ATTACHMENT E
Douglas and Partners Geotechnical Investigation 1988

REPORT ON
GEOTECHNICAL INVESTIGATION
NORTH TUNCURRY PLANNING STUDY -
SOUTHERN PRECINCT

PREPARED FOR
SINCLAIR KNIGHT & PARTNERS PTY. LTD.

FEBRUARY, 1988

Geotechnical Consultants

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SSI/10653

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CONTENTS

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1. INTRODUCTION

Great Lakes Shire Council and Taree Lands Office, acting through a steering committee, are undertaking a planning study to develop a Planning Statement for the Southern Residential Precincts extension of North Tuncurry.

This report presents the findings of a geotechnical investigation and assessment of soil and groundwater conditions across the above study area.

The work was undertaken at the direction of Sinclair Knight & Partners Pty. Ltd., acting on behalf of the Project Steering Committee.

The purpose of the investigation was to provide:

- General definition of the subsoil profile and groundwater conditions across the site.
- An assessment of foundation conditions in terms of AS 2870 for residential development and more generally for commercial, industrial and high rise.
- Expected pavement subgrade and indicated CBR for the range of subgrades expected.

The scope of the investigation comprised the collection of available data, airphoto interpretation, the excavation of 10 backhoe test pits in the various terrain/vegetation categories identified, static cone penetrometer testing at 2 locations and the measurement of infiltration rates by a double ring infiltrometer.

Details of the findings from the above together with engineering assessments and comments are contained within.

2. SITE LOCATION, DESCRIPTION, REGIONAL GEOLOGICAL SETTING AND AVAILABLE SUBSURFACE DATA

The site is located north of Tuncurry, N.S.W.. The area is bounded by the Pacific Ocean (Nine Mile Beach) to the east, Tuncurry Road to the west, the Tuncurry township to the south and undeveloped land some six kilometres north of the Tuncurry township.

In plan, the site covers an area with east-west and north-south dimensions of approximately 1.5 kms and 4 kms respectively.

Most of the site consists of prograded dune sands which have been fixed by vegetation. As such, the ground level across the site is irregular. Survey data supplied by the Great Lakes Shire Council shows that the average levels vary from 3.0 m (AHD) to 6.0 m (AHD) in the south of the site to 4.8 m (AHD) to 6.3 m (AHD) in the north.

Existing developments on the site include a golf course, old aeroplane runway and an extensive track system through the dense scrub and tree covered area.

Reference 1 indicates the soils below the site were formed during the Holocene period and should comprise recently deposited marine, estuary and fluvial sediments. The eastern portion of the site is reported to comprise beach and foredune sand with sediments to the west comprising back barrier deposits of sandy estuary origin of fine to medium grained sands.

Reference 2 indicates that the sands are water bearing with large reserves of groundwater. Recharge of the groundwater beds occurs directly from rainfall infiltration with the natural balance maintained by discharge via transpiration and groundwater flow to adjacent free water bodies.

Water supplies of 0.5 to 1.0 l/s may be obtained from nominal 50 mm diameter spearpoints where water levels are within a few metres of the ground surface. Groundwater supplies of more than 20 l/s have been reported from individual bores or spearpoint batteries installed for mining purposes. For example, Water Resources records show that spearpoint battery Nos. 47062/63 comprising 8 spears, 12 metres apart screened between depths of 1.8 m to 6.2 m yielded 22 l/s.

The groundwater within the coastal dunes is characteristically low in salinity and hardness with total salinity between 200 to 300 mg/l usually and hardness values ranging from 20 to 100 mg/l. Low pH values are common around 5 and hence the groundwater is potentially corrosive, (Reference 2). It is also noted that dissolved iron in the deeper aquifer zone is sometimes a problem for domestic and town water supplies.

Sand mining has been carried out to the north of the study area however there is no evidence of mining within the study area.

The study area has, however, been extensively explored by drilling by Mineral Deposits Limited for mineral sands. The existing grid of tracks through the area is understood to have been installed for exploration access. Drillers logs of bores and cross-sections were made available by Mineral Deposits Limited. Two cross-sections, one at either end of the site (244S and 392S), prepared from this information, are shown on Drawing SSI/10653/2 to 5.

The sections indicate that the subsurface profile comprises essentially sands, gravels and claybound sands. Perusal of the log show no records of significant peat or swamp sediments.

The MDL drilling on 244S was carried out three times; mid 1973, at the end of 1978, early 1979, and mid 1980. Drilling for 392S was carried out in mid 1977.

Rainfall records for Forster indicate a long term average annual rainfall of 1238 mm. The Bureau of Meterology reported the following rainfall for the above drilling years.

Year	Rainfall (mm)
1973	807
1977	1259
1978/1979	1300/705
1980	653

Over the period from 1970 to 1987 the yearly average rainfall has fluctuated from 653 mm to 1701 mm.

With reference to sections on Drawing Nos. SSI/10653-2 to 5, it may be seen that the MDL drilling indicates that the depth to the groundwater fluctuates from one drilling period to another. Water levels in mid 1973 and 1979/1980 were similar along 244S at depths generally in the order of 3 to 5 m below the surface at an average RL in the order of 1.0 m AHD. However, in mid 1980, water levels were some 2 - 3 metres higher despite this being in the middle of a drought period.

Along section 293S bores drilled during a period of approximately average rainfall indicate a depth to the groundwater of 1.5 to 4 m at approximately RL 2 m (AHD).

3. INVESTIGATION

Air photograph interpretation showed a distinct change in vegetation cover between the north-east and south-west of the site. Subsequent subsurface investigation work, however revealed no significant change in soils conditions between the two areas.

Ten backhoe pits were excavated across the site to depths of up to 2.7 m. The pits were logged and sampled by an experienced geotechnician. Standpipe piezometers were installed in Pits 7 & 8. Dynamic penetrometer testing was carried out adjacent to each of the pits to allow an assessment of the density of the sands.

Two static cone penetrometer (Dutch cone) tests were taken to cone refusal at 6.8 (DC1) and 23.0 m (DC2) to confirm deep subsurface conditions shown by the MDL drilling.

Three double ring infiltrometer tests were carried out at the following locations:

TP8 - surface level (natural vegetation and topsoil conditions)
TP8 - 0.3 m below surface level (in clean sand)
On the fairway of the golf course (pasture improved conditions).

The purpose of this testing was to provide a direct measure of permeability and water infiltration rates into the ground under differing vegetation covers.

The locations of the test holes are shown on the attached plan, SSI/10653/1.

4. INVESTIGATION FINDINGS

The detailed findings of the test pits are shown on the test pit report sheets attached together with general notes defining the descriptive terms used on the logs.

In summary, conditions across the site were relatively uniform and may be summarised as follows:

Description	Depth (m)
	Surface level
SAND, grey with roots and organics	
	0.2/0.4
SAND, light brown, dry to moist, wet at ground water level	
	0.6/2.7 (Maximum depth of test pits)

The dynamic cone penetrometer testing shows that the upper 0.45 to 0.7 m of the sands are generally in a very loose state and that loose conditions often continue for in the order of 1 m.

Some lightly cemented sand was encountered in Pits 2, 3 & 5.

Groundwater was encountered in Pits 7 and 8 at depths of 1.8 m and 1.2 m respectively.

The results of the cone penetrometer testing are shown on the attached profile sheets. Some notes on the method of interpretation of the profiles are also attached. In summary, the Dutch cone penetrometer tests encountered sands to the full depth of penetration varying from loose (in the upper 0.7 to 1.8 m) becoming loose to medium dense and then dense to very dense at depth. The exception to the above was a 0.7 m thick band of firm clay encountered in DC7 at a depth of 18.3 m and very loose to loose sands from 16 m to 18.3 m immediately above the clay.

The results of the double ring infiltrometer testing are shown on Figures 1 to 3. The following infiltration rates were recorded:

- TP8 at surface level - 1.7 m/hr
- TP8 at 0.3 m below surface level - 2.8 m/hr
- On golf course fairway - 0.07 m/hr.

5. COMMENTS AND DISCUSSION

5.1 Proposed Development

It is understood that it is proposed to develop the site for primarily urban, mixed density residential development. A number of drainage options are being studied. One option under review is the discharge of stormwater into the sandbeds via infiltration basins.

5.2 Subsurface Soil Conditions

The subsurface investigation and perusal of available data revealed generally sands, gravels and clay bound sands. Only one layer of peat was recorded in the north-western corner of the site by Mineral Deposits Limited bore 16E (244S). This layer is at a depth of 4.9 m to 4.8 m and appears to be an isolated occurrence based on the findings of DC2 and the other Mineral Deposits bores.

The surface sands are in a very loose to loose condition generally and would require densification to provide a suitable foundation strata.

No evidence of prior mining or filling was noted on the site. No evidence of slope instability was recorded, however downslope creep of sand on dune slopes was evidenced by vegetation growth in some areas. Lightly cemented sands were encountered in some pits, however the degree of induration does not appear to be extensive as has been encountered in other coastal sands.

Based on the above subsurface conditions, the site is considered suitable for development as proposed provided the guidelines outlined below are complied with.

5.3 Earthworks

The following comments are intended for general guidance in residential development associated with cut and filling up to 2 m. Work in excess of this should be subjected to specific review.

(i) Filling

All subdivisional fills should be placed in a controlled, compacted manner.

The following suggested procedure should be adopted for structural filling after removal of vegetation.

- Strip to stockpile organic sandy topsoil for later re-use.
- Compact the sand subgrade using a heavy (10 tonne static weight) smooth drum vibrating roller to a minimum density index of 70% (AS 1289 E6.1).
- Place and compact sand fill in horizontal layers of maximum thickness 300 mm loose to the above density index.

It is suggested that fill batter slopes should be limited to a maximum batter of 1V:3H to facilitate topsoil replacement and revegetation and prevent erosion or retained by an adequately designed structure. Batters of up to 1V:2H are feasible but difficult to maintain and would probably require covering by a revetment type structure to prevent erosion.

(ii) Excavations

The sands will be readily excavatable. Batter slopes should be as for filling or alternatively the excavation should be supported by an adequately designed retaining structure.

5.4 Footings

(i) Residential

Provided earthworks on the site are carried out in a controlled manner such that all filling and the exposed natural subgrade be compacted to a minimum density index of 70%, it is considered that the site will classify as a Class A site in accordance with AS 2870.

The dynamic penetrometer results indicate that achievement of a 70% density index will require densification of the existing strata beneath proposed house lots by rolling with a heavy (10 tonne static weight roller). The sands should be saturated during rolling to obtain maximum benefit from the roller.

The achieved density level may be checked by using a dynamic penetrometer (AS 1289 F3.3). A blow count of 10 blows/300 mm of penetrometer penetration at depths below 0.3 m below the surface is considered to be equivalent to a density index of 70%.

(ii) Other than Residential

The difference in DC1 and DC2 depth to refusal and density profile indicates that foundation levels for heavily loaded structures will vary from one location to another. Accordingly, it is suggested that footings for other than domestic one and two storey residential buildings should be the subject of an individual site investigation prior to design and construction.

5.5 Retaining Structures

The sand fill is medium grained and thus would be expected to have an angle of internal friction of about 30^{o}, and a bulk density in the order of 18 to 20 kN/m^{3}. These values may be used for retaining wall design. The retaining structures should be founded on a sand stratum, densified to a minimum density index of 70%.

5.6 Pavements

Previous experience has shown that a soaked CBR of 10% may be expected from a medium grained sand subgrade compacted to 70% density index. Higher values may be achieved where greater compactive effort or surcharge pressures are adopted.

It is suggested that this value would be applicable for planning design subject to confirmation during construction.

5.7 Subsoil Permeability and Groundwater Conditions

Permeability

Soil particle gradings show that the sands are medium grained (see attached grading curves). Based on empirical correlation between the D_{10} grain size and permeability (Hazen's formula), a coefficient of permeability of the sand sampled below the topsoil of 4 x 10^{-4} m/sec has been calculated for the sand subgrade below the organic sand (topsoil layer).

