

**AN INVESTIGATION INTO THE SOILS  
AND SOIL LANDSCAPES OF THE  
DONGARA PROJECT AREA**

**Prepared for**

**Tiwest Pty Ltd**

**by**

**D. C. Blandford & Associates Pty Ltd**

**ABN 22 009 402 706**

**July, 2007**

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# TABLE OF CONTENTS

	Page
<i>List of Figures</i>	<i>iii</i>
<i>List of Tables</i>	<i>iii</i>
<i>List of Plates</i>	<i>iii</i>
<b>1.0 EXECUTIVE SUMMARY</b>	<b>1</b>
<b>2.0 INTRODUCTION</b>	
2.1 Location	2
2.2 Scales in Time and Space	2
2.3 Physical Framework	2
<b>3.0 METHOD</b>	
3.1 Literature Review	3
3.2 Air Photo Interpretation	3
3.3 Soil profile Description	5
3.4 Site Vegetation Description	5
<b>4.0 SOIL LANDSCAPES OF THE DONGARA PROJECT AREA</b>	
4.1 Introduction	7
4.2 Soil Landscape Units	7
4.2.1 The Eastern Ferricrete/Clay Unit	7
4.2.2 The Central Sand Plain	10
4.2.3 The Western Relict Palaeo Lake System	10
<b>5.0 SOILS OF THE DONGARA PROJECT AREA</b>	
5.1 Introduction	13
5.2 Soils of the Eastern Ferricrete Landscape	13
5.3 Soils of The Central Sand Plain	16
5.4 Soils of the Western Relict Palaeo Lake System	19
5.5 General Soil Characteristics	20
5.5.1 Surface Infiltration Rates	20
5.5.2 Soil Chemistry	21
<b>6.0 DISCUSSION</b>	
6.1 Physical Characteristics	22
6.1.1 Aggregate Stability	22
6.1.2 Surface Infiltration Rates	22
6.1.3 Induration and Moisture Retention	23
6.2 The Western Relict Palaeo Lake Landscape	24
6.2.1 Classification Issues	24
6.2.2 Profile Characteristics and the Dominance of Silica	25
<b>7.0 BIBLIOGRAPHY</b>	<b>28</b>

<b>8.0</b>	<b>APPENDICES</b>	29
Appendix I	Soil Profiles	30
Appendix II	Table of Soil Data	31
Appendix III	Particle Size Distribution Curves	34
Appendix IV	Dry Density Ratios	35
Appendix V	Permeability	36
Appendix VI	Aggregate Stability Chemistry	37
Appendix VII	Soil Chemistry	38

## LIST OF FIGURES

- Figure 1 Regional time-stratigraphic framework showing the location of the project area within the boundaries of the Eneabba Plain.
- Figure 2 The physical framework of the Dongara project Area according to broad scale lithologic characteristics.
- Figure 3 Soil Landscapes of the Dongara project area.

## LIST OF TABLES

Table 1	Profile Characteristics of the Eastern Ferricrete Landscape
Table 2	Data for Eastern Ferricrete Soils
Table 3	Aggregate Stability Analysis for Eastern Ferricrete Soils
Table 4	Profile Characteristics for the Central Sand Plain
Table 5	Data for Soils of the central Sand Plain
Table 6	Aggregate Stability Analysis for Central Sand Plain Soils
Table 7	Profile Characteristics of the Western Relict Palaeo Lake System
Table 8	Data for Soils of the Western Relict Palaeo Lakes
Table 9	Surface Infiltration Rates
Table 10	Soil Chemical Data

## LIST OF PLATES

Plate 1	Ferricrete profile at Site 58
Plate 2	Ferricrete profile at Site 31
Plate 3	Truncated Lateritic Podsollic soil at Site 39
Plate 4	Deep white aeolian sand at Site 7
Plate 5	Deep fine to medium sand at Site 54
Plate 6	Deep aeolian sand at Site 20
Plate 7	Fine-grained aeolian sand at Site 14
Plate 8	Profile Characteristics at Site 46
Plate 9	Profile Characteristics at Site 55
Plate 10	Profile Characteristics at Site 6
Plate 11	Profile Characteristics at Site 17
Plate 12	Typical Dispersion Characteristics
Plate 13	A Lobe of Wet Soil Exposed at Site 85
Plate 14	Pedogenic Silica at Site 21A
Plate 15	Micro-capping Structure
Plate 16	A Complex Silica Dominated profile
Plate 17	Silica Stalagmitic Column from Site 15
Plate 18	A Competent Silica Stalagmite from Site 80

## 1.0 EXECUTIVE SUMMARY

The Dongara soil and soil landscapes survey project area covers approximately 113km<sup>2</sup> and is located 28km south-east of the coastal hamlet of Port Denison. The area lies west of the Gingin Scarp and east of a band of outcropping Tamala Limestone in a physiographic feature known as the Eneabba Plain.

Three soil landscapes are defined: an eastern ferricrete/clay system, a central sand plain system, and a western relict palaeo lake system. Each has a distinctive suite of soil profile characteristics. The eastern ferricrete system, which was formed by alluvial/colluvial outwash fans passing off the scarp onto the coastal plain has profiles in which the presence of ferricrete dominates, either as well sorted gravels or older, strongly weathered Fe rubble. Clays may be associated with these deposits and many of the profiles are duplex in nature.

The central sand plain, the largest and dominant soil landscape, comprises generally aeolian sand sheets, which in part, on-lap the eastern ferricrete sediments. The sands also partly obscure the western palaeo lake system. The soils in this landscape are deep sands, at times well sorted, and demonstrating generally strong fabric development. Deeper horizons display strong induration. Locally, dunes have been formed but this surface form is not common.

