DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY
ENGINEERING DIVISION

GEOLOGICAL INVESTIGATIONS

TARCOOLA ALICE SPRINGS RAILWAY

ROBIN RISE TO MARLA BORE SECTION

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SUMMARY AND CONCLUSIONS

Geological mapping for engineering purposes along the Robin Rise to Marla Bore Section has revealed a predominant surface material of silty residual soil with areas of drift and dune sand, underlain by kaolinised Bulldog Shale bedrock. A zone of calcified soil, varying from powder calcrete through weak gravelly to strong sheet calcrete occurs immediately above bedrock. Minor areas of strong jasper silcrete, gravelly alluvium, silcrete ferricrete and powder gypsum also occur. Engineering properties of these materials have been estimated from field examination and physical testing, and may be summarised as follows:-

..... Most soil materials are suitable for common fill, except for the powder gypsum associated with scattered playas and possibly some of the kaolinised Bulldog Shale.

..... Calcrete, alluvial gravel and possibly jasper silcrete will provide sources of selected fill up to the Murloocoppie area (chainage B60.0 km). Thereafter selected fill will be more difficult to obtain and the variable calcified soil horizon will have to be utilised.

..... No significant foundation problems are likely to occur provided undercutting is carried out in playas and compaction in areas of powder calcrete.

..... Excavation can be readily carried out by earthmoving equipment although heavy ripping and blasting may prove necessary in sheet calcrete, silcrete and in portions of the Bulldog Shale.

..... Gravels marginally suited for concrete aggregate occur at Long Creek and Mabel Creek. These materials are predominantly silcrete and reactive with cement. No other suitable sources of aggregate have been located and the use of ballast material for concrete is recommended.

..... Groundwater investigations continue along this section of the line. So far sufficient quantities for compaction are indicated although most water encountered is saline ranging from 3 000 to 66 000 mg/l. No potable water has so far been encountered.

INTRODUCTION

The first report on the Engineering Geological investigations for the Tarcoola Alice Springs Railway covered the Section from Tarcoola to Robin Rise (Jeune: Rept.Bk.No. 72/157). This report continues the investigations for a further 250 km north to Marla Bore Airstrip. Purpose of the investigations are to:-

.... Examine and describe the rocks and soils to determine their engineering properties.

.... Locate suitable sources of concrete aggregate.

.... Locate sources of water for camp and construction use.

.... Examine foundation conditions for bridges at stream crossing sites.

This report presents the results of geological investigations along the Robin Rise to Marla Bore Section of the proposed line, together with a summary of the results of Hydrogeological Drilling to the end of 1973. It has been compiled by J. Selby and G.H. McNally from notes and maps prepared by R.F. Jeune.

Bridge sites along this section at Long's Creek and Mabel Creek, have been investigated and are covered by a separate report (Jeune, Rept.Bk.No. 72/192). Drilling at other minor bridge sites is in progress and results will be presented at completion of the programme (McNally, 1975, in preparation).

METHODS

Base maps covering this Section of the proposed line (from A160 km to B196 km) at a scale of 1:24 000 were supplied by Commonwealth Railways, together with working plans and sections.

Soils and rocks were examined in natural exposures, pits and in a series of trenches excavated by bulldozer. These trenches have been left open for inspection, and it is requested that they be filled in during construction.

Selected samples of materials were submitted to South Australian Highways Department and to the Engineering and Water Supply Department (Appendix III).

Geological boundaries were plotted from air photo interpretation, supplemented by field checks.

TOPOGRAPHY

Topography over this part of the railway varies and may be summarised as follows:-

Section	Topography
Robin Rise to Mabel Creek	Flat stony desert of lag gravel*
Mabel Creek to Murloocoppie	Low undulating hills with sharp rock outcrops
Murloocoppie to Mt. Willoughby	Flat sandy desert with claypan "crab-holes"*
Mt. Willoughby to Wintinna Hill	Low undulating hills with sharp rock outcrops
Wintinna Hill to Marla Bore	Flat sandy desert

Two major water courses, Long Creek and Mabel Creek, cross the line. "Crab-holes" occur in the floor of many of the shallow claypans and this country (Qpr) becomes very difficult to negotiate in wet weather.

GEOLOGY AND ENGINEERING PROPERTIES

The regional stratigraphic sequence is given in Table 1 and detailed surface geology is shown on the maps. Dual symbols have been used on the maps in which the upper symbol indicates surface material and the lower, probable subsurface material. This system has been devised because the presence of subsurface calcrete is important in the planning of construction techniques.

A detailed discussion of each stratigraphic unit follows. Samples tested from each unit are listed in Table 3. and a summary of anticipated conditions in Appendix I.

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*Lag gravel: Residual accumulation of coarser particles from which the finer material has been blown away.

*Crab-hole: A cavity usually occurring in the centre of a shallow claypan caused by the infiltration of runoff into deeper, more permeable layers.

RECENT ALLUVIUM (Qra)

Unconsolidated, generally clean, sands and silty sands of the present stream courses.

Minor deposits of locally derived sands and silty sands partially fill minor watercourses. Such deposits are thin (15-30 cm), of extremely limited extent and are probably mobile during periods of runoff. Large quantities of fine gravel occupy the channels of Long Creek and Mabel Creek. These deposits are discussed in greater detail in Jeune, 1972 (Rept.Bk.No. 72/192).

Engineering Properties

Deposits in local watercourses would be suitable for low strength concrete but quantities are too small for practical exploitation. Since these deposits are mobile, culverts must be designed to accept high bed loads. Culvert sites should be undercut to relatively impervious materials to prevent undermining and collapse.

Alluvial materials are suitable for use as fill but their poor grading may cause difficulties in compaction. Normal earth moving methods should prove adequate.

PLAYA DEPOSITS (Qrl)

Saline, gypseous, clayey and silty deposits of lakes, claypans and swamps (usually dry).

Depressions forming local base level for closed drainage systems contain fine grained alluvial deposits, commonly mixed with variable proportions of gypsum and soluble salts. A porous, low density surface crust of evaporite is common in larger playas. Although these deposits are normally dry they become soft and wet after rain. A bed of compact crystalline gypsum encountered in playas on the Tarcoola-Robin Rise Section appears to form an impervious seal limiting the downward percolation of surface water but there is no certainty that this seal is ubiquitous. Total thickness of playa deposits is unknown.

Engineering Properties

Softening of playa deposits following rain is a potential cause of foundation failure, and since drainage is virtually impossible, design should allow for the possibility of such softening occurring during service. Removal of the thinner deposits and replacement with moisture-insensitive material (e.g. drift sand) is recommended. Where thicker deposits are encountered, it is suggested that design should provide for the correction of any settlement by packing and that the toes of potential shear failures should be loaded by berms of wide based fills. Excessive undercutting (say greater than 0.5 m) in thick deposits and replacement with sand is not recommended as this would provide a percolation path to lower levels.

Provision of culverts through fills is recommended to prevent the build up of hydraulic gradients.

Normal earth moving excavation methods, possibly with light ripping should prove adequate when materials are dry. However, should these materials become wet they become impassable to wheeled traffic, and tracked machinery or possibly a dragline may prove necessary. Heavy ripping may be required if excavation of the compact crystalline gypsum bed becomes necessary.

Use of Playa Deposits as fill is not recommended due to the presence of soluble salts. However, their use as a non load-bearing water-bound protective skin may prevent excessive wind erosion of sand fill.

DRIFT SANDS (Qrs) AND DUNE SAND (Qrd)

Sands and silty sands forming drift sheets and dunes.

These sand deposits are normally red-brown in colour, loose to medium dense, poorly graded and contain only minor clay binder.

Dunes are confused in form, and partially fixed by vegetation but areas of blow-out are common and sand movement is active. The major period of sand movement was probably Late Pleistocene - Early Holocene and present sand movement could be due to the removal of binding vegetation by pastoral activity.

Engineering Properties

Bearing capacities are adequate and no significant settlement should occur provided loose surface material is removed or compacted prior to emplacement of fill. Normal earth moving methods, possibly with minimal light ripping, should prove adequate.

Although binder content is low, these materials are suitable for fill. Relative compaction at natural moisture contents will be low, and problems with dust and "live" materials will almost certainly arise. Deflation will almost certainly occur during service life. It is recommended that wherever possible at least the outer layers of fills should be compacted damp and protected by silcrete gravel, calcified soil, or Residual Soil.

Batter angles in fill and long term cut batter angles should approach the angle of repose of loose dry sand (33^{o}). Accordingly, both cut and fill batters of 35^{o} are recommended.

OLDER PLEISTOCENE ALLUVIUM (Qpa)

Dense to medium dense dirty gravel, gravelly sand, and silty sand with occasional silt lenses.

These deposits occupy older channels of major streams and grade laterally into Residual Soil (Qpr) and Tertiary Silcrete (Tsi).

Engineering Properties

Bearing capacity is adequate for fills. Normal earth moving methods, possibly with minimal light ripping, should prove adequate. All materials examined should prove adequate as fill and no protection against deflation should be necessary. Batter angles of 35^{o} are recommended for both cuts and fills.

Care should be taken to ensure that stream channels are not unduly restricted as, although these materials appear to resist scour under present conditions, it is likely that scour could occur if stream velocities are increased significantly.

RESIDUAL SOIL (Qpr and Qps)

Medium-dense red brown silty clay, commonly with scattered sub-rounded pebbles up to 5 cm diameter. A lag gravel ("gibber") surface skin is common, and much of the area mapped as Residual Soil forms "Crab-hole country" - a series of scattered circular hollows up to 5 metres in diameter and up to 1 metre deep. When wet, residual soil becomes extremely soft and slippery (impassable to 4 wheel drive vehicles). Gravelly slope wash material of the same age has been distinguished as (Qps). The unit referred to as the "Doonbara Formation equivalent" in bridge site logs (McNally, 1975) is largely a Residual Soil in origin, though it may have been reworked in places by stream action.

Engineering Properties

Although these materials soften when wet, bearing capacity should prove sufficient to support the formation. Adequate drainage should be provided. These materials should provide excellent fill if compacted damp, no protection against deflation being necessary. Fills should be shaped to shed water to prevent undue softening by rain. Minimal light ripping may be necessary in excavations. Batter angles of 45^{o} are recommended.

Laboratory sieve analysis tests (Figs. 9, 14, 18, 19, 21, 22 and 33) indicate that this material is moderately well-graded with a variable silt/clay content.

CALCRETE (Qca) AND CALCIFIED SOIL (Qcl)

Nodular and strong sheet calcrete (Qca) and zone of sub-soil lime accumulation (Qcl).

The following classification has been adopted from a more comprehensive scheme proposed by Netterberg (1967).

Nodular calcrete - Discrete, medium strong to strong concretions of carbonate-cemented soil in a loose calcareous soil matrix.

Sheet calcrete - Medium strong to strong near horizontal, continuous near continuous or broken sheets of carbonate-cemented soil, underlain by loose fine grained carbonate powder calcrete.

Calcified soil - Soil weakly cemented by carbonate.

These categories intergrade but have been found useful as descriptive terms. Although sheet calcrete and nodular calcrete have slightly different engineering properties, it was not found practical to map them separately, as their natural surface expressions are similar.

Netterberg states that sheet calcrete is invariably underlain by loose powder calcrete, and that the stronger the sheet calcrete the weaker and more useless for road building purposes will be the underlying powder calcrete. Although sheet calcrete could rarely be penetrated during this present survey no evidence was found to contradict Netterberg's generalisation, and loose powder calcrete may be expected to underly sheet calcrete.

During this survey, weak ironpan was almost invariably found in intimate mixtures with calcified soil and has been mapped with the calcified soil.

Sheet and nodular calcrete are almost invariably overlain by a thin zone of calcified soil.

Calcrete and calcified soil are zones of subsoil lime accumulation thought to result from concentration of windblown calcareous dust blown from the Nullarbor Plain. Although probably still forming, the main period of formation was probably contemporaneous with the period of main sand movement, i.e. Late Pleistocene - Early Holocene.

Engineering Properties

Sheet calcrete should have reasonable bearing capacity provided there remains a thickness of not less than about 0.8 m over the underlying powder calcrete. It is recommended that, wherever calcrete is encountered in excavation its thickness should be checked with a jack hammer hole prior to emplacement of fill. Every effort should be made to avoid excessive excavation of calcrete into the underlying weaker material. Calcified soil by the nature of its wind blown deposition in an arid climate, commonly consists of sand grains weakly cemented by lime and is of low density. These materials are of low bearing capacity and "collapse" readily under load particularly when wet. It is difficult to tell in the field which limy sands are "collapsing" and which are "non-collapsing" as density is the main indicator. Thus it is recommended that all limy soils (including nodular calcrete) should be compacted, preferably with the addition of water, prior to placement of fill. This should result in a dense strong foundation material, with no likelihood of differential settlement. Densities achieved by dry compaction are likely to be low.

Excavation of calcified soil and nodular calcrete required only light ripping by the rubber tyred Le Torneau LW16 dozer used in investigations. However this machine proved incapable of ripping strong sheet calcrete and heavier tracked machinery will be necessary. Blasting may be necessary if particularly strong calcrete is encountered.

All the limy materials except powder calcrete would make good fill material, as any reworking results in the breakage of the weak lime cement bond between sand grains and thus, in placing, a reasonably dense fill result. Compaction will be improved by addition of water.

Some wind erosion of the lime may occur on exposed surfaces, but the severity would depend on the presence and quantity of gravel sized calcrete particles. Use of calcrete, preferably water bound, as a protective outer zone is recommended.

Due to the lime cement, batters may stand at a steep angle in the dry condition, but for long term stability batters of 35° are recommended.

YOUNGER SILCRETE (Qsi) - "JASPER"

Medium strong to strong, red, pink and white silcrete and silicified kaolin clay, forming ridge cappings and scarps.

This material apparently formed during a later phase of silicification than Tertiary Silcrete (Tsi) from which it varies mainly in colour, lower density, closer jointing (2-5 cm) and lower strength. In most exposures examined it grades down through slightly silicified white and red kaolinitic clay to unsilicified white kaolin clay (bleached Bulldog Shale). Silicification is thought to post date kaolinization, and is probably early Pleistocene in age.

Engineering Properties

Bearing capacity is adequate to support the formation. Excavation will require medium to heavy ripping with some blasting. These materials would form acceptable fill. A waterbound mixture of younger silcrete and Residual Soil would form a good protective blanket to protect underlying materials against deflation or scour. Since scarps stand vertically, cut batters could be expected also to stand vertically.

FERRICRETE (Tfe)

Strong sheet ferricrete (ironstone) and coarse lag gravel resulting from the physical disintegration of such sheets.

Intact and near intact ferricrete sheets cover large areas adjacent to the Long's Creek Crossing. Thickness of sheet ferricrete could not be accurately measured but is estimated at 30-50 cm.

Sheet ferricrete appears to be closely related to Tertiary Silcrete (Tsi) and marks the position of the same mid-Tertiary land surface.

Engineering Properties

Intact and disintegrated sheet ferricrete should provide adequate foundations for earthworks. Excavation will require medium to heavy ripping, though only minor blasting should be necessary. Ferricrete should form acceptable fill, particularly if mixed with suitable fines to act as binder. Its use as a protective blanket over sand fill is recommended.

TERTIARY SILCRETE (Tsi)

Strong sheet silcrete, and coarse lag gravel resulting from the physical disintegration of such sheets.

Small areas of intact or near intact sheet silcrete occur as ridge cappings and as isolated patches in topographic lows. Thickness of sheet silcrete could not be measured but is estimated at 30-50 cm.

Sheet silcrete marks the position of an old mid-Tertiary land surface that has been almost completely destroyed by more recent erosion.

Engineering Properties.

Sheet silcrete should provide adequate foundations for earthworks and no surface preparation should be necessary before emplacement of formation. Excavation will probably require light to medium ripping and minor blasting. The rubber tyred Le Torneau LW16 tractor used in investigations proved incapable of ripping sheet silcrete but heavier tracked machines should prove suitable and only minor blasting should be necessary. Use of material as a protective blanket over sand fills is recommended.

Silcrete contains silica as opal or chalcedony and is potentially reactive with cement. The extremely sharp fragments that are liable to fly when silcrete is crushed or struck could cause serious injury and construction staff should be advised to protect their eyesight when working with this material. The life of rubber tyres is likely to be low.

BULLDOG SHALE (Klb)

Stiff white and red/white mottled kaolinitic clay and weak siltstone, in part weakly cemented by secondary silicification.

Stratigraphic Relations

Kaolinitic clay mapped in this report as Bulldog Shale represents the upper part of the unit that has been substantially modified by Tertiary and Quaternary weathering processes. Silicification of this weathered profile, presumably during early Quaternary times formed a silcrete profile, mapped separately in this report as Younger Silcrete (Qsi).

Disintegration of this silcrete profile and further weathering appatently formed the soil profile mapped as Residual Soil (Qpr).

Kaolinitic clay mapped as Bulldog Shale (Klb) probably underlies most of the area covered by this report and can thus be expected in deep excavations. It occurs at surface or near surface only where overlying materials have been stripped by comparatively recent erosion.

Engineering Properties

Special laboratory tests were devised to cope with the blocky nature of this material:-

.... samples were crushed to pass BS 3/4" (19 mm) sieve and sieve analyses were carried out.

.... Representative samples of these were sieved on a BS No. 7 (2.36 mm) sieve, the portions retained being washed and oven dried. The oven-dried samples were supported on sieves under a fine garden sprinkler and the water turned on. Moisture contents were taken at ten minute intervals for one hour. Moisture content versus time graphs are shown in Fig. 36.

.... The crushed samples MWBP 1 and B49.200 km (passing 19 mm sieve) were wetted to the moisture content corresponding to ten minutes sprinkling, and sample B139.100 km wetted to the moisture content corresponding to twenty minutes sprinkling. These samples were compacted using the Modified AASHO Test and then the whole compacted sample was oven-dried to obtain moisture content and dry density.

.... Sieve analysis was carried out on each sample to ascertain breakdown during compaction.

Results of all of these tests are given in Figs. 10, 16, 20, 26, 27 and 34.

It may be noted that the effect of wetting and compaction tends to produce fairly uniform, well-graded curves for each sample. Bulk densities, although low, are considered acceptable for embankment fill. Material well-cemented by iron oxide or silica may be expected to compact adequately at low moisture contents. However the whiter, more kaolinitic material such as that found at Mount Willoughby Borrow Pit has performed poorly as unsealed surface course on the Stuart Highway, after excessive wetting due to heavy rain.

It is recommended that compaction be carried out after visual rejection of the most kaolinitic material, at low moisture content and at low loads, preferably with a grid roller. Some of the more cemented material may also prove acceptable for selected fill. Excessive compaction should be avoided.

Normal earthmoving machinery should prove adequate for excavation and it is expected that bearing capacity of the dry in situ material will prove adequate.

Further comments on the compaction of this and other fill materials are included in Appendix III.

CADNA-OWIE FORMATION (Klc)

Weak to very weak white quartz sandstone (or compact sand) with kaolinitic matrix. Irregular secondary silica cementation forms zones of strong rock.

No Cadna-owie Formation was identified in outcrop but was encountered in drilling at Long's Creek bridge sites (Jeune 1972, RB. 72/192, discussed as Algebuckina Sandstone). Cadna-owie Formation is believed to underly small areas adjacent to Long Creek.

Engineering Properties

Bearing capacity is high. Excavation may require ripping and could require blasting should strong silicification be encountered. Sandstone should make excellent fill. Cut batter angles of 45^{o} and fill batters of 25^{o} are suggested.

WATER SUPPLIES

Compaction water requirements have been estimated at 230 m^3/day. Saline water is acceptable for compaction but small quantities of potable water are required for mixing concrete and for camp purposes.

Rainfall is intermittent and permanent water supplies are absent.

Drilling Programme

By completion of the 1973 drilling programme in October 1973 a total of 7 successful bores had been completed along this section of the railway. Results of drilling are summarised in Table 2 and successful bores are shown on the detailed geological plans.

Drilling continued during 1974 and 1975.

Potable water

Groundwater at Murloocoppie (Water well 29, at B56.5 km) was found to be comparatively fresh although yield was low. This water may be suitable for general use.

Fresh water also occurs at Mt. Willoughby and this will be further investigated during the 1974 season.

Water for Concrete

Generally water most suitable for concrete making has a Total Dissolved Solids (TDS) content of less than 5 000 mg/l and an Na ion content of under 1 000 mg/l. If these TDS values are exceeded, tests for reduced strength and length change should be carried out before using the water. A high Na/K ion content is significant if an alkali-reactive aggregate is to be used. In addition a Cl ion content of 1500 mg/l is generally accepted as the maximum permissable figure for concrete in contact with reinforcing steel.

Adopting the above criteria an assessment of the suitability for concrete from all water wells so far drilled on this section of the line has been given in Table 2. This information is based on full analyses given by Smith (Rept.Bk.74/12).

CONCRETE AGGREGATE

Gravel deposits suitable as sources of low quality aggregate have been located in the river beds of Long Creek and Mabel Creek. The gravel is composed predominantly of silcrete which is reactive with cement, although this material has been used for concrete in engineering projects at Coober Pedy. Available volume of this material has been estimated by Jeune (Rept.Bk.72/192).

Tertiary silcrete could be crushed and screened to provide aggregate but quantities available at any site are low. This silcrete contains opal or chalcedony and so is potentially reactive with cement, though it has been used as a source of concrete aggregate in engineering projects at Coober Pedy.

Good quality sheet and nodular calcrete is used for concrete aggregate in some areas of the State. Its quality is however variable and much of this material has a high dust content after crushing.

The most reliable source of concrete would appear to be ballast material, which for this Section of the line will probably consist of porphyry from Perfection Well.

13th March, 1975
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TABLE 1

PROBABLE REGIONAL STRATIGRAPHIC SEQUENCE

(ROBIN RISE TO MARLA BORE SECTION)

Age	Mapping Symbol	Unit	Lithology
	Qra	RECENT ALLUVIUM	Unconsolidated, generally clean sands and gravels of the present stream courses.
	Qrl	PLAYA DEPOSITS	Saline, gypseous, clayey, and silty deposits of lakes, clay pans and swamps (usually dry).
QUATERNARY	Qrs	DRIFT SAND	Sands and silty sands forming drift sheets.
	Qrd	DUNE SAND	Sands and silty sands forming dunes.
	Qpa	OLDER ALLUVIUM	Dirty gravel and sand of former river channels.
	Qpr/Qps	RESIDUAL SOIL	Silty clay with a skin of lag gravel.
	Qcl	CALCIFIED SOIL	Zone of subsoil lime accumulation.
	Qca	CALCRETE	Nodular, and strong sheet calcrete.
	Qsi	YOUNGER SILCRETE	"Jasper" silcrete forming ridge cappings and scarps.
	Tfe	FERRICRETE	Sheet "ironstone" and coarse lag gravel.
TERTIARY	Tsi	TERTIARY SILCRETE	Sheet silcrete and coarse lag gravel.
MESOZOIC	Klb	BULLDOG SHALE	Mottled kaolinitic clay partly silicified.
	Klc	CADNA-OWIE FORMATION	White Quartz sandstone with kaolinitic matrix.

TABLE 2

GROUNDWATER SUMMARY
(ROBIN RISE TO MARLA BORE SECTION)

Well	Location km	Depth m	Static W.L. m	Yield l/sec (gph)	Salinity mg/l	Main Aquifer	Suitability for Concrete
17	162A	58.5	13.4	7.8 (6200)	66 900	Jua	Probably unsuitable
15	170A	39	20	5.3 (4200)	42 200	Jua	Probably unsuitable
26	202A	100	73	2.0* (1600)	8 200	Jua	Not suitable for reinforced. Strength and shrinkage tests recommended.
27	1B	94	65	2.5 (2000)	2 500	Jua	Suitable
28	17B	132	105	0.5* (400)	3 500	Jua	Borderline for reinforced
29	56½B	50	30	1.0 (800)	1 735	Klb	Suitable
30	To be completed in 1974 season						

*Bore is capable of greater yield

Jua Algebuckina Sandstone

Klb Bulldog Shale

NOTE: Water well drilling is to be continued along this section during 1975

TABLE 3

SUMMARY OF LABORATORY SOIL TEST RESULTS

Compaction Tests

Sample Chainage (km)	Mapping Unit	Consistency Limits				Est. C.B.R.	Field M.C.%*	Standard AASHO**		Modified AASHO	
		L.L.	P.L.	P.I.	L.S.			M.D.D.(p.c.f.)	O.M.C.%	M.D.D.(p.c.f.)	O.M.C.%
164.7B	Dune Sand (Qrd)	-	-	N.P.	-	13.7	1	-	-	116	10
179.0B	" "	-	-	N.P.	0	19	0.5	114	11	-	-
160.0B	Drift Sand on Residual Soil (Qrs/Qpr)	20	12	8	-	14.5	3	-	-	130	8
27.9B	Residual Soil(Qpr)	36	32	4	2	28	6.3	95	23	-	-
97.0B	" "	43	17	26	12	7.3	6.8	105	19	-	-
100.0B	" "	-	-	N.P.	-	42	9.5	-	-	95	21.5
130.0B	" "	48	22	26	-	8.2	7	-	-	113	14
190.0B	" "	20	9	11	5	19	3.5	137	9	-	-
170.0A	Residual Soil + Silcrete (Qpr + Qsi)	29	17	12	-	17	-	-	-	127	9.5
200.0A	Residual Soil on Calcrete (Qpr/Qca)	-	-	N.P.	-	72	-	-	-	-	-
177.4A	Bulldog Shale(Klb)	51	25	26	-	7.6	-	-	-	110	17
49.2B	" "	-	-	-	-	-	-	-	-	89	11
139.1B	" "	-	-	-	-	-	-	-	-	82	29
144.0B	" "	62	24	38	16	4	16.3	92	26	-	-
Mt. Willoughby Borrow Pit	" "	-	-	-	-	-	-	-	-	103	12
161.5A	Playa Deposits (Qrl)	35	16	19	-	9.6	-	-	-	117	14.5

* After transportation of unsealed samples to Adelaide
** Compaction curves not available

APPENDIX I - ROBIN RISE TO MARLA BORE SECTION
SUMMARY OF ANTICIPATED CONDITIONS

Chainage (km)	Predominant Material	Suggested Fill Material (a) Common Fill	(b) Selected Fill	Comments
A159.5 to 162.0	Sand dunes on calcrete	Dune sand but protection against deflation may be necessary. Fill batters 35° recommended.	Calcrete	Blasting may be necessary to remove calcrete.
A162.0	Small playa	Dune sand	Calcrete	Undercut upper powder gypsum layer. Fill should accept settlement and resist shear failure.
A162.2 to 169.0	Variable silty residual soil with patches of drift sand and ferricrete lag gravel.	Drift sand and residual soil	Long's Creek gravel but addition of binder may be necessary	Heavy ripping may be required in ferricrete patches.
A169.0 to 169.8	Long Creek Alluvium			See Jeune (Rept.Bk.72/192) for Bridge site investigation.
A169.8 to 176.0	Silty residual soil grading to calcified soil	Residual soil	Long's Creek gravel	
A176.0 to 178.0	Jasper silcrete on Bulldog Shale	Silcrete	Long's Creek gravel	Silcrete may require heavy ripping and blasting
A178.0 to B0.0	Silty residual soil on calcrete with scattered small playas	Residual soil	Calcrete or Mabel Creek gravel	Blasting may be necessary to remove calcrete
B0.0 to 1.0	Mabel Creek Alluvium			See Jeune (Rept.Bk.72/192) for Bridge site investigation