Permeability may also be estimated from the infiltration test in the medium sands at a depth of 0.3 m (TP8). If a hydraulic gradient of 1 is assumed then a permeability of 7 x 10^{-4} m/sec is indicated. It is noted however that this method of assessing infiltration often over-predicts actual infiltration. Large scale testing on similar graded sands from the Tomago sandbeds have yielded values in the order of 2 - 4 x 10^{-4} m/sec.

The above permeabilities are of the same order of magnitude and it is suggested that a lower bound value of coefficient of permeability of 3 x 10^{-4} m/sec be used for assessment of stormwater flow within the clean sands.

The presence of any organic layer or vegetation dramatically reduces the infiltration rate. The effect of a topsoil zone/fines in the soil can be seen by comparison between infiltration rates at a depth of 300 mm and the surface in the natural scrub (TP8) and more dramatically where actual lawn cover is established.

Account of this effect should be taken in the design of soakage or infiltration areas where regrassing or topsoil (organic) build-up is expected.

Porosity

No data has been collected on the porosity of the sand at this site. Available data collected on studies of similar medium grained sands in the Tomago sandbeds indicates a porosity of between 30 to 40%.

Groundwater Levels

Existing limited data from Mineral Deposits Limited indicates water level changes up to in the order of several metres can occur under the one transpiration environment due to climatic variations with possible larger changes in extreme rainfall periods. Insufficient data is available to ascertain whether this represents the maximum likely fluctuation. However, as an indication, review of the records of long term monitoring of the sandbeds at Tomago, which has a similar average rainfall (1134 mm), shows that groundwater level variations of the order of 3 metres have regularly been observed.

Definition of fluctuations at this site and mean water levels would require long term monitoring of water levels and correlation with rainfall. We have considered the possibility of attempts to correlate existing limited water level data to groundwater levels for predicted methods, however published experienced (Reference 3) indicates such correlations are difficult to model accurately even with extensive data.

Decreases in the groundwater levels at Tomago during periods of low rainfall after water table rises have been monitored as being in the order of 0.2 m per month. Hence general groundwater level falls after rain could be expected to be relatively slow at this site.

Feasibility of Stormwater Disposal into the Groundwater System

While it is yet to be proven, it is likely that the groundwater level will rise to the ground surface in the lower portions of the site (i.e. RL 3 m AHD) during periods of intense rainfall.

As noted above it is expected that the rate of fall of the groundwater level after rises will be relatively slow. Hence any infiltration ponds created in the lower portion of the site may be expected to retain water for a considerably longer period than indicated by the infiltrometer testing.

In addition to the above, the removal of vegetation for development would be expected to at least initially dramatically reduce the transpiration rate. As the same volume of water will be entering the aquifer it may be expected that the average groundwater table level will rise.

In the absence of groundwater extraction, the long term magnitude of the rise will depend on the difference between the transpiration rate of the existing system and that of a developed urban environment.

In the short term during development of the area, assuming the following: all vegetation is removed; an existing evapotranspiration rate of 800 mm per year; and, a sand porosity of 35%; the water table would rise some 2.3 metres.

Clearly this is an upper bound value since all evapotranspiration will not be lost and as the water table rises so the hydraulic gradient will also rise, increasing lateral outflow from the system. It is, however suggested that the recorded extent of the water level fluctuations and the expected rises in water level due to changes in the transpiration rates require definition prior to infiltration basins being adopted as a means of stormwater disposal.

6. CONCLUSIONS AND SUMMARY

A geotechnical investigation of the southern precinct of the planned North Tuncurry Urban Extension has been carried out. The work comprised the review of available data, air photo interpretation, excavation of test pits, static cone penetrometer testing and infiltrometer testing.

The site was found to be underlain generally by sand under a thin (0.2/0.4 m) sandy topsoil layer. Peat/organics was identified only in one apparently isolated area in the north-western corner of the site.

Mineral Deposits Limited exploration drilling (undertaken for sand mining exploration) carried out in 1973, 1977, 1978/79 and 1980 indicates that groundwater levels vary several metres.

Infiltrometer rates vary from 2.8 m/hr for clean sands to 0.07 m/hr for grass golf course areas.

The site is considered geotechnically suitable for urban development with sand being the foundation stratum. The sand is in part loose and should be compacted prior to footing construction. Earthworks guidelines are given within Section 5.3. Following compaction, foundation conditions would classify as Class A, in accordance with AS 2870.

Non-residential development involving heavily loaded structures should be subject to individual geotechnical investigation prior to development.

Pavements over sand subgrade prepared in accordance with compaction specifications given within may be proportioned using a CBR of 10%.

Infiltrometer testing, grading and previous experience indicate the sand (below the topsoil zone) has a premeability in the range of 2 to 7 x 10^{-4} m/sec. A coefficient of 3 x 10^{-4} m/sec is suggested for assessment of stormwater flow within the sands.

Previous experience indicates the sands will have a porosity in the order of 30 to 40%.

Available data indicates groundwater level changes up to in the order of 3 m, however this may not be the maximum variation. The groundwater level is a balance of outflow from the aquifer, evapotranspiration and rainfall infiltration (in the absence of extraction by man). Development is expected to reduce the evapotranspiration component. If stormwater discharge into the aquifer is undertaken, a rise in the groundwater level would therefore be expected. The level to which the groundwater table would rise under the combination of a high rainfall period and a change in evapotranspiration has not been determined.

Qualification of evapotranspiration rates and long term water level/rainfall monitoring would be required to evaluate the above.

It is suggested that the extent of groundwater level fluctuations requires definition prior to development, in particular where the use of infiltration basins are proposed as a means of stormwater disposal.

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References

1. Croft & Associates Pty. Ltd., 1983 - North Tuncurry Planning Study (unpublished).

2. Department of Water Resources - Notes on Groundwater 1:100,000 Geological Map Series Camberwell, Dungog and Bulahdelah Sheet (unpublished).

3. Viswanathan, M.N., 1984. Recharge Characteristics of an Unconfined Aquifer from the Rainfall - Watertable Relationship. Jnl. of Hydrology, 70 (1984) 233-250.

NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretative rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, the S.A.A. Site Investigation Code. In general, descriptions cover the following properties — strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (e.g. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descend into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (e.g. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (e.g. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test F3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7 blows

as 4, 6, 7
N = 13

- In a case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40mm

as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test F4.1.

In the tests, a 35 mm diameter rod with a cone tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is output on continuous chart recorders. The plotted results given in this report have been traced from the original records.

The information provided on the charts comprises:—

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower (A) scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main (B) scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve resistance to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

$$q_c \text{ (MPa)} = (0.4 \text{ to } 0.6) \text{ N (blows per 300 mm)}$$

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

$$q_c = (12 \text{ to } 18)\ c_u$$

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two, relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test F 3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test F3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems:

- In low permeability soils, ground water although present, may enter the hole slowly, or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent prior weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (e.g. a three storey building) the information and interpretation may not be relevant if the design proposal is changed (e.g. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency.
- changes in policy or interpretation of policy by statutory authorities.
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

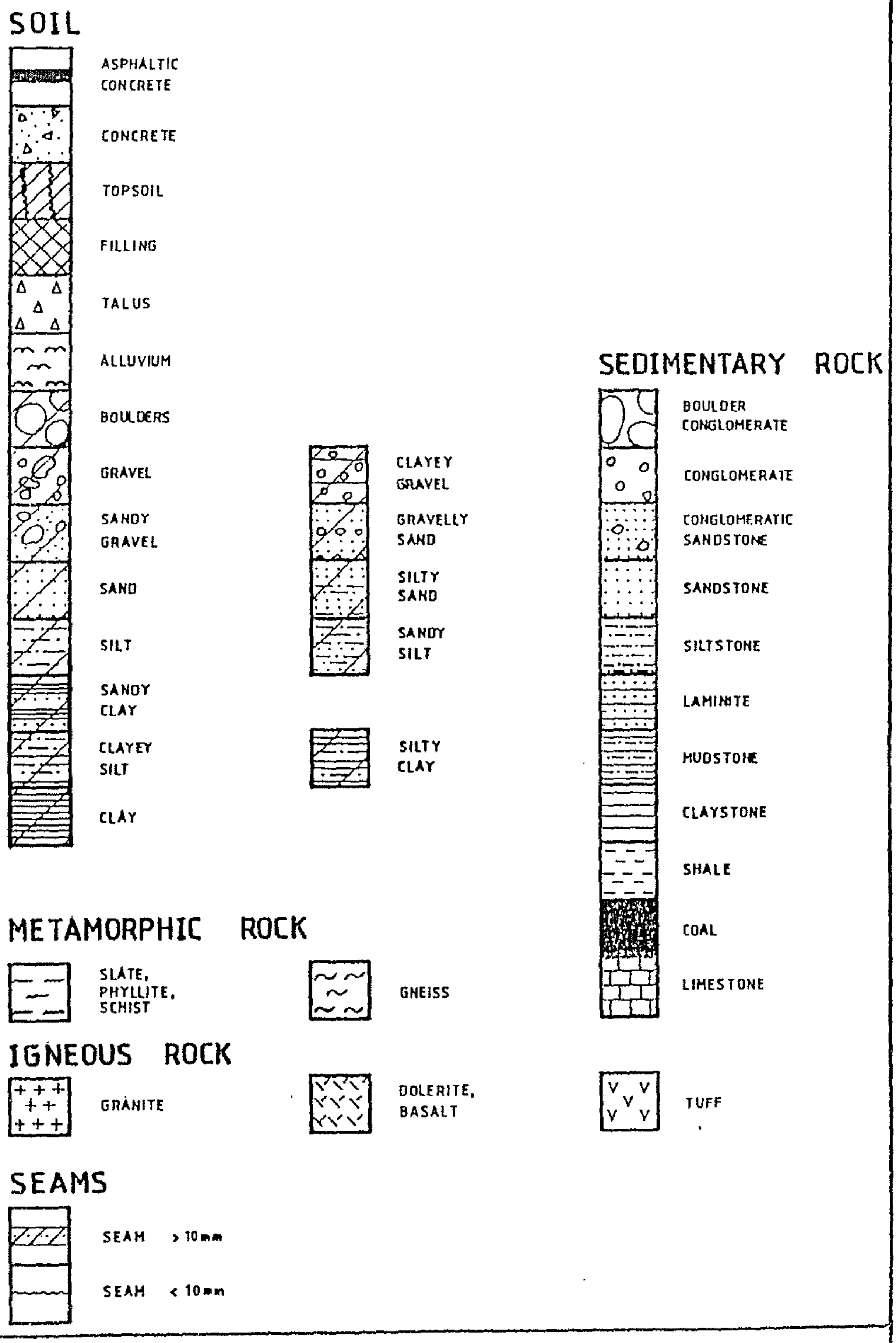
In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assit in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.



GRAPHIC SYMBOLS FOR SOIL & ROCK

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 1/2/1988
PIT No. 1
(In hol

PROJECT SOUTHERN PRECINCT STUDY
PROJECT No. SST/10653

LOCATION NORTH TUNCURRY
SURFACE LEVEL

	Depth metres	Description of Strata	Strata	Type & Depth
	0.2	SAND - dry to moist, grey medium grained sand with roots		D @ 0.1
0.5 1.0 1.5	1.9	SAND - dry to moist, light brown, medium grained sand		D @ 0.7
2.0 2.5	2.6	SAND - moist, brown, medium grained sand		D @ 2.2
3.0		TERMINATED AT 2.6 METRES.		

Dynamic Penetrometer Depth	Blows/150 mm	
	–	150
	1	300
	1	450
	2	600
	3	750
	3	900
	4	1050
	5	1200
		1350
		1500
		1650
		1800
		1950
		2100
		2250

EQUIPMENT Backhoe, 450 mm diameter
LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
[ ] - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J. Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.