The western relict palaeo lake system appears to be the remnants of an ancient, and much larger lake system that was probably continuous along the length of the project area. Profile morphology is complex, tends to be characterised by well-defined horizonation that is stratigraphic rather than pedologic, and dominated by pedogenic and biogenic silica. The nature of silica precipitation indicates long periods of geomorphic stability.

It is likely that the development of the sand sheet and the demise of the lake system were contemporaneous and it is likely that both were associated with the onset of aridity. There is field evidence indicating that some drainage systems, originating from the outwash fans entered the lake system, at least in the southern areas.

Surface soils are generally non-dispersive, slightly acid in soil reaction, non-saline, and have high infiltration rates. Organic carbon is low, as is sulphur, and phosphorus is very low. Dry density ratios tend to be elevated due, in part, to age (consolidation) and eluviation-illuviation systems, and fabric development is generally better developed than at sites at Cooljarloo. As would be expected, the surface sands gave high variability in textural volumes, although fine to medium sands were dominant. At the depths investigated, soil profiles throughout the central sand plain lacked significant horizonation beyond colour change and fabric development.

No profiles demonstrated evidence of prolonged water retention within the upper profile nor effects of prolonged saturation at depth. Despite the dry conditions, there was no evidence to suggest that lateral through-profile drainage was a major process in the upper profiles.

At the time of the survey, vegetation was exhibiting drought stress and site-specific soil moisture data indicated soil moisture contents down to a low of 0.1%.

## 2.0 INTRODUCTION

### 2.1 LOCATION

The centre of the Dongara Project area is located approximately 28km south-east from the coastal hamlet of Port Denison on the shore of Azurine Bay, and some 370km north of Perth. The Project Area, which lies east of the Brand Highway covers an area of approximately 113km<sup>2</sup>. Mount Adams Road passes east to west through the area, joining the Brand Highway approximately 9km west of the project area boundary.

### 2.2 SCALES OF TIME AND SPACE

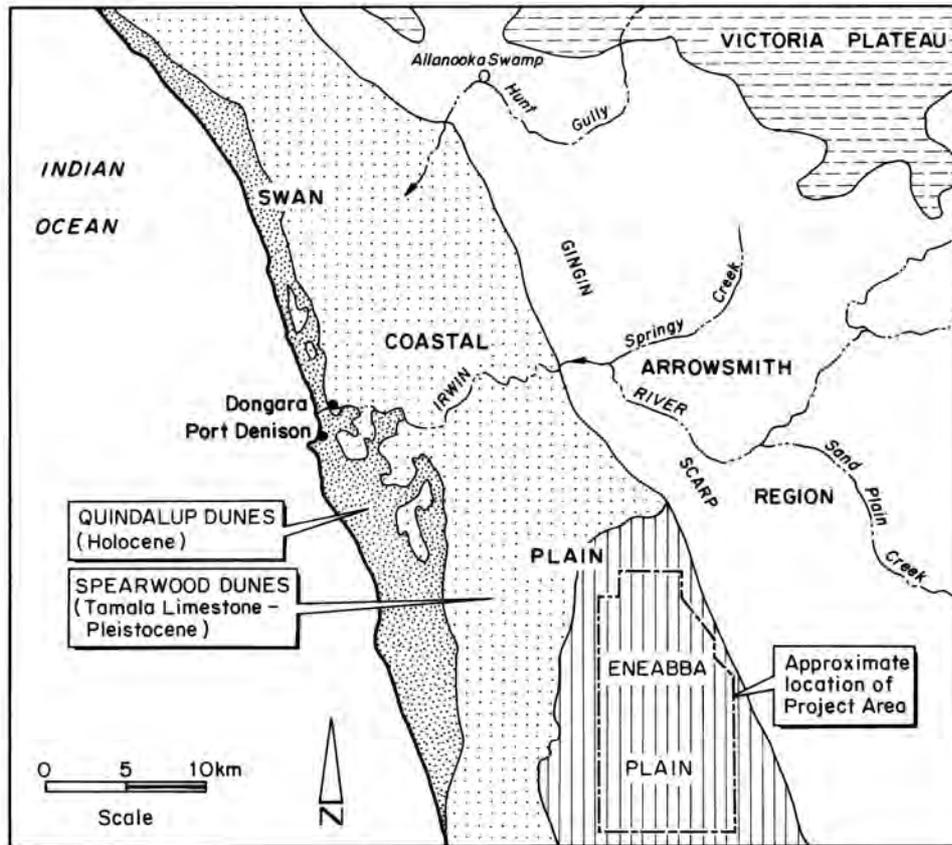
The Swan Coastal Plain forms the major regional physiographic unit of the project area and within this unit, three principal sub-units can be recognised. These are:

- a coastal dune system of Holocene age (<10,000 ybp), the Quindalup Dune System (McArthur and Bettenay, 1960; Semeniuk *et al.*, 1989), which, west of the project area has a width of 4.5km, and immediately to the east is;
- an inland dune system of Middle to Late Pleistocene age (800,000 ybp to 100,000 ybp), the Spearwood Dune System (McArthur and Bettenay, 1960), now referred to as the Tamala Limestone, outcrops of which are present in the central project area; and
- the Eneabba Plain (Playford *et al.* 1976), an area of undulating but gently rising plain between the Tamala Limestone and the Gingin Scarp.

The Dongara Project Area lies wholly within the Eneabba Plain and is shown in Figure 1.