B1.0 to 8.7	Silty residual soil on calcrete	Residual soil	Calcrete or Mabel Creek gravel	Blasting may be necessary in calcrete
B8.7 to 17.5	Silty residual soil grading to calcified soil	Residual soil	Calcified soil may be suitable	
B17.5 to 21.0	Silty residual soil on clayey Bulldog Shale	Residual soil	Calcified soil may be suitable from next section or local alluvium if sufficient.	Bulldog Shale will need visual checking for fill suitability.
B21.0 to 35.0	Silty residual soil grading to calcified soil with jasper silcrete	Residual soil and silcrete	Possibly silcrete or local alluvium if sufficient	Blasting may be necessary in silcrete
B35.0 to 40.0	Residual and calcified soil on shallow Bulldog Shale. Jasper silcrete also present	Residual soil and silcrete	Calcified soil or possibly silcrete	
B40.0 to 45.0	Residual soil grading to calcified soil	Residual soil	Calcified soil	
B45.0 to 55.0	Residual soil and jasper silcrete on shallow Bulldog Shale	Residual soil and silcrete	Possibly silcrete	
B55.0 to 61.2	Residual soil grading to calcified soil	Residual soil	Possibly silcrete	
B61.2 to 70.0 approx.	Drift sand on residual and calcified soil	Drift sand and residual soil	Suitable selected fill will be difficult to obtain from now on. Calcified soil has been suggested as only alternative	

B70.0 approx. to 84.0	Drift sand with scattered dunes on older calcified alluvium	Drift and dune sand	Older alluvium	Protection of sand embankments against deflation may be necessary
B84.0 to 104.3	Residual soil grading to calcified soil with scattered playas after 95.0	Residual soil	Possibly calcified soil	Undercut powder gypsum in playa at 101.8 km
B104.3 to 126.0	Drift sand on residual soil grading to calcified soil	Drift sand and residual soil	Calcified soil	Playa at Cadney Park now by-passed by new alignment
B126.0 to 134.0	Residual soil grading to calcified soil	Residual soil	Calcified soil	
B134.0 to 145.0	Residual and calcified soil with outcrops of Bulldog Shale. Scattered jasper silcrete	Residual soil and silcrete	Silcrete and/or calcified soil	Bulldog shale rippable.
B145.0 to 153.3	Residual soil grading to calcified soil	Residual soil	Calcified soil	
B153.3 to 163.6	Drift sand on residual and calcified soil	Residual soil	Calcified soil	
B163.6 to 196.0	Dune and drift sand on residual and calcified soil	Sand and residual soil	Calcified soil	Protection of sand embankments against deflation may be necessary

APPENDIX II

ROBIN RISE TO MARLA BORE SECTION

km	TRENCH LOGS	MAP UNIT
159A		
Surface	Gibber (Tsi) to 30 cm diameter, usually 3-4 cm	Qpr
0-60 cm	Red-brown silty clay, occasional rounded Tsi pebbles to 5 cm. Basal 15 cm weakly iron cemented	
Grades to 60-100	Calcified red-brown silty clay occasional Tsi pebbles	Qcl
Grades to 100 +	Silcrete (Tsi) boulders to 60 cm (rare) in weak calcrete, minor Fe cement. Difficult to rip.	Qca
160.4A		
Surface	Dune sand	Qrd
0-50+ cm	Very loose, red-brown fine sand.	
165.9A		
Surface	Gibber (Tsi, Tfe) to 5 cm, scattered on sand	
0-70 cm	Red-brown silty clay, occasional Tsi (rounded) to 5 cm	Qpr
70-90	Calcified red-brown silty clay, occasional Tsi	Qcl
90-100+	Sandstone, weak, weathered, slightly calcified and silicified	Klc
166.5A		
Surface	Gibber to 5 cm on sand	
0-60 cm	Red-brown silty clay, occasional Tsi (rounded) to 5 cm	Qpr
60-100	Calcified red-brown silty clay, occasional Tsi pebbles	Qcl
100-130	Sandstone, weak, weathered, slightly calcified and silicified Rippable with heavy plant	Klc
167.5A		
Surface	Ironstone gravel to 30 cm in sand	
0-75 cm	Red-brown silty clay, occasional Tsi pebbles (rounded)	Qpr
75-100	Sandstone, weak, weathered, minor clay, paleosol remnants, minor gypsum crystals	Klc
100+	Weak weathered sandstone	Klc
168.0A		
Surface	Ironstone lag gravel	
0-60 cm	Red-brown silty clay, occasional Tsi pebbles	Qpr
60-120	Tsi and Tfe boulders to 15 cm in calcified soil matrix	Qcl
120+	Weak, weathered sandstone	Klc
170.02A		
Surface	Gibber, rounded, Tsi, 3 cm (red)	
0-30 cm	Red-brown silty clay, very weak soil structure	Qpr
30-70	Calcified red-brown silty clay	Qcl
70-110+	Calcified red-brown silty clay with weak ironpan	?Klb

176.2A		
Long's Creek overflow channel		
0-50 cm	Dense dirty gravel)	
50-70	Dense gravel, green clay matrix)	Qpa
70-80+	Dense clean gravel to 2 cm)	
177.4A	Top of ridge	
Surface	Gibber to 20 cm usually subrounded (Tsi)	
0-70 cm	Red-brown silty clay, occasional rounded to sub angular Tsi to 5 cm	Qsi
70+	Strong calcified, silicified shale of Mabel Creek. Rippable with heavy machinery. (Note: Calcrete adjacent, undermined by rabbits)	Klb
180.0A		
Surface	Gibber, 5 cm, rounded	
0-40 cm	Red-brown clayey silt("bulldust") weak soil structure	Qpr
40-60	Calcified red-brown clayey silt	Qcl
Grading to		
60-160	Weak porous calcrete with occasional rounded Tsi pebbles	Qca
181.9A	Top of ridge	
Surface	Gibber, mainly red. Rare blocks white Tsi in situ nearby (up to 60 cm)	
0-25 cm	Red-brown silty clay. Moderate soil development)	
25-85	Orange-brown compact clayey silt with 20-30% sub) angular silcrete (Tsi) gravel	Qpr
85-100+	Calcified orange-brown compact clayey silt with 20-30% subangular (Tsi) gravel	Qcl
184.9A	Top of ridge	
Surface	Gibber to 10 cm, mainly red silcrete	
0-45 cm	Red-brown clayey silt	Qpr
45-110+	Calcified red-brown clayey silt, grading to very weak calcrete (Crumbly but probably compacts satisfactorily with water)	Qcl / Qca
190.0A		
Surface	Gibber (round) 3-4 cm	
0-30 cm	Red-brown clayey silt, rare pebbles	Qpr
30+	Strong sheet calcrete	Qca
200.0A		
Surface	Rounded gibber to 5 cm	
0-25 cm	Red-brown clayey silt, occasional pebbles	Qpr
Grading to		
25-105+	Laminated weak calcrete and ironpan in red-brown clayey silt matrix	Qca
105	Limit of ripping (LW16)	
210.6A		
Surface	Gibber to 20 cm (Tsi) red and grey angular sub-rounded	
0-20 cm	Dark brown nutty clay (soil horizon))	
20-80	Medium dense orange-brown clayey silt with 20-30%) subangular to sub rounded Tsi to 20 cm usually 5cm)	Qpr
80+	Silicified, calcified red-white mottled clay (shale) Too strong to rip with LW16 rippable heavy plant	Klb

10.0B		
Surface	Crabhole with gibber to 10 cm	
0-60 cm	Red-brown silty clay, rare (Tsi) to 1 cm	Qpr
60-110+	Interbedded weak calcrete and ironpan with occasional Tsi rounded to 10 cm	Qcl
13.4B	Stream bed	
Surface	Crabholes with gibber to 10 cm	
0-40 cm	Red-brown silty clay, occasional Tsi to 5 cm, sub rounded	Qpr
40-90+	Weak calcrete, ironpan, laminated	Qcl
18.5B	Bed of stream	
Surface	Sand	
0-40 cm	Red-brown silt, trace gravel to 1 cm	Qra
40-100+	Dense silty gravel to 5 cm	Qra-Qpa
19.6B		
0-100 cm	Dense silty gravel, (narrow stream bed)	Qpa
20.00B		
Surface	Angular shale fragments, part silicified, to 1-2 cm	
0-80+ cm	Red-brown clayey silt with angular shale fragments	?Qpr / ?Klb
20.60B		
Surface	Angular shale chips 1-5%, white, purple	Qpr
0-100+ cm	Medium strong white and purple siltstone (shale) Rippable LW16	Klb
24.1B	Bed of stream	
0-40 cm	Loose red-brown gravelly sand, mobile	Qra
40-120	Dense orange brown clayey silt with 30% gravel to 2 cm	Qpa
120+	Gravel, 10 cm, in very stiff silty clay matrix	Qpa
27.85B		
Surface	Gibber to 5 cm	
0-40 cm	Red-brown silty clay	Qpr
40-50+	Weak ironpan?	
30.00B		
Surface	Gibber on crabhole	
0-50 cm	Red-brown silty clay rare gravel (Tsi, Qca) to 5 cm. No lime.	Qpr
50-75+	Tsi (round) to 5 cm in matrix of red sandy silt, calcified, ironpan	Qcl
35.0B		
Surface	Gibber, round, 5 cm on crabholes	
0-50 cm	Red-brown silty clay rare pebbles (round) to 2 cm	Qpr
50-110	Weak laminated calcrete and ironpan	Qcl
40.0B		
Surface	Gibber (round) to 5 cm	
0-30 cm	Orange-brown silt	Qpr
30-50+	Weak ironpan, minor calcrete	

45.4B		
Surface	Flat gibber rounded, 2-3 cm	
0-35 cm	Red-brown clayey silt	Qpr
35-50+	Weak laminated calcrete/ironpan,	Qcl
53.95B	Bed of major stream	
	Mixture of boulders to 20 cm, powdery calcrete and green silty clay	Qpr
60.0B		
Surface	Rounded Tsi, white and red 2-3 cm	Qpr
0-30 cm	Orange-brown compact clayey silt	
30-50+	Calcareous cemented orange-brown clayey silt with iron cementing	
69.95B		
Surface	Sandy silt with scattered Tsi and Tfe to 2 cm	
0-40 cm	Orange-brown fine sandy silt with occasional rounded pebbles to 1 cm	Qpr
40-60+	Platy calcrete/ironpan mixture, medium strong. Will compact well if wet	Qcl
87.0B		
Surface	Drift sand with ironstone pan gravel in crabhole terrain	
0-50 cm	Red-brown silty clay	Qpr
50-60+	Iron and lime cemented shale	Qcl/Klb
97.0B	Surface crabhole	
0-80 cm	Red-brown silty clay	Qpr
80-100+	Calcified and ferruginised shale	Qcl/Klb
100.0B		
Surface	Rounded gibber to 3 cm in silty matrix	
0-10 cm	Fine red-brown clayey silt	Qpr
10-80+	Calcified and iron cemented silt and silty clay	Qcl
106.0B		
Surface	Drift with scattered rounded gibber to 3 cm	Qrs
0-20 cm	Red-brown clayey silt	Qpr
20-40+	Calcified and ferruginised shale	Qcl/Klb
110.0B		
Surface	Drift, scattered gibber	
0-25 cm	Red-brown fine sandy silt, trace gravel to 1 cm	Qrs
25-35+	Calcified and ferruginised shale	Qcl
114.5B	Cadney Park Claypan	
0-20 cm	Loose grey-brown clayey silt	Qrl
20-30	Loose powdery limey silt	
30-60	Stiff greenish grey blocky clay, high plasticity	
60+	Strong ironpan, too strong to rip (LW16)	
128.95B	Bed of watercourse	
Surface	Drift	
0-70+ cm	Dense well rounded Tsi gravel to 3 cm in silty sand matrix	Qpa

130.0B		
Surface	Gibber (10 cm) and crabholes	
0-45 cm	Red-brown silty clay	Qpr
45-50+	Strong to medium strong iron cemented shale	Klb
140.0B		
Surface	Gibber to 10 cm	
0-40 cm	Red-brown silty clay, rare pebbles	Qpr
40-100	Calcified silty clay (shale)	Klb
144.0B	Saddle	
Surface	Coarse rounded to subangular Tsi gibber and yellow siltstone chips. Minor crabhole development	
0-80 cm	Red-brown silty clay, scattered Tsi pebbles	Qpr
80-120+	Pinkish white weak siltstone	Klb
150.0B		
Surface	Rounded gibber to 5 cm on crabhole	
0-60 cm	Red-brown silty clay with weak calcrete and ironpan	Qpr
60-70	Weak calcrete/ironpan	Qcl
160.0B		
Surface	Drift sand	
0-100 cm	Drift sand with occasional lenses well rounded gravel to 5 cm	Qrs
100+	Weak ironpan in silt matrix	Qpr
169.2		
Surface	White angular silicified shale chips in silt matrix	
0-20 cm	Angular white silicified shale chips in silt matrix	Qpr
20+	Strong calcrete with shale chips. Too strong for LW16 but could be ripped by D9	Qca
170.0B		
0-80 cm	Dune sand	Qrd
80+	Strong calcrete with minor yellow silicified shale chips	Qca
174.2B	Floodway	
Surface	Sand	Qrs
0-100 cm	Silty sand	Qpr
100+	Calcified silty sand	Qcl
180.0B		
Surface	Dune sand	Qrd
0-50 cm	Red-brown fine sandy silt	Qrs
50-70+	Strong calcrete with minor silicified shale	Qca/Klb
190.0B		
Surface	Sand with scattered ironstone (rounded) to 1 cm	Qrs
0-65 cm	Red-brown silty fine sand with rounded gravel	Qpr
65-95+	Weak calcrete and ironpan	Qcl
192.8B		
Surface	Angular white silicified shale chips in silt matrix	Qpr
0-60 cm	Calcified silt with 20-30% angular white silicified shale chips	Qcl
60-80+	Strong calcrete with shale chips	Qca/Klb

APPENDIX III

ROBIN RISE TO MARLA BORE SECTION

REPORT ON LABORATORY TESTS ON EMBANKMENT FILL MATERIALS

by

Mr. S. Ronan
Engineering and Water Supply Department

GENERAL

A request was received on 4th September 1974, from the Department of Mines Engineering Geology Section to run a series of laboratory tests on embankment fill materials from locations between chanages B. 49.2 km and B. 164.7 km.

SAMPLE DESCRIPTIONS AND LABORATORY TESTS

The descriptions of the samples supplied by the Department of Mines are given below in Table 1.

TABLE 1

Sample No.	Description
B. 49.2 km (Klb)	Yellow-brown KAOLINITE; blocky, partly altered.
B. 100.0 km (Qpr)	Red-brown LATERITE: VERY FRIABLE
B. 130.0 km (Qpr)	Red-brown SILTY CLAY; very friable
B. 139.0 km (Klb)	White KAOLINITE: blocky; hard
B. 160.0 km (Qrs/Qpr)	Red-brown SILTY (CLAYEY) SAND
B. 164.7 km (Qrd)	Red-brown FINE SAND
MWBP.1	White KAOLINITE; blocky, hard

The following laboratory tests were requested:-

Sieve analysis
Atterberg limits, where applicable
Modified compaction tests
Estimated Californian Bearing ratio (CBR)

The test results, together with a description of the test procedures are appended. The South Australian Highways Department method of estimating CBR was used to obtain the CBR values.

COMPACTION RECOMMENDATIONS

KAOLINITE: (BULLDOG SHALE)	This should be treated as a weak rock. It should be compacted with a vibrating roller so as to achieve the best packing of this granular material. It only requires enough water to weaken the sharp edges and to aid the packing together of the blocky pieces. Nothing useful will be achieved by trying to grind it into a powder.
LATERITE AND SAND: (RESIDUAL SOIL)	These materials have very flat compaction curves and once a minimum amount of water has been added, little increase in density will be achieved by adding more.

SILTY CLAY: (RESIDUAL SOIL)	Probably the best form of compact will be a sheepsfoot roller if a heavy standard of compaction is required. The heavier the roller the lower the optimum moisture content.
SILTY (CLAYEY) SAND: (DRIFT SAND OVER RESIDUAL SOIL)	It is not certain if this should be treated as a sand or a clay as it has a predominantly sandy grading but appears to have a clays compaction curve. A trial will show how it behaves.
TRIAL FILLS:	These should be run on the various materials to determine the most effective compactive method.
WATER:	Either salt or fresh water can be used for the compaction of these soils. Comparative tests have been run in the laboratory by compacting samples B100, B130, B160 and B164.7 firstly with distilled water and then with salt water. These samples were then "surface-washed" with distilled water (to simulate flooding of an embankment). Samples B130 and B160 showed little loosening of their surfaces. Sample B164 showed some loosing of the surface with the salt water-compacted material being slightly more effected than that compacted with fresh water. Sample B100 had a dramatic surface loosening, this being more pronounced where the sample had been compacted with salt water. It is therefore recommended that this latter material should be faced when it is used in a location which is liable to be flooded or subject to water erosion.

S. RONAN

DESIGNING ENGINEER
SOILS & FOUNDATIONS

3.10.74

LABORATORY TEST PROCEDURES

Sieve Analyses were done on all samples as received. Figs. 1-7.

1. BULLDOG SHALE SAMPLES (MWBP1, B49.200 km & B139.100 km)

   1.1 These samples were crushed to pass a 19 mm (3/4") sieve and then sieve analyses were done. The results are shown on Figs. 20, 26 and 34.

   1.2 Representative samples of these were sieved on a 2.36 mm (BS7) sieve, the portions retained being washed and oven dried. The oven dried samples were supported on sieves under a fine garden sprinkler and the water turned on. Moisture contents were taken at ten minute intervals for one hour. A moisture content versus time graph was drawn for each sample. The results are shown on Fig. 36.

   1.3 The crushed Kaolinite samples MWBP1 & B49.200 km (passing 19 mm sieve) were wetted to the moisture content corresponding to ten minutes sprinking, and sample B139.00 km wetted to the moisture content corresponding to twenty minutes sprinkling. These samples were then compacted using modified compactive effort (as A89 Test 12A), then the whole compacted sample was oven dried to obtain moisture content and dry density.

   1.4 Sieve analyses were done on the three compacted samples to ascertain breakdown during compaction. The grading curves are also shown on Figs. 20, 26 and 34.

2. OTHER SAMPLES (B100.00 km, B130.00 km, B160.00 km & B164.70 km)

   2.1 Modified compaction tests were done on these four samples, using the saline water provided; the tests starting at the moisture contents of the samples as received. Compaction curves are shown on Figs. 23, 25, 29 and 31.

   2.2 Atterberg limits were done on the portion of sample passing a 425 micron sieve from samples B130.00 km & B160.00 km. Samples B100.00 km & B164.70 km were found to be non-plastic. Estimated C.B.R.'s were calculated for these four samples. Atterberg limits results and estimated C.B.R. valves are shown on the respective compaction test sheets.

DEPARTMENT OF MINES - SOUTH AUSTRALIA

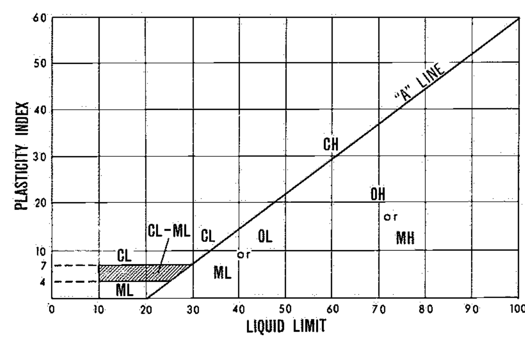
ENGINEERING CLASSIFICATION OF SOILS

The Unified Soil Classification System

	FIELD INVESTIGATION PROCEDURES Excluding particles larger than 7·5cm and basing fractions on estimated weights			GROUP SYMBOL	GROUP NAME and typical materials	LABORATORY CLASSIFICATION CRITERIA		
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 B.S. sieve size	**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	Coarse-grained soil classified on basis of percentage of fines, as follows PERCENT OF FINES — GRAVELS — SANDS Less than 5 — GW GP — SW SP More than 12 — GM GC — SM SC 5 to 12 Borderline cases, use 2 symbols	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = (D_{30})^2/D_{10} \times D_{60}$ 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 indentification see **ML** below	GM	**GRAVEL, excess silty fines;** poorly graded gravel-sand-silt mixtures		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
			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		$C_u = D_{60}/D_{10}$ Greater than 6 $C_c = (D_{30})^2/D_{10} \times D_{60}$ 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 indentification see **ML** below	SM	**SAND, excess silty fines;** poorly graded sand-silt mixtures		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
			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	

GRAIN SIZE CURVES to be used to identify soil fractions

	FIELD INVESTIGATION PROCEDURES on fraction smaller than 0.4mm. (passing B.S. 36 sieve)							GROUP SYMBOL	GROUP NAME and typical materials
		SOIL CAST (soil wet)	SOIL THREAD	SHINE	DILATANCY	ODOUR	DRY STRENGTH		
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 B.S. sieve size	**SILTS AND CLAYS** Liquid limit less than 50	Forms fragile cast Cracks form when kneaded while moist	Thick crumbly thread; easily broken	None to very dull	Distinct	Not significant	None to slight	ML	**SILT SOIL, low plasticity;** inorganic silts and very fine silty or clayey sands, rock flour
		Cast maybe handled freely without breaking Can be kneaded moist without cracking Material adheres to the hand	Thread can be pointed as fine as a lead pencil but is fragile	Moderate	None to slight	Not significant	Moderate	CL	**CLAY SOIL, low plasticity;** inorganic clays of low to medium plasticity, gravelly clay, sand, clays, silty clays, lean clays
		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	OL	**ORGANIC SOIL, low plasticity;** organic silts and silt clays of low plasticity
	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 slight	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						Pt	**PEATY SOIL;** Peat and other highly organic soils



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 COLARADO 1960.

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DEPARTMENT OF MINES - SOUTH AUSTRALIA

ENGINEERING CLASSIFICATION OF SOILS

The Unified Soil Classification System

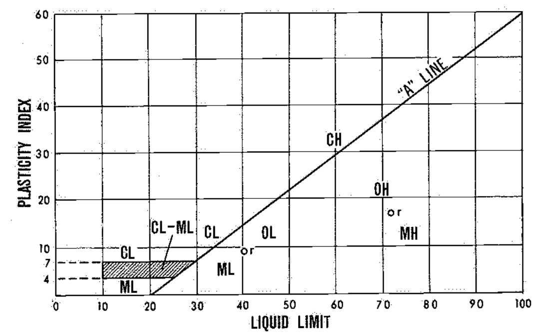
			FIELD INVESTIGATION PROCEDURES Excluding particles larger than 7·5cm and basing fractions on estimated weights	GROUP SYMBOL	GROUP NAME and typical materials	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS More than 50% of material is larger than No. 200 B.S. sieve size	GRAVELS More than 50% 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	$C_u = D_{60}/D_{10}$ Greater than 4 $C_c = (D_{30})^2/(D_{10} \times D_{60})$ 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 indentification see **ML** below	GM	**GRAVEL, excess silty fines;** poorly graded gravel-sand-silt mixtures	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
			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	$C_u = D_{60}/D_{10}$ Greater than 6 $C_c = (D_{30})^2/(D_{10} \times D_{60})$ 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 indentification see **ML** below	SM	**SAND, excess silty fines;** poorly graded sand-silt mixtures	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
			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	

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	GW GP	SW SP
More than 12	GM GC	SM SC
5 to 12	Borderline cases, use 2 symbols	

		FIELD INVESTIGATION PROCEDURES on fraction smaller than 0.4mm. (passing B.S. 36 sieve)						GROUP SYMBOL	GROUP NAME and typical materials
		SOIL CAST (soil wet)	SOIL THREAD	SHINE	DILATANCY	ODOUR	DRY STRENGTH		
FINE-GRAINED SOILS More than 50% of material is smaller than No. 200 B.S. sieve size	SILTS AND CLAYS Liquid limit less than 50	Forms fragile cast Cracks form when kneaded while moist	Thick crumbly thread; easily broken	None to very dull	Distinct	Not significant	None to slight	ML	**SILT SOIL, low plasticity;** inorganic silts and very fine silty or clayey sands, rock flour
		Cast maybe handled freely without breaking Can be kneaded moist without cracking Material adheres to the hand	Thread can be pointed as fine as a lead pencil but is fragile	Moderate	None to slight	Not significant	Moderate	CL	**CLAY SOIL, low plasticity;** inorganic clays of low to medium plasticity, gravelly clay, sand, clays, silty clays, lean clays
		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	OL	**ORGANIC SOIL, low plasticity;** organic silts and silt clays of low plasticity
	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 slight	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						Pt	**PEATY SOIL;** Peat and other highly organic soils

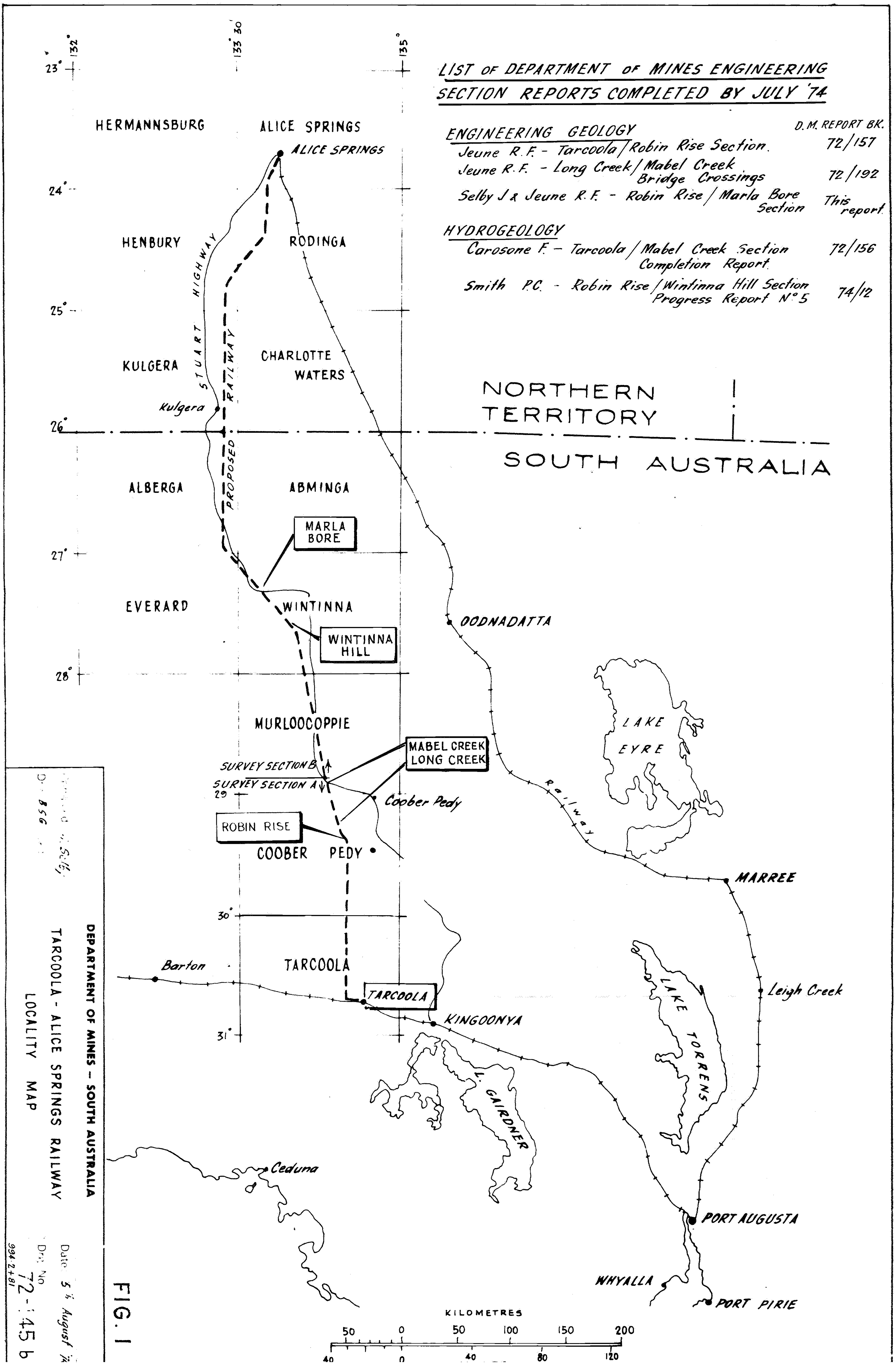


PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

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.