DATE 1/2/1988

PIT No 1 (Crest of hill)

PROJECT SOUTHERN PRECINCT STUDY

PROJECT No. SSI/10653

LOCATION NORTH TUNCURRY

SURFACE LEVEL

	Depth metres	Description of Strata	Sampling and In Situ Testing				
			Strata	Type & Depth	Dynamic Penetrometer		
					Depth	Blows/150 mm	
	0.25	SAND - moist, grey, medium grained sand with roots					150
							300
		SAND - dry, light brown, medium grained sand					450
0.5	0.6						600
		TERMINATED AT 0.6 METRES.					750
1.0							900
							1050
							1200
							1350
1.5							1500
							1650
							1800
							1950
2.0							2100
							2250
2.5							
3.0							

EQUIPMENT Backhoe, 450 mm diameter

LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
Uxx - x mm tube
( ) - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.

DATE 1/2/1988

PIT No 2
(In hol

PROJECT SOUTHERN PRECINCT STUDY

PROJECT No. SS1/10653

LOCATION NORTH TUNCURRY

SURFACE LEVEL

Depth metres	Description of Strata	Sampling and In Situ Testing Strata	Type & Depth	Dynamic Penetrometer Depth	Blows/150 mm	
0.2	SAND - dry to moist, grey, medium grained sand with roots		D @ 0.1		-	15
					1	30
0.5	SAND - dry to moist, light brown, medium grained sand				1	45
					2	60
					3	75
					2	900
1.0			D @ 1.0		3	105
					3	120
1.4						135
1.5	SAND - moist, mottled brown, medium grained sand, some lightly cemented					150
						165
						180
						195
2.0			D @ 2.0			210
						225
2.5						
2.6	TERMINATED AT 2.6 METRES.					
3.0						

EQUIPMENT Backhoe, 450 mm diameter

LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U[x] - x mm tube
[ ] - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.

DATE 1/2/1988

PIT No 2
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PROJECT SOUTHERN PRECINCT STUDY

PROJECT No. SS1/10653

LOCATION NORTH TUNCURRY

SURFACE LEVEL

Depth metres	Description of Strata	Sampling and In Situ Testing				
		Strata	Type & Depth	Dynamic Penetrometer		
				Depth	Blows/150 mm	
0.25	SAND - dry to moist, grey, medium grained sand with roots					150
						300
	SAND - dry, light brown, medium grained sand					450
0.6						600
	TERMINATED AT 0.6 METRES.					750
						900
						1050
						1200
						1350
						1500
						1650
						1800
						1950
						2100
						2250

0.5
1.0
1.5
2.0
2.5
3.0

EQUIPMENT Backhoe, 450 mm diameter

LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
[ ] - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J. Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 1/2/1988
PIT No
(In hol
PROJECT SOUTHERN PRECINCT STUDY
PROJECT No. SSI/10653
LOCATION NORTH TUNCURRY
SURFACE LEVEL

Depth metres	Description of Strata	Strata	Type & Depth
	SAND - moist, grey, medium grained sand with roots		D @ 0.1
0.3			
0.5	SAND - dry, light brown, medium grained sand		
			D @ 0.9
1.0			
1.5			
	* some bands of dark brown, lightly cemented sand from 1.8m - 2.5m		
2.0			
2.5			
2.7			
	TERMINATED AT 2.7 METRES.		
3.0			

Sampling and In Situ Testing

Dynamic Penetrometer Depth	Blows/150 mm	
	-	15
	1	30
	2	45
	2	60
	2	75
	3	90
	2	105
	3	120
		135
		150
		165
		180
		195
		210
		225

EQUIPMENT Backhoe, 450 mm diameter
LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
Ux1 - x mm tube
[ ] - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 1/2/1988
PIT No

PROJECT SOUTHERN PRECINCT STUDY
PROJECT No. SSI/10653

LOCATION NORTH TUNCURRY
SURFACE LEVEL

Depth metres	Description of Strata	Sampling and In Situ Testing: Strata	Type & Depth	Dynamic Penetrometer: Depth	Blows/150 mm	
0.4	SAND - moist, grey, medium grained sand with numerous roots (up to 60 mm)		D @ 0.2		- 1	15 30
0.5 1.0 1.3	SAND - dry to moist, light grey, medium grained sand		D @ 1.0		1 1 3 2 3 3	450 600 750 900 105 120
1.5 1.7	SAND - light brown, medium grained sand					135 150 165
2.0 2.4	SAND - dry to moist, mottled brown, medium grained sand		D @ 2.0			1800 1950 2100 2250
2.5 3.0	TERMINATED AT 2.4 METRES.					

EQUIPMENT Backhoe, 450 mm diameter
LOGGED R. Jones

GROUND WATER OBS No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
Ux - x mm tube
( ) - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partner

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.

DATE 1/2/1988

PIT No

PROJECT SOUTHERN PRECINCT STUDY

PROJECT No. SS1/10653

LOCATION NORTH TUNCURRY

SURFACE LEVEL

	Depth metres	Description of Strata	Sampling and In Situ Testing		Dynamic Penetrometer		
			Strata	Type & Depth	Depth	Blows/150 mm	
	0.2	SAND - dry to moist, grey, medium grained sand with roots		D @ 0.1		-	15
						2	30
0.5		SAND - dry to moist, light brown, medium grained sand				1	45
						2	60
						3	75
				D @ 0.8		3	90
1.0						5	105
						4	120
							135
1.5							150
	1.6						165
		SAND - mottled brown, medium grained sand, some lightly cemented					180
							195
2.0				D @ 2.0			210
							225
2.5							
	2.7						
		TERMINATED AT 2.7 METRES.					
3.0							

EQUIPMENT Backhoe, 450 mm diameter

LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
( ) - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

[illegible]IENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 1/2/1988
PIT No 6

PROJECT SOUTHERN PRECINCT STUDY
PROJECT No. SS1/10653

LOCATION NORTH TUNCURRY
SURFACE LEVEL

Depth metres	Description of Strata	Sampling and In Situ Testing Strata	Type & Depth	Dynamic Penetrometer Depth	Blows/150 mm	
0.25	SAND - dry to moist, grey, medium grained sand with roots		D @ 0.1		-	150
	SAND - dry, light brown, medium grained sand				1	300
					1	450
					2	600
					3	750
			D @ 0.8		3	900
					4	1050
					4	1200
						1350
						1500
						1650
						1800
						1950
						2100
2.2						2250
	TERMINATED AT 2.2 METRES.					

0.5
1.0
1.5
2.0
2.5
3.0

EQUIPMENT Backhoe, 450 mm diameter
LOGGED R. Jones

GROUND WATER OBS. No free groundwater observed.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
( ) - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 1/2/1988
PIT No 7
PROJECT SOUTHERN PRECINCT STUDY
PROJECT No. SS1/10653
LOCATION NORTH TUNCURRY
SURFACE LEVEL

	Depth metres	Description of Strata	Sampling and In Situ Testing				
			Strata	Type & Depth	Dynamic Penetrometer Depth	Blows/150 mm	
		SAND - dry to moist, grey, medium grained sand with roots				-	150
	0.35			D @ 0.2		2	300
0.5		SAND - dry to moist, light brown, medium grained sand				2	450
						2	600
						2	750
						2	900
1.0				D @ 1.0		3	1050
						3	1200
							1350
1.5							1500
	1.7						1650
		SAND - wet, brown, medium grained sand		D @ 1.8			1800
							1950
2.0							2100
	2.3						2250
2.5		TERMINATED AT 2.3 METRES (STANDPIPE TO 2.3 METRES)					
3.0							

EQUIPMENT Backhoe, 450 mm diameter
LOGGED R. Jones

GROUND WATER OBS. Free groundwater observed at 1.8 metres.

REMARKS

SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
[ ] - nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

TEST PIT REPORT

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.

DATE 1/2/1988

PIT No 8

PROJECT SOUTHERN PRECINCT STUDY

PROJECT No. SS1/10653

LOCATION NORTH TUNCURRY

SURFACE LEVEL

Depth metres	Description of Strata	Strata	Type & Depth
0.2	SAND - moist, light grey, medium grained sand		D @ 0.1
1.2	SAND - moist, light brown, medium grained sand		D @ 0.8
2.0	SAND - wet, brown, medium grained sand		D @ 1.5 Sample of groundwater
	TERMINATED AT 2.0 METRES. Standpipe installed to depth of 2.0 metres.		

0.5 1.0 1.5 2.0 2.5 3.0

Sampling and In Situ Testing

Dynamic Penetrometer

Depth	Blows/150 mm	
	-	150
	2	300
	1	450
	3	600
	3	750
	5	900
	6	1050
	8	1200
		1350
		1500
		1650
		1800
		1950
		2100
		2250

EQUIPMENT Backhoe, 450 mm diameter

LOGGED R. Jones

GROUND WATER OBS. Free groundwater observed at 1.2 metres.

REMARKS

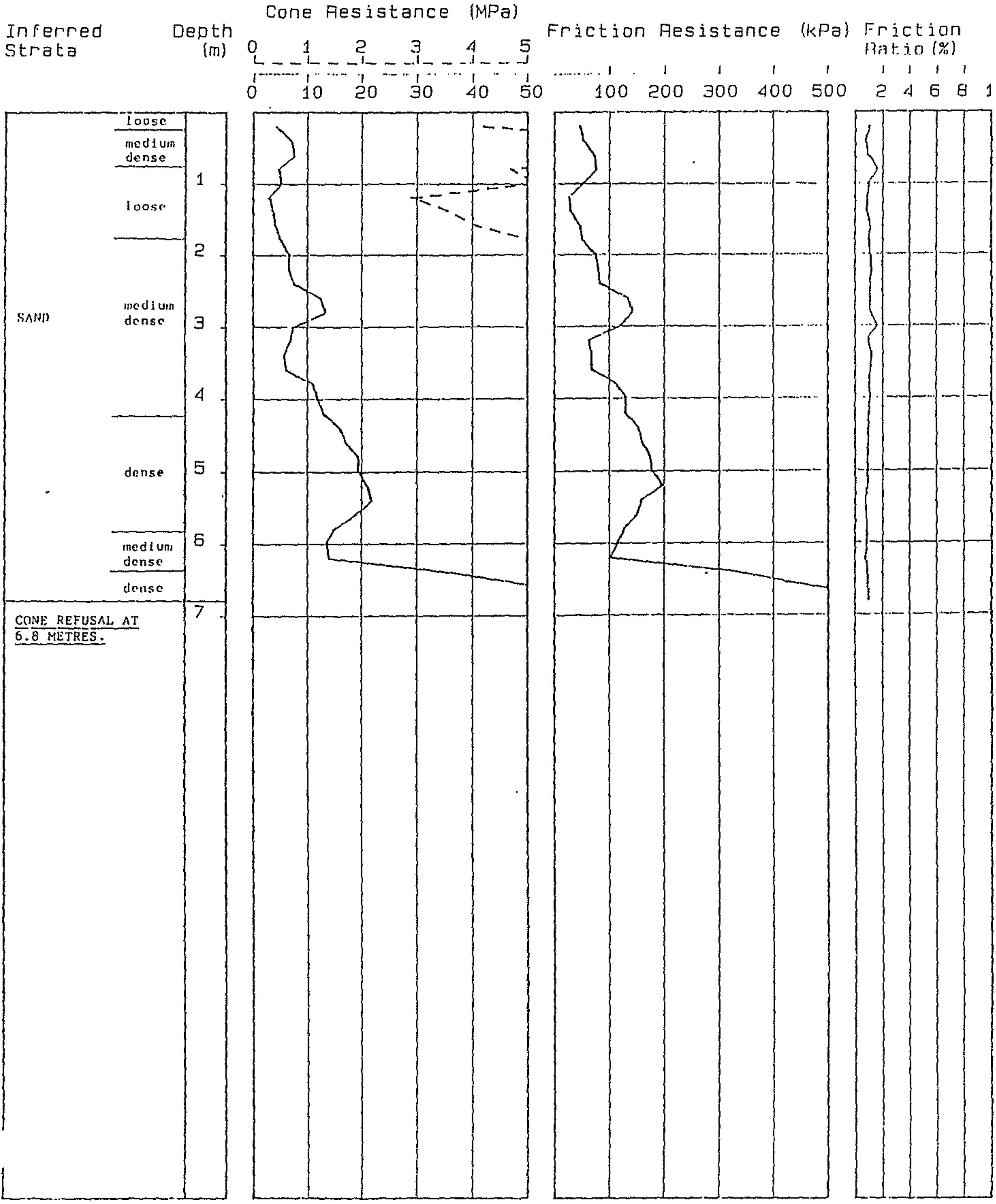
SAMPLE TYPE
D - disturbed
B - bulk
U(x) - x mm tube
( )- nil recovery

Values represent the number of blows of a 9 kg hammer having a free fall of 600 mm to drive a 16 mm blunt ended rod for a penetration of 150 mm.

