Rept.Bk.No. 69/106
G.S. No. 4360

DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

ENGINEERING DIVISION

NATIONAL ART GALLERY - FOUNDATION FAILURE

GEOLOGICAL INVESTIGATIONS - PROGRESS REPORT NO. 1

MAINTENANCE STAGE

Sec. 562, Hd. of Adelaide

Client: Public Buildings Department

by

W.R.P. BOUCAUT
SENIOR GEOLOGIST

and

J.H. FRYAR
GEOLOGIST
ENGINEERING GEOLOGY SECTION

DM.1823/68

7th November, 1969

DEPARTMENT OF MINES
SOUTH AUSTRALIA

NATIONAL ART GALLERY - FOUNDATION FAILURE

GEOLOGICAL INVESTIGATIONS - PROGRESS REPORT NO. 1

MAINTENANCE STAGE

Sec. 562, Hd. Adelaide

Client: Public Buildings Department

by

W.R.P. BOUCAUT
SENIOR GEOLOGIST

and

J.H. FRYER
GEOLOGIST
ENGINEERING GEOLOGY SECTION

CONTENTS

FIGURES

Rept.Bk.No. 69/106
G.S. No. 4360
DM. 1823/68

7th November, 1969.

DEPARTMENT OF MINES
SOUTH AUSTRALIA

Rept.Bk.No. 69/106
G.S. No. 4360
DM. No. 1823/68

NATIONAL ART GALLERY - FOUNDATION FAILURE

GEOLOGICAL INVESTIGATIONS - PROGRESS REPORT NO. 1

MAINTENANCE STAGE

Sec. 562, Hd. Adelaide

Client: Public Buildings Department

SUMMARY AND CONCLUSIONS

Cracking of walls within the National Gallery indicates that uneven settlement of foundations of the eastern side of the building has occurred. Investigations have indicated that this is due to bearing capacity failure in clay underlying a beam footing. The failure has been cuased by water passing along a sand layer, placed during construction beneath the foundations, and wetting and weakening of the underlying clay of the Hindmarsh Clay Formation. It is considered that the likely source of this water is a storm water drain adjacent to the foundations.

This drain has been replaced by a water tight system and piezometers have been installed to monitor any further changes in groundwater regime.

With drying out, and hence shrinkage of the clay under the foundations, some further settlement could occur.

INTRODUCTION

Recent cracking of walls within the 90-year old National Gallery indicates that uneven settlement of foundations of the eastern side of the building has occurred. A test pit dug adjacent to the foundations exposed a water bearing sand layer beneath the foundations, apparently placed during construction. In a letter dated 12th November, 1968 the Director, Public Buildings Department requested that investigations be undertaken to determine the likely source of this water.

This report describes the results of the investigations. It discusses the probable mechanism of failure, and the remedial measures carried out.

SCOPE OF INVESTIGATIONS

The following investigations have been carried out, subsequent to the discovery of severe cracking in internal walls of the Gallery.

(1) A preliminary survey of the cracking indicated that movement was due to some failure in the foundations of the eastern side of the building. Later a more detailed survey of cracking in the basement was made (Fig. 1).

(2) A test pit 5ft. deep (Fig.1) was excavated adjacent to the building foundations, to expose the material adjacent to and underlying the foundations. Geological logs of the pit are shown on Figures 2 to 4.

SITE GEOLOGY

Soil Types

There are no natural exposures near the Gallery, but the test pit and previous exposures in nearby excavations during building constructions, indicate that foundations are seated in clays of the Hindmarsh Clay Formation. It is likely that these clays are of the order of 40 ft. thick beneath the building. They are generally uniform, highly plastic (CH), clays, very stiff to hard, at moisture content close to the plastic limit. They have been overconsolidated by dessication.

The clay exposed in the basement beneath the southern end of the Gallery is at a very low moisture content, as indicated by shrinkage cracks open as much as 0.3ft. (Fig.1).

The test pit indicated that the upper few feet of the clay is limy and weaker than the underlying material. Above this is developed a clay soil, 'B' horizon, up to 1ft. thick.