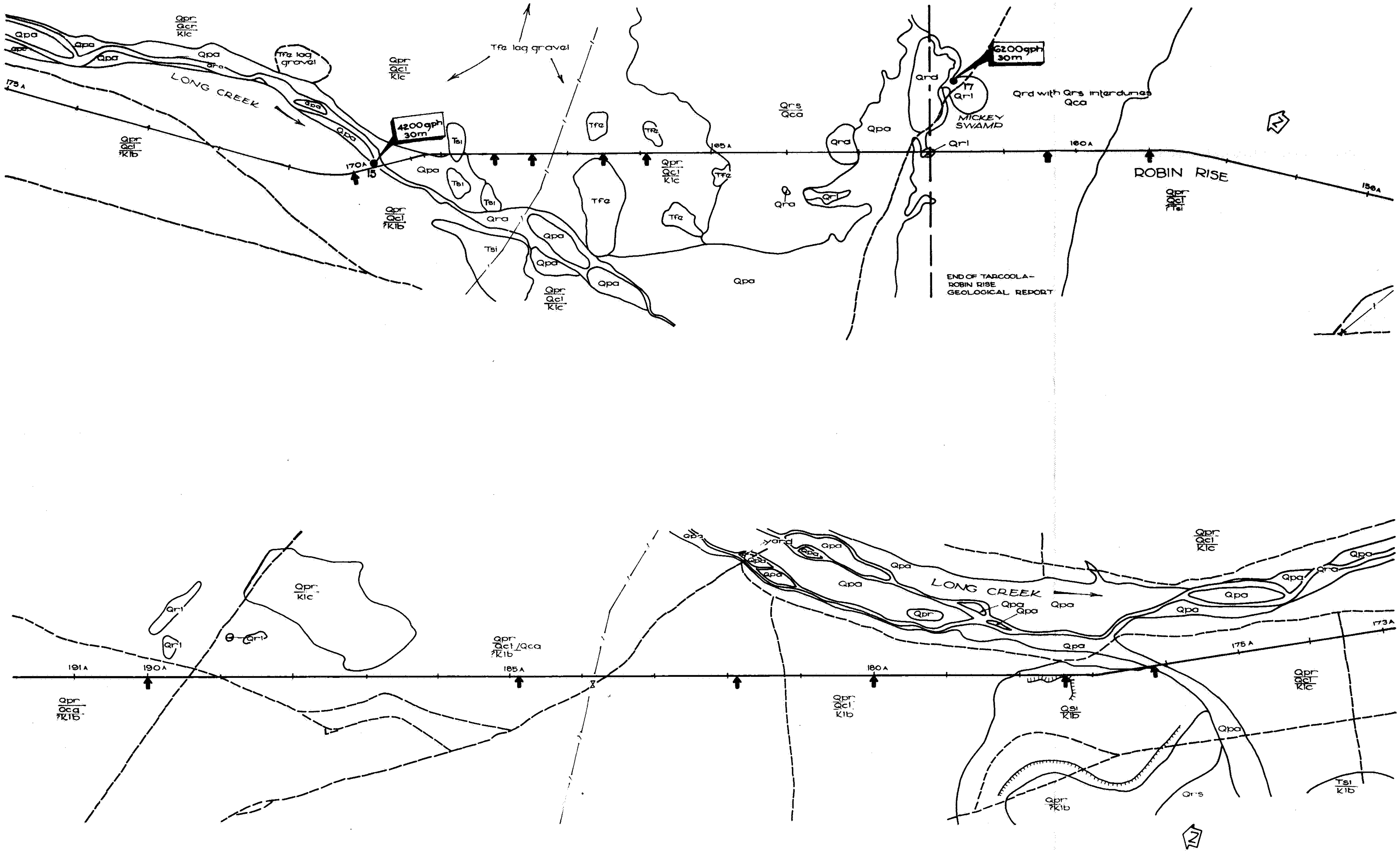
Based on "The Unified Soil Classification System" United States Department of the Interior, Bureau of Reclamation "Earth Manual" First Edition, Denver COLARADO 1960.

70–641



LIST OF DEPARTMENT OF MINES ENGINEERING SECTION REPORTS COMPLETED BY JULY '74
ENGINEERING GEOLOGY
D.M. REPORT BK.
Jeune R.F. - Tarcoola/Robin Rise Section. 72/157
Jeune R.F. - Long Creek/Mabel Creek Bridge Crossings 72/192
Selby J & Jeune R.F. - Robin Rise/Marla Bore Section This report
HYDROGEOLOGY
Carosone F. - Tarcoola/Mabel Creek Section Completion Report 72/156
Smith P.C. - Robin Rise/Wintinna Hill Section Progress Report N° 5 74/12
NORTHERN TERRITORY
SOUTH AUSTRALIA
HERMANNSBURG
ALICE SPRINGS
HENBURY
RODINGA
KULGERA
CHARLOTTE WATERS
ALBERGA
ABMINGA
EVERARD
WINTINNA
MURLOOCOPPIE
COOBER PEDY
TARCOOLA
STUART HIGHWAY
PROPOSED RAILWAY
Kulgera
MARLA BORE
WINTINNA HILL
MABEL CREEK
LONG CREEK
SURVEY SECTION B
SURVEY SECTION A
ROBIN RISE
Coober Pedy
OODNADATTA
LAKE EYRE
Railway
MARREE
Leigh Creek
LAKE TORRENS
L. GAIRDNER
Barton
KINGOONYA
Ceduna
PORT AUGUSTA
WHYALLA
PORT PIRIE
KILOMETRES
50 0 50 100 150 200
40 0 40 80 120
132°
133° 30'
135°
23°
24°
25°
26°
27°
28°
29
30°
31°

DEPARTMENT OF MINES – SOUTH AUSTRALIA
TARCOOLA - ALICE SPRINGS RAILWAY
LOCALITY MAP
FIG. 1
Date 5th August '74
Drg No 72-145b



LEGEND

(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL Red brown silty clay with a skin of lag gravel. Forms "crab hole country". Qps is gravelly slope wash material
Qrd	DUNE SAND Sand and silty sand forming dunes
Qrs	DRIFT SAND Sand and silty sand forming drift sheets. Qrs [illegible] drift generally <50 cms; Qrs [illegible] >50 cms
Qrl	PLAYA DEPOSITS [illegible] gypseous clay and silt of lakes, claypans and swamps, usually dry
Qra	RECENT ALLUVIUM Unconsolidated, generally [illegible] sand and gravel of the present stream courses
Qrg	GYPSEOUS DUNE [illegible] gypsum and gypsum sand mixtures forming dunes
Qsi	[illegible] Red, pink and white "duger" [illegible]
Tfe	FERRICRETE Strong sheet ferricrete "ironstone" and coarse lag gravel resulting from disintegration of the sheets
Tsi	OLDER SILCRETE Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets
Klb	[illegible] SHALE Stiff white and red mottled kaolinitic clay in part weakly cemented by secondary silicification
Klc	CADNA-OWIE FORMATION Weak white quartz sandstone with kaolinitic matrix

X 84	Soil sample location
➡	Investigation Trench
205	Surveyed rail centre line with km peg
	HYDROGEOLOGICAL INVESTIGATION BORES
●	Successful
	Unsuccessful
6000 / 30m	Yield in gallons / hour; Pump depth in metres
	Geological boundary
	Scarp
	Dry weather tracks
	Fence
	Gate
	Windmill

SCALE IN KILOMETRES

0 1 2 3

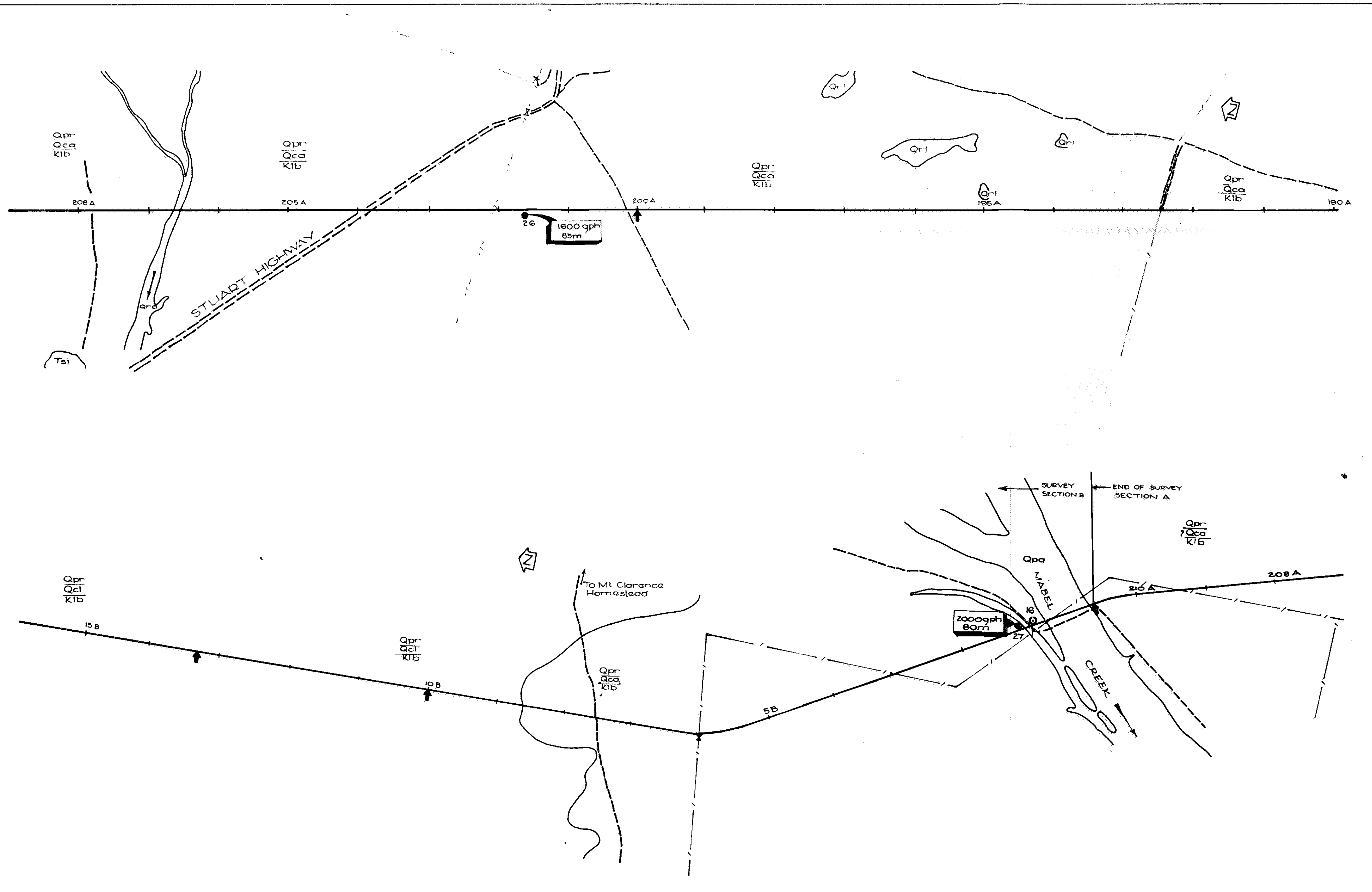
SCALE IN MILES

½ 0 1 2

N.B. THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL.

FIG. 2

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
TARCOOLA – ALICE SPRINGS RAILWAY 156A KILOMETRE TO 191A KILOMETRE SECTION			
ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J.	Scale: 1:24000(ORIG)
		Drn. R.B.	Date: 11 July 1974
Director of Mines	SUP. GEOLOGIST	Ckd. A.F.	Drg. No. 74-514 8a



LEGEND

(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL Red-brown silty clay with a skin of lag gravel. Forms "crab hole country". Qpa is gravelly slope wash material
Qrd	DUNE SAND: Sand and silty sand forming dunes
Qrs	DRIFT SAND Sand and silty sand forming drift sheets Qrs (1) Thin drift generally <50 cms Qrs (2) Thick " " >50 cms
Qrl	PLAYA DEPOSITS Saline, gypseous, clays and silts of lakes, claypans and swamps, usually dry
Qra	RECENT ALLUVIUM Unconsolidated, generally clean, sands and gravels of the present stream courses
Qrg	GYPSEOUS DUNES Powdery gypsum and gypsum/sand mixtures forming dunes
Qsi	YOUNGER SILCRETE Red, pink and white "Jasper" silcrete forming ridge cappings and scarps
Tfe	FERRICRETE Strong sheet ferricrete ("ironstone") and coarse lag gravel resulting from disintegration of the sheets
Tsi	OLDER SILCRETE Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets
Klb	BULLDOG SHALE Stiff white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification
Klc	CADNA-OWIE FORMATION Weak white quartz sandstone with kaolinitic matrix

X 84 Soil sample location

Soil Investigation Trench

206 Surveyed rail centre line with km peg

HYDROGEOLOGICAL INVESTIGATION BORES

Successful

Unsuccessful

Yield in gallons/hour

Pump depth in metres

Geological boundary

Scarp

Dry weather tracks

Fence

Gate

Windmill

SCALE IN KILOMETRES

1 0 1 2 3

SCALE IN MILES

1 0 1 2

NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

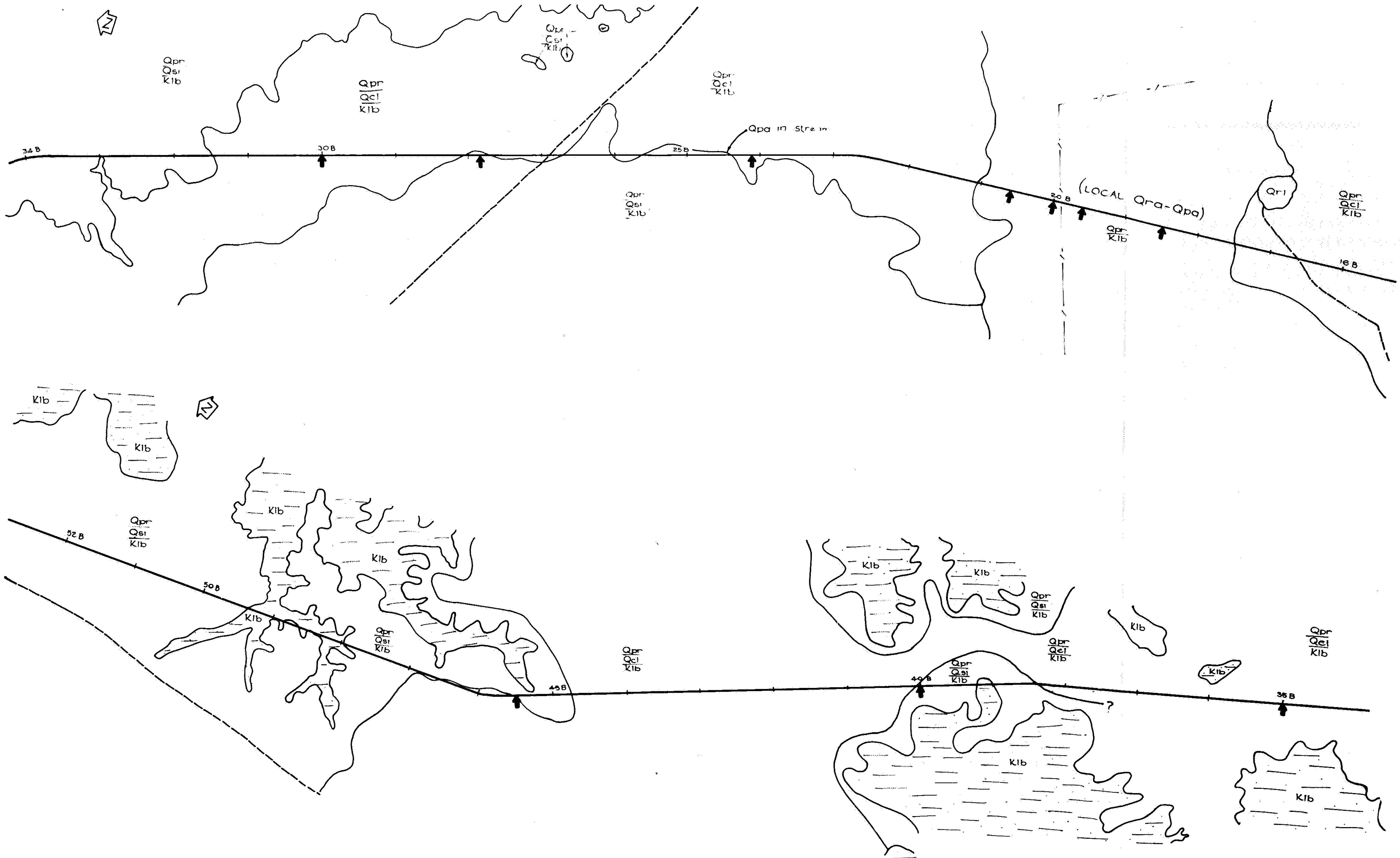
FIG.3

DEPARTMENT OF MINES – SOUTH AUSTRALIA

TARCOOLA – ALICE SPRINGS RAILWAY

190A KILOMETRE TO 15B KILOMETRE SECTION

ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J	Scale: 1:24000
			Date: 13th July 1974
Director of Mines	SUP. GEOLOGIST	Drn. R.B. / Chd. A.F.	Drg. No. 74-515 Bq



LEGEND
(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL Red-brown silty clay with a skin of lag gravel. Forms "crab hole country". Qpa is gravelly slope wash material.
Qrd	DUNE SAND Sand and silty sand forming dunes
Qrs	DRIFT SAND Sand and silty sand forming drift sheets Qrs (1) Thin drift generally <50 cms Qrs (2) Thick " " >50 cms
Qrl	PLAYA DEPOSITS Saline, gypseous, clays and silts of lakes, claypans and swamps, usually dry
Qra	RECENT ALLUVIUM Unconsolidated, generally clean, sands and gravels of the present stream courses
Qrg	GYPSEOUS DUNES Powdery gypsum and gypsum/sand mixtures forming dunes
Qsi	YOUNGER SILCRETE Red, pink and white "Jasper" silcrete forming ridge cappings and scarps
Tfe	FERRICRETE Strong sheet ferricrete ("ironstone") and coarse lag gravel resulting from disintegration of the sheets
Tsi	OLDER SILCRETE Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets
Klb	BULLDOG SHALE Stiff white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification
Klc	CADNA-OWIE FORMATION Weak white quartz sandstone with kaolinitic matrix

X 84	Soil sample location
	Soil Investigation Trench
205	Surveyed rail centre line with km peg
	HYDROGEOLOGICAL INVESTIGATION BORES
	Successful
	Unsuccessful
	Yield in gallons/hour Pump depth in metres
	Geological boundary
	Scarp
	Dry weather tracks
	Fence
	Gate
	Windmill

SCALE IN KILOMETRES

1 0 1 2 3

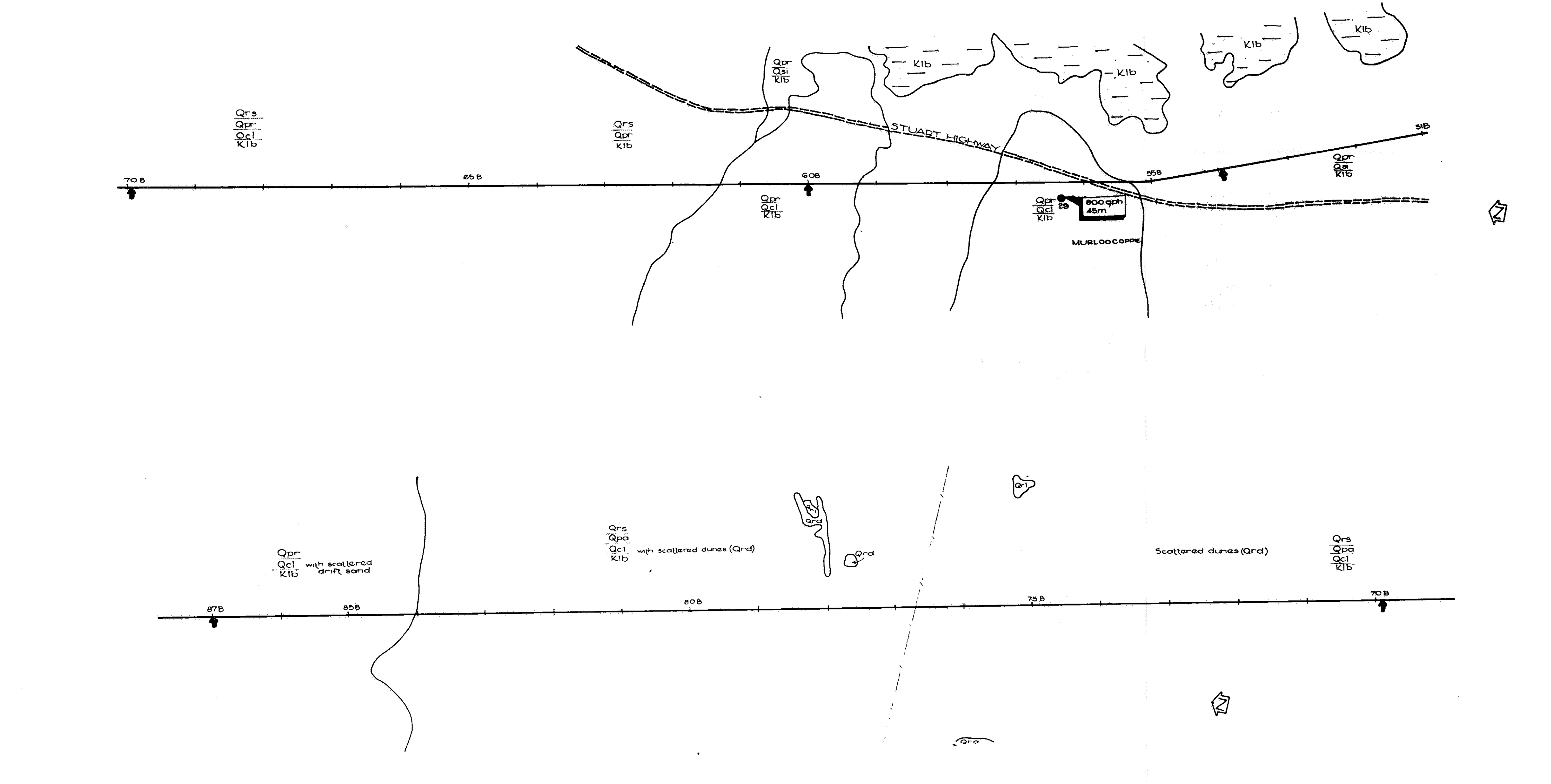
SCALE IN MILES

1 0 1 2

NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

FIG. 4

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
TARCOOLA – ALICE SPRINGS RAILWAY 16B KILOMETRE TO 52B KILOMETRE SECTION			
ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J.	Scale: 1:24000(ORIG)
			Date: 12 July 1974
Director of Mines	SUP GEOLOGIST	Drn. R.B.	Drg. No. 74-516 8a
		Ckd. A.F.	