D.J.Douglas & Partners

RESULTS OF CONE PENETROMETER TEST

CLIENT	SINCLAIR KNIGHT & PARTNERS	TEST No	1
PROJECT	NORTH TUNCURRY SOUTHERN PRECINCT PLANNING STUDY	DATE	8/2/88
LOCATION	NORTH TUNCURRY	PROJECT No	SSI/10653
		SURFACE RL	



REMARKS:

RESULTS OF CONE PENETROMETER TEST

CLIENT SINCLAIR KNIGHT & PARTNERS

PROJECT NORTH TUNCURRY
SOUTHERN PRECINCT PLANNING STUDY

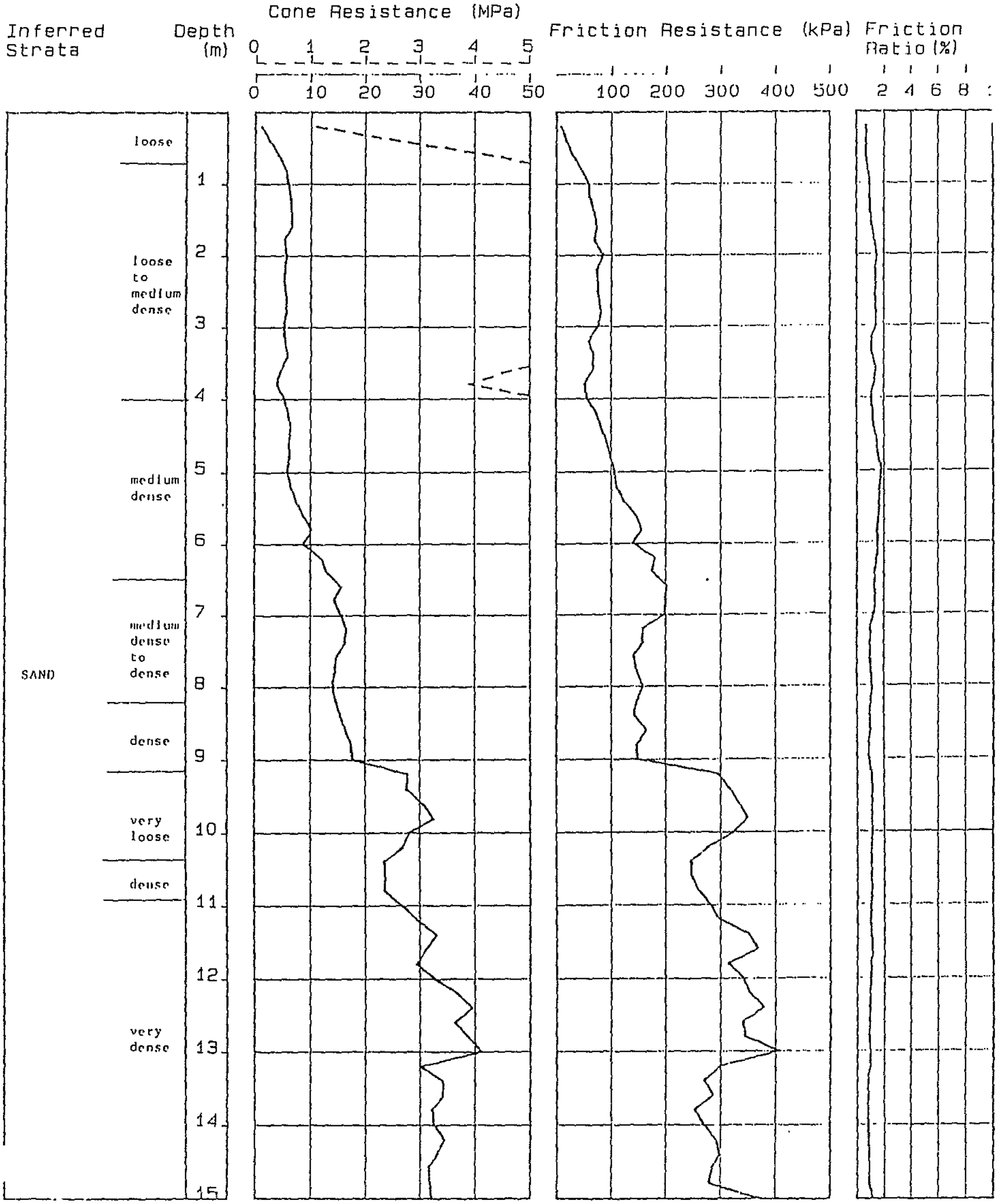
LOCATION NORTH TUNCURRY

TEST No 2 P 1of2

DATE 8/2/88

PROJECT No SSI/10653

SURFACE RL

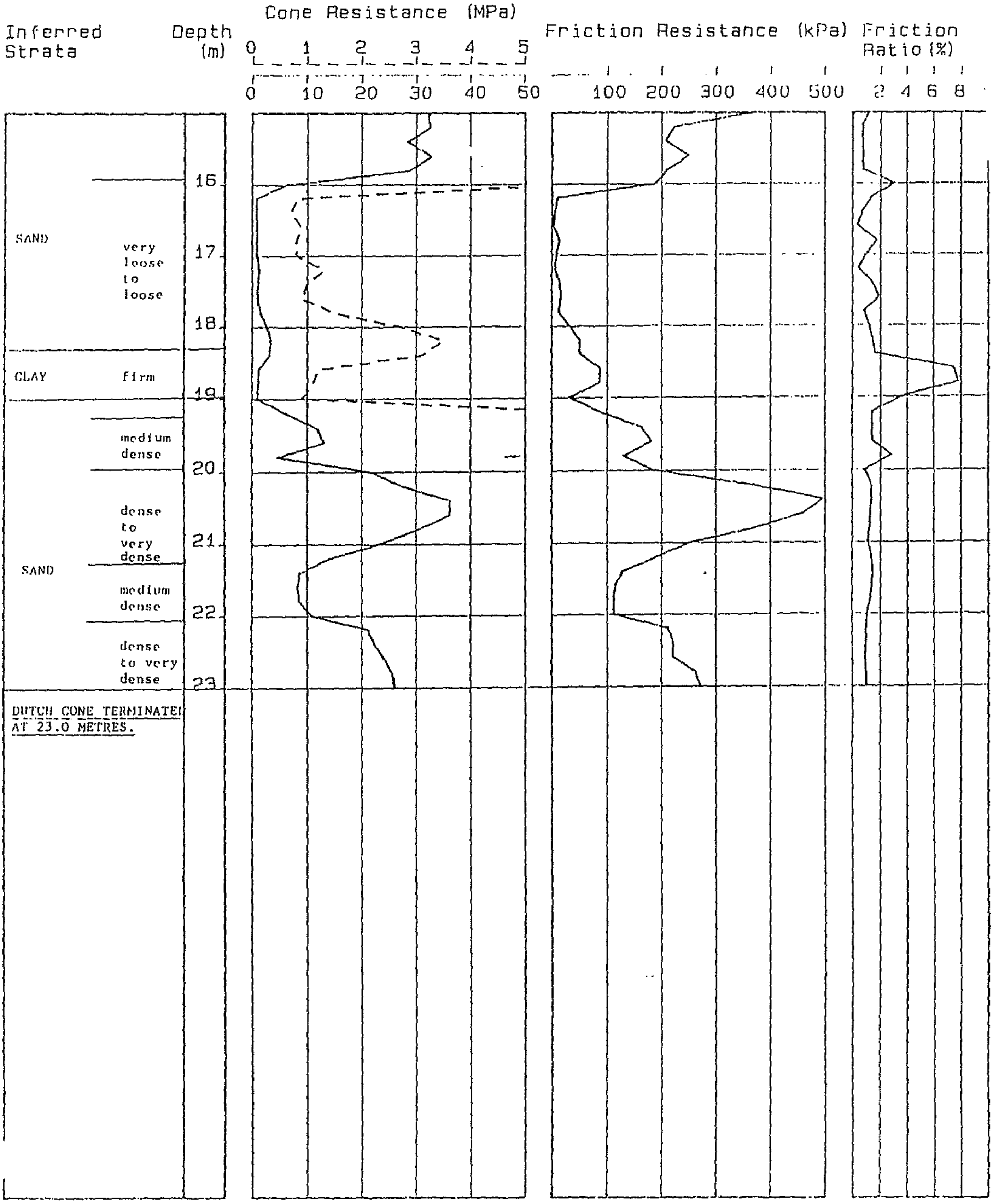


REMARKS:

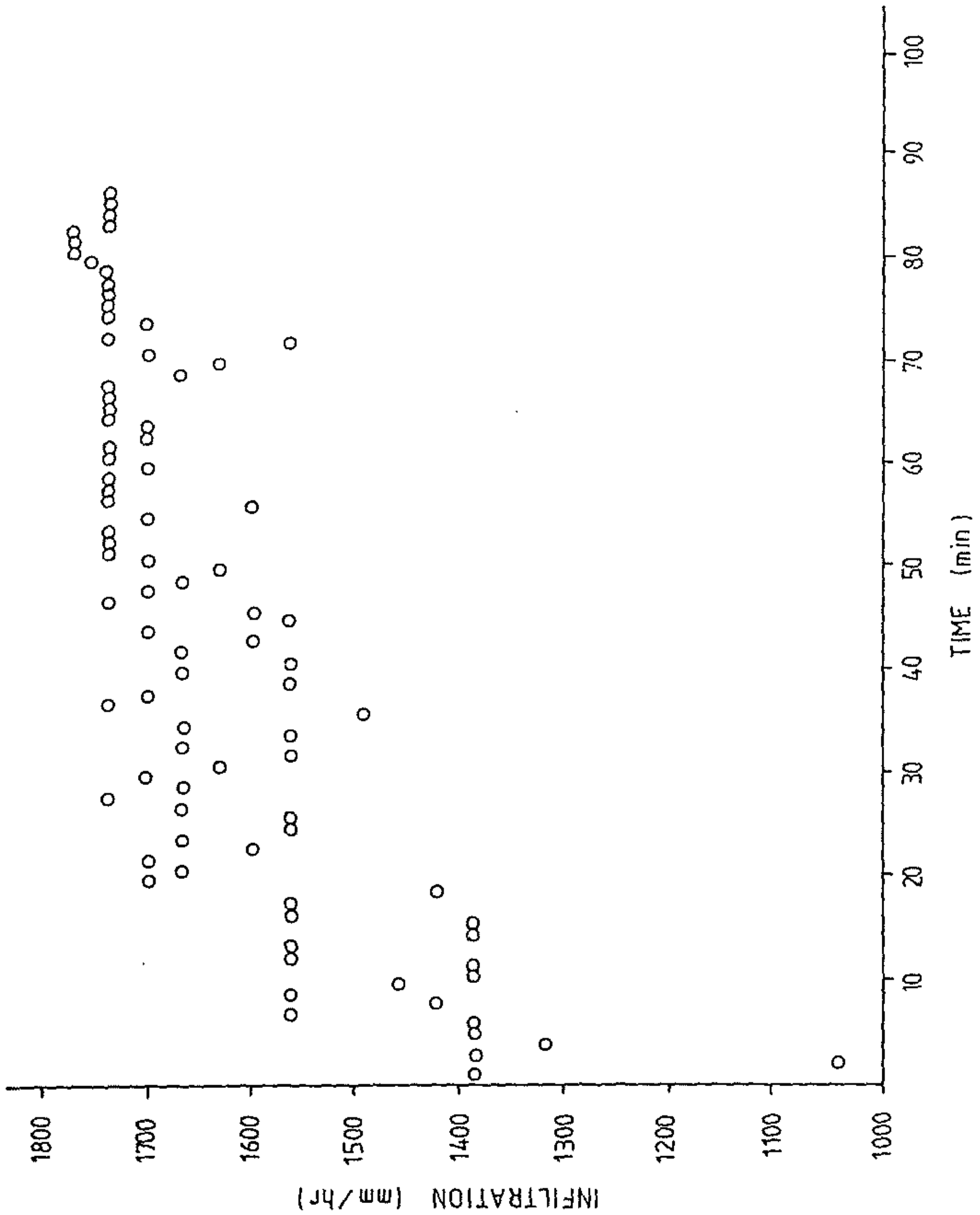
continued over/

RESULTS OF CONE PENETROMETER TEST

CLIENT	SINCLAIR KNIGHT & PARTNERS	TEST No	2	P 2of2
PROJECT	NORTH TUNCURRY SOUTHERN PRECINCT PLANNING STUDY	DATE	8/2/88	
LOCATION	NORTH TUNCURRY	PROJECT No	SSI/10653	
		SURFACE RL		



REMARKS:

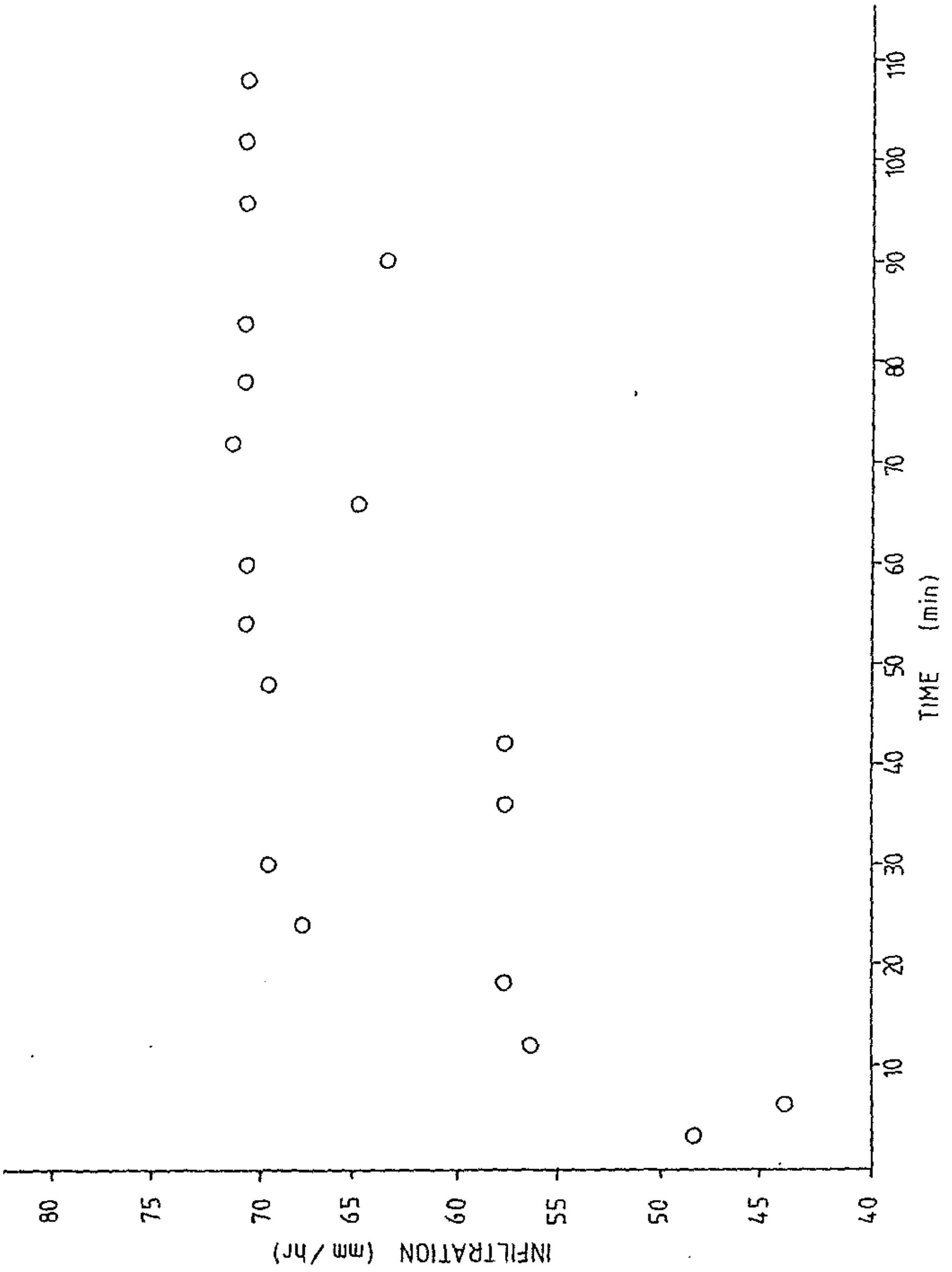


DOUBLE RING INFILTROMETER TEST AT LOCATION OF PIT 8 S.L.
NORTH TUNCURRY – SOUTHERN PRECINCT PLANNING STUDY

SCALE:

SSI / 10653
~~DRAWING No~~.: Figure No.1

D.J. Douglas & Partners

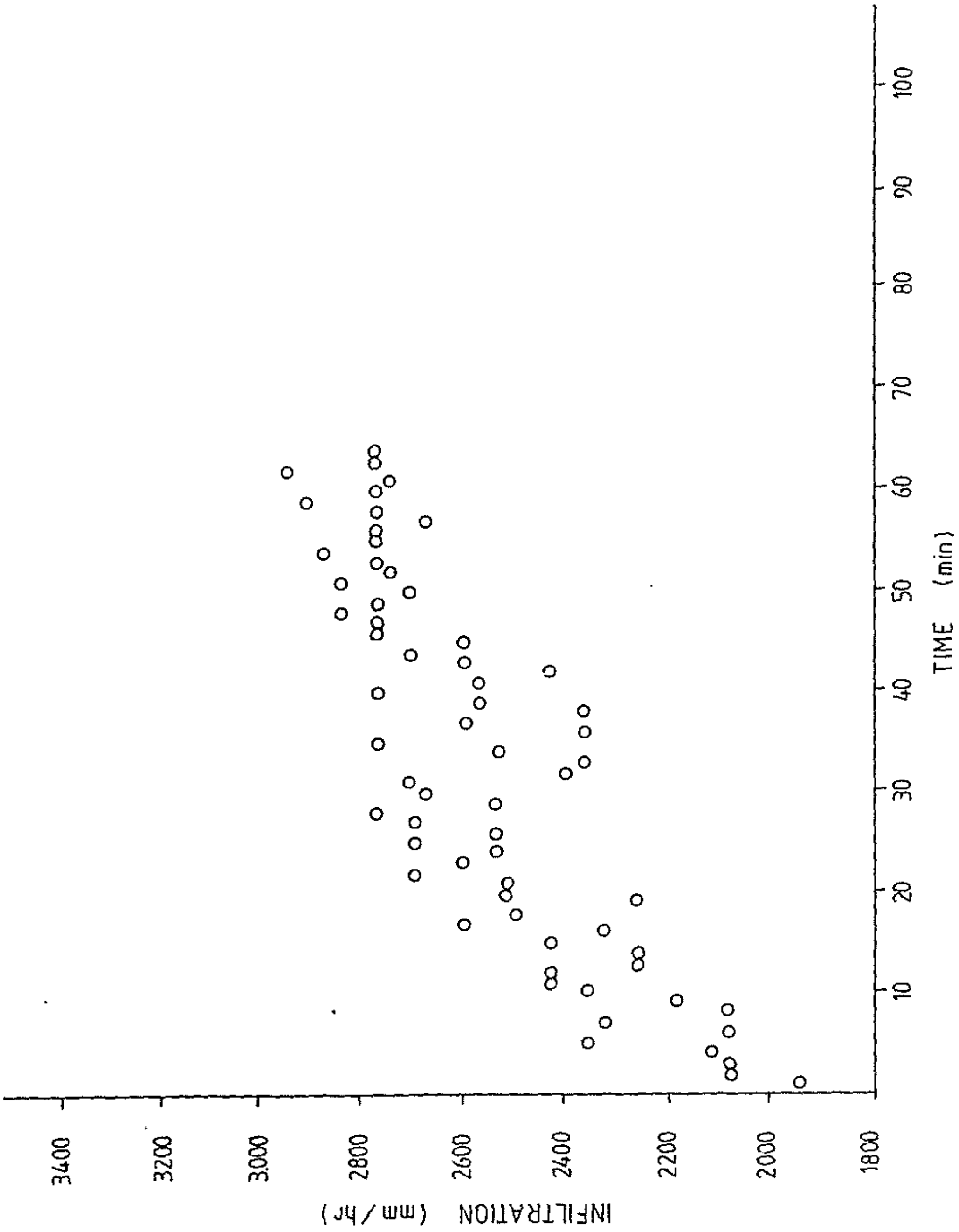


DOUBLE RING INFILTROMETER TEST ON GOLF COURSE
NORTH TUNCURRY – SOUTHERN PRECINCT PLANNING STUDY

SCALE:

SSI / 10653
~~DRAWING No~~.:Figure No.2

D.J. Douglas & Partners



DOUBLE RING INFILTROMETER TEST LOCATION OF TEST PIT 8, 300mm below S.L.
NORTH TUNCURRY – SOUTHERN PRECINCT PLANNING STUDY

SCALE:

SSI / 10653
~~DRAWING No.~~:Figure No.3

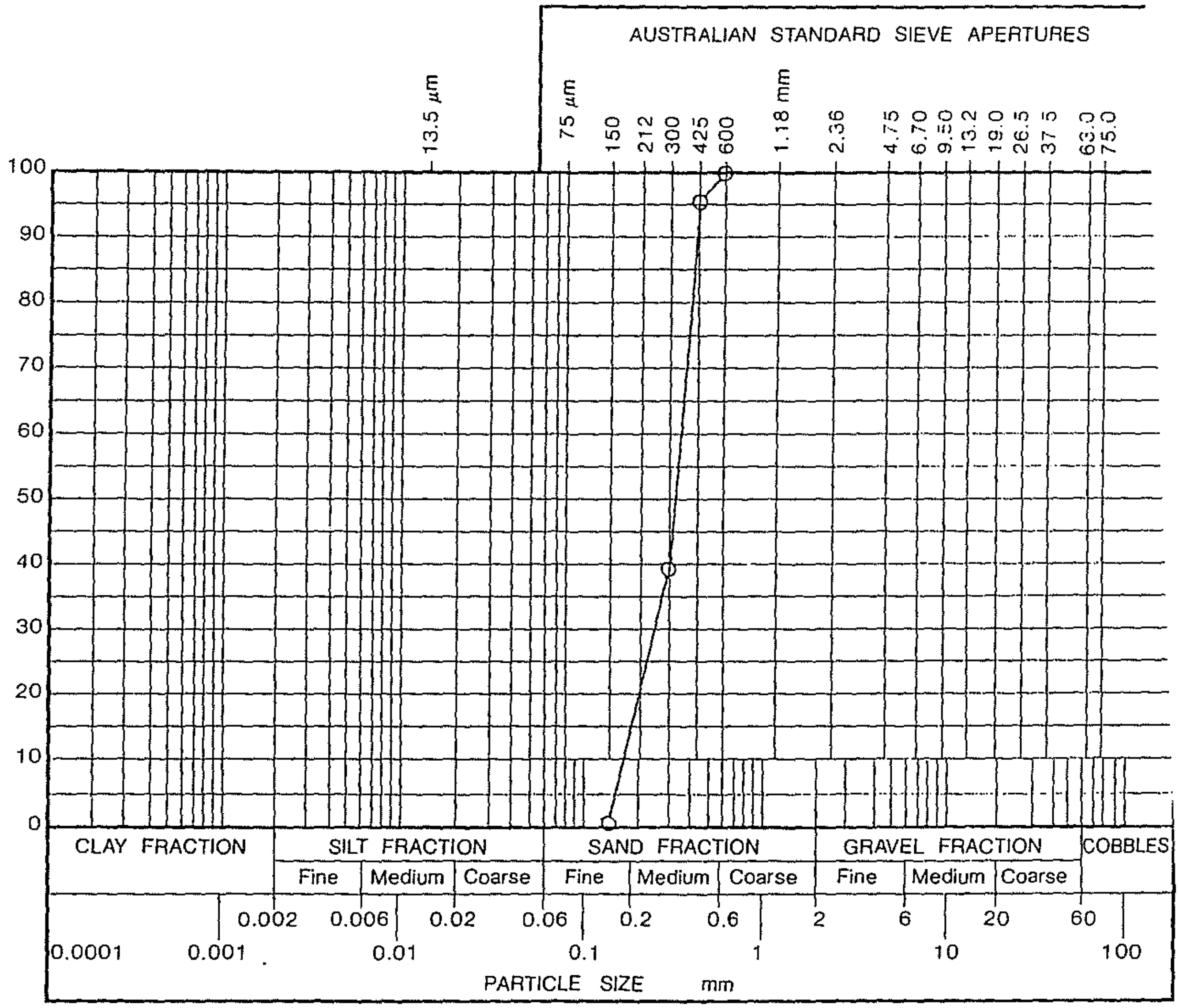
D.J. Douglas & Partners

RESULTS OF PARTICLE SIZE DISTRIBUTION TEST

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD. DATE 8/2/1988

PROJECT SOUTHERN PRECINCT STUDY PROJECT NO. SSI/10653

LOCATION NORTH TUNCURRY TEST LOC. 2 DEPTH 1.0



DESCRIPTION Light brown medium grained sand.

PRETREATMENT Nil

LOSS IN MASS ON PRETREATMENT %
SOIL PARTICLE DENSITY t/m³
TEST METHOD 1289 C6.1

TESTED I. Piper
CHECKED G. Eastwood

LABORATORY LOCATION Newcastle REPORT NO. SSI/10653/1

SIGNED G. Eastwood

NATA

This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

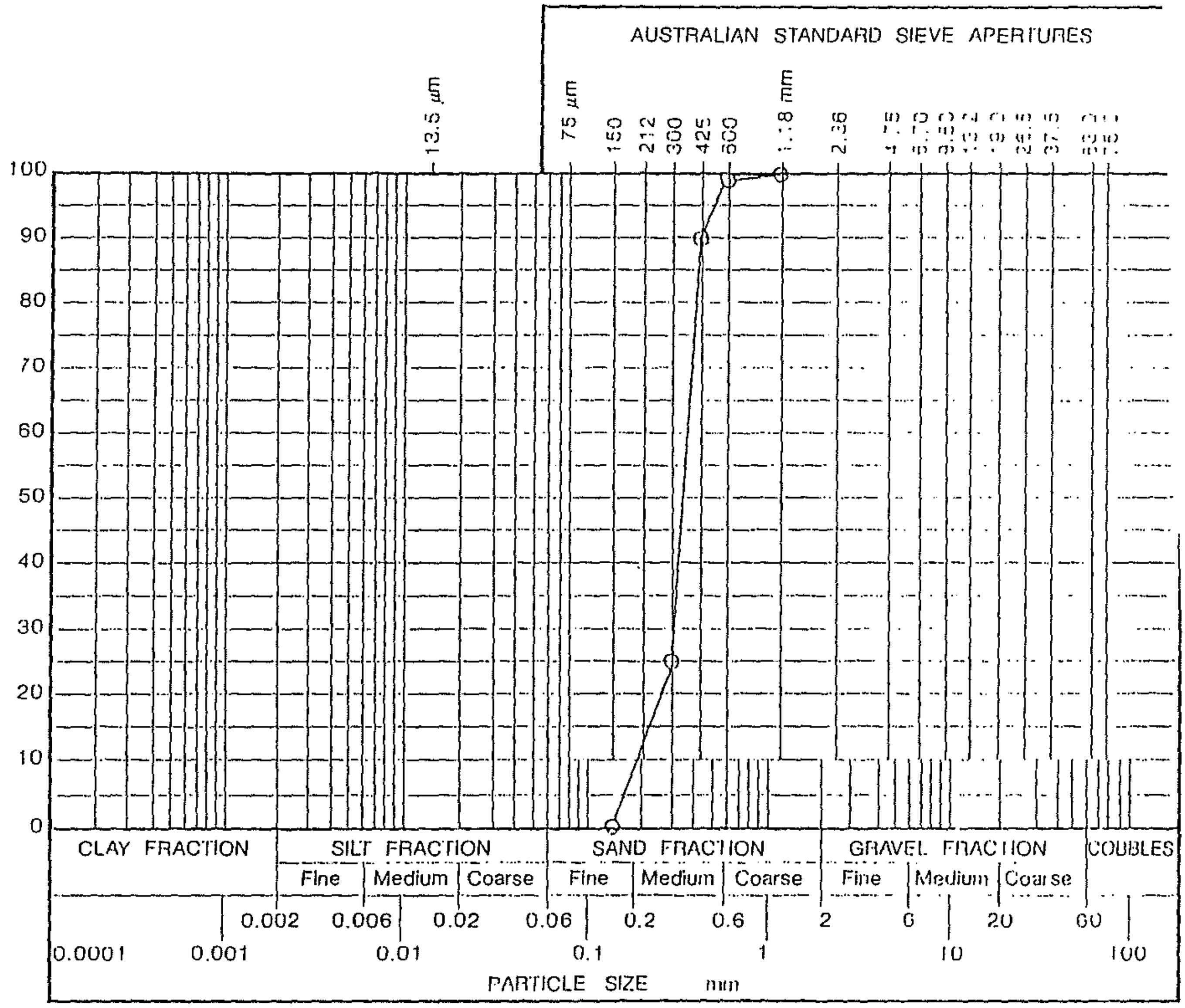
GROUND TEST PTY LIMITED
A subsidiary of D.J. Douglas & Partners Pty Ltd

RESULTS OF PARTICLE SIZE DISTRIBUTION TEST

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD. DATE 8/2/1988

PROJECT SOUTHERN PRECINCT STUDY PROJECT NO. SS1/10653

LOCATION NORTH TUNCURRY TEST LOC. 2 DEPTH 2.0



DESCRIPTION Mottled brown, medium grained sand with some cemented sand fragments.

PRETREATMENT Nil

LOSS IN MASS ON PRETREATMENT %

SOIL PARTICLE DENSITY t/m³

TEST METHOD AS 1289 C6.1

TESTED I. Piper

CHECKED G. Eastwood

SIGNED G. Eastwood

LABORATORY LOCATION Newcastle

REPORT NO. SS1/10653/2

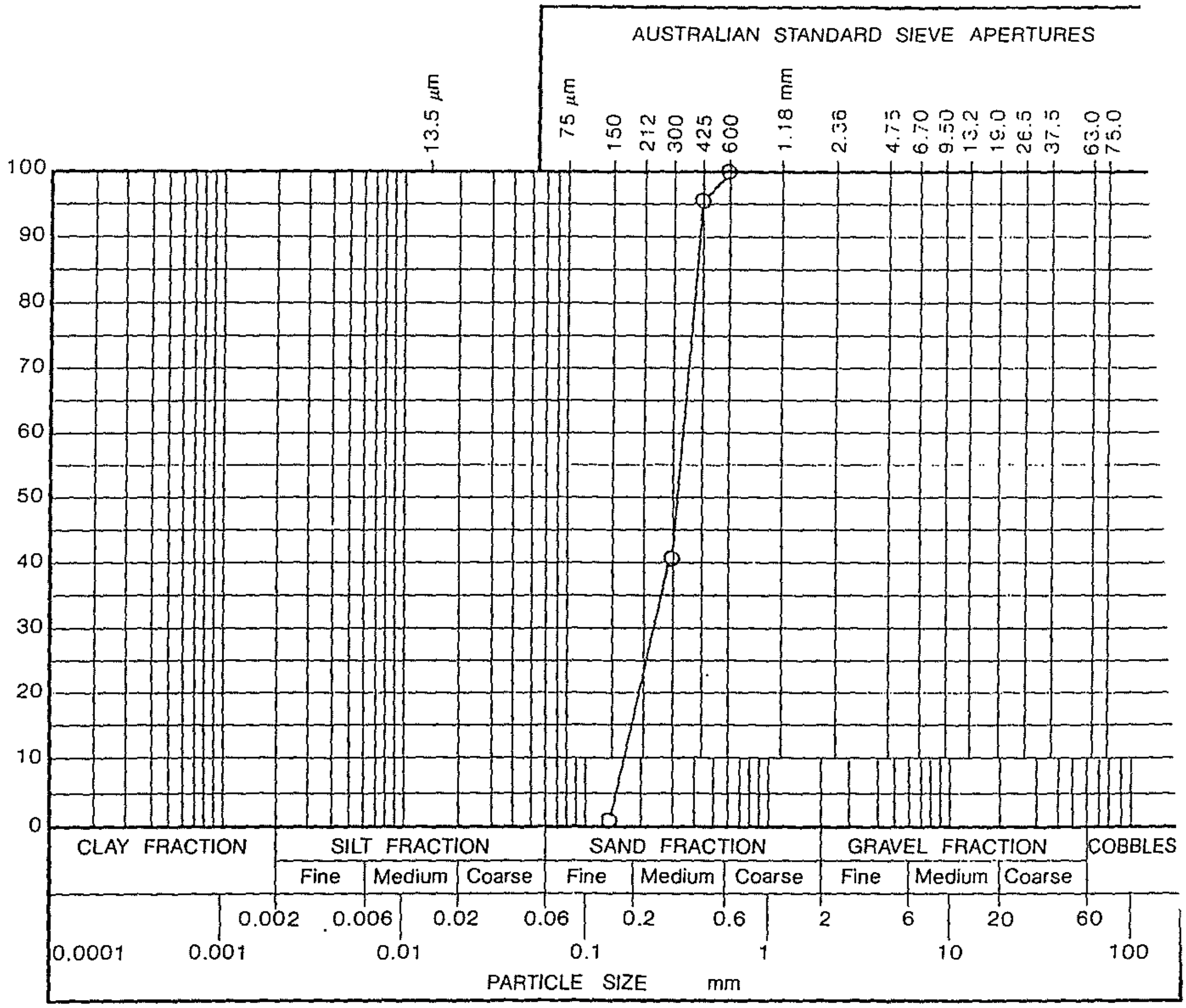
This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

GROUND TEST PTY LIMITED

A subsidiary of D.J. Douglas & Partners Pty Ltd

RESULTS OF PARTICLE SIZE DISTRIBUTION TEST

CLIENT SINCLAIR KNIGHT & PARTNERS PTY. LTD.
DATE 8/2/1988
PROJECT SOUTHERN PRECINCT STUDY
PROJECT NO. SSI/10653
LOCATION NORTH TUNCURRY
TEST LOC. 6
DEPTH 0.