### 2.3 PHYSICAL FRAMEWORK

The physical framework of the project area, defined as surface lithology, is set out in Figure 2. The north-south axis of the area of investigation parallels the regional grain of the country, formed by two sub-parallel soil landscape systems. These are swamp and lacustrine deposits forming an irregular band running the full length of the area along the western side, and a larger area of non-calcareous sand over the remainder (Mory, 1995). The area is bounded on the east by the Gingin Scarp, which reaches its maximum elevation of 256m at Mt Adams. The Gingin Scarp which is characterised by a westerly facing slope of a generally uniform gradient and comprising sand over ferruginous laterite is the source area of a number of drainage systems that discharge onto the project area along its eastern boundary. The drainage systems present today are relicts of a larger palaeo drainage system that operated during much wetter periods, probably during the Pleistocene. These systems were modified by the onset of aridity, which resulted in an increase in sediment loads, and reduced periodicity of discharge events. Two major systems can be recognised, a smaller channel system entering the project area near the eastern end of Mount Adams road and a second, larger system that enters the project area south of the Tompkins Road – Mount Adams Road intersection. These systems are characterised by a series of outwash alluvial deposits. Neither of these contemporary drainage systems have continuous and well incised channels.



**Figure 1** Regional time-stratigraphic framework showing the location of the project area within the boundaries of the Eneabba Plain (modified from Mory, 1995)

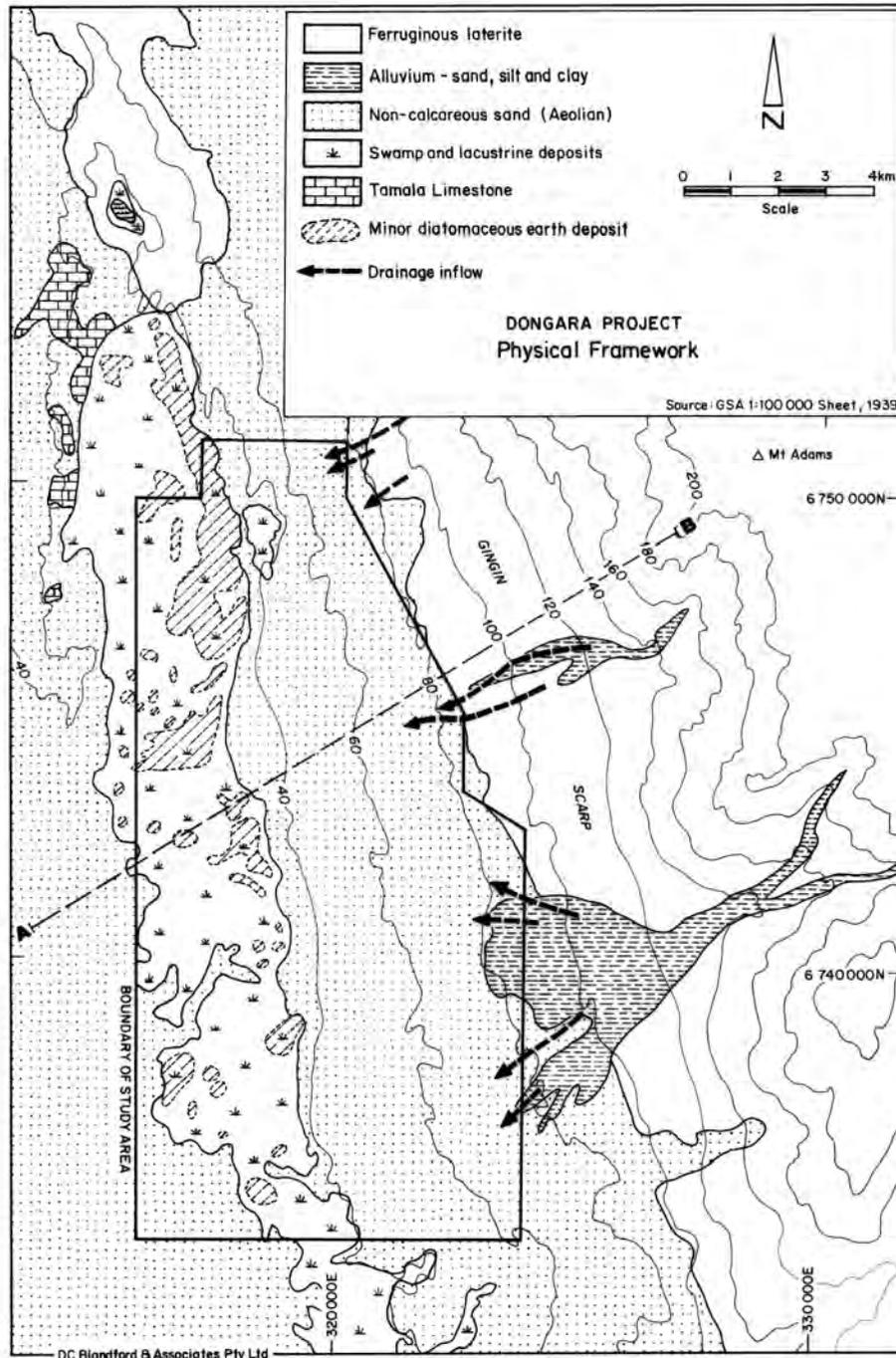
### 3.0 METHOD

#### 3.1 REVIEW OF LITERATURE

There are no soils data available at the scale of the project area. However, general references were consulted including various geological publications and topographic maps.

#### 3.2 PHOTO INTERPRETATION

Aerial photography, at a scale of 1:20,000 was used for general project area definition, and for site location. This was followed by a reconnaissance survey to relate vegetation photo patterns to landform and surface hydrology system characteristics. In addition, air photo interpretation, using stereoscopy, at a scale of 1:25,000 was used to help define soil landscape patterns, and broad scale process-response patterns.



**Figure 2:** The physical framework of the Dongara project Area according to broad scale lithologic characteristics as defined by GSWA. The two major relict drainage systems are also evident. The directional drainage arrows have been added by the author (modified from Mory, 1995).

### 3.3 SOIL PROFILE DESCRIPTION

Soil profiles were examined using inspection pits excavated with a backhoe to refusal, or to a depth commensurate with the location. A total of 74 sites were described to varying degrees of detail.

