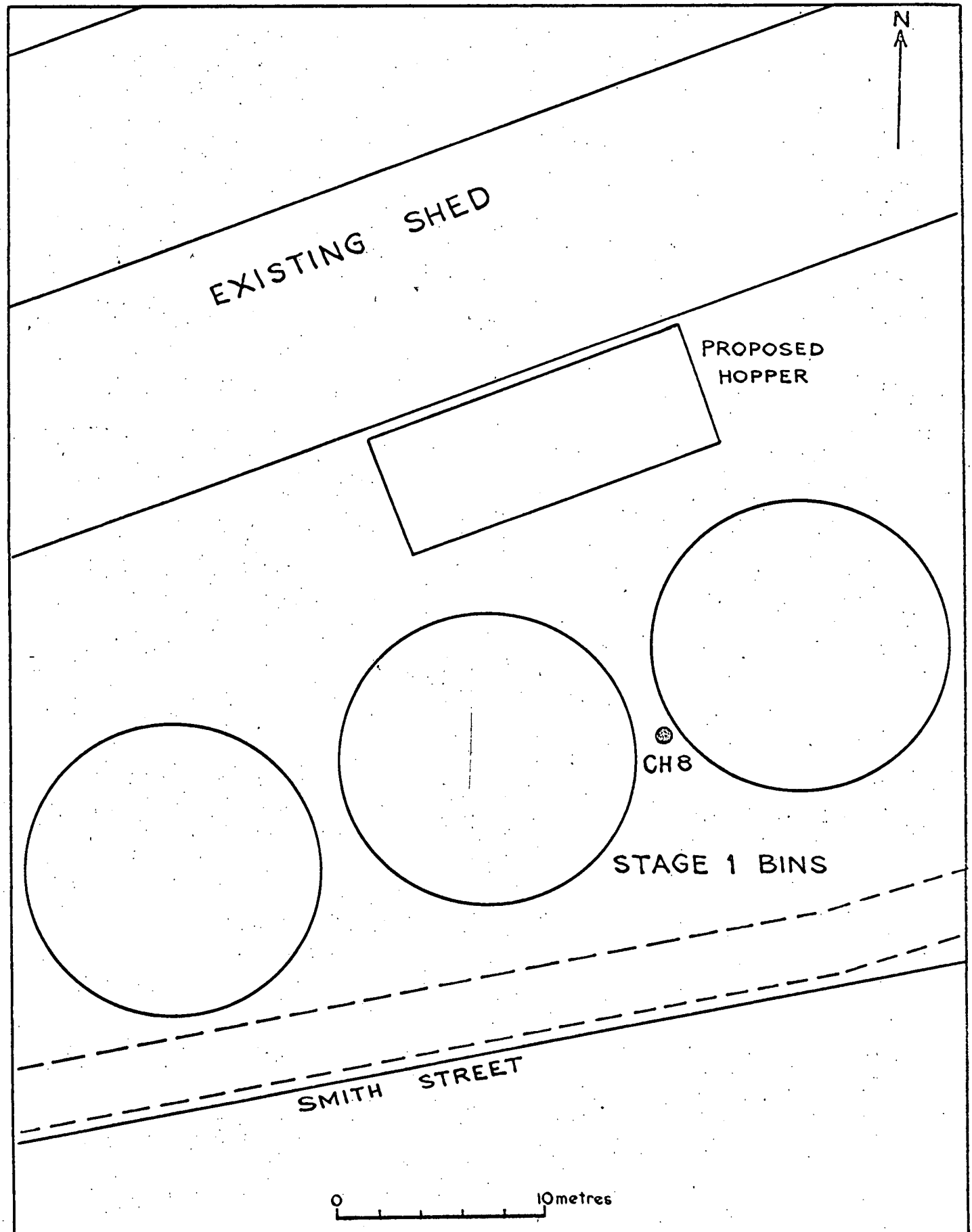


FIG 2

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale: 1:250
Compiled: J. Selby	NARACOORTE SILO	Date: 22-6-78
Drn. A.F. | Ckd.	FOUNDATION INVESTIGATION	Drg. No.
	LOCATION OF BORE HOLE	S13441