DESCRIPTION Light brown medium grained sand.

PRETREATMENT Nil

LOSS IN MASS ON PRETREATMENT %
SOIL PARTICLE DENSITY t/m³
TEST METHOD

TESTED I. Piper
CHECKED C. Eastwood

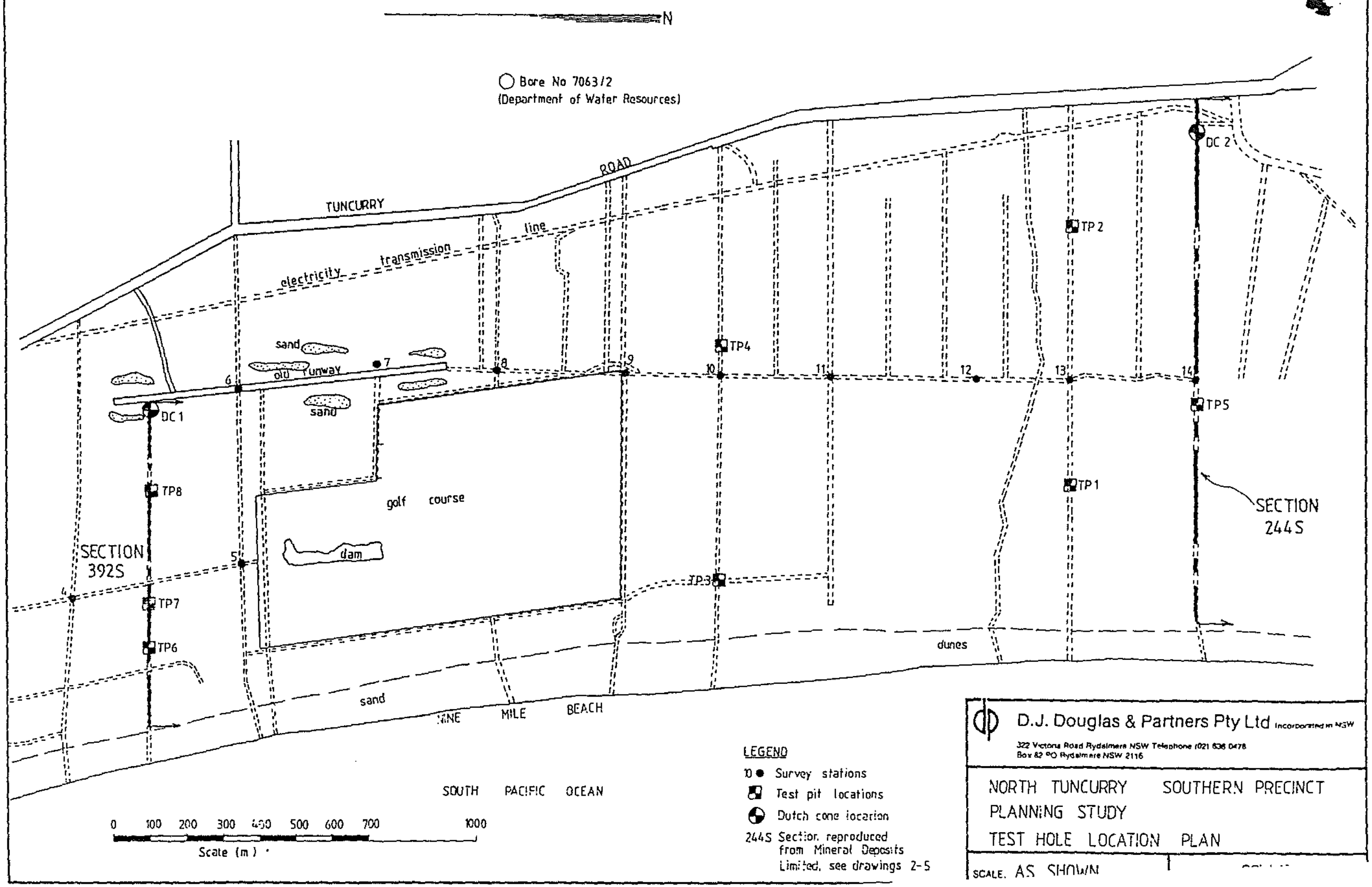
LABORATORY LOCATION Newcastle
REPORT NO. SSI/10653/3

SIGNED
C. Eastwood

NATA

This laboratory is registered by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of registration.