Because of safety requirements, inspection pits were not accessible for detailed description after a depth of about 1.5m. After this depth, profile material was brought to the surface in the backhoe bucket and assessed as a 'grab sample'. A number of inspection pits located in deep, non-coherent, single-grained sands were abandoned due to sidewall collapse.

As a general rule, the following profile characteristics were noted:

- overall pedologic organisation;
- horizonation due to colour change;
- horizonation due to textural change;
- the presence and nature of pans, ferricrete zones, or non-ferricrete gravels;
- the nature of horizon boundaries;
- texture;
- structure;
- colour; and
- fabric.

When present, the following features were also assessed and recorded:

- the presence and nature of palaeosols;
- the presence of seepage or free water in the profile;
- indicators of geomorphic pre-history; and
- the presence of relict palaeo drainage systems.

Samples, representative of the range of materials present, were collected for laboratory analysis from appropriate sites to define the particle size distribution within the profile and within profile horizons and to generally characterise the range of materials present.

Each profile was photographed where possible, but the overall greater depth of the surface sands and the greater depth to the clay layer - surface sand interface, precluded detailed profile photography. In some instances, the surface of the inspection pit, together with the surrounding vegetation was photographed.

### 3.4 SITE VEGETATION DESCRIPTION

At each soil inspection pit site, a list of dominant species was recorded, together with a description of the vegetation structure, following the system used by Woodman Environmental Consulting (WEC). WEC has recently undertaken vegetation mapping within the project area. The criteria used for structural descriptions have been modified from the original Muir (1977) structural classification system.

Because this is a very specific site-based description, the data presented here will, at times, show marked variations to the broad-scale mapping carried out by WEC. Site specific information including topography, aspect, and estimated percentages of bare ground, litter and total vegetation cover were also recorded. The following project area protocols, specific to the disturbance required for excavation of soil inspection pits included:

- All drill lines and access tracks that had not been botanically surveyed, and those not highlighted on the project area field maps by the proponent as being a recently cleared or rolled tracks, were walked by a botanist to check for DRF and Priority flora, prior to vehicle access. Further, all test

pit excavation sites were checked prior to excavation and the site relocated if necessary. Site relocation (measured in metres) occurred several times during the survey.

- The location of DRF and Priority plants had been flagged on a number of lines prior to this survey, and these locations were avoided by driving around the flagging.
- Damage to vegetation at all sites was kept to a minimum with the pit oriented to utilise the track for both pit excavation and overburden storage. Topsoil was stockpiled separately for replacement at the end of backfilling.
- A photographic record of pre- and post-disturbance, for all sites, was also included in survey protocols.

## **4.0 SOIL LANDSCAPES OF THE DONGARA PROJECT AREA**

### **4.1 INTRODUCTION**

Three soil landscapes are identified in the Dongara project area. These are:

1. An eastern ferricrete/clay profile system confined to a complex series of outwash alluvial structures.
2. A central sand plain comprising deep uniform, generally aeolian sand profiles
3. A western relict palaeo lake system.

While the gross soil landscapes are evident, and definable using air photo interpretation, the boundaries between the eastern and central units is at times obscure. It is readily apparent that the old drainage systems, discharging onto a palaeo outwash plain brought with them abundant iron-rich rubble in the form of eroded lateritic debris from eastern uplands. The subsequent weathering of this debris has allowed definition of the eastern landscape unit through its impact on soil profile characteristics. The central sand plain extends the full width of the project area, in places blanketing the palaeo lake system along the western side of the area, and in part, on-lapping the eastern unit. The palaeo lake system area has been given its own landscape unit ranking due to the distinct stratigraphy within individual profiles and clearly defined boundaries with the central sand plain. The soil landscape units are shown in Figure 3 against a background of project area infrastructure and soil test pit sites.