LEGEND

(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM Dirty gravel and silty sand deposits of former river channels
Qpr	RED [illegible] SOIL Red brown silty clay with a skin of lag gravel Forms "crab hole country" Qps is gravelly slope wash material
Qrd	DUNE SAND Sand and silty sand forming dunes
Qrs	DRIFT SAND Sand and silty sand forming drift sheet [illegible] Drift generally 30 cms [illegible]
Qrl	PLAYA DEPOSIT [illegible] gypseous clay and silt of areas [illegible] and swamps [illegible]
Qra	RECENT ALLUVIUM [illegible] generally [illegible] and gravels of the present stream courses
Qrg	[illegible] and gypsum sand [illegible]
Qsi	[illegible] white "opal" [illegible]
TFe	FERRICRETE strong sheet ferricrete [illegible] and coarse lag gravel resulting from disintegration of the sheets
[illegible]	OLDER SILCRETE strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets
Klb	[illegible] white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification
K[illegible]	[illegible] FORMATION Weak white quartz sandstone with [illegible] matrix

X 84	Soil sample location
	Investigation Trench
205	Surveyed rail centre line with 5m peg
	HYDROGEOLOGICAL INVESTIGATION BORES
●	Successful
	Unsuccessful
	Yield in gallons hour
	Pump depth in metres
	Geological boundary
	Scarp
	Dry weather tracks
	Fence
	Gate
	Windmill

SCALE IN KILOMETRES

1 0 1 2 3

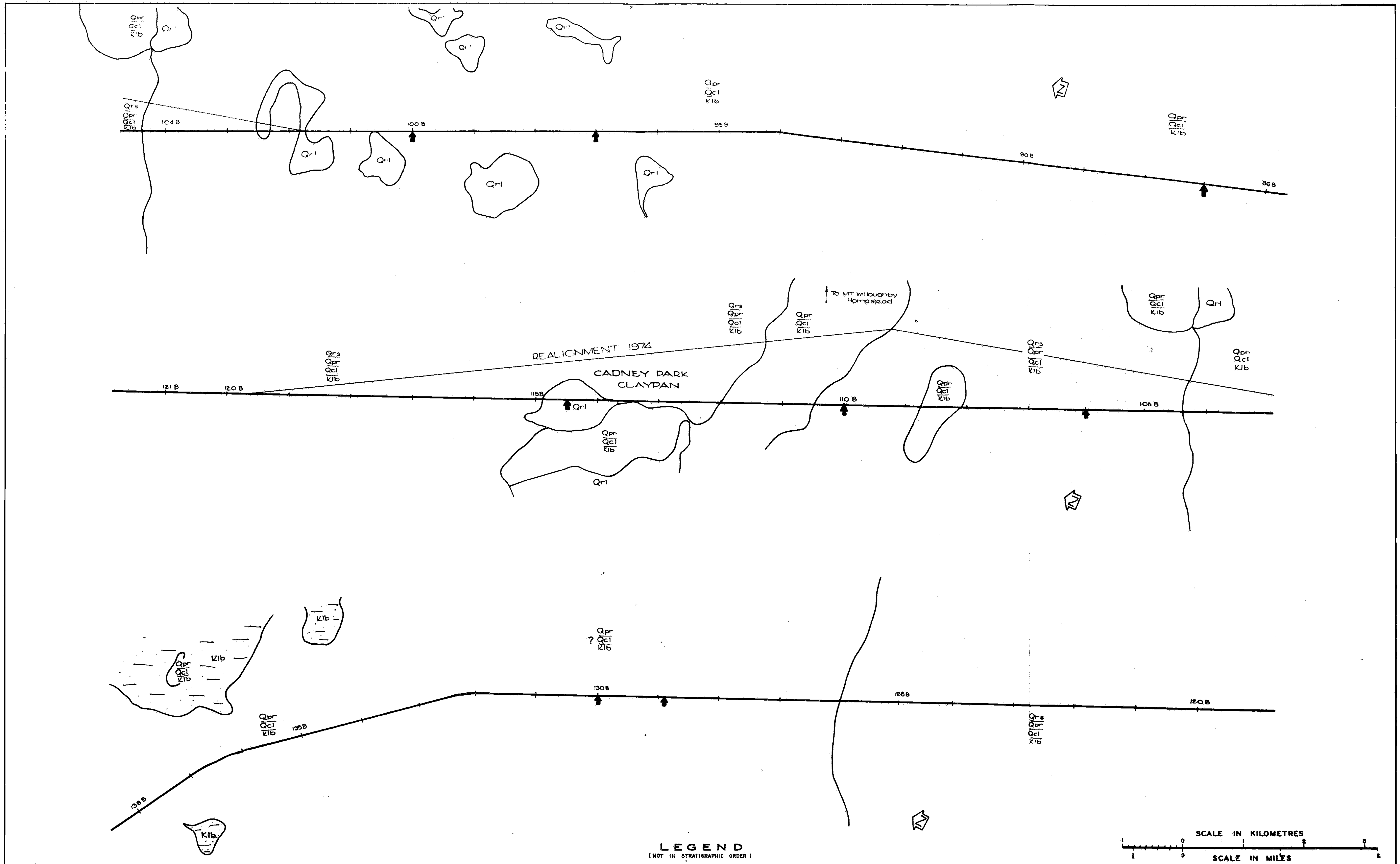
½ 0 1 2

SCALE IN MILES

NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

FIG.5

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
TARCOOLA — ALICE SPRINGS RAILWAY 51B KILOMETRE TO 87B KILOMETRE SECTION			
ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J	Scale: 1 : 24000(ORIG)
			Date: 12th July 1974
Director of Mines	SUP GEOLOGIST	Drn. R B	Drg. No. 74-517 Ba
		Ckd. A F	



LEGEND
(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE : Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL : Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM : Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL : Red-brown silty clay with a skin of lag gravel. Forms "crab hole country". Qpo is gravelly slope wash material.
Qrd	DUNE SAND : Sand and silty sand forming dunes
Qrs	DRIFT SAND : Sand and silty sand forming drift sheets Qrs (1) Thin drift generally <50 cms Qrs (2) Thick " " >50 cms
Qrl	PLAYA DEPOSITS : Saline, gypseous, clays and silts of lakes, claypans and swamps, usually dry.
Qra	RECENT ALLUVIUM : Unconsolidated, generally clean, sands and gravels of the present stream courses
Qrg	GYPSEOUS DUNES : Powdery gypsum and gypsum/sand mixtures forming dunes
Qsi	YOUNGER SILCRETE : Red, pink and white "Jasper" silcrete forming ridge cappings and scarps
Tfe	FERRICRETE : Strong sheet ferricrete ("ironstone") and coarse lag gravel resulting from disintegration of the sheets.
Tsi	OLDER SILCRETE : Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets.
Klb	BULLDOG SHALE : Stiff white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification
Klc	CADNA-OWIE FORMATION : Weak white quartz sandstone with kaolinitic matrix

X 84	Soil sample location
	Soil Investigation Trench
205	Surveyed rail centre line with km peg
	HYDROGEOLOGICAL INVESTIGATION BORES
●	Successful
○	Unsuccessful
	Yield in gallons/hour Pump depth in metres
	Geological boundary
	Scarp
	Dry weather tracks
	Fence
	Gate
	Windmill

SCALE IN KILOMETRES

SCALE IN MILES

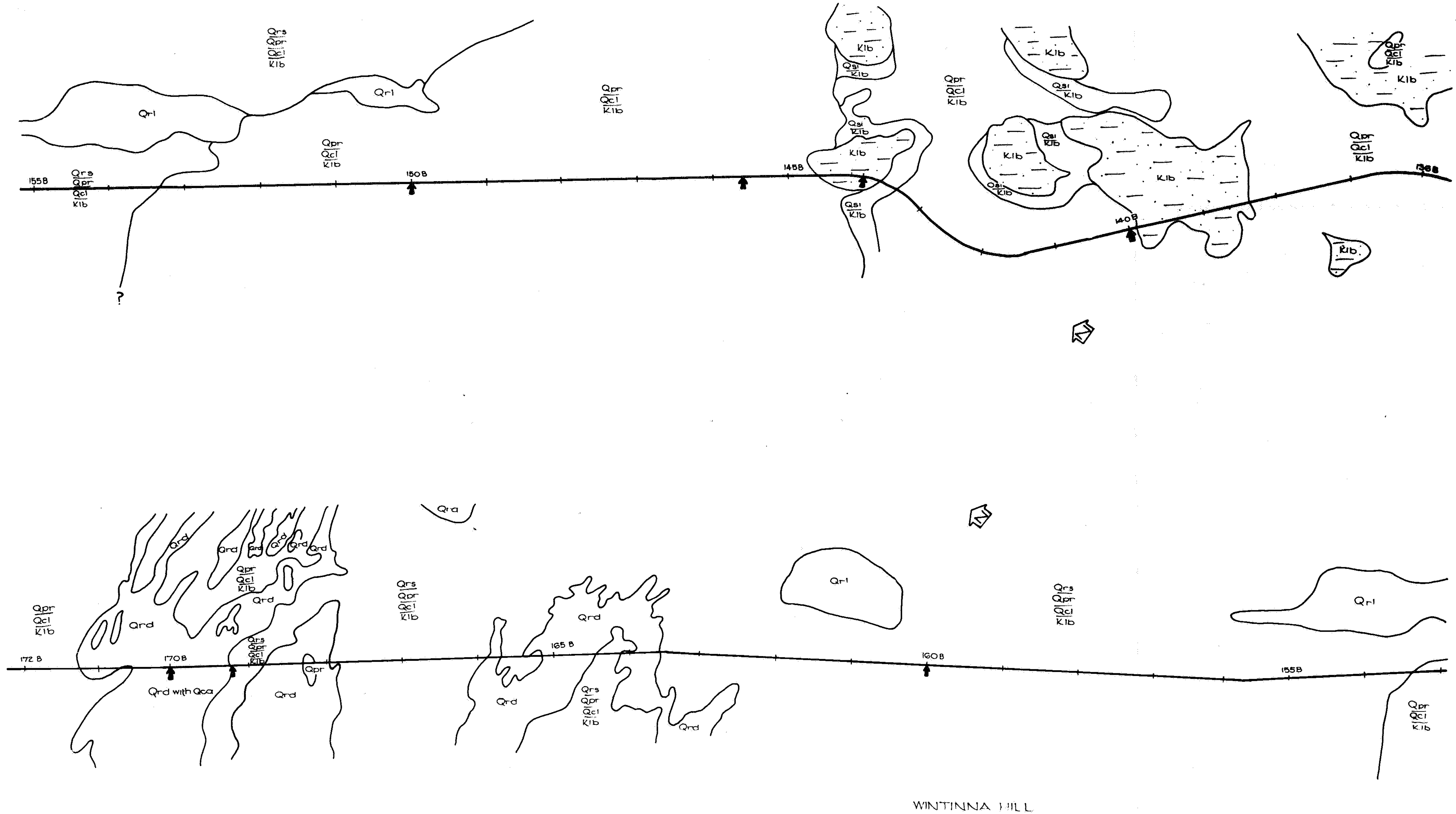
NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

FIG.6

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY
868 KILOMETRE TO 1388 KILOMETRE SECTION

ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J.	Scale: 1 : 24000(ORIG)
			Date: 15th July 1974
Director of Mines	SUP GEOLOGIST	Drn. R B Chd. A.F.	Drg. No. 74-518 Ba



LEGEND

(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE Nodular and strong sheet calcrete
Qc	CALCIFIED SOIL Zone of subsoil lime accumulation
Qpa	OLDER ALLUVIUM Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL Red brown silty clay with a skin of lag gravel forms "crab hole country" Qps is gravelly slope wash material
Qrd	DUNE SAND Sand and silty sand forming dunes
Qrs	DRIFT SAND Sand and silty sand forming drift sheets Qrs (i) Thin drift generally <50 cms Qrs (ii) Thick " >50 cms
Qrl	PLAYA DEPOSITS Saline, gypseous, clays and silts of lakes, claypans and swamps, usually dry
Qra	RECENT ALLUVIUM Unconsolidated, generally clay, sands and gravels of the present stream courses
Qrg	GYPSEOUS DUNES Powdery gypsum and gypsum sand mixtures forming dunes
Qsi	YOUNGER SILCRETE Red pink and white "jasper" silcrete forming ridge cappings and scarps
Tfe	FERRICRETE Strong sheet ferricrete ("ironstone") and coarse lag gravel resulting from disintegration of the sheets
Tsi	OLDER SILCRETE Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets
Klb	BULLDOG SHALE Grey white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification
Klc	CADNA OWIE FORMATION Weak white quartz sandstone with kaolinitic matrix

X 84	Soil sample location
	Soil investigation trench
205	Surveyed rail centre line with km peg
	HYDROGEOLOGICAL INVESTIGATION BORES
●	Successful
	Unsuccessful
6000, 30	Yield in gallons/hour Pump depth in metres
	Geological boundary
	Scarp
	Dry weather tracks
	Fence
	Gate
	Windmill

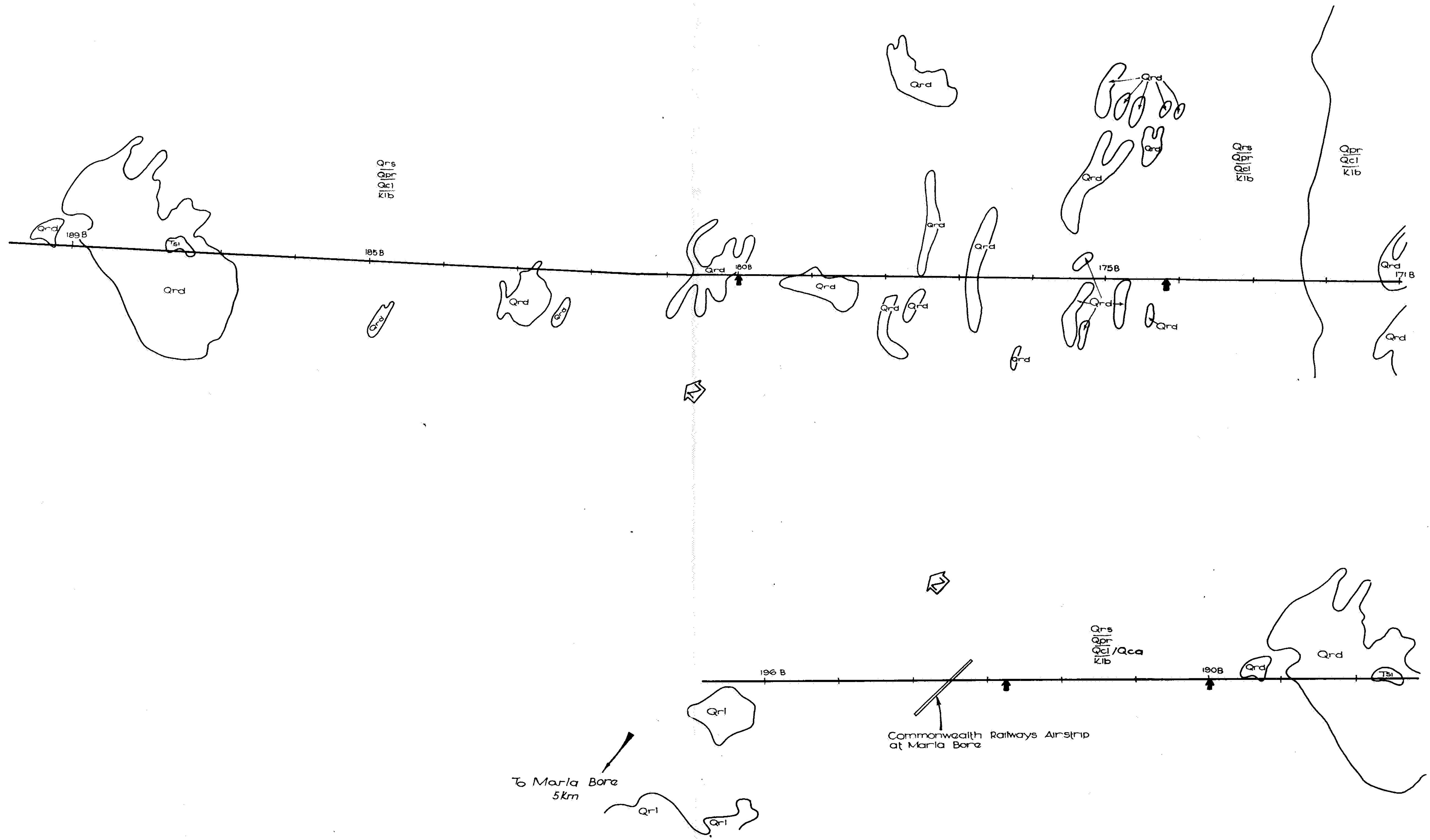
SCALE IN KILOMETRES
1 0 1 2 3

SCALE IN MILES
1 ½ 0 1 2

NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

FIG 7

DEPARTMENT OF MINES — SOUTH AUSTRALIA			
TARCOOLA – ALICE SPRINGS RAILWAY 136B KILOMETRE TO 172B KILOMETRE SECTION			
ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J.	Scale: 1:24000 (ORIG)
		Drn. R.B.	Date: 18th July 1974
Director of Mines	SUP. GEOLOGIST	Ckd. A.F.	Drg. No. 74–519 Bq



LEGEND
(NOT IN STRATIGRAPHIC ORDER)

Qca	CALCRETE: Nodular and strong sheet calcrete
Qcl	CALCIFIED SOIL: Zone of subsoil lime accumulation.
Qpa	OLDER ALLUVIUM: Dirty gravel and silty sand deposits of former river channels
Qpr	RESIDUAL SOIL: Red-brown silty clay with a skin of lag gravel. Forms "crab hole country". Qps is gravelly slope wash material.
Qrd	DUNE SAND: Sand and silty sand forming dunes.
Qrs	DRIFT SAND: Sand and silty sand forming drift sheets. Qrs (1) Thin drift generally <50 cms; Qrs (2) Thick " " >50 cms.
Qrl	PLAYA DEPOSITS: Saline, gypseous, clays and silts of lakes, claypans and swamps, usually dry.
Qra	RECENT ALLUVIUM: Unconsolidated, generally clean, sands and gravels of the present stream courses.
Qrg	GYPSEOUS DUNES: Powdery gypsum and gypsum/sand mixtures forming dunes.
Qsi	YOUNGER SILCRETE: Red, pink and white "Jasper" silcrete forming ridge cappings and scarps
Tfe	FERRICRETE: Strong sheet ferricrete ("ironstone") and coarse lag gravel resulting from disintegration of the sheets.
Tsi	OLDER SILCRETE: Strong sheet silcrete and coarse lag gravel resulting from disintegration of the sheets.
Klb	BULLDOG SHALE: Stiff white and red mottled kaolinitic clay, in part weakly cemented by secondary silicification.
Klc	CADNA-OWIE FORMATION: Weak white quartz sandstone with kaolinitic matrix.

× 84 Soil sample location

Soil Investigation Trench

206 Surveyed rail centre line with km. peg

HYDROGEOLOGICAL INVESTIGATION BORES

Successful

Unsuccessful

Yield in gallons/hour

Pump depth in metres

Geological boundary

Scarp

Dry weather tracks

Fence

Gate

Windmill

SCALE IN KILOMETRES

1 0 1 2 3

SCALE IN MILES

1/2 0 1 2

NB: THIS PLAN WAS PRODUCED FROM AERIAL PHOTOS WITHOUT THE USE OF GROUND CONTROL

FIG. 8

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA – ALICE SPRINGS RAILWAY

171B KILOMETRE TO 196B KILOMETRE SECTION

ENGINEERING GEOLOGY SECTION	GEOLOGIST	Compiled R.F.J.	Scale: 1:24000 (OR16)
			Date: 15th July 1974
Director of Mines	SUP GEOLOGIST	Drn. RB	Drg. No. 74-520 Ba
		Ckd. A.F	

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: A.R.

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

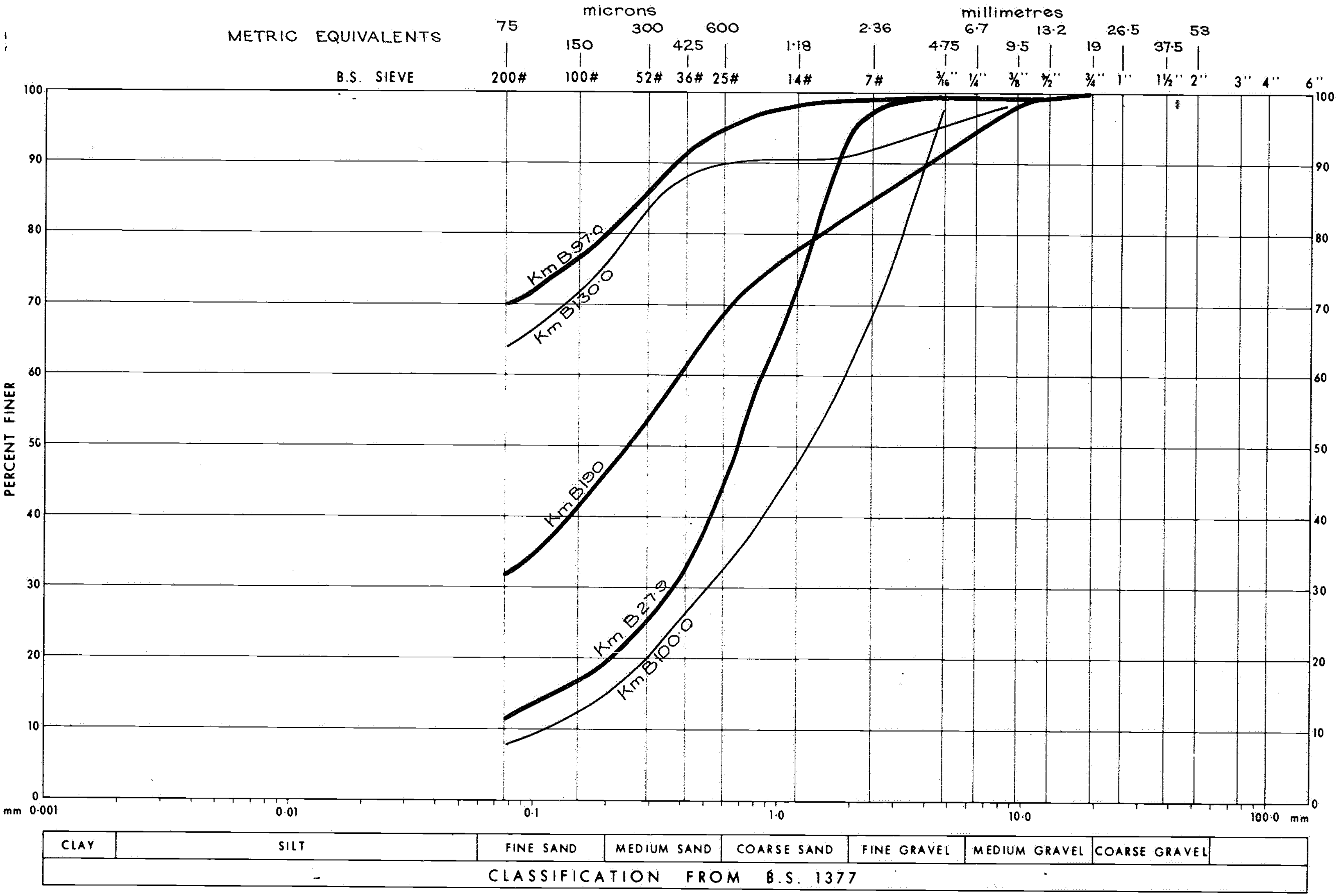
ROBIN RISE TO MARLA BORE — SUMMARY OF RESIDUAL SOIL (Qpr)

Scale: As shown

Date: 24TH JULY 1974

FIG: 9

Drg No. S11369



NOTE: Sample number is chainage location.

PF No 59548 MG

ENGINEERING GEOLOGY SECTION

Compiled: G.H.McN

Drn: A.R.

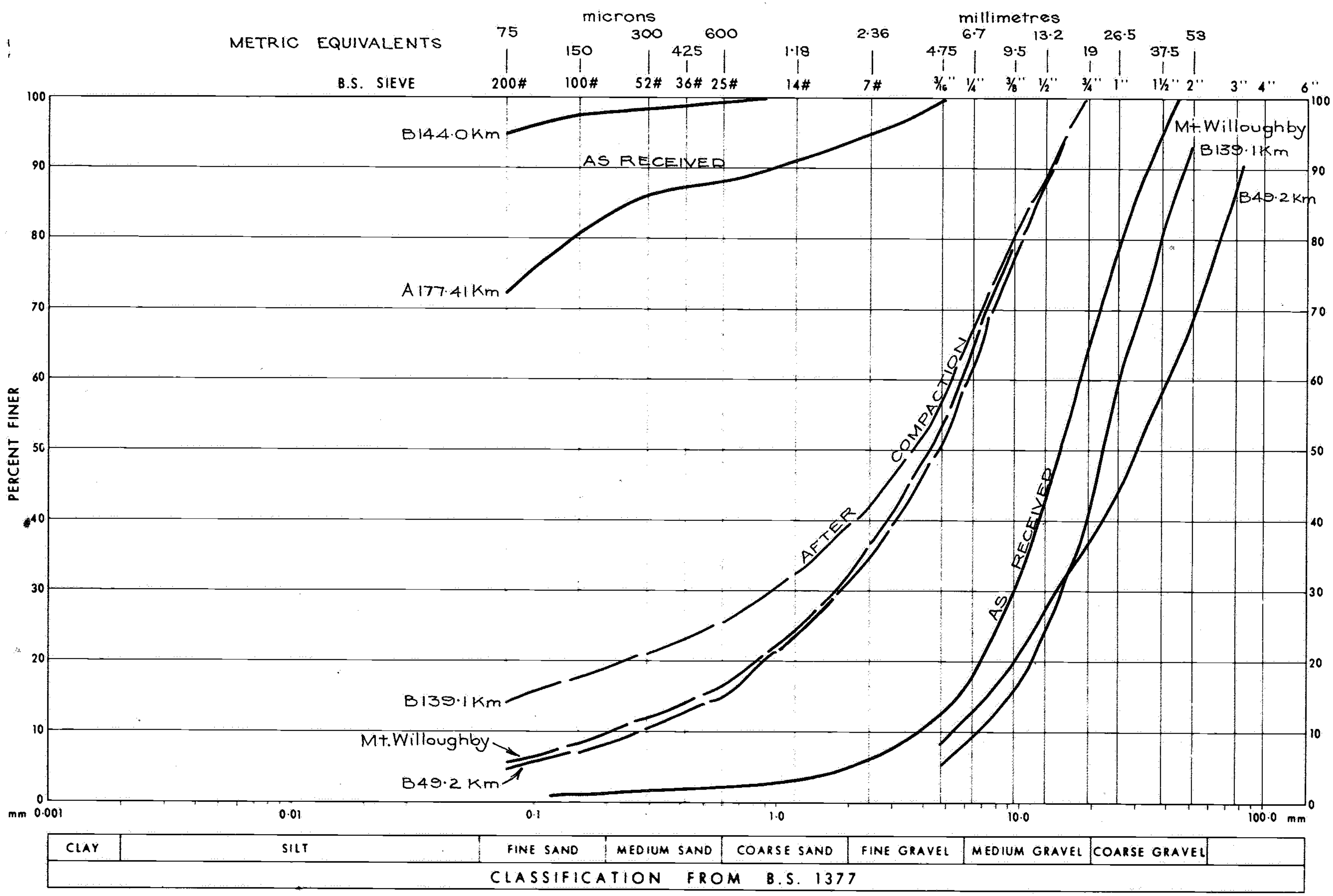
Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

ROBIN RISE TO MARLA — BORE — SUMMARY OF RESULTS ON BULLDOG SHALE (Klb)



Scale: As shown

Date: 6TH March 1975

FIG: 10

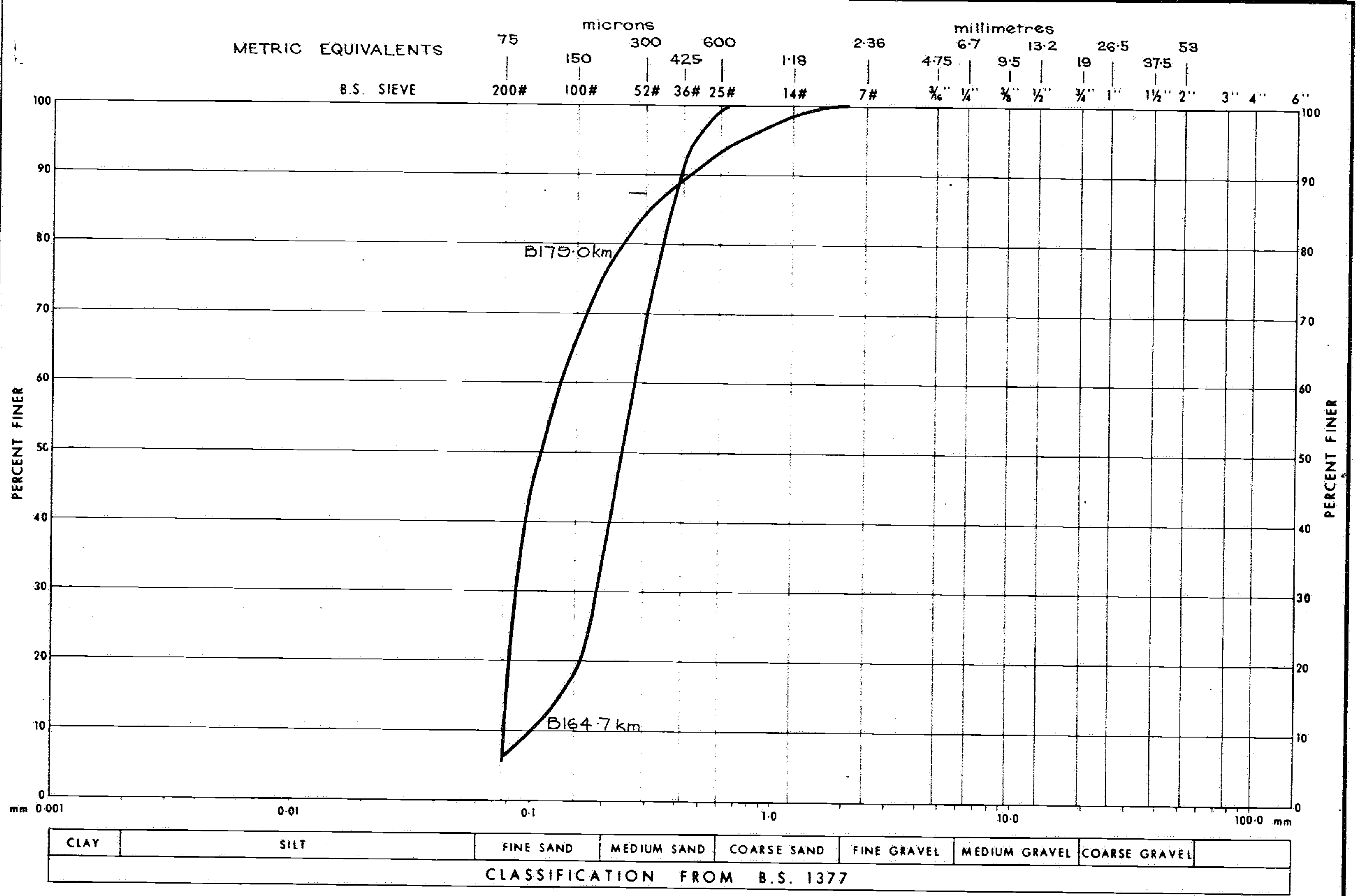
Drg No. S11370

ENGINEERING GEOLOGY SECTION

Compiled: G.H.McN.