Throughout the Adelaide city area the upper surface of the Hindmarsh Clay Formation is deformed into a series of mounds and depressions (gilgai structures, Allchurch 1965). Exposures in the test pit and the mounds and depressions in the roadway on the eastern side of the building

(Fig. 1) indicate that gilgai structures probably occur in this area.

Groundwater

Throughout this area the main piezometric surface is below the base of the Hindmarsh Clay Formation, that is below 40ft. below ground surface.

However, commonly, the near surface depressions associated with gilgai structures contain perched groundwater. These are fed by leaking services, rain or watering of gardens.

BUILDING CONSTRUCTION

The test pit indicated that during construction a trench had been dug to the strong clays below the limy layer, a layer of clean fine sand, a few inches thick, placed in the bottom, and the trench then backfilled with a lime-cemented concrete. A beam type concrete foundation was placed on top. The building floors are constructed on R.S.J. beams supported on pillars (Fig. 1). A basement was constructed under the northern end of the building and then, in the past few years, extended further southwards, until at present only a small section under the building is not utilized as a basement (Fig. 1). In this section access can be obtained into a space about 4 ft. high between the floor of the ground floor of the building, and the natural ground surface.

MECHANISM OF FOUNDATION FAILURE

It is considered that failure was initiated by a relatively large amount of water gaining access to the sand layer underneath the foundations. This water was absorbed readily by the underlying clay which probably was previously at a very low moisture content. The clay is a highly expansive type and normally would be expected to cause uplift of footings, However in this situation of a relatively high load at shallow depth, its bearing capacity was exceeded. The footing settled and probably tilted slightly outwards, as indicated by the sense of the movement observed along the cracks in the building.

The source of the water is not completely proven, but it is probably the underground storm water drain on the eastern side of the building (Fig. 1). To confirm the interconnection between this drain and the sand layer, the drain was divided into two sections by blocking the pipe at sumps, and then pumping water into the uphill sumps. Leakages of up to 500 gal/hr. occurred from both sections during testing and water was observed to be flowing in the sand layer at the bottom of the test pit, and eventually rose 1 foot in the previously nearly dry pit.

It is considered that, during normal operations of the drain, insufficient water would leak from the pipe to affect the surrounding soil to any extent. However blockage of the drain, and thence build-up of head in it, would be sufficient to cause water to flow from the pipe into the sand layer. Enquiries showed that in September, 1968 the drain had in fact been checked for leakages and it was found to be blocked at a sump. Also one downpipe sump was found to be broken, and connection between the bottom of one downpipe and the drain was found to be by a rusted tin fitted loosely over the pipe.

REMEDIAL MEASURES

To prevent further leakage from the drain the existing earthenware pipe was excavated and replaced by pipes with watertight rubber seal connections. The connections between the downpipes and the drain were also repaired.

To observe further the groundwater behaviour beneath the footing 2 water level observation points (Fig. 1) were installed adjacent to it. Also 2 further observation points were installed adjacent to the drain (Fig. 1) to detect the presence of water due to leakage from it.

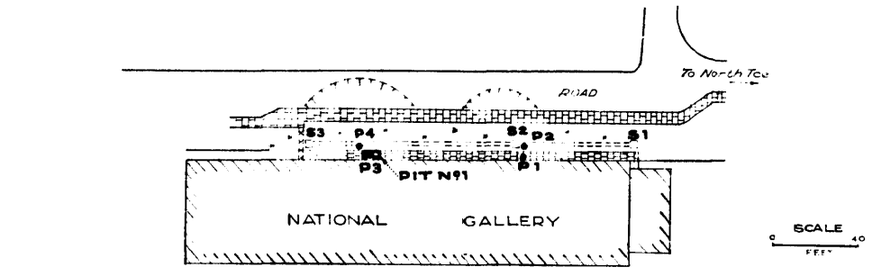
WRPB:JHF:NHW:JB
7.11.1969

W.R.P. BOUCAUT
SENIOR GEOLOGIST
ENGINEERING GEOLOGY SECTION

JH. FRYER
GEOLOGIST
ENGINEERING GEOLOGY SECTION

REFERENCES

ALLCHURCH, P.D., 1965. Gilgai Type Structures in "Mottled Clays" beneath the city of Adelaide, The Geological Survey of South Australia, Quarterly Geological Notes No.14, April 1965.