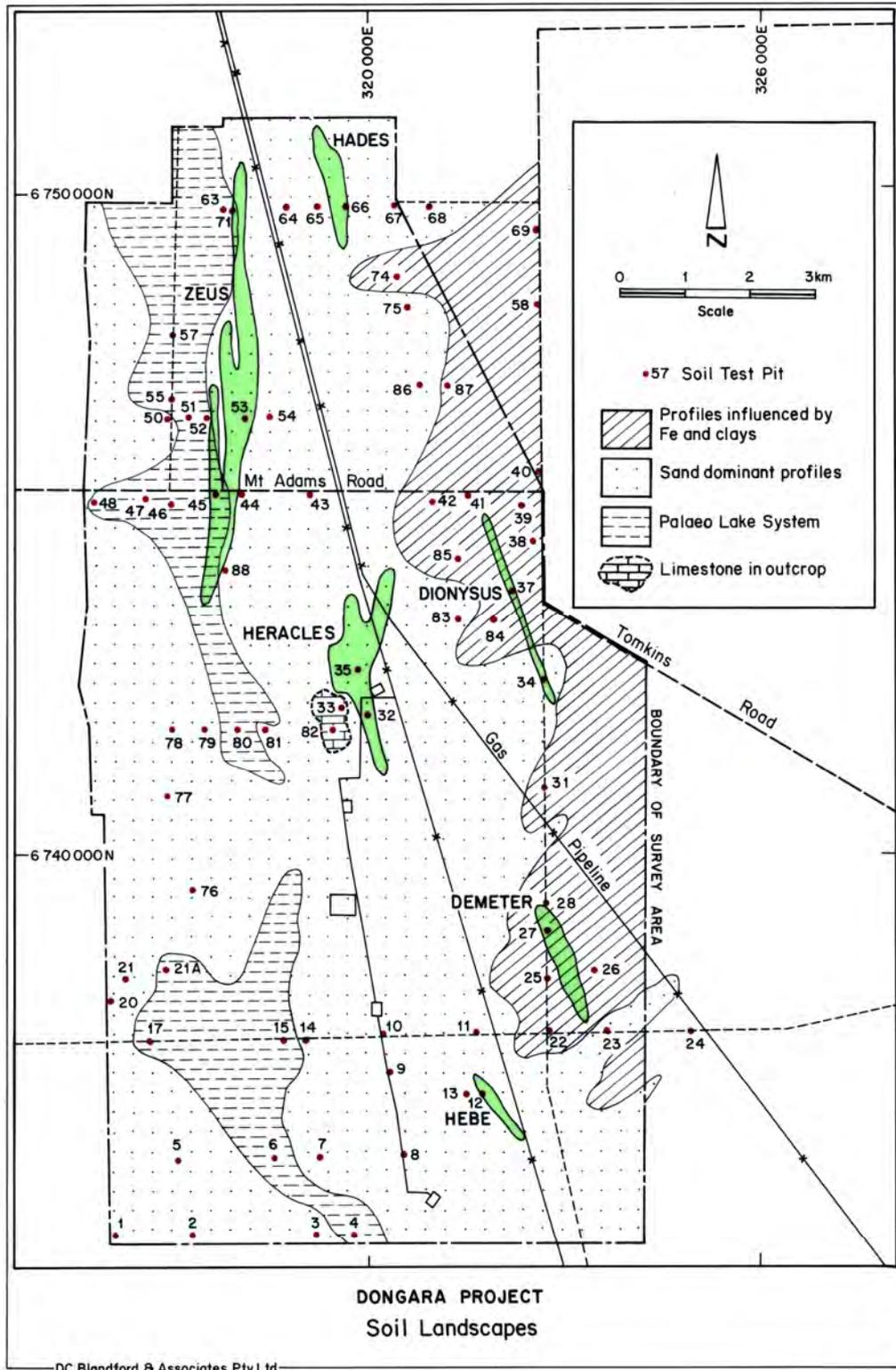
### **4.2 SOIL LANDSCAPE UNITS**

#### **4.2.1 The Eastern Ferricrete/Clay Unit**

The eastern ferricrete/clay unit has been identified on the basis of the presence of either duplex profiles or on the presence of ferricrete within the profile. There are no depth-dependent criteria associated with these characteristics. This unit is confined to the area of a complex series of outwash alluvial structures, comprising a number of lobes, the dominant being the Demeter Lobe and the Dionysus Lobe. Profiles within this soil landscape are complex with sand upper horizons (A horizons) overlying lower (B) horizons that contain ferricrete rubble in various stages of weathering, nodular to pisolitic ferricrete gravels, or residual weathering ferricrete debris, all of which are generally associated with non-smectite clays. In some areas, such as at site 39, the A horizon has been almost completely removed by erosion, leaving the clayey B horizon just below the surface. In other locations, the depth of the clay layer ranges from 1m to 2m below the surface.

The presence of weathering ferricrete rubble, or a clay horizon, is a precursor to inclusion in this unit and in a number of sites, these characteristics were only found at depth in the profile. No attempt has been made to differentiate profile characteristics on either the depth of ferricrete rubble, nor the extent of the resultant increase in fines content.

The principal profile characteristics include duplex profiles, the presence of highly weathered to unweathered Ferricrete rubble, nodules, or pisolites, and profiles in which there is strong fabric development and elevated moisture retention. Typical profile characteristics of this landscape are given in Plates 1 to 3.



**Figure 3:** The soil landscapes of the Dongara project area.

**PROFILE CHARACTERISTICS OF THE EASTERN FERRICRETE/CLAY SOIL LANDSCAPE**



**Plate 1:** Ferricrete profile at Site 58



**Plate 2:** Ferricrete profile at Site 31



**Plate 3:** Truncated lateritic podsol soil at Site 39. The B horizon (arrowed) demonstrates spatially discrete dispersion.

#### 4.2.2 The Central Sand Plain

The central sand plain comprises deep uniform sand profiles in which the solum is dominated by the sand fraction, which may vary from fine- to coarse-grained sand. This is an extensive soil landscape and accordingly contains a wide range of soil and profile characteristics. It is probable that if pit excavation penetrated to greater depths, the sheet sand would be found to overlie palaeo sediments of alluvial/colluvial origin belonging to the outwash debris of the eastern drainage lines or remnants of the palaeo lake system.

The sheet sands of the central sand plain are complex in surface form and demonstrate directional structure. It is probable that they form an on-lapping relationship with the ferricrete landscape to the east. The sheet sands, while blanketing, in part, the palaeo lake system, have themselves been reworked by wind, which has also maintained exposure of the palaeo lake sediments. In other areas, it is likely that the old lakes remained uncovered by aeolian sands, with some degree of temporal uniformity in stagnation of the sand sheet and the loss of surface water from the lakes.

Many of the soil profiles developed within the sheet sands are characterised by a high degree of fabric development and induration. This level of material competence, which was demonstrated by non-collapse of profiles to depths exceeding 3m, is attributed, in part, to the greater age of the sediments at Dongara, relative to, say, the much younger sediments at Falcon and Cooljarloo. Characteristic soil profiles from this soil landscape are shown in Plates 4 to 7 and discussed further in Section 5.3.

#### 4.2.3 The Western Relict Palaeo Lake System

We have used the term relict to indicate that what is exposed and accessible at the surface is all that remains of a past, well-developed, fluvio-lacustrine system that appears to be partially intact outside the study area.