Drn: A.R.

Ckd:



DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

ROBIN RISE TO MARLA BORE — SUMMARY OF RESULTS ON DUNE SAND (Qrd)

Scale: As shown

Date: 6TH March 1975

FIG: 11

Drg No. S11371

PF Nº S9548 MG

PF Nº S9548 MG

DEPARTMENT OF MINES — SOUTH AUSTRALIA

ENGINEERING GEOLOGY SECTION

Compiled: GHMcN

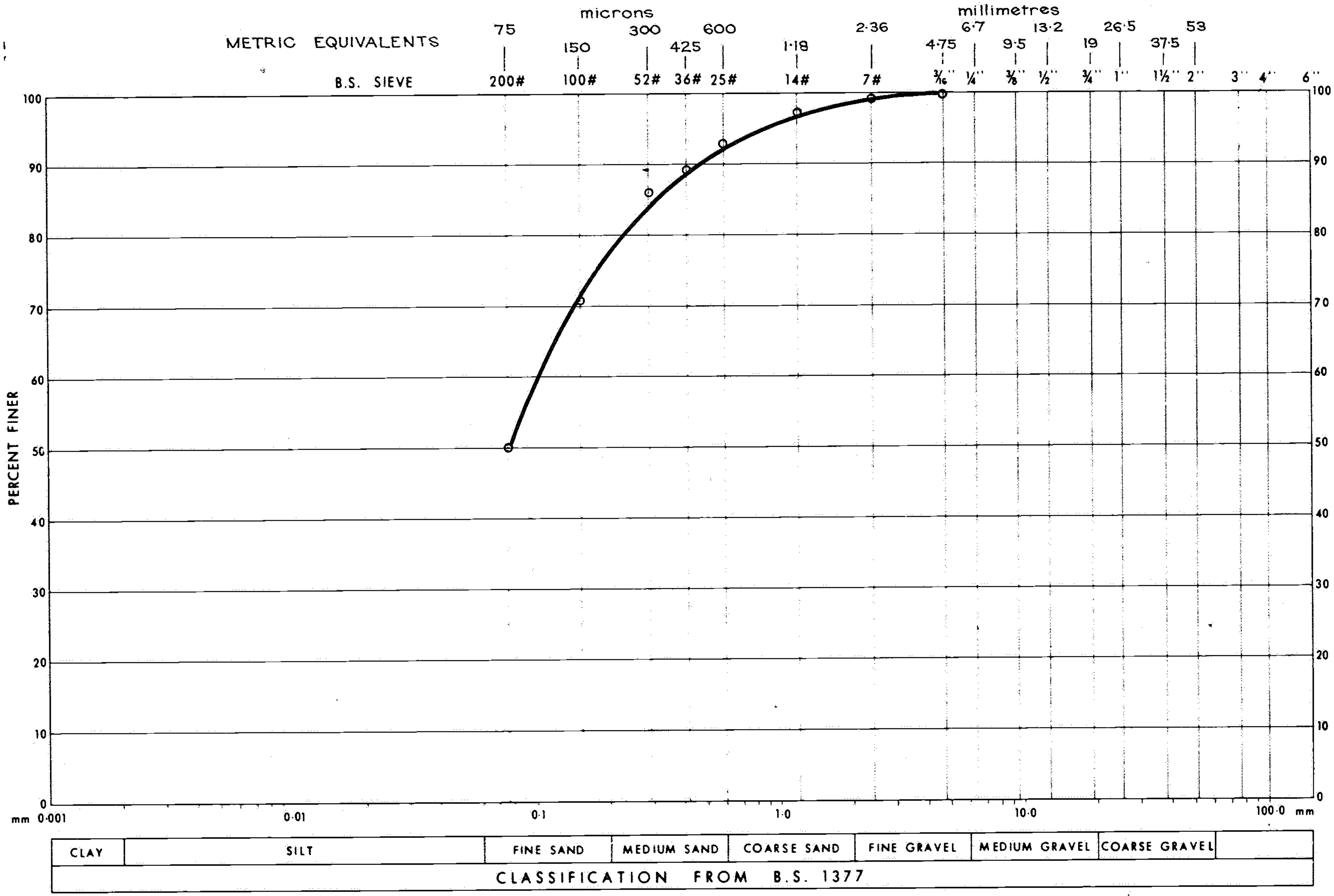
Drn:

Ckd:

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

PLAYA DEPOSITS (Qr-l) - Ch. A161.5



Scale: As shown

Date: 5-3-75

FIG: 12

Drg No. S11372

PF Nº 9829 Bab

Ckd:

Drn: J.W.

Compiled: J. Selby

ENGINEERING GEOLOGY SECTION

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

PLAYA DEPOSITS (Qrl)

Scale As shown

Date

FIG. 13

Drg No. S 11373

ATTERBERG LIMITS:

Liquid Limit 35 %   Plasticity Index 19

Plastic Limit 16 %   Linear Shrinkage — %

COMPACTION:

Maximum Dry Density 117 lbs/cub.ft.

Optimum Moisture Content 14·5 %

Natural Moisture Content — %

Compacted Dry Density at Natural Moisture Content

lbs/cub.ft.

%AASHO

CALIFORNIAN BEARING RATIO: (estimated)

9·6 %

COMMENTS:

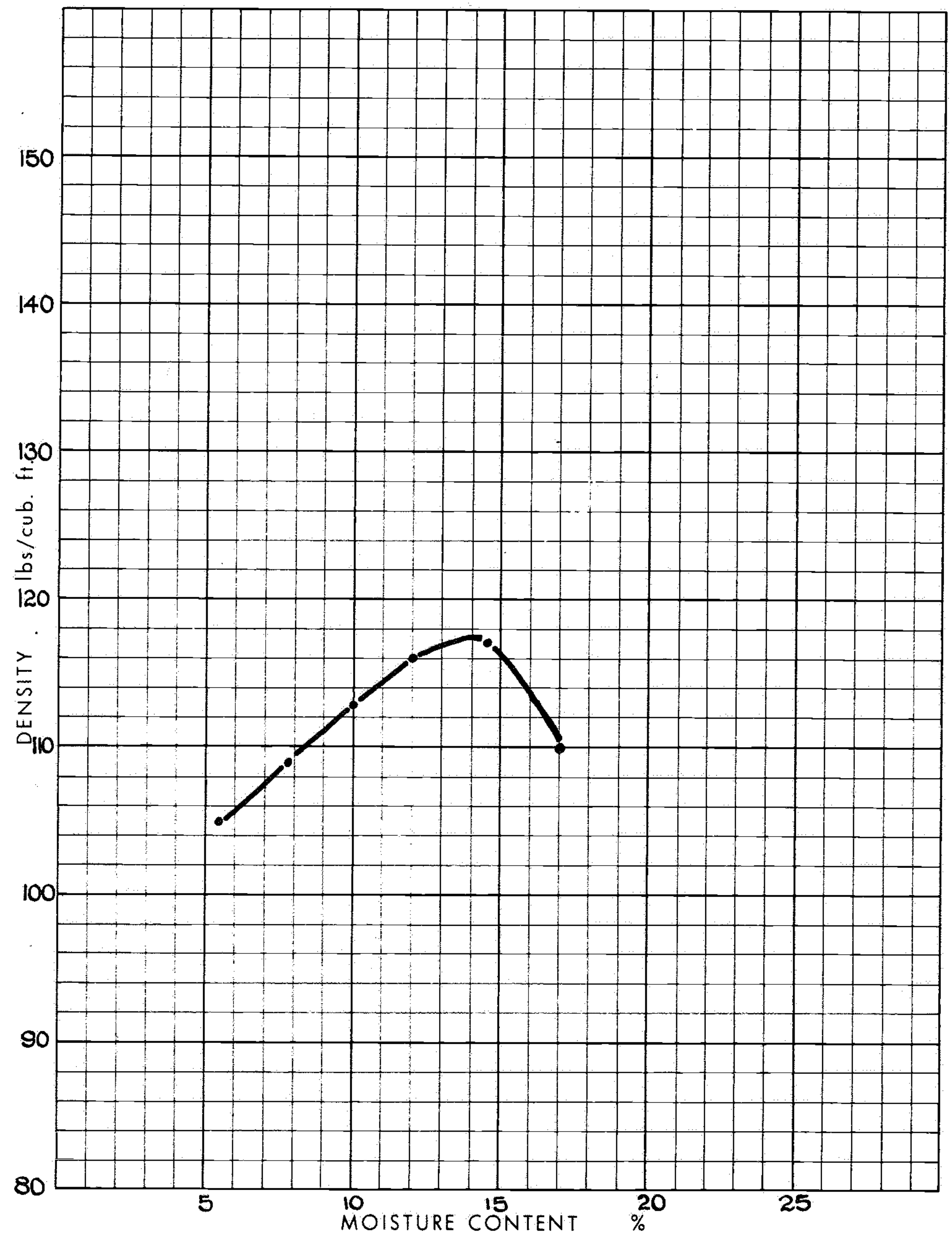
Saline water used

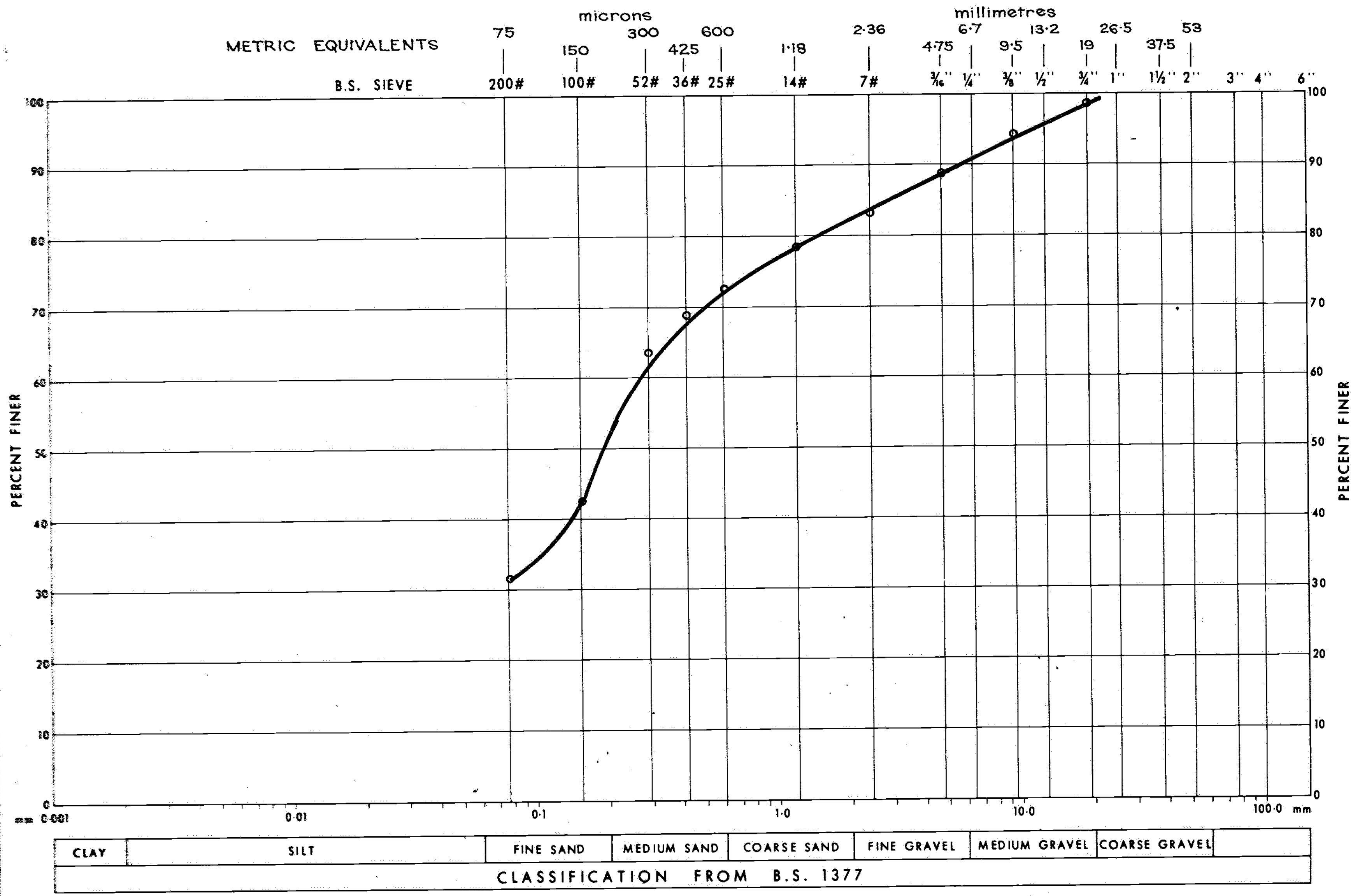
DESCRIPTION OF MATERIAL

Sandy Clay

SAMPLE No. A161·5km   LOCATION

MODIFIED A.A.S.H.O. COMPACTION TEST





ENGINEERING GEOLOGY SECTION

Compiled: G.H. McN

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

RESIDUAL SOIL & SILCRETE (Qpr+Qsi) CH.A170·0

Scale: As shown

Date: 5-3-75

FIG: 14

Drg No. S11374

PF Nº S9548 MG

PF Nº 9829 Bab

ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

RESIDUAL SOIL & SILCRETE (Qpr & Qsi)

Scale: As shown

Date: 25-3-75

FIG: 15

Drg No. S11375

ATTERBERG LIMITS:

Liquid Limit 29 % Plasticity Index 12

Plastic Limit 17 % Linear Shrinkage — %

COMPACTION:

Maximum Dry Density 127 lbs/cub.ft.

Optimum Moisture Content 9.5 %

Natural Moisture Content %

Compacted Dry Density at Natural Moisture Content
lbs/cub.ft.
%AASHO

CALIFORNIAN BEARING RATIO: (estimated)

17 %

COMMENTS:

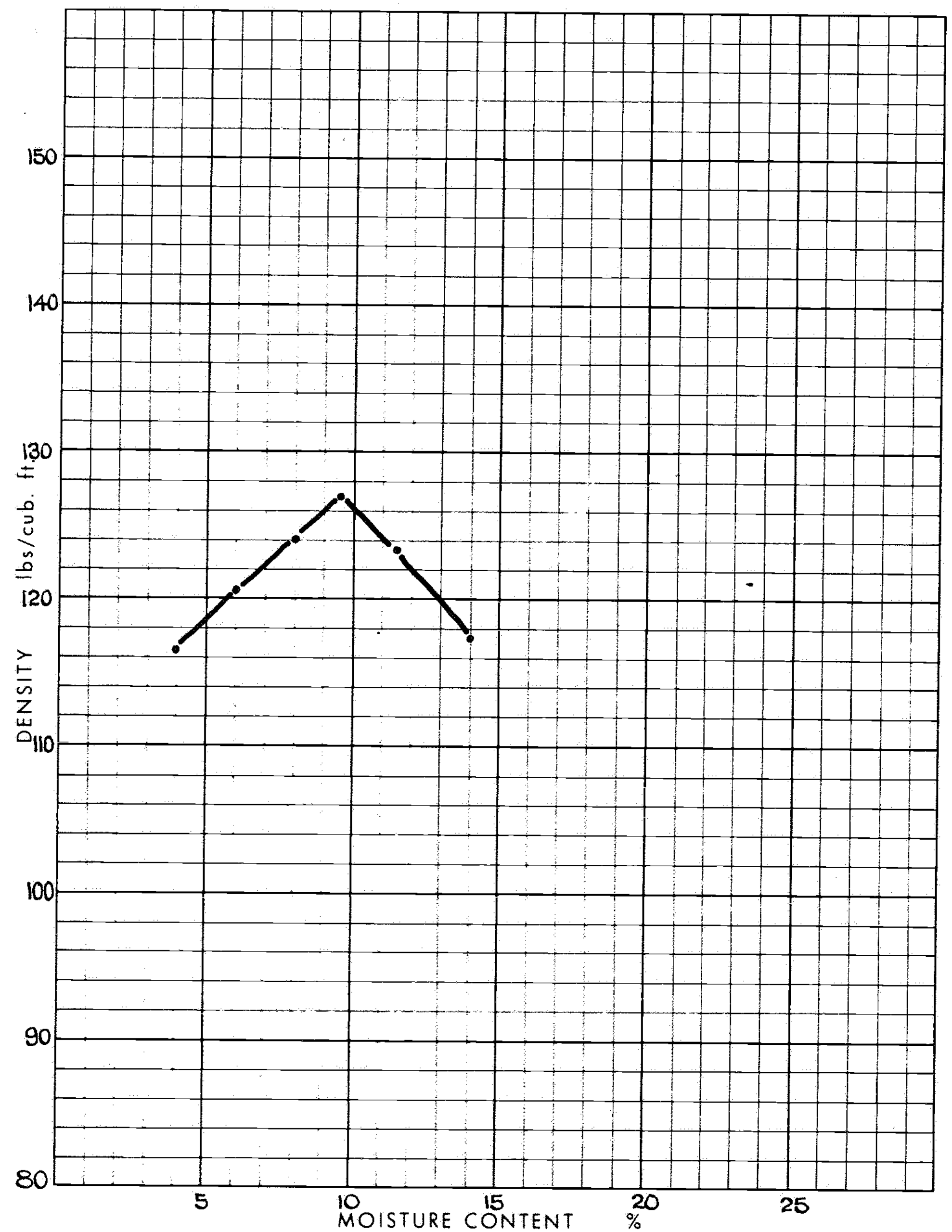
Saline water used

DESCRIPTION OF MATERIAL

Gravelly and sandy silt

SAMPLE No. A170·0km LOCATION

MODIFIED A.A.S.H.O. COMPACTION TEST



PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: G.H. McN

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

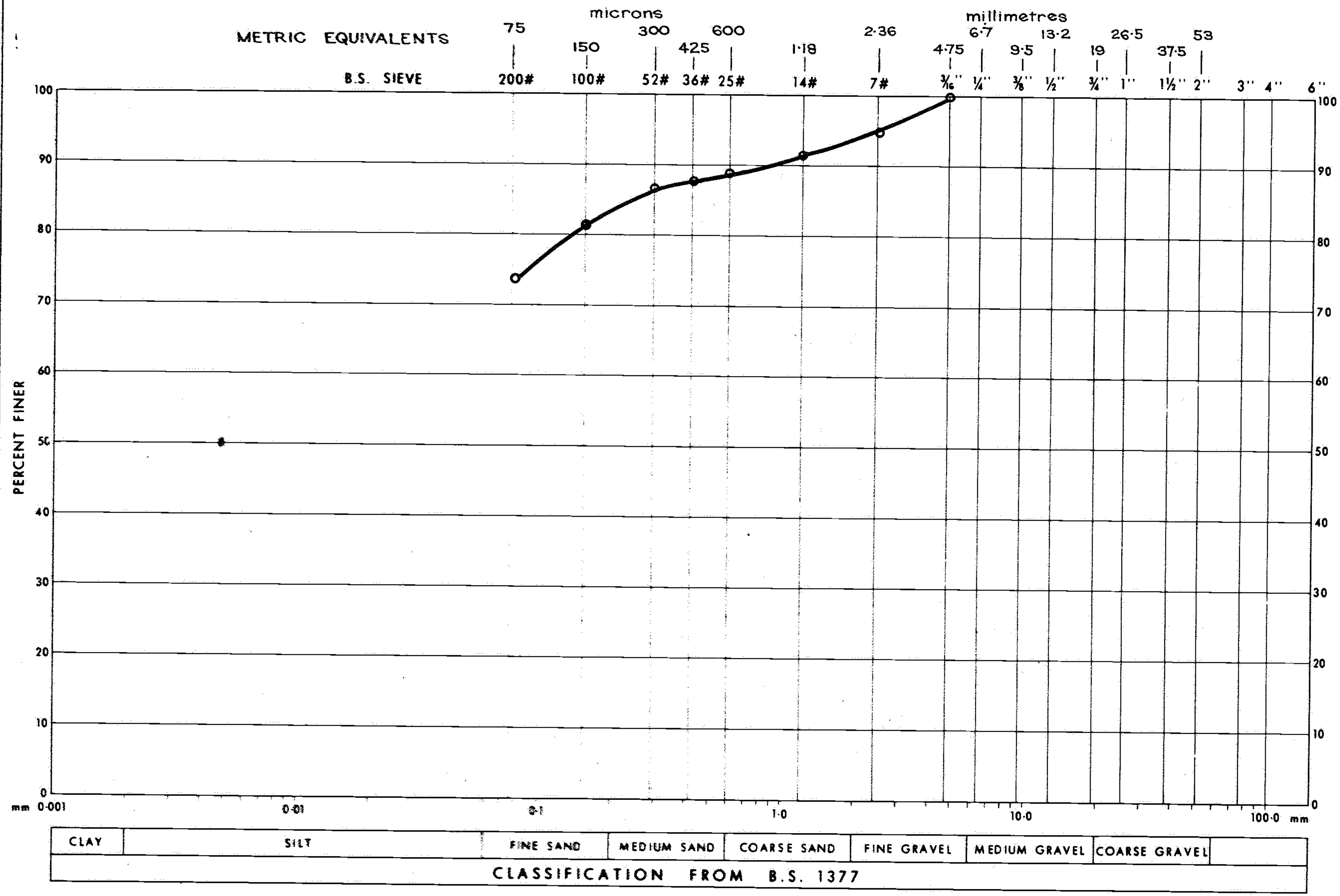
BULLDOG SHALE (Klb) - Ch. A177·4 km.

Scale: As shown

Date: 15-3-75

FIG: 16

Drg No. S11376



Note – 15% Crystalline Gypsum removed prior to sieving.

DEPARTMENT OF MINES — SOUTH AUSTRALIA

ENGINEERING GEOLOGY SECTION

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

BULLDOG SHALE (Klb)

Compiled: J. Selby

Drn: J.W.

Ckd:

Scale: As shown

Date:

FIG: 17

Drg No. S11377

PF Nº 9829 Bab

MODIFIED A.A.S.H.O. COMPACTION TEST

ATTERBERG LIMITS:

Liquid Limit 51 %   Plasticity Index 26

Plastic Limit 25 %   Linear Shrinkage — %

COMPACTION:

Maximum Dry Density 110 lbs/cub.ft.

Optimum Moisture Content 17 %

Natural Moisture Content — %

Compacted Dry Density at Natural Moisture Content lbs/cub.ft.