GROUND TEST PTY LIMITED
A subsidiary of D J. Douglas & Partners Pty Ltd

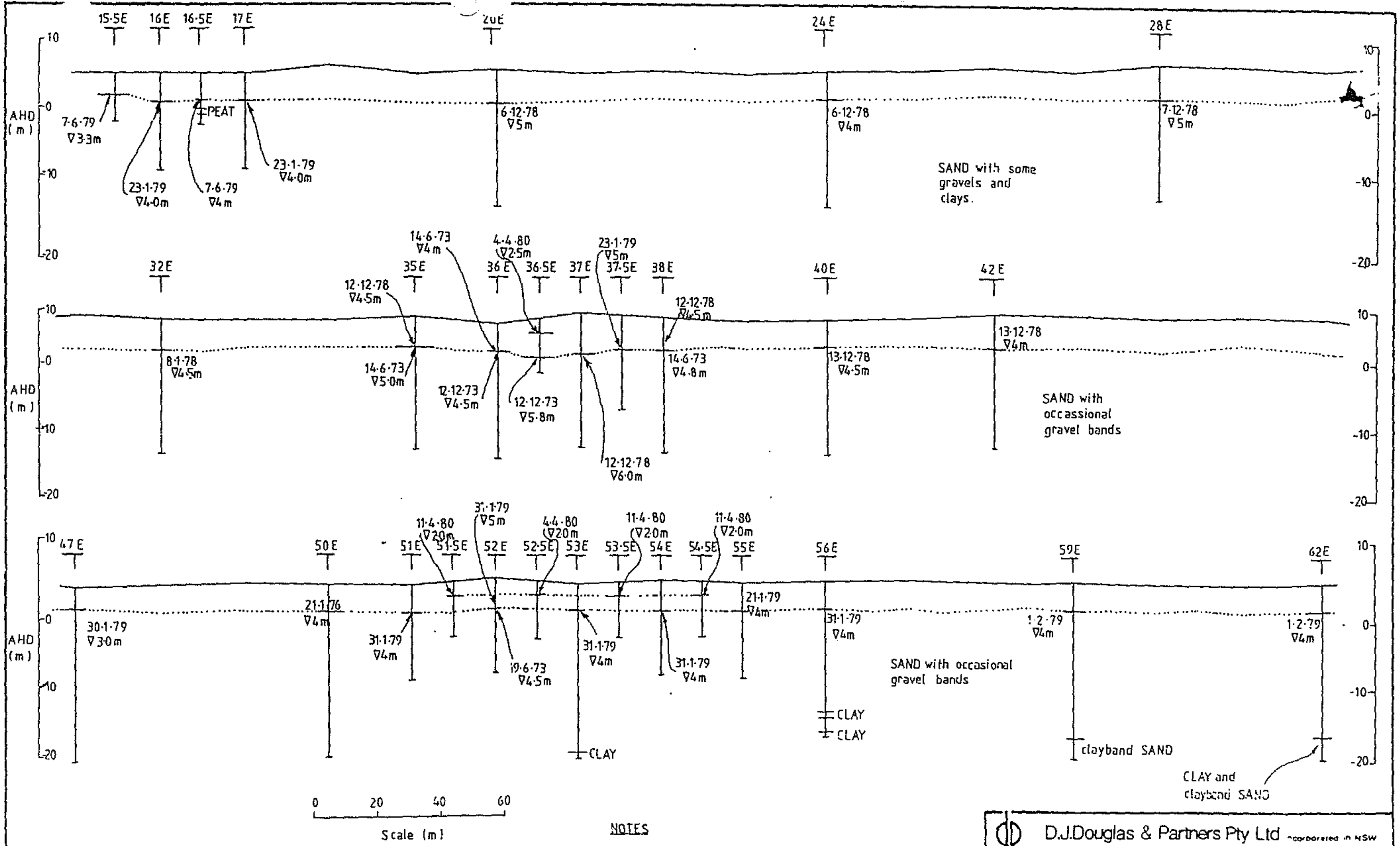


D.J. Douglas & Partners Pty Ltd Incorporated in NSW

322 Victoria Road Rydalmere NSW Telephone (02) 638 0478
Box 82 PO Rydalmere NSW 2116

NORTH TUNCURRY SOUTHERN PRECINCT
PLANNING STUDY
TEST HOLE LOCATION PLAN

SCALE. AS SHOWN

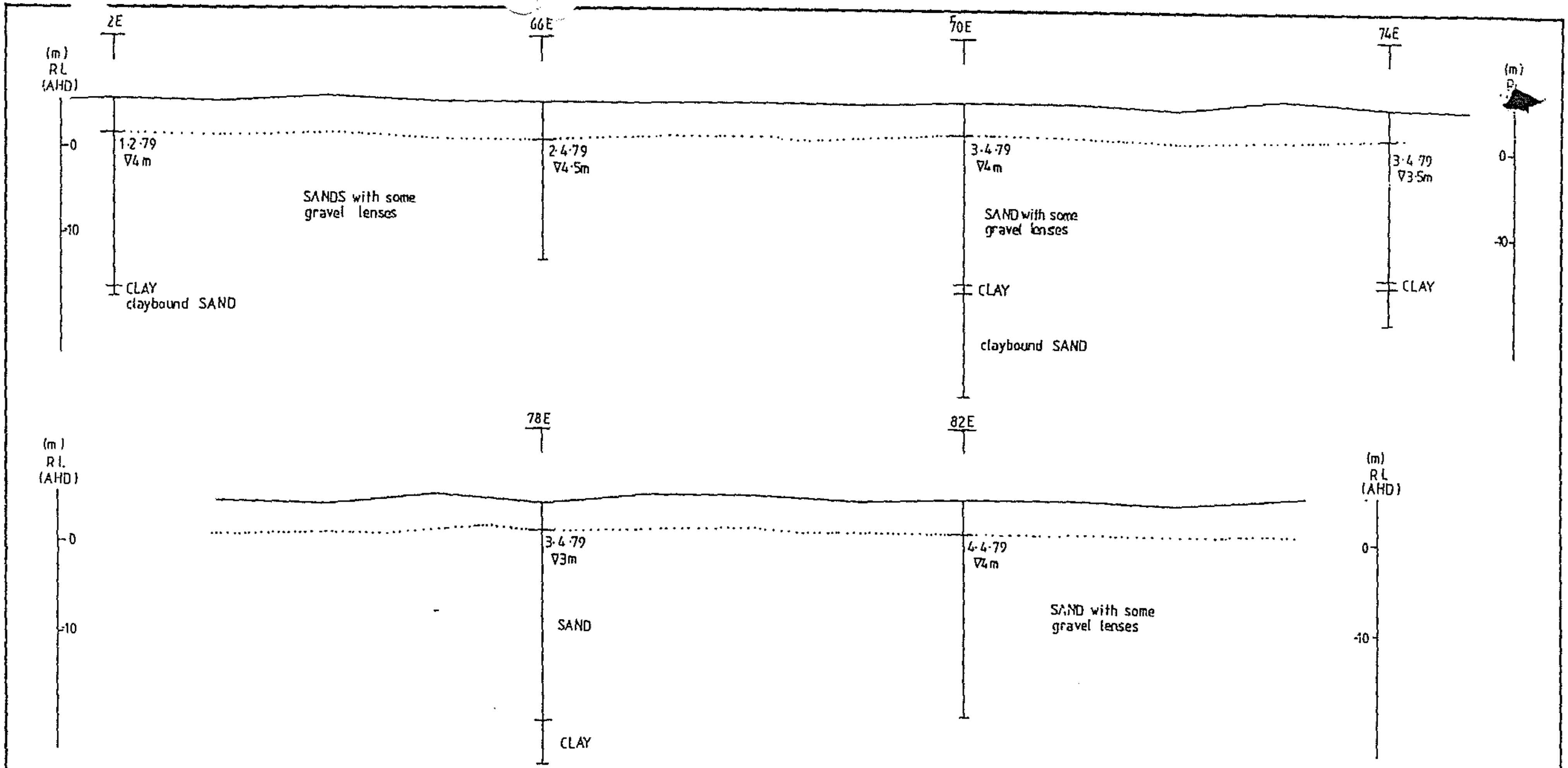


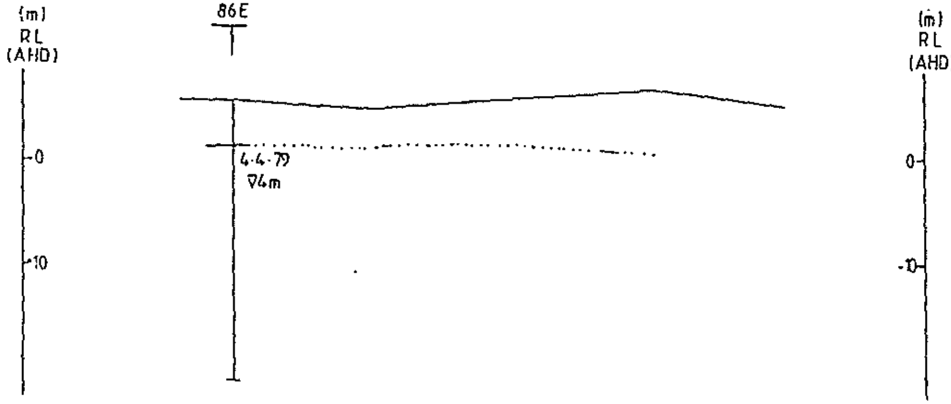
NOTES

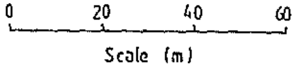
- SECTION REPRODUCED IN PART FROM MINERAL DEPOSITS LIMITED DRAWINGS "TUNCURRY CROSS SECTION LINE 244 S"
- RLs ARE APPROX ONLY AND BASED ON PWD TUNCURRY WATER SUPPLY DATUM EQUALING PLUS 1m AHD.

D.J.Douglas & Partners Pty Ltd incorporated in NSW
8 South Street Rydalmere NSW Telephone 02 638 0478
Box 82 PO Rydalmere NSW 2116

NORTH TUNCURRY – SOUTHERN PRECINCT
PLANNING STUDY
MDL Section 244 S – (16E to 62E)





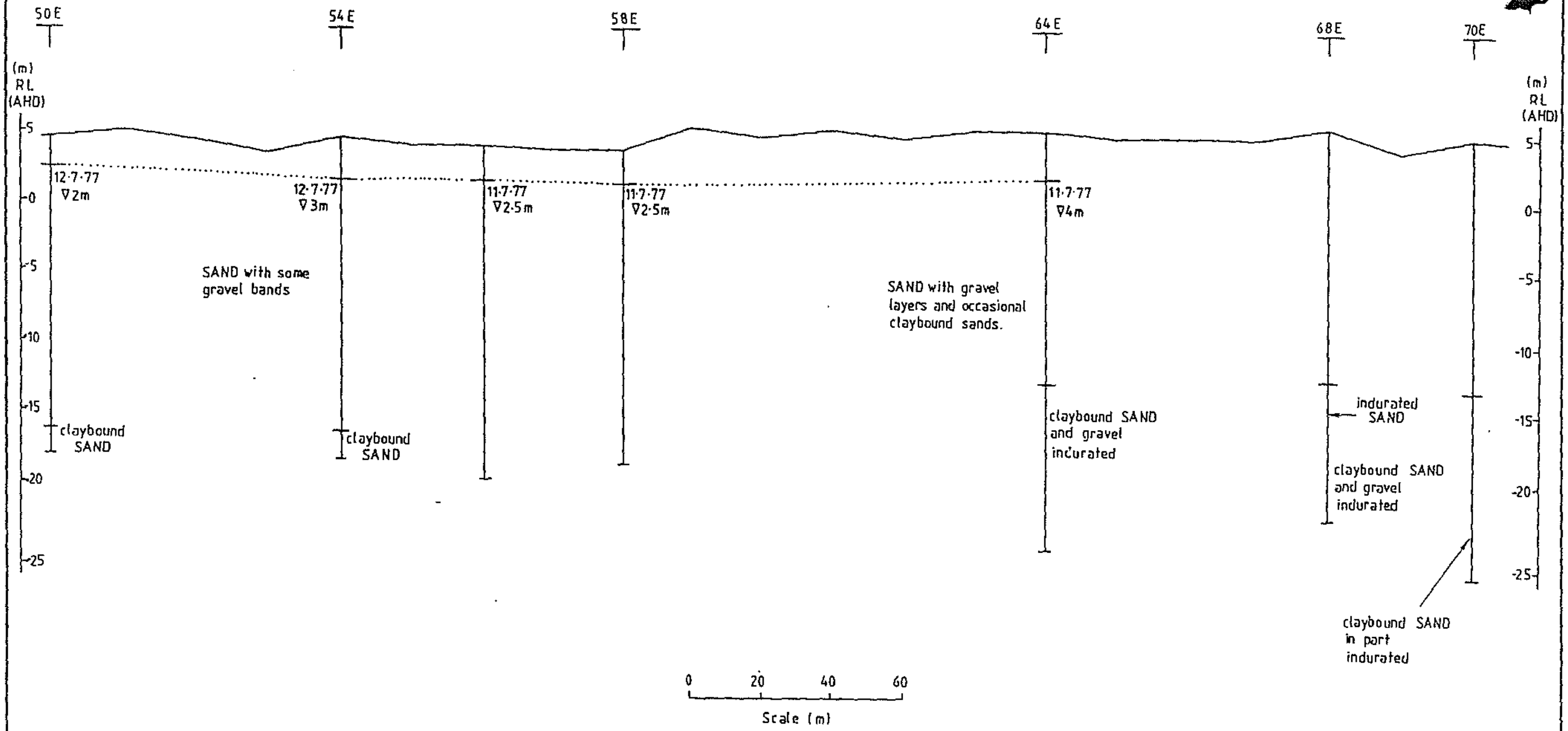


NOTES:

- SECTION REPRODUCED IN PART FROM MINERAL DEPOSITS LIMITED DRAWINGS TUNCURRY CROSS SECTION LINE 244 S
- RLs ARE APPROX ONLY AND BASED ON PWD TUNCURRY WATER SUPPLY DATUM EQUALING PLUS 1m AHD.

D.J.Douglas & Partners Pty Ltd incorporated in NSW
8 South Street Rydalmere NSW Telephone (02) 638 0478
Box 82 PO Rydalmere NSW 2116

NORTH TUNCURRY – SOUTHERN PRECINCT
PLANNING STUDY
MDL Section 244 S – (62E to 90E)



NOTES

- SECTION REPRODUCED IN PART FROM MINERAL DEPOSITS LIMITED DRAWINGS TUNCURRY CROSS SECTION LINE 3925 sheets 1 to 3.
- RLs ARE APPROX ONLY AND BASED ON PWD TUNCURRY WATER SUPPLY DATUM EQUALING PLUS 1m AHD.

D.J.Douglas & Partners Pty Ltd incorporated in NSW

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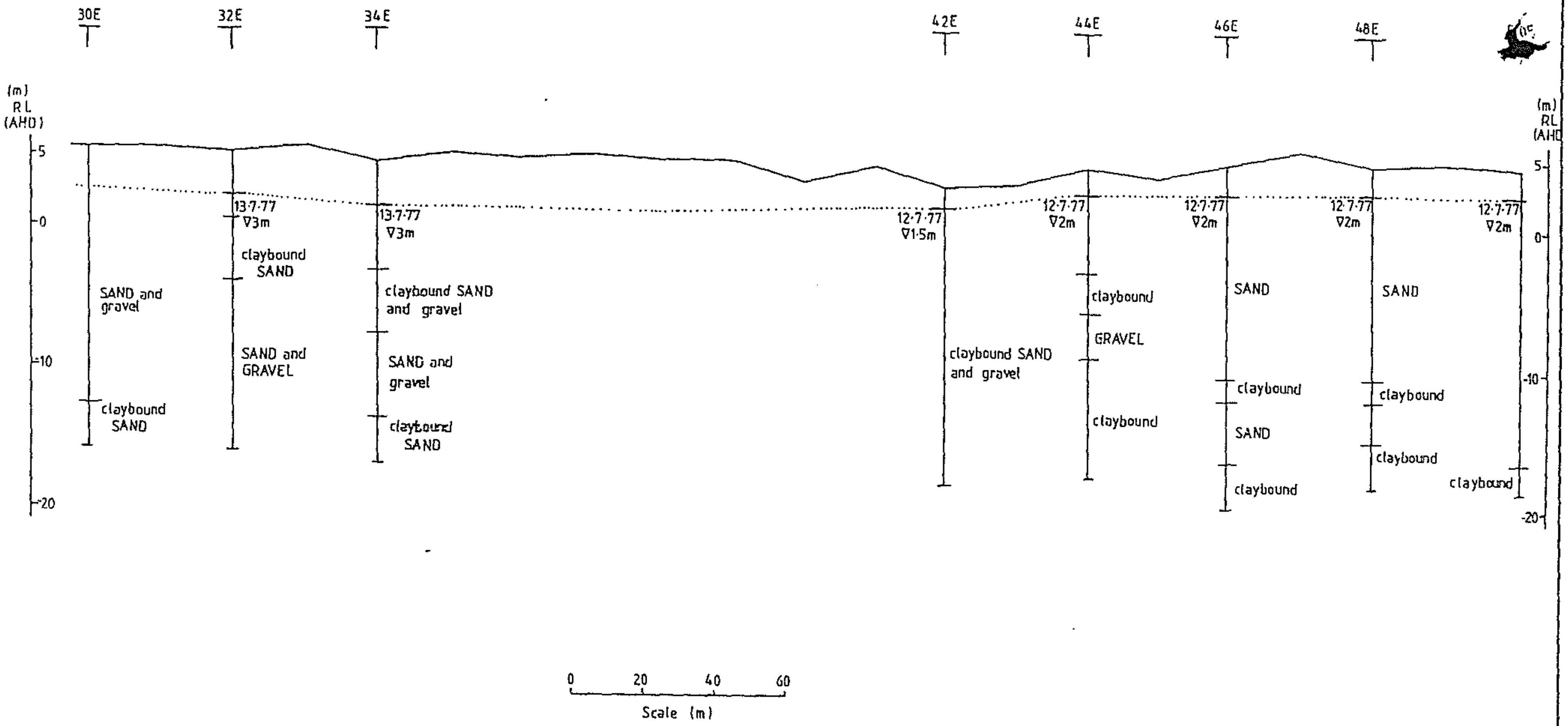
Box 82 PO Rydalmere NSW 2116

NORTH TUNCURRY – SOUTHERN PRECINCT
PLANNING STUDY
MDL Section 3925 S – (50E to 70E)



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NORTH TUNCURRY - SOUTHERN PRECINCT
PLANNING STUDY
MDL Section 3925 S – (30E to 50E)

SCALE AS SHOWN
DRAWING No SSL/10652-5