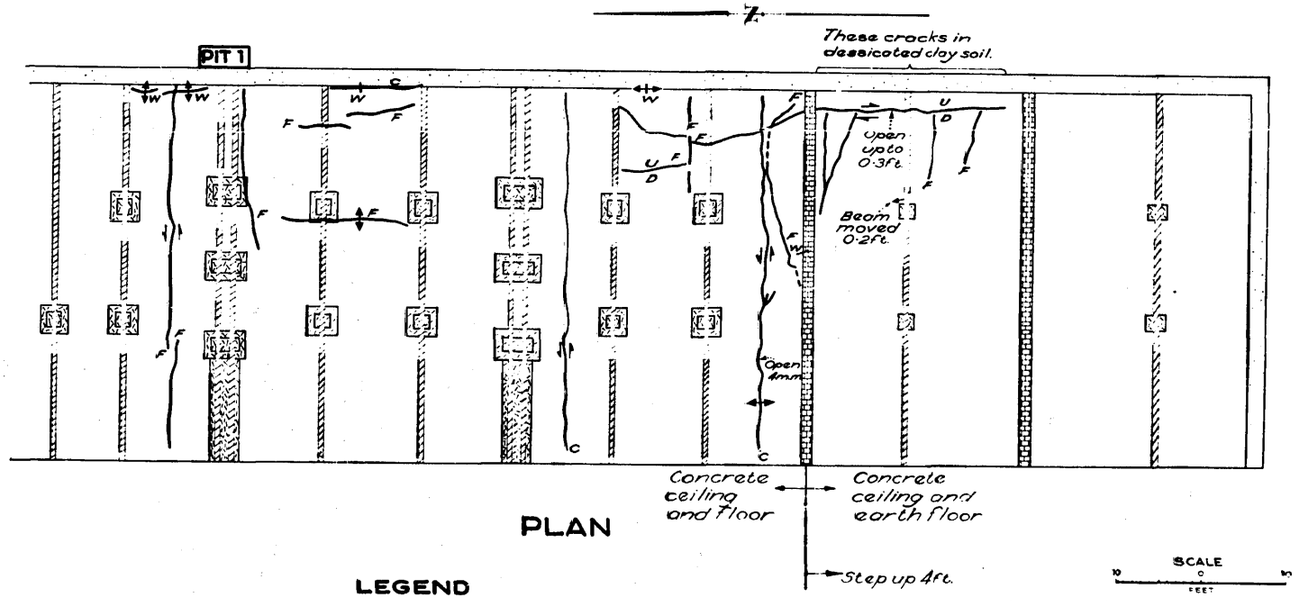


LOCALITY PLAN

LEGEND

- Concrete slab paving
- Retaining wall
- Grassed area
- S1 Underground drain with Sump N° 1
- Depressed area
- P1 Piezometer
- Test Pit N° 1