This soil landscape is located along the western side of the project area and forms a spatially discontinuous series of highly stratified sediments. Profiles tend to be complex, no two profiles are alike, and all profiles, examined in the field, are characterised by the presence of silica. Pedogenic silica appears to be common, with distinctive forms such as globules, irregular masses, nodules, pendants and stalagmites being characteristic forms. A number of sites displayed secondary precipitation of silica as a thick skin over already partially cemented but quite porous clean sands. Elsewhere, biogenic silica is present as thin, highly stratified sediment, often inter-bedded with, or infused with, calcium carbonate. The profiles examined in this landscape all demonstrate a complex pre-history in terms of depositional environment and field evidence suggests strong periodicity in process during a period of geomorphic stability.

Field evidence also suggests that this soil landscape, and particularly the individual profiles examined, is not subject to prolonged inundation nor to extended periods of waterlogging. The relict palaeo lakes do not fit naturally into a classification of wetlands for the Swan Coastal Plain. This is discussed in greater depth in section 6.

Typical characteristics of soil profiles within this landscape are shown in Plates 8 to 11.

## PROFILE CHARACTERISTICS OF THE CENTRAL SAND PLAIN



**Plate 4:** Deep white aeolian sand.



**Plate 5:** Deep fine to medium sand.



**Plate 6:** Deep aeolian sand.



**Plate 7:** Fine-grained aeolian sand.

## PROFILE CHARACTERISTICS FROM THE RELICT PALAEO LAKE SYSTEM

Some profiles contain pedogenic silica as a key feature. Biogenic silica is also present at a number of sites where it may be inter-bedded or infused with calcium carbonate.



**Plate 8:**



**Plate 9**



**Plate 10:**



**Plate 11**

## **5.0 SOILS OF THE DONGARA PROJECT AREA**

### **5.1 INTRODUCTION**

The soils of the Dongara project area are discussed in terms of their respective soil landscapes (see Figure 3). The boundaries shown in Figure 3 are, in part, implied boundaries, as the stratigraphic relationship between the alluvial/colluvial outwash sediments and the sand sheet deposits of the central sand plain have not been confirmed. Further, the project area topography suggests that the ferricrete soil landscape along the eastern boundary may have been an area of accelerated erosion, as evidenced by the truncated profiles at Site 39 and 40. Both sites however are well within the Dionysus Lobe, suggesting concentrated drainage system processes. Field evidence indicates that as distance westward increases, the presence of pisolitic ferricrete and relatively unweathered ferricrete debris, both decreases in volume and increases in depth below the surface.

As would be expected, the central sand plain contains great variability in profile characteristics, as do the profiles examined in the western relict palaeo lake system where all 14 profiles examined displayed different characteristics, and no two profiles were the same.

### **5.2 SOILS OF THE EASTERN FERRICRETE LANDSCAPE**

The soils of this landscape are characterised by the presence of ferricrete at some depth in the profile, or by the presence of a distinctive clay horizon resulting in a typical duplex profile. The ferricrete may range from a horizon of very well sorted, well rounded nodules, pisolites, or sub-angular to sub-rounded gravels to halos of hematitic and goethitic clays within a sand matrix. The degree of weathering of ferricrete rubble, the depth below the surface, and the high degree of induration present, suggest a considerable time span since deposition.

The clay horizons present are all dominated by kaolinitic material, demonstrating low plasticity and, typically, orange/grey mottling. Clay contents of 25% ( $\% < 2\mu\text{m}$ ) were normal for this material. In many profiles, pisolitic ferricrete and rubble occurred within a matrix of gritty sand or clays. Eighteen profiles are located within this soil landscape and the defining characteristics are set out in Table 1.

There are two major provinces in this landscape, defined by the Demeter Lobe in the south and the Dionysus Lobe in the north. The Dionysus Lobe is generally characterised by distinct clay horizons within the solum while profiles in the Demeter Lobe do not display clay horizons at the depths investigated. The inference here, based on the nature of the sediments, is that the Demeter Lobe has first, been the major discharge system in terms of the volume of water, and second, has resulted from discharge continuing well after the onset of aridity probably resulting in erosion and reworking of any remaining clay horizons within the earlier solum. Field evidence also indicates a sub-surface (4m bgl) narrow elongated band of outwash debris extending south-west across Hebe. While this outwash debris has not been mapped, it does give credence to an on-lapping relationship for the central sand sheet relative to the eastern fluvial sediments.

Data for soils in this landscape are set out in Table 2 and Table 3.

**TABLE 1****Profile Characteristics of the Eastern Ferricrete Landscape**

<b>Site Number</b>	<b>Depth Excavated (m)</b>	<b>Description</b>
69	2.0	Lateritic Podsollic Soil. Sand over Fe nodules over mottled sandy clay loam.
58	>1.0	Duplex profile, sand over well sorted Fe pisolites, over scattered pisolites in a FSL matrix.
74	2.2	Sand, over horizon of large Fe nodules (15x6mm) over gritty FSL.
87	3.0	High energy outwash deposit, sand over well-rounded pisolitic gravel, over gravel in sand matrix, qtz grains to 3mm with strong fabric development above the gravel horizon.
40	1.0	Lateritic podsollic soil, sand over gravel horizon over a mottled, slaking, non-dispersive, highly stratified light sandy clay loam.
41	2.6	Sand over fine to medium-grained indurated sand with strong fabric development, Fe weathering and small pisolites at depth.
39	1.0	Yellow podsollic soil (Dy5.5), sand over a mottled, dispersive Ec=2(1), sandy clay loam.
38	1.6	Sand over indurated sand, over indurated mottled, non-dispersive light sandy clay loam.
84	2.7	Sand over indurated yellow sand, over indurated sand with weathered Fe nodules.
31	2.8	Scour structure with white sand over a thin horizon of Fe pisolites forming a drape structure over non-dispersive fine sandy clay loam Ec=5/6. The scour infill of clayey gritty sand is dispersive, Ec=2(2) with rapid slaking..
22	3.0	Sand over indurated yellow sand gravel in a sand matrix over abundant gravel in a sand matrix over gritty clayey sand with Fe gravels.
25	2.8	Alluvial outwash fan. Sand over unweathered Fe pebbles to 40mm in a clayey sand matrix. Fabric development increasing with depth.
26	2.2	Gritty sand over indurated gritty sand with Fe staining at depth.
27	3.3	Alluvial outwash fan. Fine to medium sub-angular to sub-rounded sand over indurated gritty sand with weathering Fe pebbles to 30mm over sandy clay loam.
28	2.3	Sand over an indurated weathered Fe stained gritty sand to clayey sand at base.