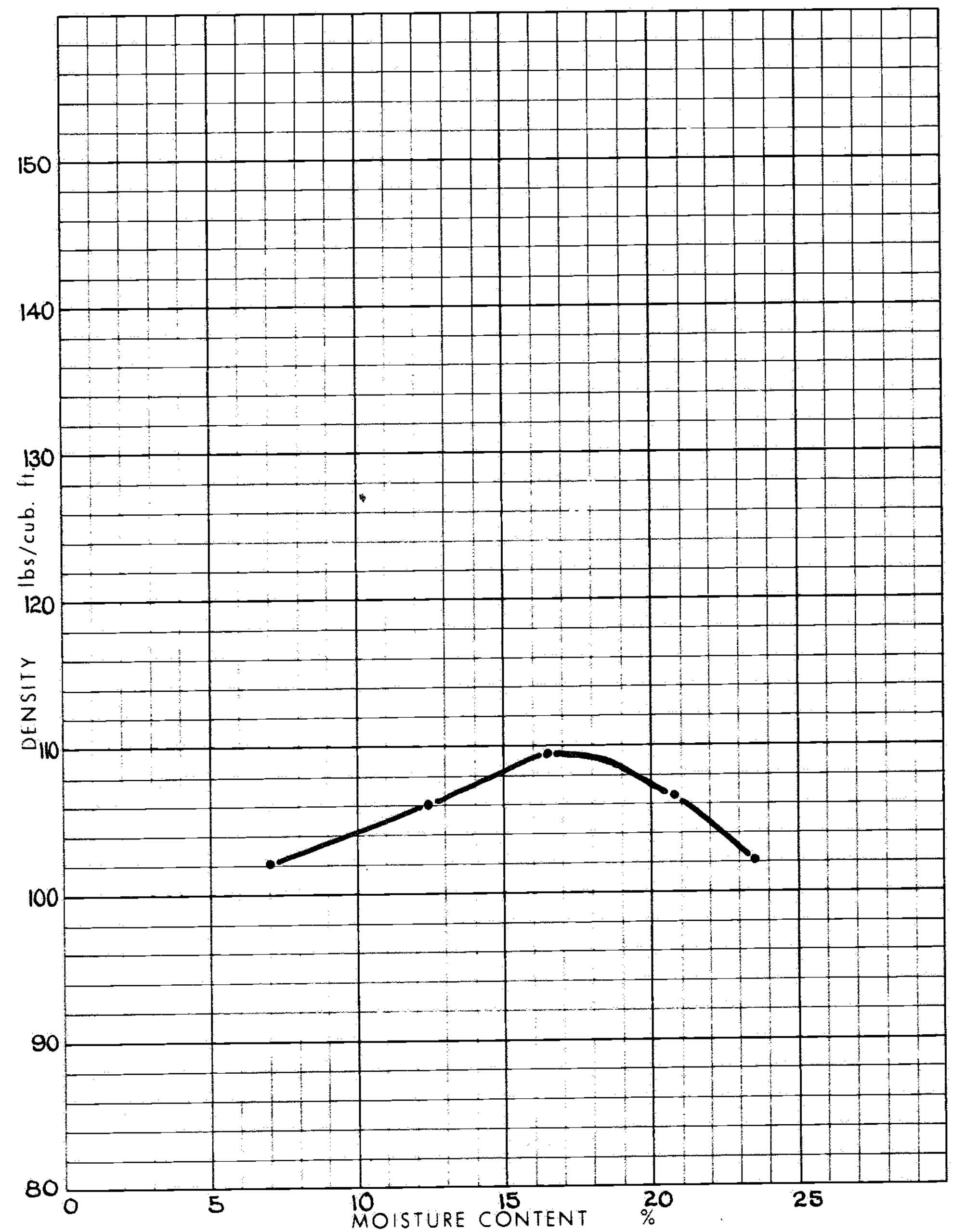
%AASHO

CALIFORNIAN BEARING RATIO: (estimated)

%

COMMENTS:

Saline water used



DESCRIPTION OF MATERIAL

Sandy or clayey silt

SAMPLE No. A177·4 km.   LOCATION

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: G.H.McN

Drn: J.Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

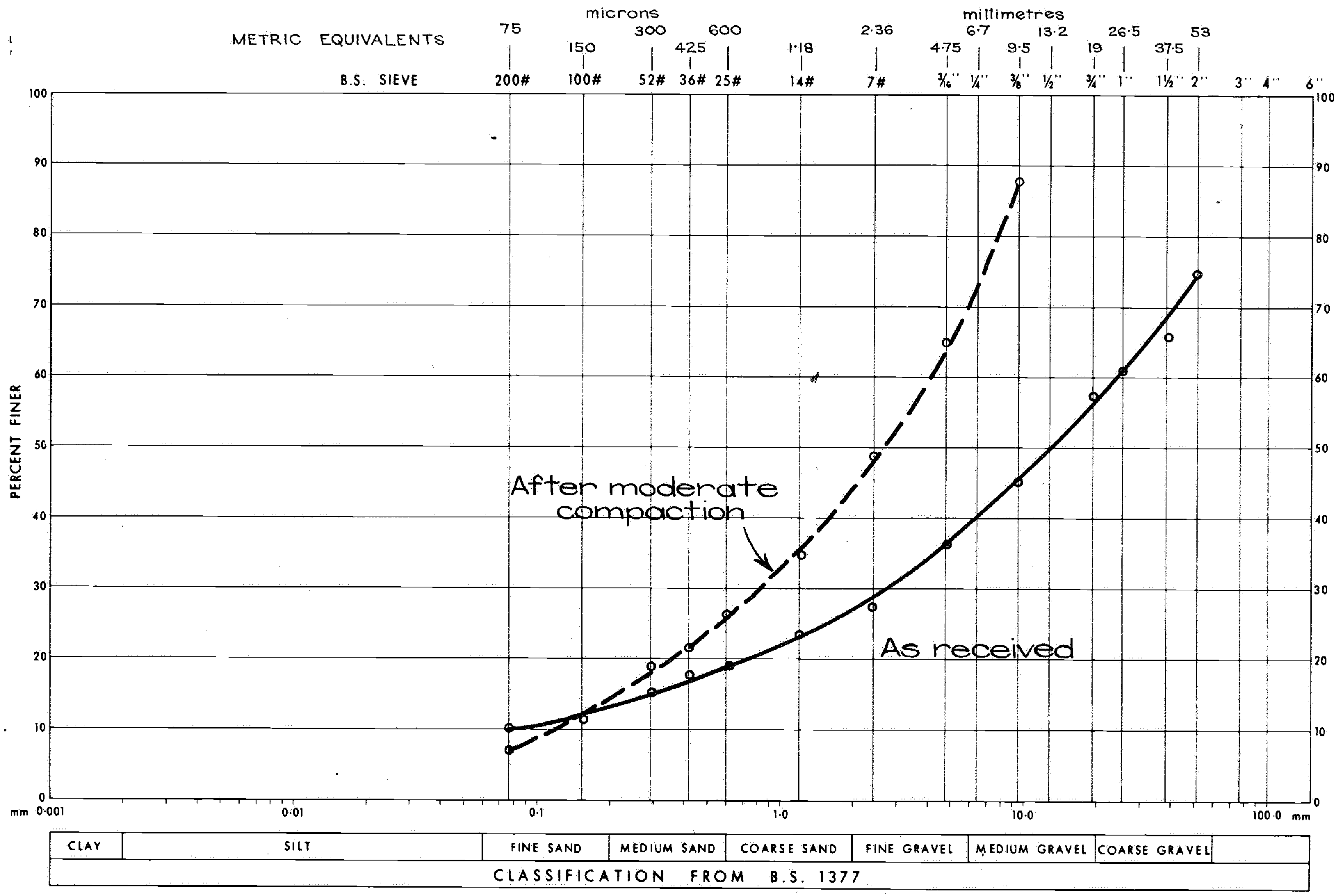
RESIDUAL SOIL ON CALCRETE (Qpr/Qca) ChA200·0km

Scale: As shown

Date: 15-3-75

FIG: 18

Drg No. S 11378



Note :- Insuffient material for compaction test.

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: G.H.McN

Drn: J.Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

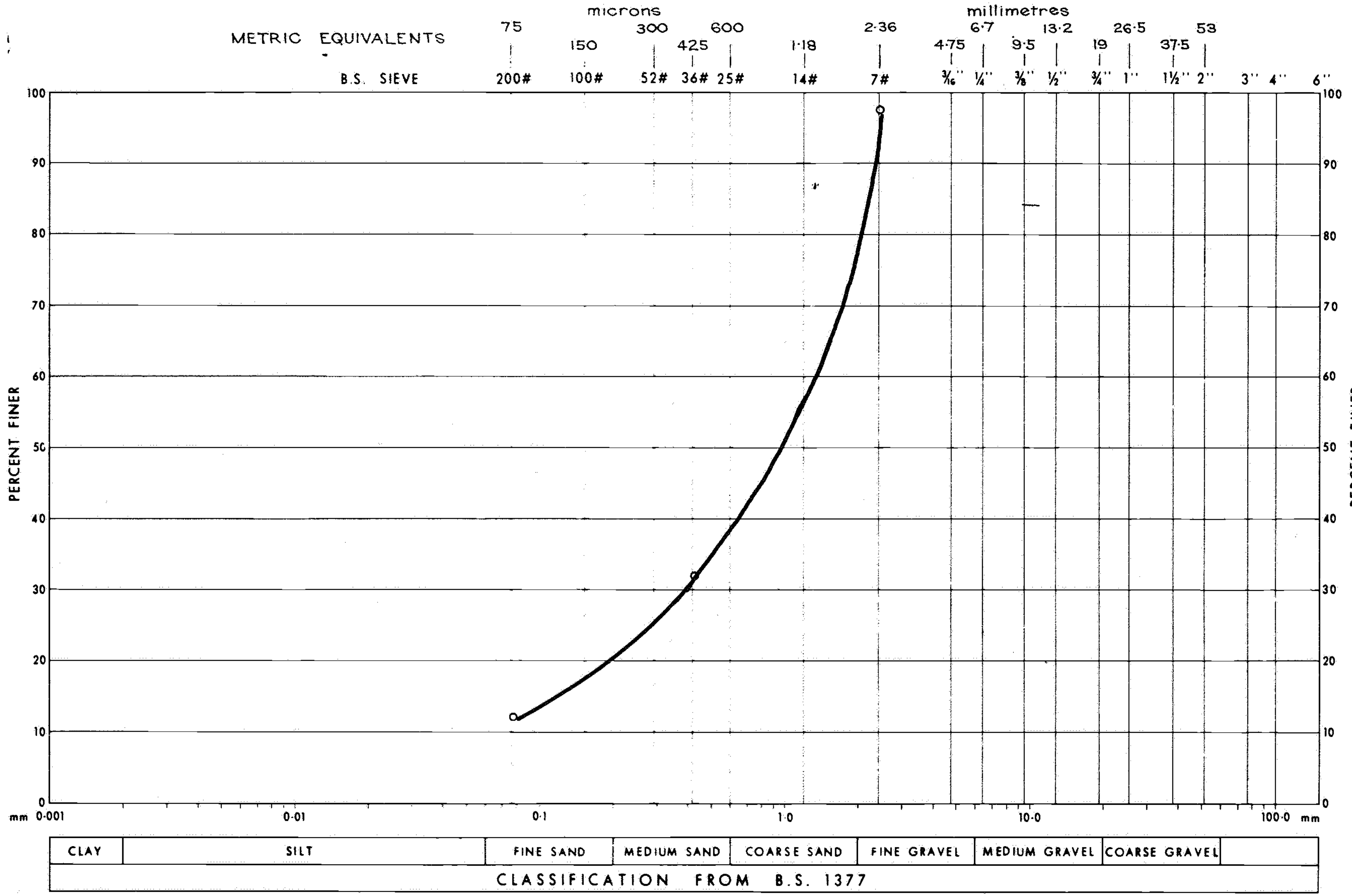
RESIDUAL SOIL (Qpr) - Ch.B 27·9 km

Scale: As shown

Date: 5-3-75

FIG: 19

Drg No. S11379



Note :- Compaction curve not available. Results of Standard AASHO test. M.D.D. 95 p.c.f., O.M.C. 23%.
L.L. 36, P.L. 32, P.I. 4, L.S. 2, est. C.B.R. 28%,
field M.C. 6·3%.

PF Nº 59548 MG

ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

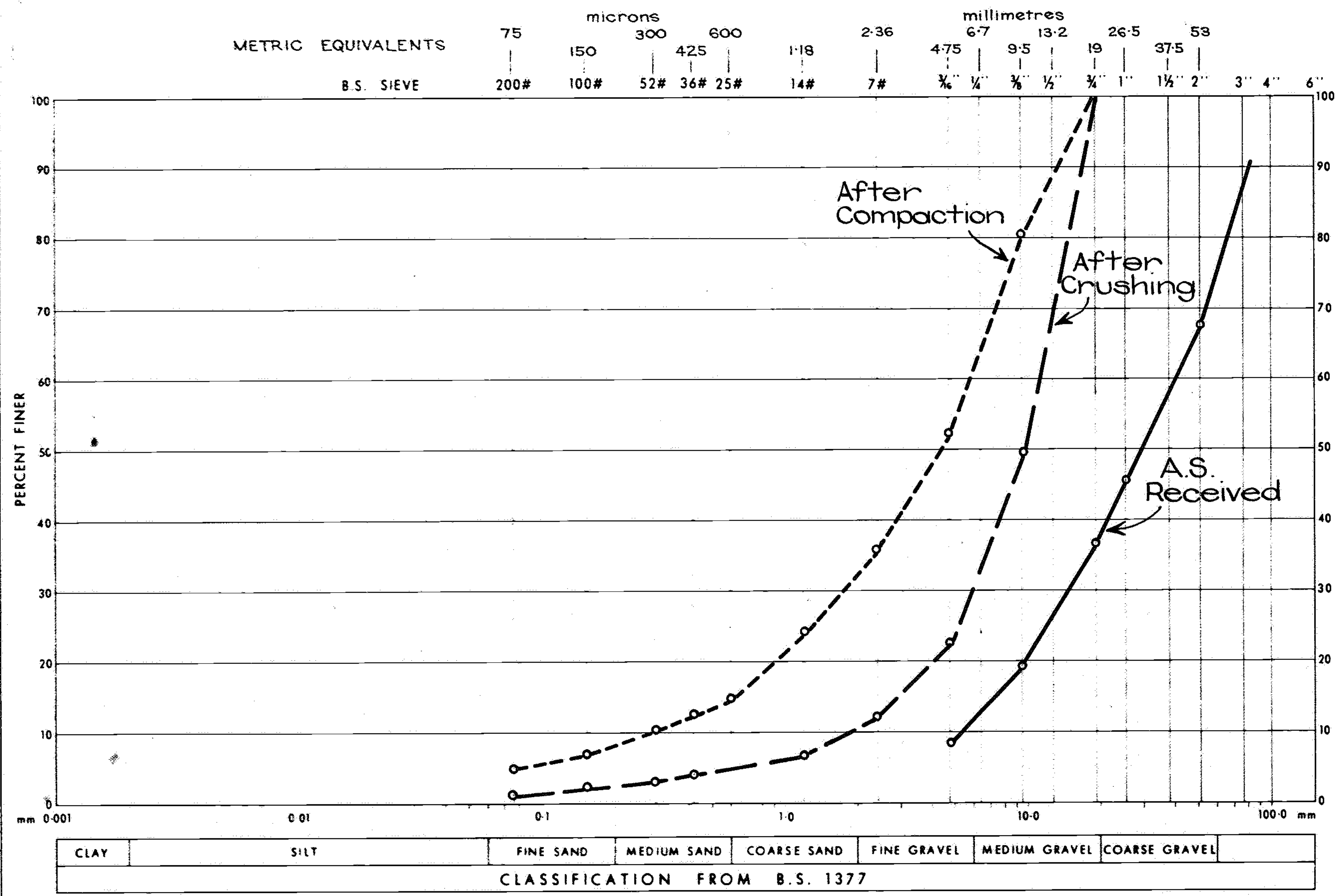
BULLDOG SHALE (Klb)- ch B49·2 km

Scale: As shown

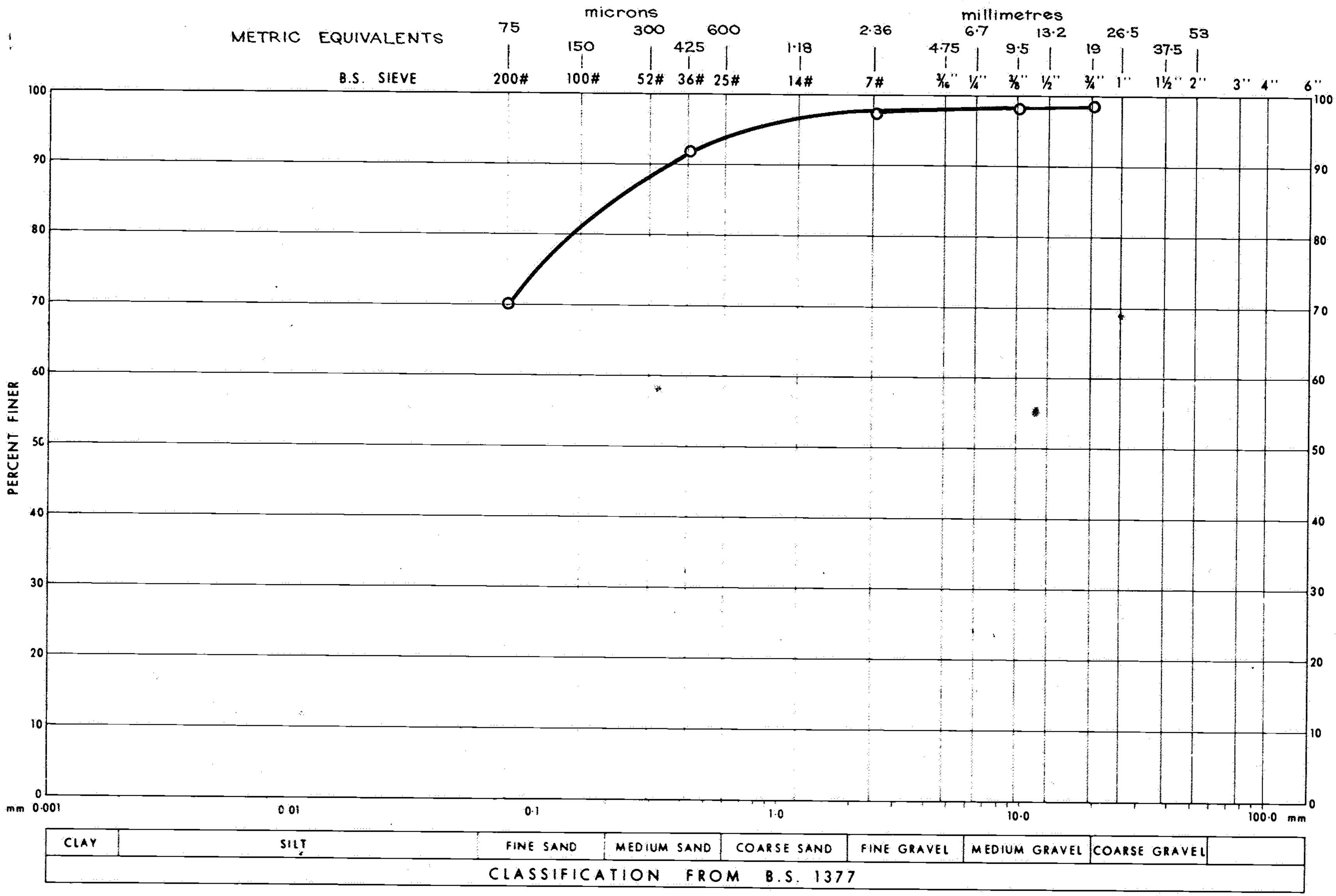
Date: 17th Sept '74

FIG: 20

Drg No. S11380



Note :- As received material crushed to pass 3/4" (19mm) sieve.
Results of one-point modified compaction test, M.D.D. 89 p.c.t., O.M.C. 11%



Note :- Compaction curve not available. Results of standard AASHO test, M.D.D. 105 p.c.f., O.M.C. 19%.
L.L.43, P.L.17, P.I. 26, L.S. 12, est. C.B.R. 7·3%,
field M.C. 6·8%.

ENGINEERING GEOLOGY SECTION

Compiled: G.H.McN.

Drn:

Ckd:

PF Nº S9548 MG

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

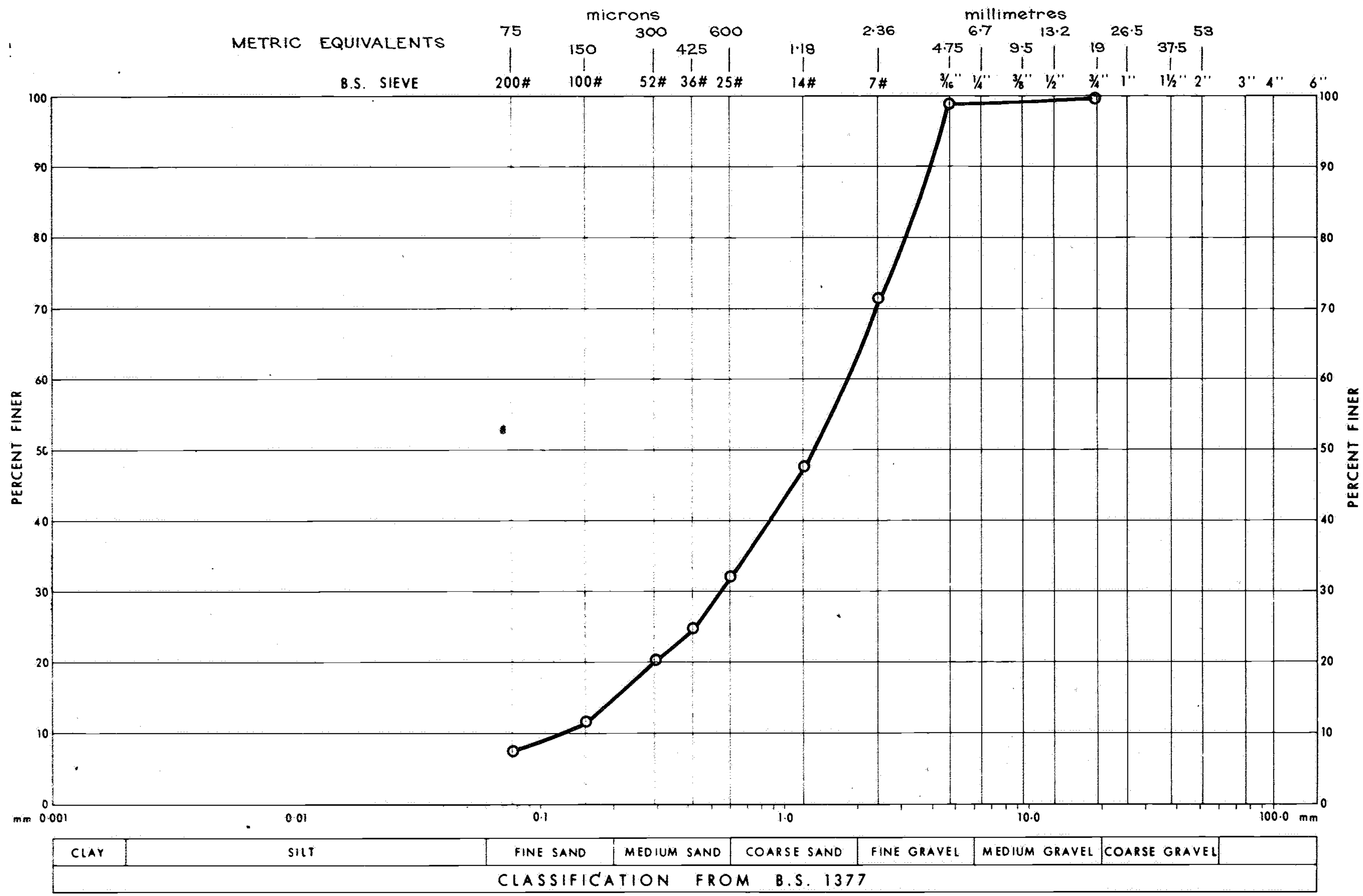
RESIDUAL SOIL (Qpr) - Ch. B97 km.

Scale: As shown

Date: 5-3-75

FIG: 21

Drg No. S11381



ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

RESIDUAL SOIL (Qpr) - Ch. B100·0 Km

Scale: As shown

Date: 17-9-

FIG: 22

Drg No. S11382

PF Nº 59548 MG

PF Nº 9829 Bab

ENGINEERING GEOLOGY SECTION

Compiled: J.Selby

Drn: J.W.

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

RESIDUAL SOIL (Qpr)

Scale: As shown

Date: 17th Sept '74

FIG. 23

Drg No. S11383

ATTERBERG LIMITS: Non-plastic

Liquid Limit % Plasticity Index

Plastic Limit % Linear Shrinkage %

COMPACTION:

Maximum Dry Density 95·0 lbs/cub.ft.

Optimum Moisture Content 21·5 %

Natural Moisture Content NA %

Compacted Dry Density at Natural Moisture Content lbs/cub.ft.

%AASHO

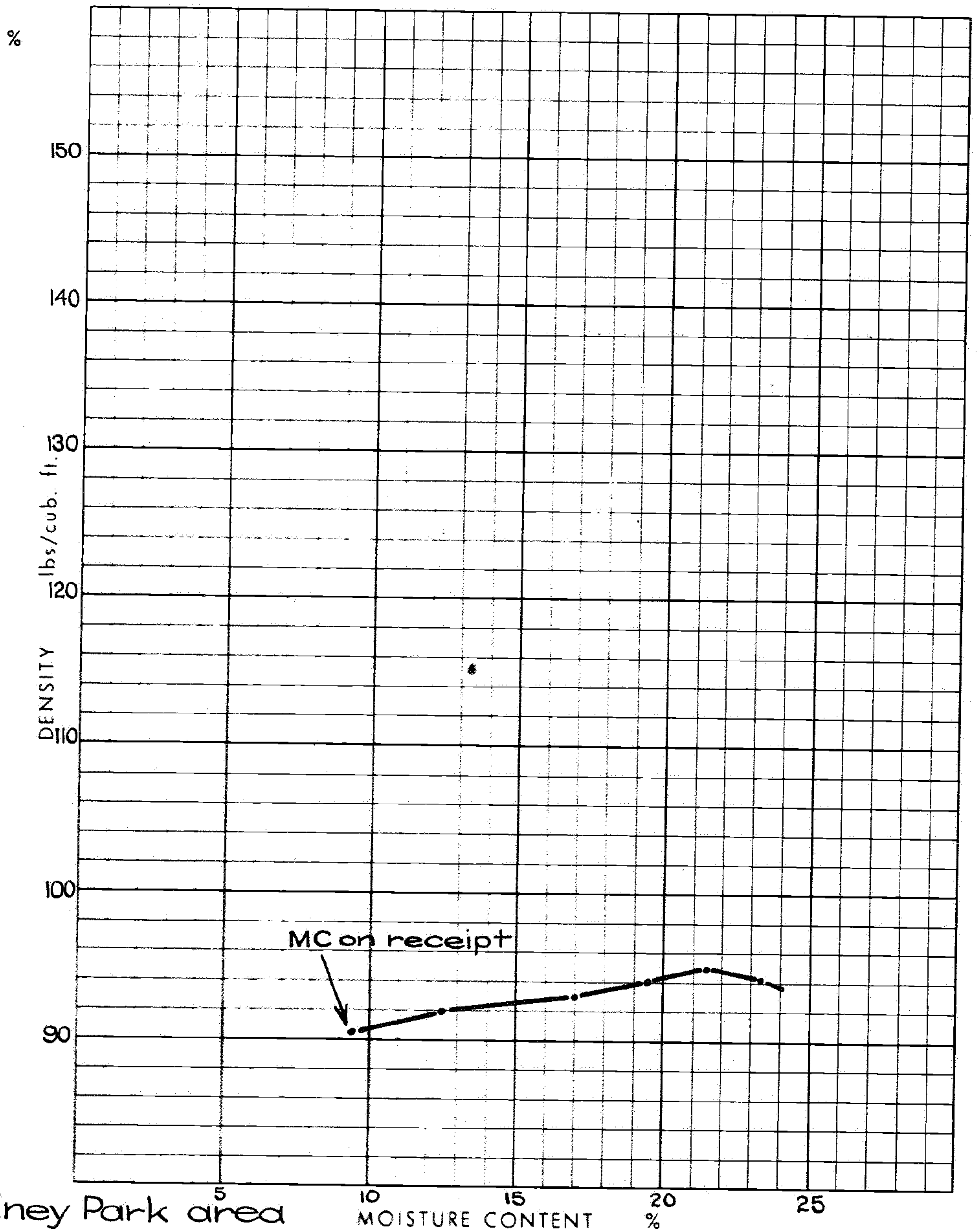
CALIFORNIAN BEARING RATIO: (estimated)

42 %

COMMENTS:

Saline water used

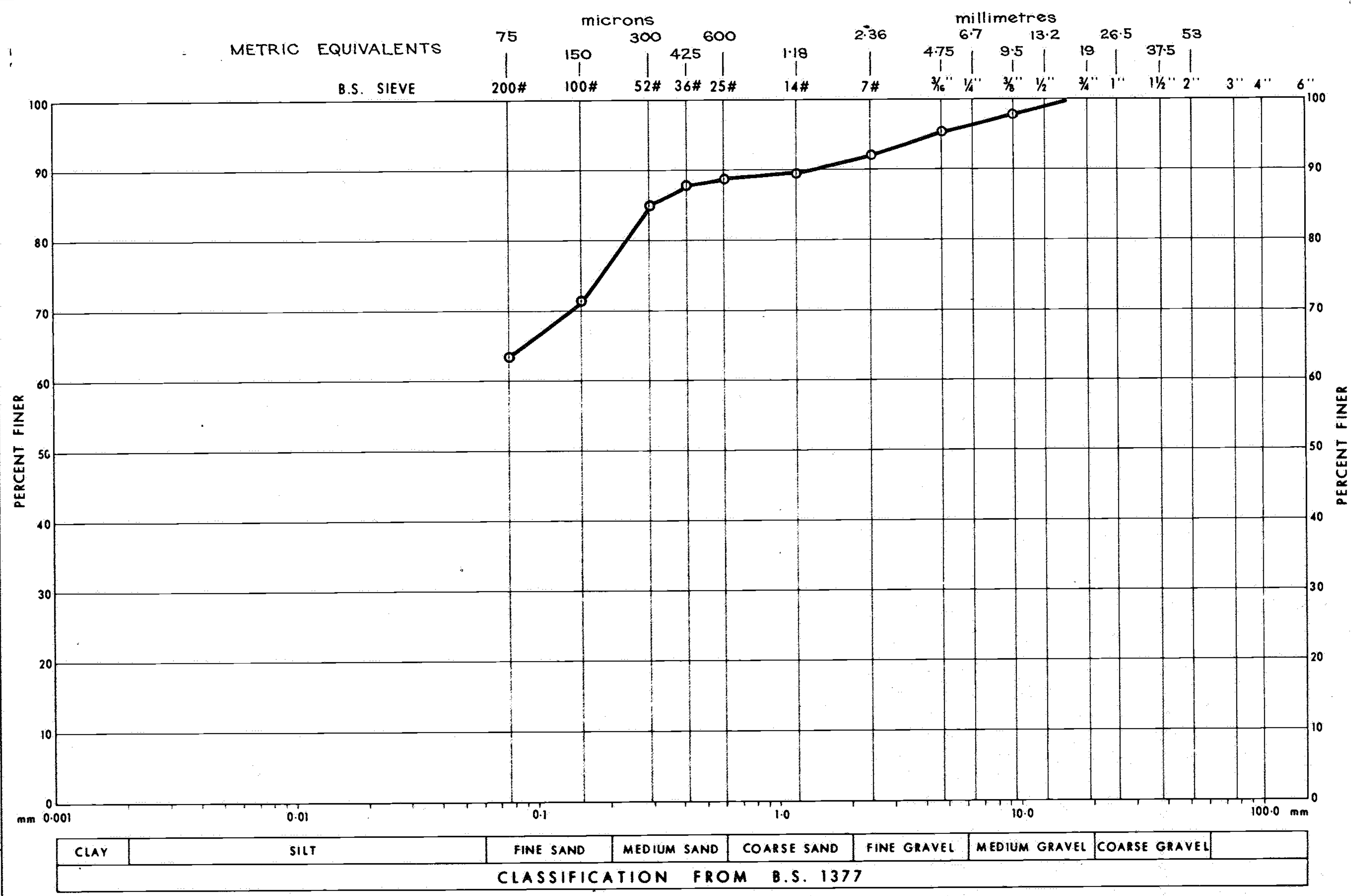
MODIFIED A.A.S.H.O. COMPACTION TEST



DESCRIPTION OF MATERIAL

Red-brown silty sand

SAMPLE No. B 100·0 Km LOCATION Cadney Park area



ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams.