PIT N°1



PLAN

LEGEND

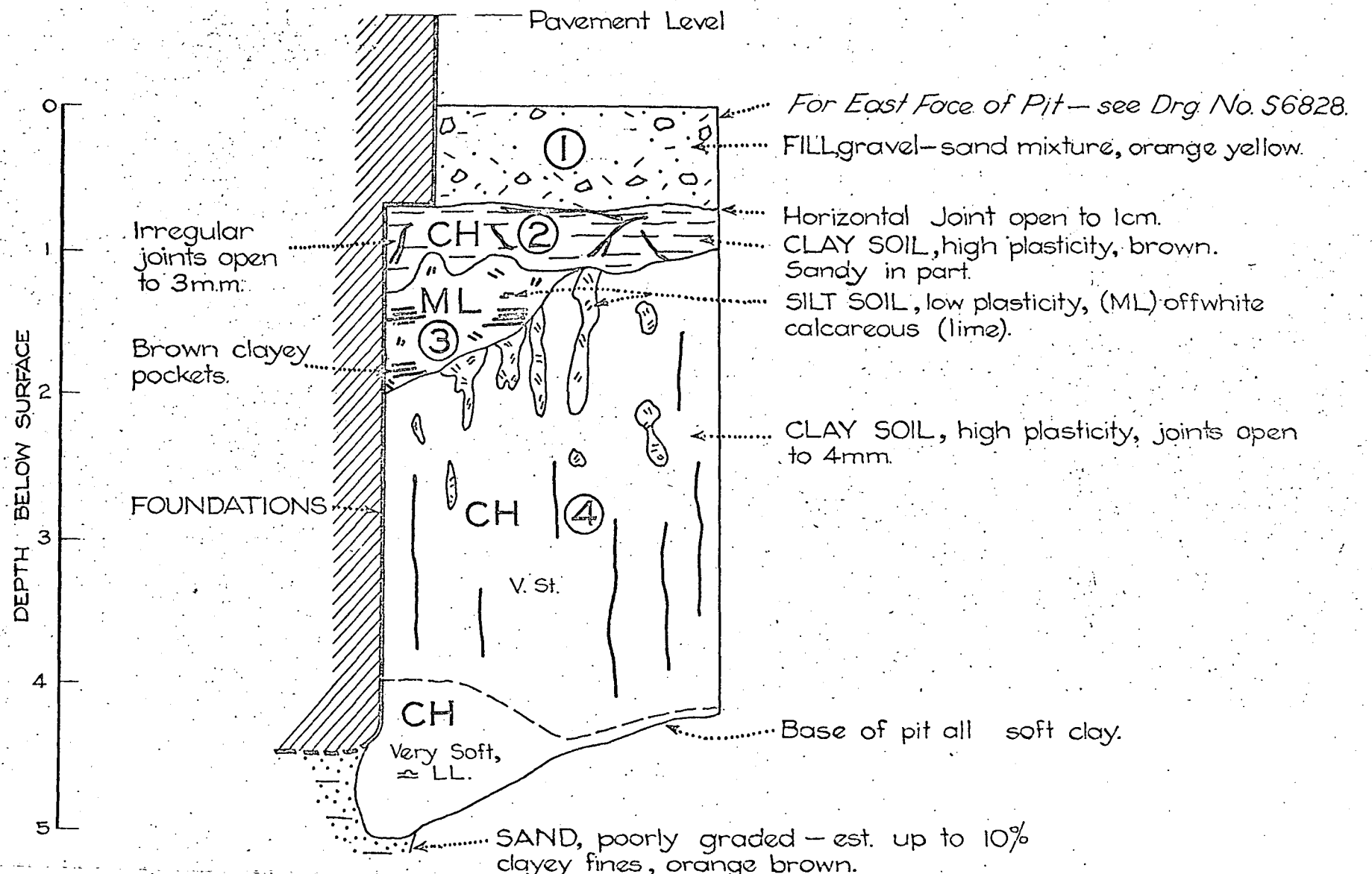
- Concrete & brick pillar (Pad footing)
- External wall (Strip footing)
- Internal wall (Strip footing)
- R.S.J. beam in basement
- Crack in wall (W) / " ceiling (C) / " floor (F) open to 2m.m. unless otherwise shown.
- Sense of displacement - up (U) down (D)

-as mapped January 1969

FIG. 1

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
NATIONAL ART GALLERY SEC. 562 Hd ADELAIDE LOCALITY PLAN AND PLAN OF PORTION OF BASEMENT SHOWING CRACKING			
ENGINEERING GEOLOGY SECTION	J. H. Fryar	Drn.	SCAL. As above
		Tcd. G.A.F	69-918
Director of Mines	SEN. GEOLOGIST	Chd.	H26
		Exd.	DATE: 4 Nov. 69

LOG OF NORTH FACE



DEPARTMENT OF MINES — SOUTH AUSTRALIA

NATIONAL ART GALLERY

PIT No. 1.

LOG OF NORTH FACE

ENGINEERING GEOLOGY SECTION

GEOLOGIST

Drn. JHF

Tcd. AMcD

Ckd.