**TABLE 2****Data for Eastern Ferricrete Soils**

Location [Site No]	Depth [mm]	Clay [%]	Silt [%]	Sand [%]	Gravel [%]	DDR [%]	MDD [t/m <sup>3</sup> ]	K [m/s]
27	150	< 3	< 3	95	< 2	91.0	1.78	-
	600	< 5	< 5	95	< 2	88.0	1.82	-
	1100	< 5	< 5	95	2	90.0	1.82	-
37	100	< 5	< 5	91	0	88.5	1.84	1.1x10 <sup>-4</sup>
	900	18	5	75	2	98.5	1.84	5.6x10 <sup>-5</sup>
	1580	11	7	80	2	89.5	1.84	-
12	200	< 4	< 4	96	-	93	1.84	-
	730	< 5	< 5	94	-	90.5	1.84	-
	1200	9	3	88	-	91.5	1.84	-
40	600	32	17	48	3	-	-	-
74	1200	15	3	81	1	101.7	1.60	1.0x10 <sup>-4</sup>

Notes: DDR = Dry Density Ratio in %; MDD = Maximum Dry Density in tonnes per cubic metre; K = Permeability in m/s, Site 74 DDR is a remoulded sample.

**TABLE 3****Aggregate Stability Analysis- Eastern Ferricrete Soils**

Location Site No.	Depth [m]	EC [dS/m]	pH	CEC	ESP [%]	D% [%]	EAT
12	0.2	< 0.1	6.8	4.2	< 2	0	5
37	0.1-0.3	< 0.1	7.1	4.4	< 2	0	8/5
39	0.5	0.88	6.7	6.1	8	0	6
40	0.6	0.04	7.1	7.8	1	5	6
42	2.7	< 0.01	7.1	6.0	< 2	26	8/5
87	2.5	< 0.01	6.6	5.8	2	32	6

There are a number of salient features demonstrated by the data presented in Table 2. These are the higher clay contents associated with the Dionysus Lobe to the north (shaded grey), a constancy of sand content down to a depth of 1.5m as tested and extending to the base of the profile as observed, and elevated DDR's, relative to the younger sediments at Cooljarloo (Blandford, 2003). The characteristic of having a higher DDR in mid-profile is explained by the depositional environment and is discussed further in Section 7.

The aggregate stability data presented in Table 3 indicates that the soils tested are non-saline, generally neutral in pH, are non-sodic (except for Site 39 which is marginally sodic), have low dispersion percentages and have good aggregate stability in terms of the Emerson class. Although we recorded highly dispersive soils in the field, the samples demonstrating this characteristic were drill residue samples from much deeper within the profile.

The soil profiles investigated within this eastern landscape are shown in Appendix I.

### **5.3 SOILS OF THE CENTRAL SAND PLAIN**

The profile characteristics of the central sand plain are set out in Table 4, physical characteristics are set out in Table 5, and aggregate stability data are set out in Table 6.

A brief perusal of these data indicates that the soil materials tested all displayed a high degree of uniformity down to approximately 1.5m below ground level. Clay contents are generally less than 5% and in most cases, less than 3%. The sand textures ranged from fine- to medium-grained, but occasionally, coarse textures were encountered. These coarse-grained textures provided evidence of high sheet flow velocities as the sands often became gritty with an increase in texture grade.

The depth of root penetration was variable.

The soils tested indicate high levels of aggregate stability, but rapid and at times violent, slaking.

The profiles shown in Plates 4 to 7 are typical of profiles in the central sand plain, and the reader is referred to Appendix I for additional photo coverage of soils in this landscape.

A defining feature of the sands and the profiles in this landscape is the high degree of competence (relative) of the sand material. This is demonstrated by the ability of the walls of many of the inspection pits to remain free-standing, even at depths down to 3.0m. The fundamental reason for this is the level of fabric development resulting from an eluviation-illuviation system operating over extended periods of geomorphic stability. Here, material is removed from the upper horizons (the eluvial horizon) by either suspension or in solution and re-deposited in a lower horizon (the illuvial horizon). This system may be vertical or lateral. Common to this system is the removal and re-deposition of clay, iron, aluminium, organic matter, and silica. Central to defining the system is the lack of clearly defined horizon boundaries within the sand/soil profile. The soils of the central sand plain are characterised by such profiles. Accordingly, increases in colour and associated increases in material strength can be explained by the greater age of the landscape allowing the eluvial-illuvial system to operate, resulting in increasing strength due to deposition of clays (plasma), iron oxides and silica, all of which become cementing agents by default. The result is a more competent or indurated material.