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

RESIDUAL SOIL (Qpr)-ch B.130.0k

Scale: As shown

Date: 17th Sept '74

FIG: 24

Drg No. S11384

PF Nº S9548 MG

ATTERBERG LIMITS:

Liquid Limit 48 % Plasticity Index 26

Plastic Limit 22 % Linear Shrinkage NT %

COMPACTION:

Maximum Dry Density 113 lbs/cub.ft.

Optimum Moisture Content 14 %

Natural Moisture Content NA %

Compacted Dry Density at Natural Moisture Content

lbs/cub.ft.

%AASHO

CALIFORNIAN BEARING RATIO: (estimated)

8·2 %

COMMENTS:

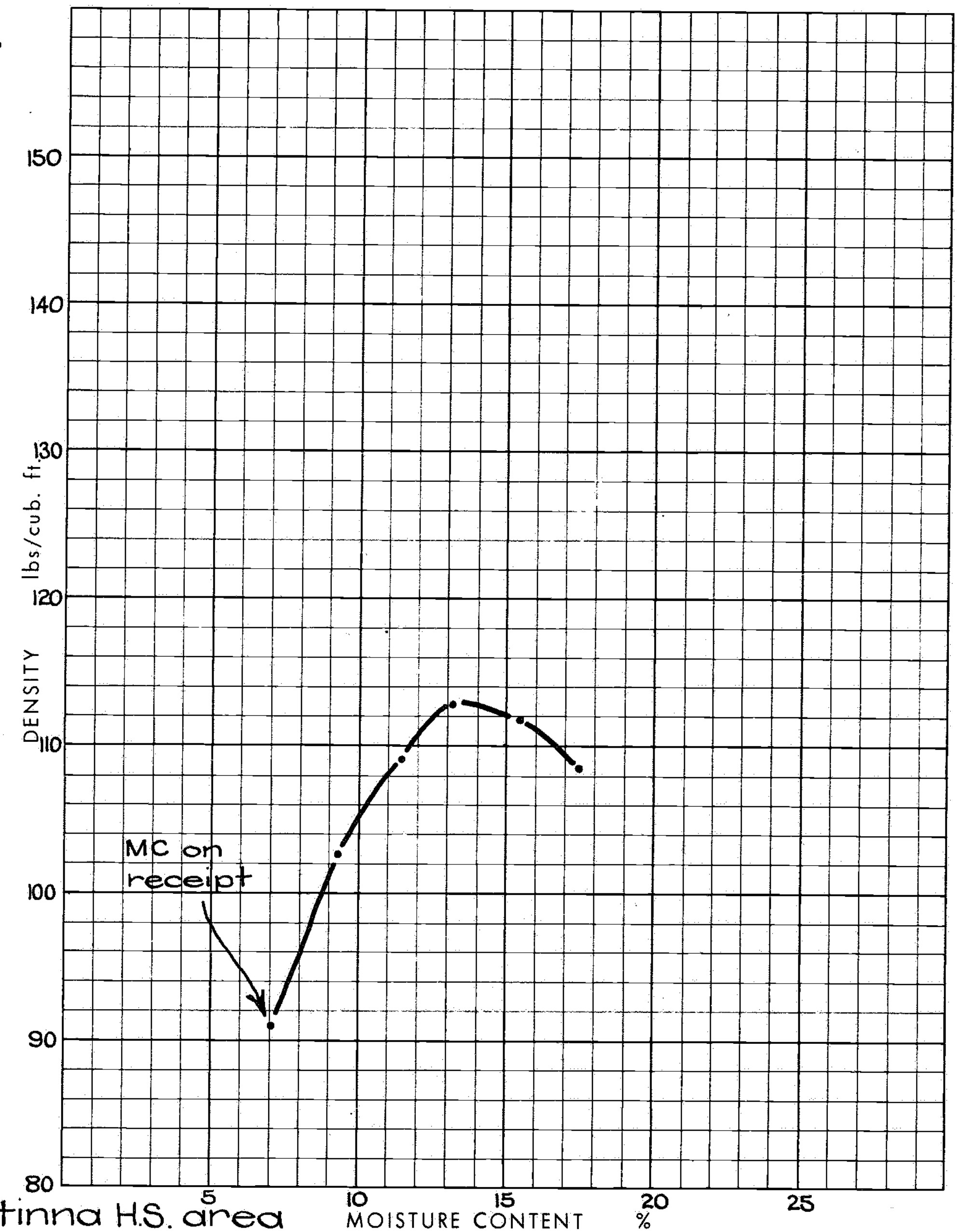
Saline water used.

DESCRIPTION OF MATERIAL

Red brown sandy, silty clay

SAMPLE No. B.130·0 km. LOCATION Wintinna H.S. area

MODIFIED A.A.S.H.O. COMPACTION TEST



ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

Ckd:

PF Nº 9829 Bab

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

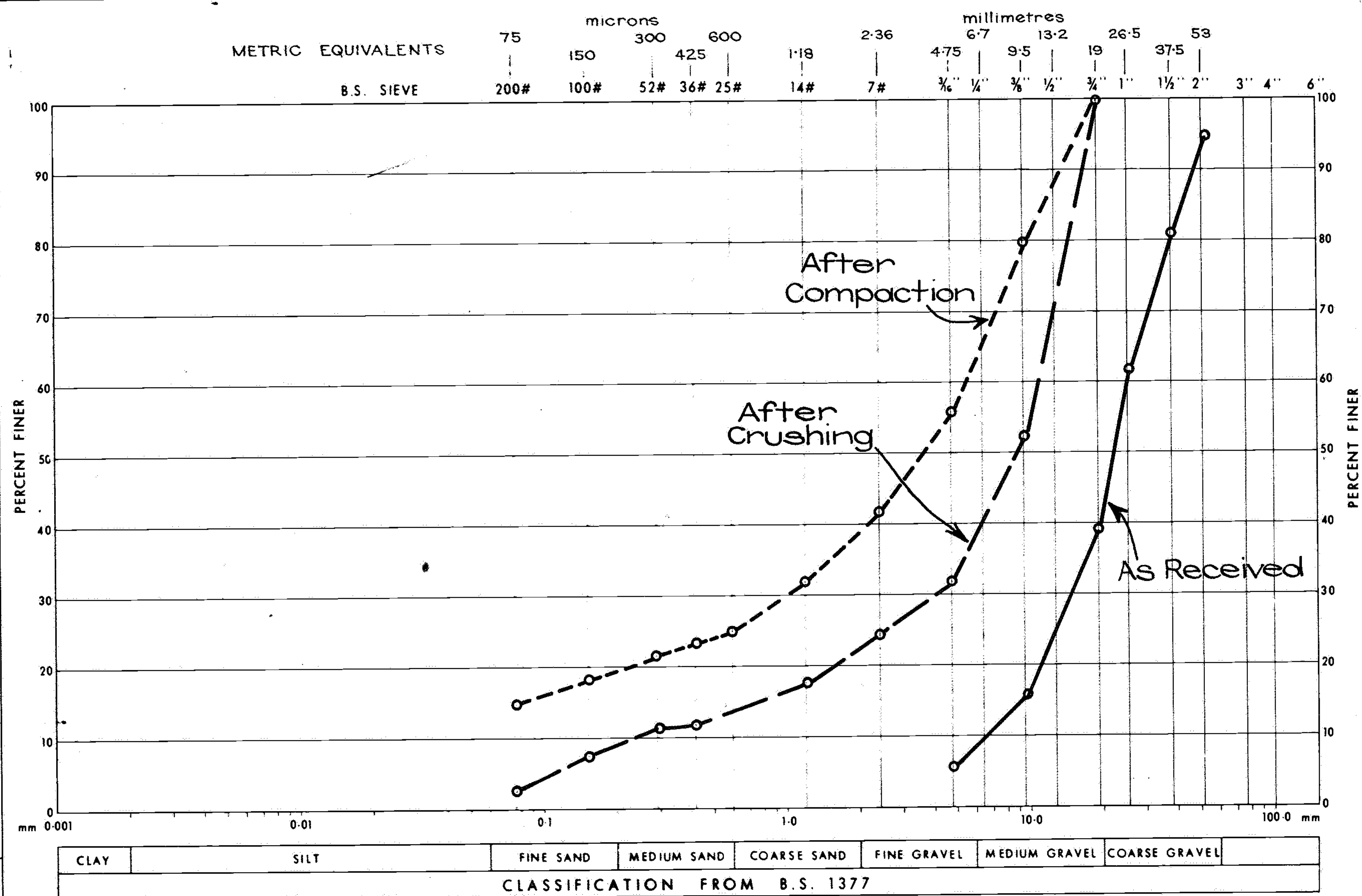
RESIDUAL SOIL (Qpr)

Scale: As shown

Date: 17th. Sept. '74

FIG: 25

Drg No. S 11385



Note :- As received material crushed to pass 3/4" (19 m.m.) sieve.
Results of one-point modified compaction test, M.D.D. 82 p.c.f., O.M.C. 29%

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

BULLDOG SHALE (Klb) - ch B139.1km

Scale: As shown

Date: 17th Sept '74

FIG: 26

Drg No. S11386

ENGINEERING GEOLOGY SECTION

Compiled: GHMcN

Drn: J.Williams

Ckd:

PF Nº S9548 MG

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

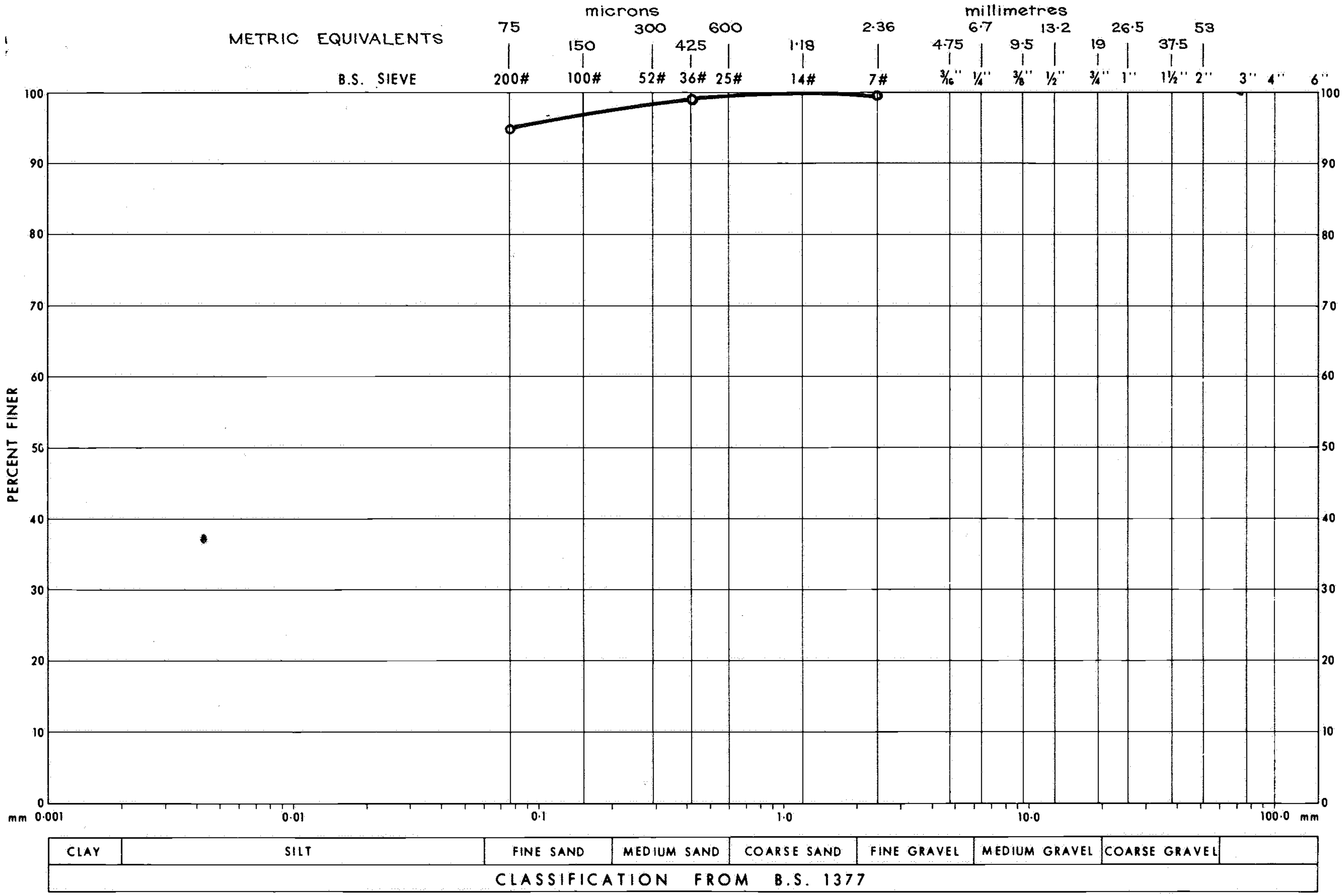
BULLDOG SHALE (Klb)-Ch. B144.0 km.

Scale: As shown

Date: 5-3-75

FIG: 27

Drg No. S11387



Note :- Compaction curve not available. Results of standard AASHO test,
M.D.D. 92 p.c.f., O.M.C. 26%.
L.L. 62, P.L. 24, P.I. 38, L.S. 16, Est. C.B.R. 4·0%, field M.C. 16·3%.

ENGINEERING GEOLOGY SECTION

Compiled: J. Selby

Drn: J. Williams

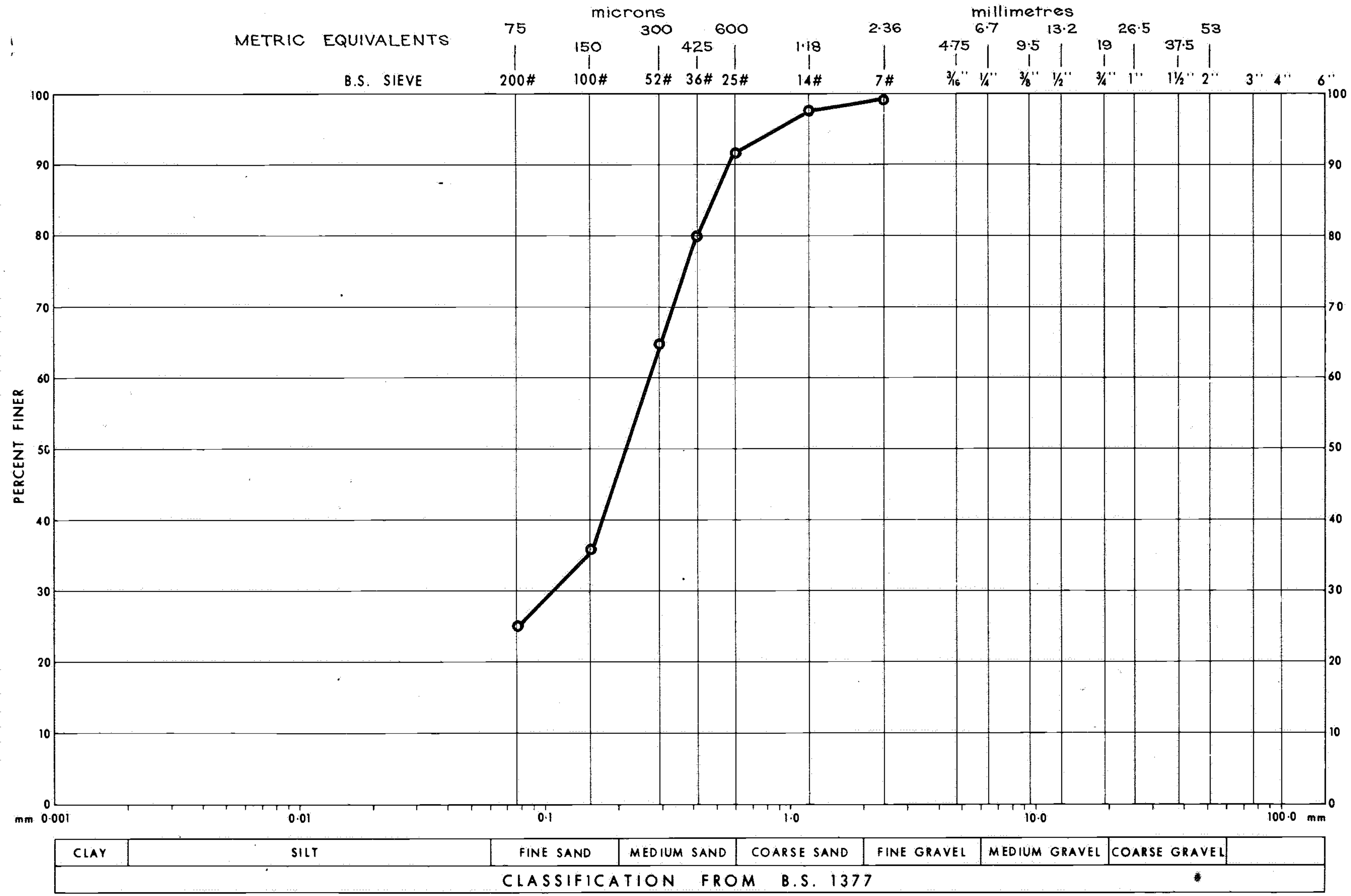
Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

DRIFT SAND/RESIDUAL SOIL - ch. B·160·0km (Qrs/Qpr)



Scale: As shown

Date: 17th Sept. '74

FIG: 28

Drg No. S11388

PF Nº 59548 MG

PF Nº 9829 Bab

Ckd:

Drn: J. Williams

Compiled: J. Selby

ENGINEERING GEOLOGY SECTION

DRIFT SAND/RESIDUAL SOIL (Qrs/Qpr)

ENGINEERING PROPERTIES OF MATERIALS

TARCOOLA — ALICE SPRINGS RAILWAY

DEPARTMENT OF MINES — SOUTH AUSTRALIA

Drg No. S 11389

FIG: 29

Date: 17th Sept. '74

Scale: As shown

ATTERBERG LIMITS:

Liquid Limit 20 %

Plasticity Index 8

Plastic Limit 12 %

Linear Shrinkage %

COMPACTION:

Maximum Dry Density 130 lbs/cub.ft.

Optimum Moisture Content 8·0 %

Natural Moisture Content NA %

Compacted Dry Density at Natural Moisture Content
lbs/cub.ft.
%AASHO

CALIFORNIAN BEARING RATIO: (estimated)

14·5 %

COMMENTS:

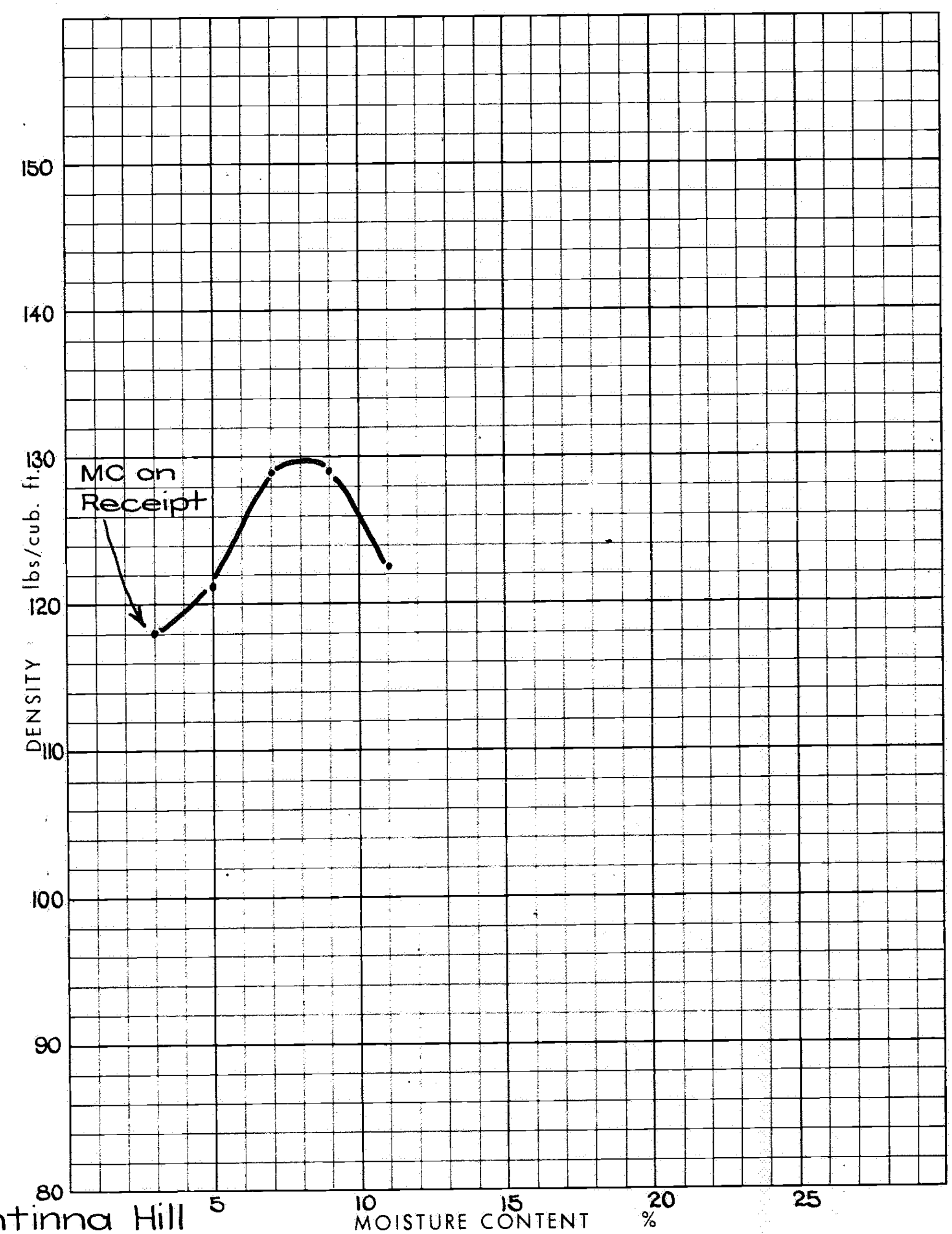
Saline water used

DESCRIPTION OF MATERIAL

Red brown silty sand

SAMPLE No. B.160·0 km LOCATION Wintinna Hill

MODIFIED A.A.S.H.O. COMPACTION TEST



ENGINEERING GEOLOGY SECTION

Compiled: J.Selby

Drn: J. Williams

Ckd:

PF Nº S9548 MG

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

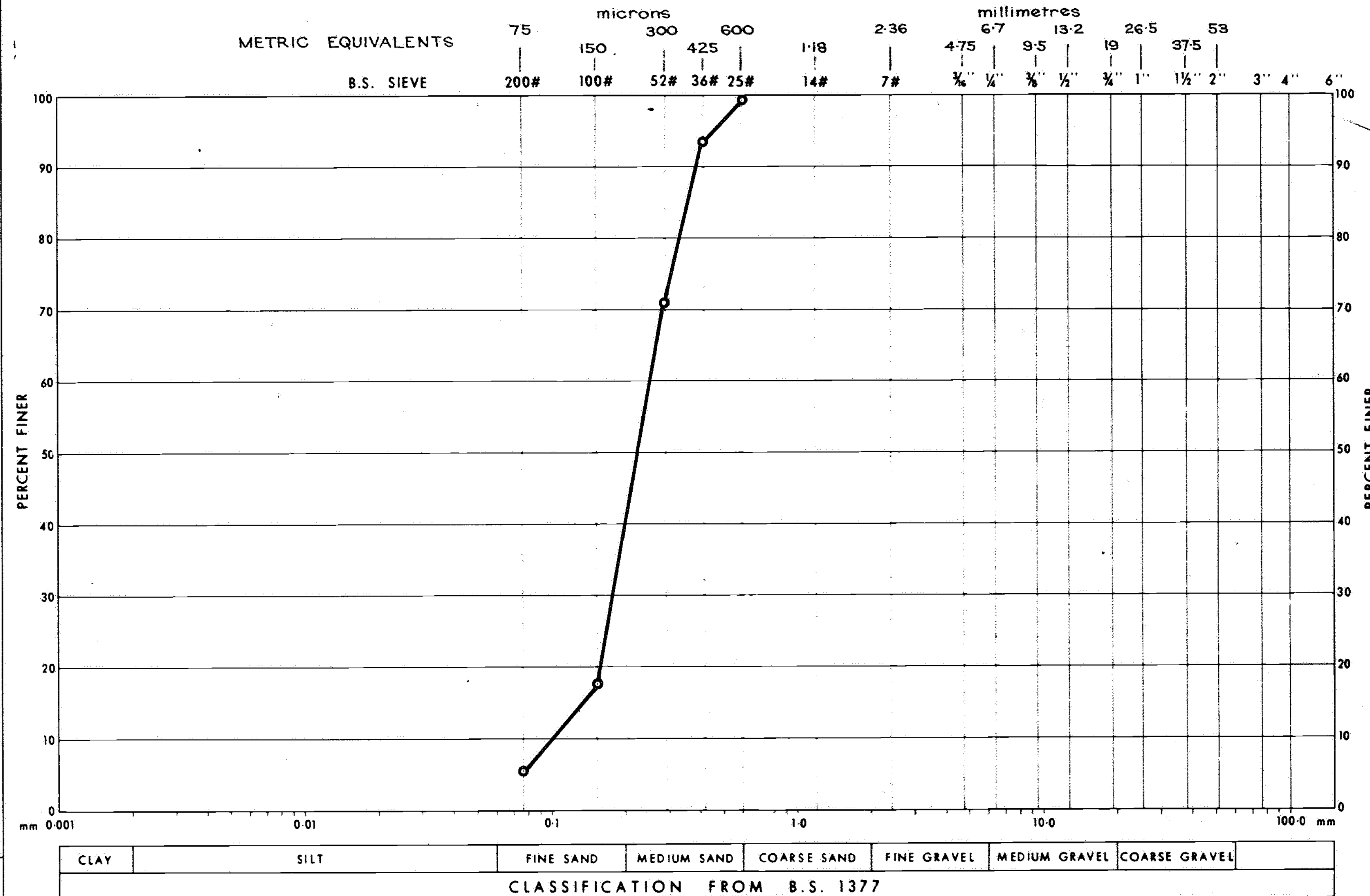
DUNE SAND (Qrd)-ch B.164·7 km

Scale: As shown

Date: 17th. Sept. '74

FIG: 30

Drg No. S11390



PF No 9829 Bab

Compiled: J.Selby
Drn: J.W.
Ckd:

ENGINEERING GEOLOGY SECTION

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

ENGINEERING PROPERTIES OF MATERIALS

DUNE SAND (Qrd)

Scale: As shown
Date: 17th Sept. '74
FIG: 31
Drg No. S 11391

ATTERBERG LIMITS: Non-plastic

Liquid Limit % Plasticity Index

Plastic Limit % Linear Shrinkage %

COMPACTION:

Maximum Dry Density 116 lbs/cub.ft.