Exd.

SCALE: 1 INCH = 1 FOOT (NATURAL)

S 7135

HaG

DATE: 6 JAN '69

FIG: 2

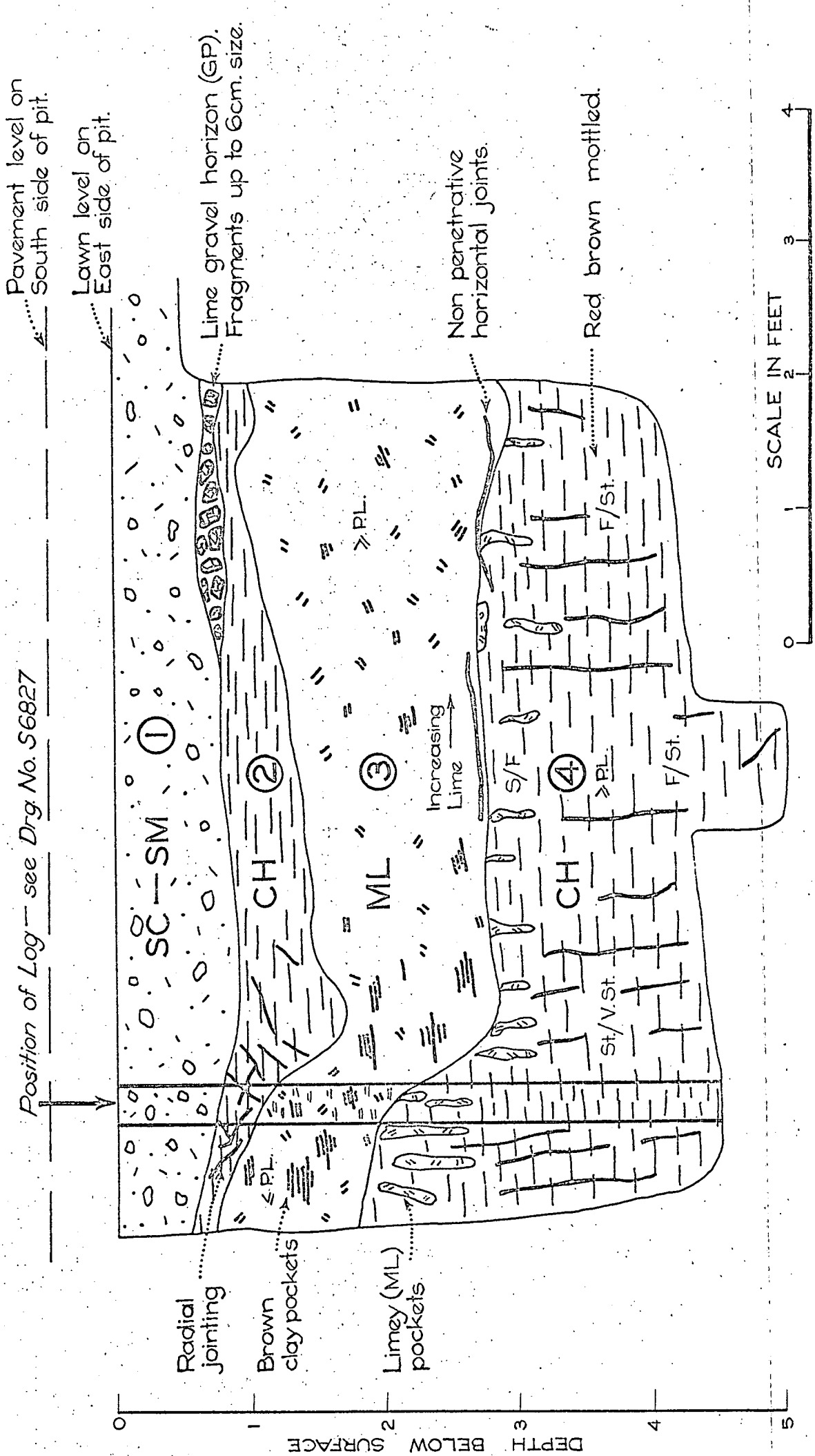


FIG: 3

DEPARTMENT OF MINES — SOUTH AUSTRALIA

ENGINEERING GEOLOGY SECTION	Drn. J.H.F.	NATIONAL ART GALLERY	SCALE: AS SHOWN
	Tcd. AMcD	PIT No. 1.	S6828
	Ckd.	LOG OF EAST FACE	Ha.6.
GEOLOGIST	Exd.		DATE: 16th Sept '68