500—11.76 H1081 O

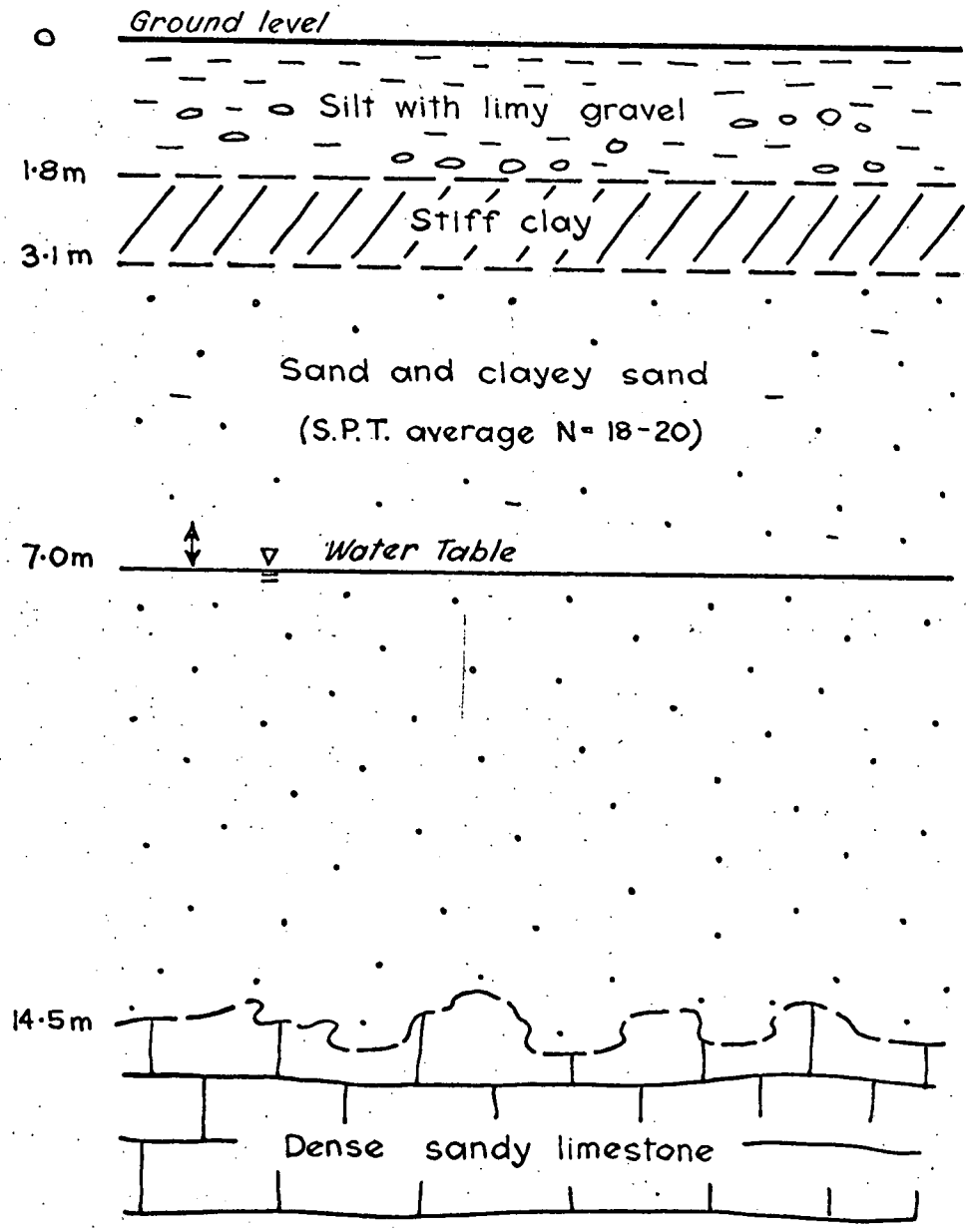


FIG. 3

	DEPARTMENT OF MINES—SOUTH AUSTRALIA	Scale:
Compiled: J. Selby	NARACOORTE SILO	Date: 22-6-78
Drn. A.F. | Ckd.	FOUNDATION INVESTIGATION	Drg. No.
	GEOLOGICAL MODEL OF SITE	S13442

500—11.76 H1081 O