Optimum Moisture Content 10 %

Natural Moisture Content NA %

Compacted Dry Density at Natural Moisture Content lbs/cub.ft.

%AASHO

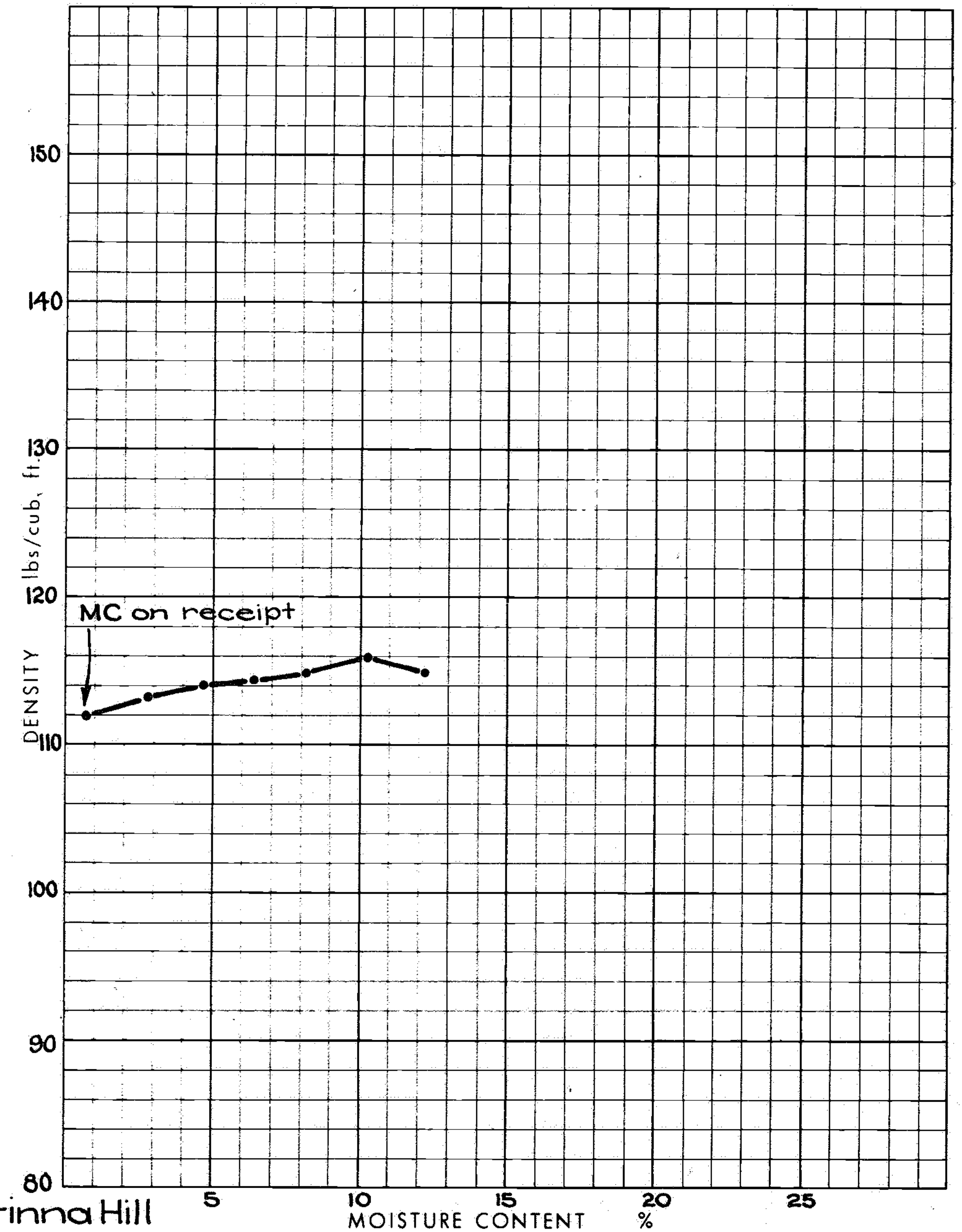
CALIFORNIAN BEARING RATIO: (estimated)

13·7%

COMMENTS:

Saline water used.

MODIFIED A.A.S.H.O. COMPACTION TEST



DESCRIPTION OF MATERIAL

Fine to medium sand

SAMPLE No. B. 164.7 LOCATION Wintinna Hill

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: GHMcN

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

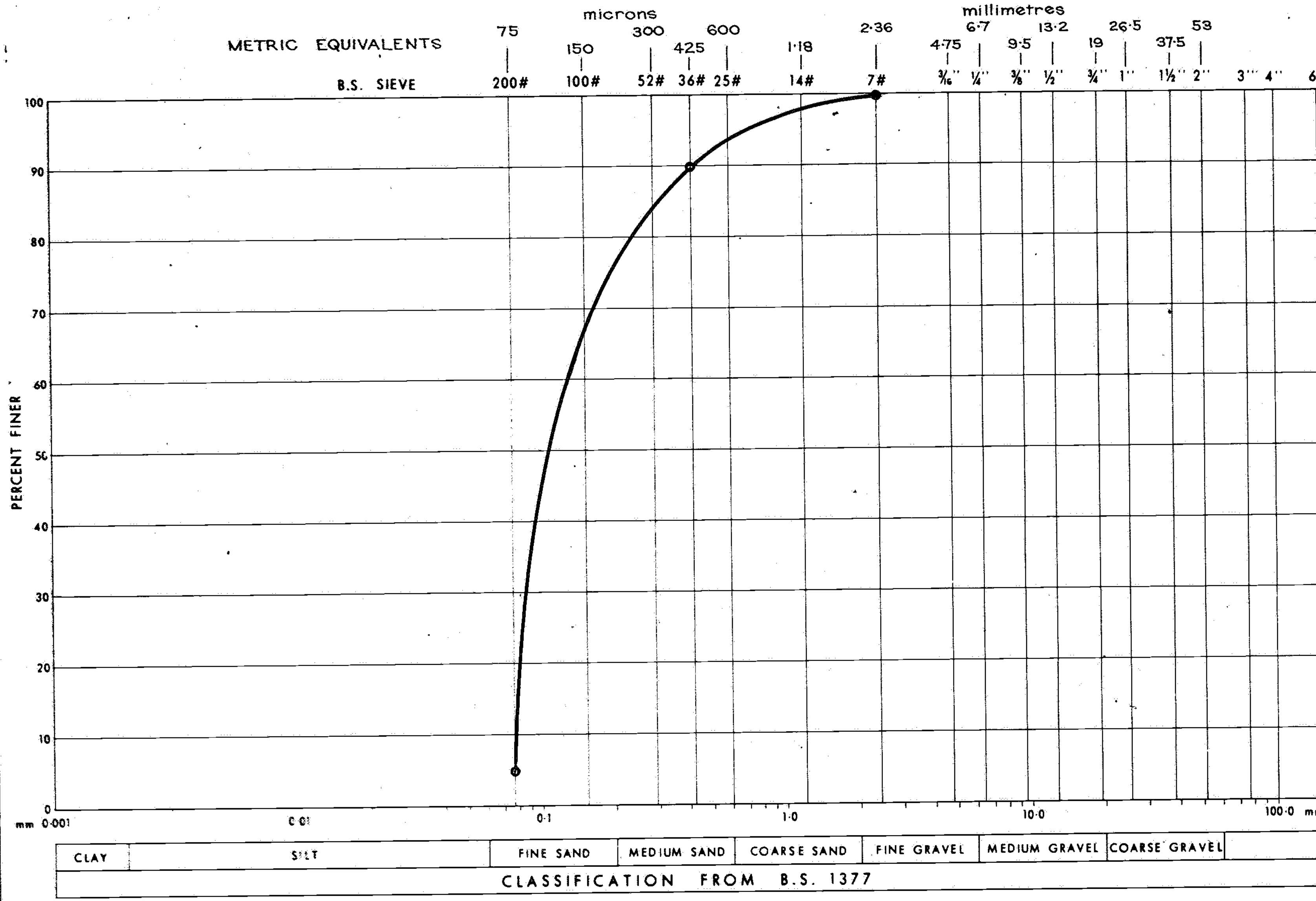
DUNE SAND(Qrd)-Ch. B179.0 km

Scale: As shown

Date: 5·3·75

FIG: 32

Drg No. S 11392



NOTE - Compaction curve not available. Results of Standard
A.A.S.H.O. test, M.D.D. 114 p.c.f., O.M.C. 11%
Non-plastic, L.S. 0, est. C.B.R. 14%, field M.C. 0·5%

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: G H McN

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

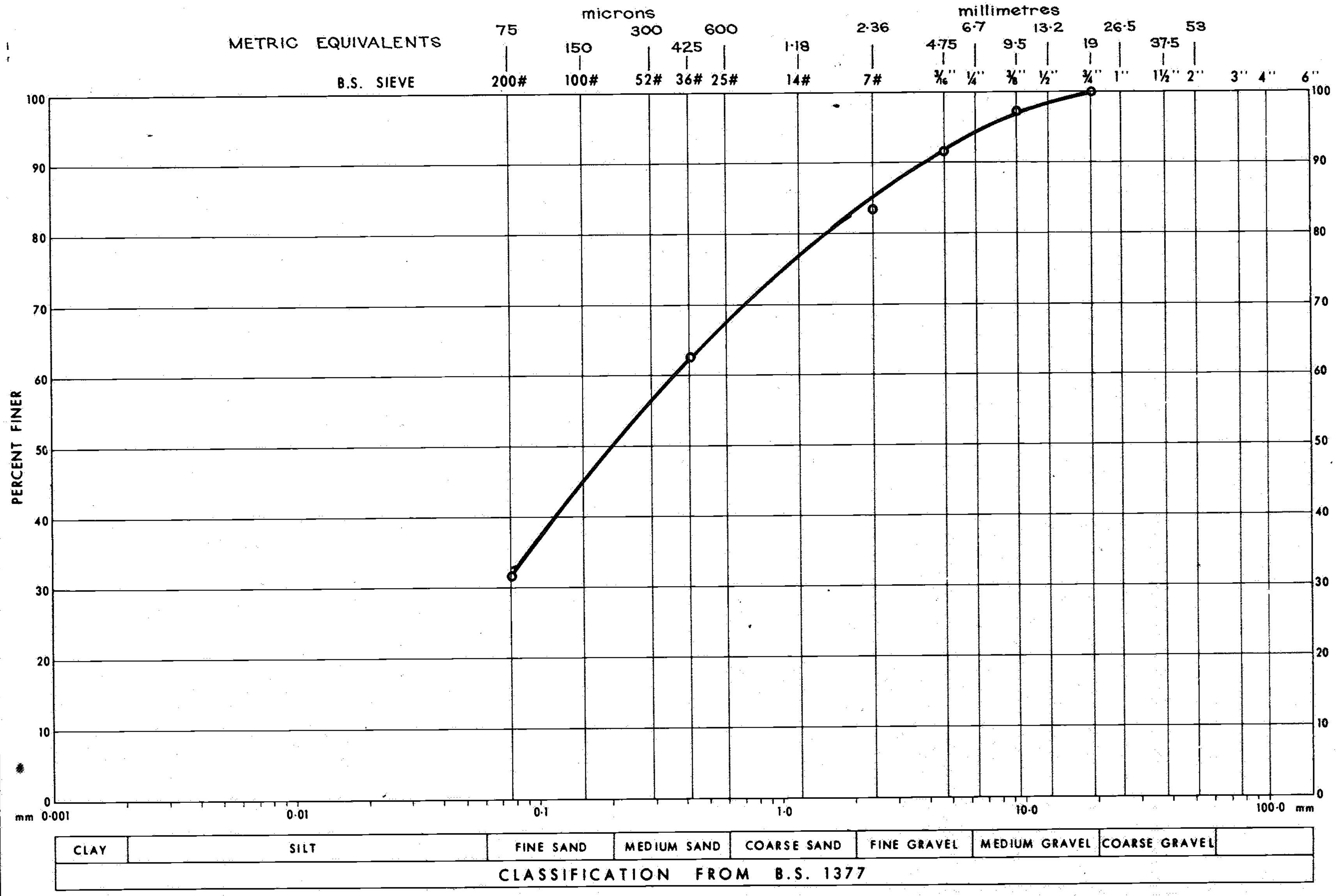
RESIDUAL SOIL (Qpr) - Ch. B190·0 km

Scale: As shown

Date: 5 - 3 - 75

FIG: 33

Drg No. S11393



NOTE : Compaction curve not available. Results of Standard A.A.S.H.O. test, M.D.D. 137 p.c.f., O.M.C. 9·0%. L.L. 20, P.L. 9, P.I. 11, L.S. 5, est. C.B.R. 19%, field M.C. 3·5%.

PF Nº S9548 MG

DEPARTMENT OF MINES — SOUTH AUSTRALIA

ENGINEERING GEOLOGY SECTION

Compiled: J.Selby

Drn: J.Williams

Ckd:

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

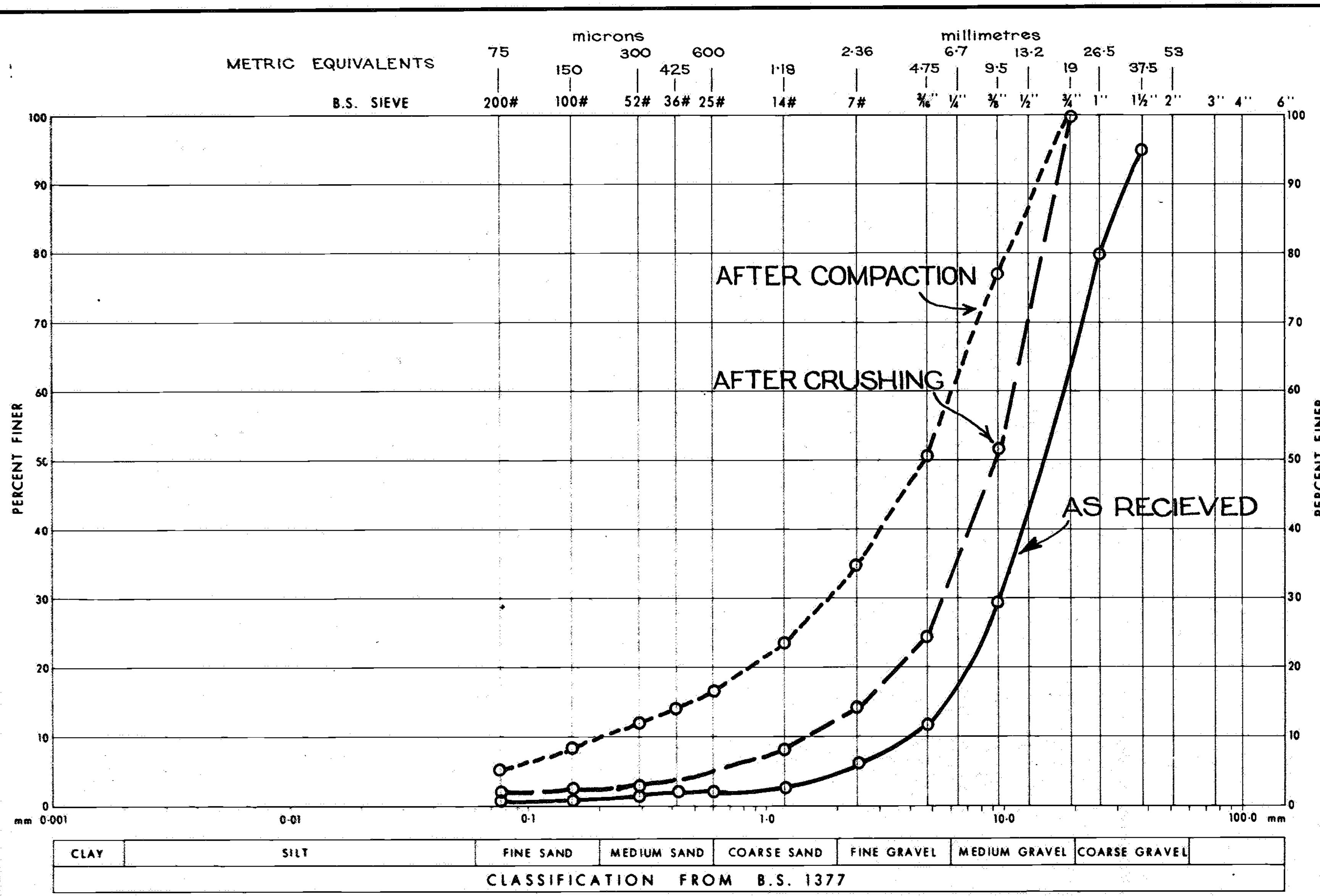
BULLDOG SHALE (Klb) Mt Willoughby Borrow Pit

Scale: As shown

Date: 17th Sept '74

FIG: 34

Drg No. S11394



NOTE : As-received material crushed to pass 3/4" (19 m.m.) sieve.
Results of one-point modified compaction test, M.D.D. 103 p.c.f. O.M.C. 12%

PF Nº S9548 MG

ENGINEERING GEOLOGY SECTION

Compiled: GH McN

Drn: J. Williams

Ckd:

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA — ALICE SPRINGS RAILWAY

TESTING OF MATERIALS

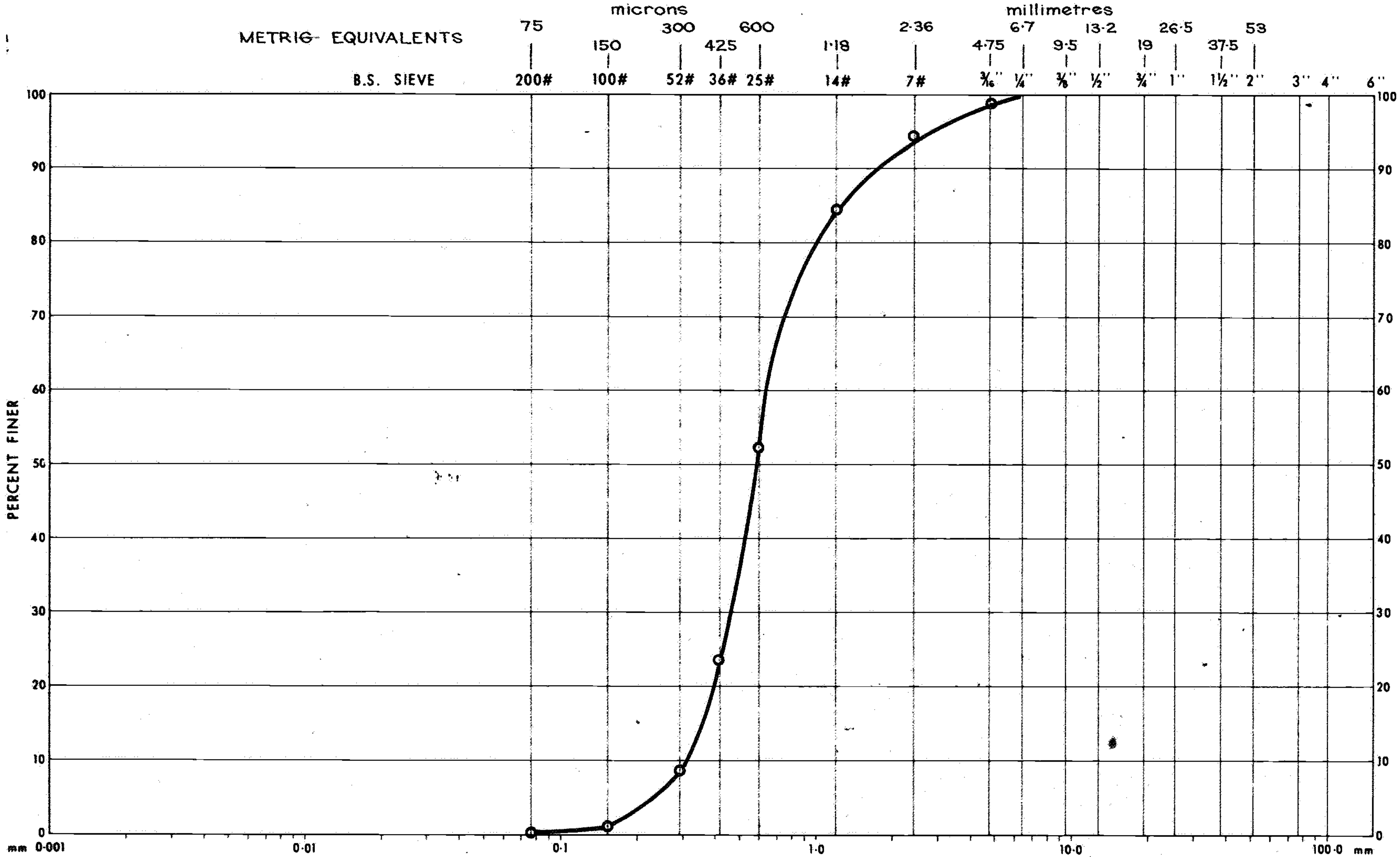
LAKE PHILLIPSON SAND

Scale: As shown

Date: 5-3-75

FIG: 35

Drg No. S11395



CLAY	SILT	FINE SAND	MEDIUM SAND	COARSE SAND	FINE GRAVEL	MEDIUM GRAVEL	COARSE GRAVEL
CLASSIFICATION FROM B.S. 1377							

NOTE :- Proposed as a source of fine concrete aggregate.

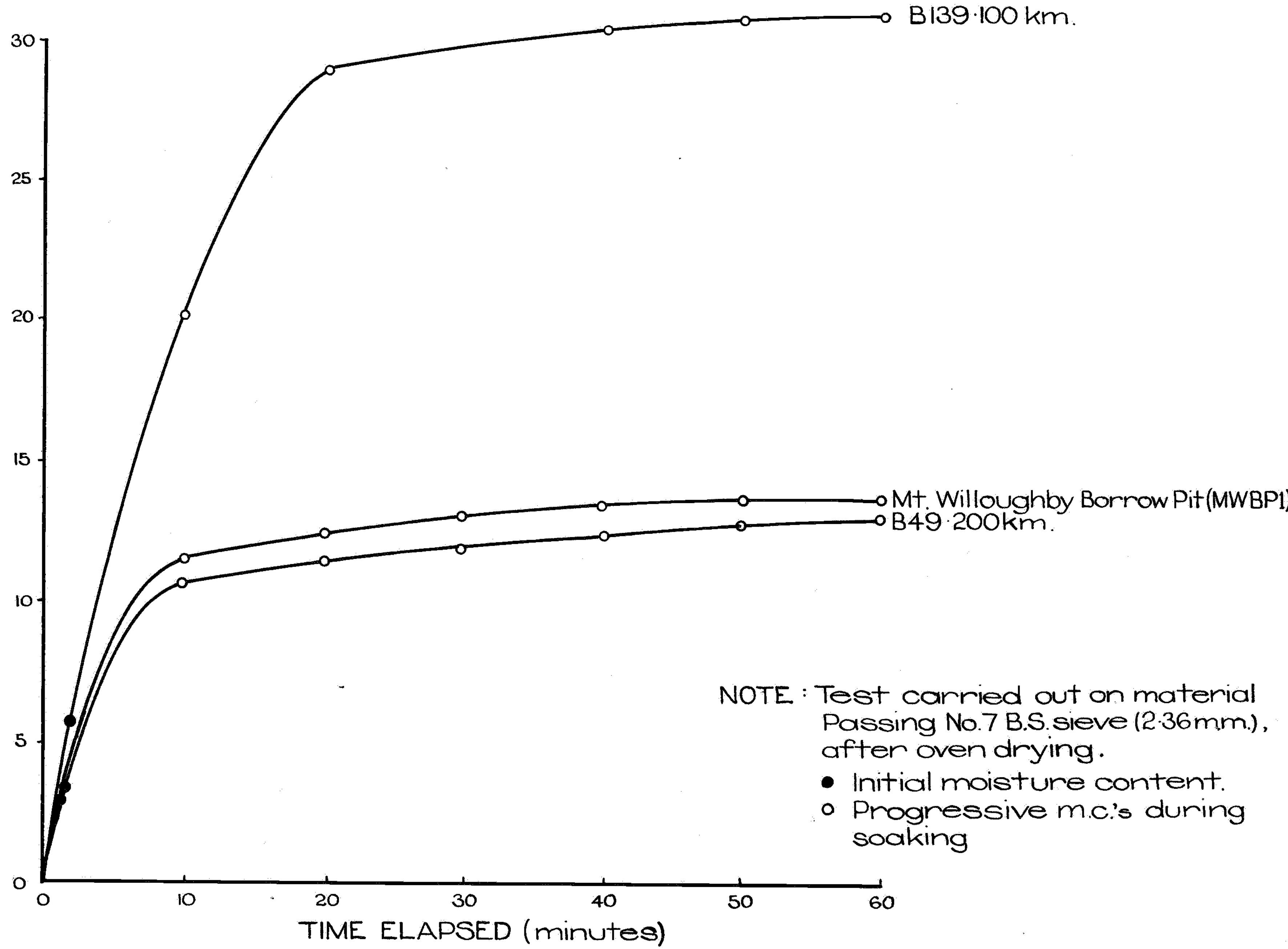


Fig. 36

DEPARTMENT OF MINES — SOUTH AUSTRALIA

TARCOOLA-ALICE SPRINGS RAILWAY
WATER ABSORPTION TESTS ON
BULLDOG SHALE (K1b)

Drn. G.McN.
Tcd. J.W.
Ckd.
Exd.

SCALE:

S11396

DATE: 5-3-75

500-2.69 665