DEPARTMENT OF MINES SOUTH AUSTRALIA

PIT NO 1

LOG OF PIT

PROJECT NATIONAL ART GALLERY

LOCATION NORTH TERRACE — SECTION GOVT. RES. — HUNDRED ADELAIDE

LANDFORM ADELAIDE PLAINS

RELIEF FLAT — Direction of fall TO NORTH

MICRORELIEF GILGAIED

DRAINAGE External MEDIUM — Internal MEDIUM — Surface Absorption MEDIUM

SURFACE VEGETATION Type LAWN AND GUM TREES

HORIZON NUMBER	SOIL/ROCK HORIZON	R.L (Feet) DEPTH (Feet)	GRAPHIC LOG	GROUP SYMBOL	SOIL DESCRIPTION GROUP NAME Unified Soil Classification U.S.B.R. Earth Manual 1st Ed. Rev 1963	OTHER GEOLOGICAL PEDOLOGICAL DESCRIPTION	SOIL/ROCK STRUCTURE	WATER LEVEL	MOISTURE CONTENT	Consistency Compactness Rel. Density	"SOILTEST" PENETROMETER UNITS * 1 2 3 4 5
(1)	FILL			SC SM	SAND, excess silt and clay fines (est. 40-50%). Grey brown. Est. 20% gravel.	Gravel fragments are siltstone sandstone and limy nodules up to 4c.m. size. Sand is quartz			H	MD	
(2)		1		CH	CLAYSOIL, high plasticity. Dark brown to blackish brown, sandy near top contains 10% gravel and 5% offwhite, limey pockets. (estimated.)	Gravel is mainly siltstone and sandstone up to 3cm. size. Sand is quartz	Angular blocky. Dull sheen on unit faces. Shrinkage cracks open to 5mm, spaced 5 to 10cm. apart.		<PL	St/Vst	
(3)		2		ML	SILT SOIL, low plasticity. Offwhite, brown mottled in parts, Est. up to 40% pockets of CLAY SOIL, high plasticity brown in part.	Silt is lime.			VPL	Silt is MC Clay is St/VSt	
(4)	HINDMARSH CLAY	3		CH	CLAY SOIL, high plasticity. Green-grey, reddish mottled at depth. Limey near top		Horizontal shrinkage cracks up to 2mm. wide at upper boundary. Columnar jointing throughout		>PL	St/V.St	
		4									
		5			BASE OF PIT 4.5FT.					Estimated	
		6			For Log of pit see Drg. No. S6828.						
		7									
		8									

REMARKS

FIG:4

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

CLASSIFICATION		CONSISTENCY (CLAY)	COMPACTNESS (SILT)	RELATIVE DENSITY (SAND)	MOISTURE CONTENT	ENGINEERING GEOLOGY SECTION
Great Soil Group	Water level 7 May 67 (date)	VS — Very Soft	Ls — Loose	VL — Very Loose	H — Humid	PLANT TYPE HAND-DUG — LOGGED J. H. F
Subgroup		S — Soft	MC — Moderately Compact	L — Loose	D — Damp	DRILLER — DATE 13th Sept '68
REFERENCE		F — Firm	C — Compact	MD — Medium Dense	M — Moist	START — TRACED AMcD
Fuller	WC Water cut	St — Stiff	VC — Very Compact	D — Dense	W — Wet	FINISH — CHECKED
Map		V. St — Very Stiff		VD — Very Dense	S — Saturated	SHEET 1 OF 1 — DRG No. S6827 Ha.G.
Photo		H — Hard			LL — Liquid Limit	
					PL — Plastic Limit	