**TABLE 4**

**Profile Characteristics of the Central Sand Plain**

Site Number	Depth Excavated (m)	Description
44	2.8	Sand with weak fabric development, zone of induration at 1.5m
50	3.0	White to grey fine to medium sand, sub-angular to sub-rounded.
54	2.6	Fine to medium sand, earthy fabric developing below 1.0m, roots to 1.6m bgl.
64	2.2	Fine to medium cream sand, sub-angular to sub-rounded, becoming yellow sand at depth.
67	2.0	Pale yellow sand, weak fabric development, sub-angular to sub-rounded over indurated fine to medium sand.
68	2.4	Pale yellow sand, weak fabric development, sub-angular to sub-rounded over indurated fine to medium sand.
75	3.0	Cream sand over creamy-yellow sand, becoming indurated with depth, qtz gravel to 3mm.
86	1.6	Cream sand over indurated yellow sand, strong fabric development,
83	2.6	Sub-angular to sub-rounded sand, strong fabric development Dispersive drill residue on surface ( $E_c=2(1)$ ).
34	3.1	Pale yellow sand with weak fabric development over strongly indurated sand over clayey sand at depth.
82	2.0	Yellow to orange sand, with weak fabric development. Isolated limestone in outcrop.
81	2.9	Sub-angular to sub-rounded fine to medium white aeolian sand.
32	2.2	Gritty sand over indurated gritty sand with Fe staining at depth.
79	3.3	Fine to medium white sand over pale yellow sand over white sand
77	2.3	Fine to medium white sand with roots to 1.3m
20	3.4	Sub-angular to sub-rounded cream sand over yellow sand over white sand, induration increasing with depth
7	3.0	White aeolian sand, frosted grains.
3	3.5	Cream sand grading to yellow sand with weak fabric development over very well sorted white sand, sub-angular to well-rounded.
8	2.3	Fine to medium yellow sand.
10	3.0	Fine to medium white sand over yellow sand with directional platy structures, roots to 1.8m
13	3.6	Fine to medium yellow sand, rounded grains at depth.
11	2.3	Pale yellow sand over medium to coarse-grained yellow sand.
35	2.5	Pale yellow sub-angular to sub-rounded sand, over yellow sand

**TABLE 5****Representative Data for Soils of the Central Sand Plain**

Location [Site No]	Depth [mm]	Clay [%]	Silt [%]	Sand [%]	Gravel [%]	DDR [%]	MDD [t/m <sup>3</sup> ]	K [m/s]
54	700	< 2	3	96	-	-	-	-
35	180	< 1	< 3	96	-	89	1.72	-
	680	< 3	3	95	-	90.5	1.81	
	1200	-	< 5	94	-	89.5	1.81	
32	1000	<3	5	93	-	-	-	9.1x10 <sup>-5</sup>
13	3600	<5	< 8	90	-	-	-	-
88	280	-	< 4	96	-	90.5	1.74	-
	800	-	< 4	96	-	-	-	-
53	200	-	< 6	94	-	-	-	-
	700	-	< 5	95	-	95.0	1.75	-
	1100	-	< 5	96	-	95.5	1.75	-
66	250	-	< 2	97	-	94.0	1.76	-
	720	-	< 5	94	-	91.0	1.76	-
	1300	-	< 5	94	-	93.0	1.76	-

Notes:

DDR = Dry Density Ratio in %

MDD = Maximum Dry Density in tonnes per cubic metre

K = Permeability in metres per second

**TABLE 6****Aggregate Stability Analysis- Central Sandplain Soils**

Location Site No.	Depth [m]	EC [dS/m]	pH	CEC	ESP [%]	D% [%]	EAT
53	0.7	< 0.01	6.6	4.5	< 2	32	6

Notes:

EC - electrical conductivity

CEC – Cation Exchange Capacity

ESP –Exchangeable Sodium Percentage

D% - Dispersion Percentage

EAT – Emerson Aggregate Test

## 5.4 SOILS OF THE WESTERN RELICT PALAEO LAKE SYSTEM

The soils of this landscape are complex, both in their intra-profile stratigraphy and in their inter-relationships with adjacent relict palaeo lake beds. No attempt is made here to elaborate on this complexity as this is addressed further in Section 6.

Major profile characteristics are set out in Table 7 and Table 8, and the reader is referred to Plates 8 to 11 for typical profile stratigraphy.

**TABLE 7**

**Profile Characteristics of the Western Relict Palaeo Lake System**

Site Number	Depth Excavated (m)	Description
63	1.8	Fine to medium sand with Si nodules to 2mm over gritty sand with plates and pendants of pedogenic silica over massive pedogenic silica.
57	2.5	Blocky pedogenic silica over sand over gritty sand with pendants, columns, over well sorted fine to medium sand.
55	1.3	Cryptogamic surface over pedogenic silica (crumb structure) over loam (pedogenic silica) over indurated sand.
51	2.6	Si granules in a sand matrix over highly stratified pedogenic silica over nodular sand over dark stained sand.
48	0.1	Loamy sand over pedogenic silica with skin development.
46	0.54	Gritty loam over highly stratified biogenic silica over massive pedogenic silica
45	2.4	Sub-angular to sub-rounded fine to medium white sand over globular silica over columnar pedogenic silica.
80	2.5	Fine sandy loam over sand over pedogenic silica, stratified, banded, over sand.
17	0.9	Loamy sand over strongly calcareous light sandy clay loam over green (olive brown) sand over a palaeo topsoil (?) over well-sorted single grain yellow sand.
15	0.6	Fine white sand over vertically structured (pendant) pedogenic silica as an extension to massive pedogenic silica.
6	1.5	Non-calcareous sand with silica nodules over highly stratified biogenic silica with infused CaCO <sub>3</sub> , over non-calcareous green sand over indurated (pan) non-calcareous green sand.
4	1.9	Biogenic silica over sand over pedogenic silica.

**TABLE 8**

**Data for Soils of the Western Relict Palaeo Lakes**

<b>Location [Site No]</b>	<b>Depth [mm]</b>	<b>Clay [%]</b>	<b>Silt [%]</b>	<b>Sand [%]</b>	<b>Gravel [%]</b>	<b>DDR [%]</b>	<b>MDD [t/m<sup>3</sup>]</b>	<b>K [m/s]</b>
21A	400	15	3	80	2	-	-	-
55	200	48	37	14	1	-	-	-
	700	< 3	< 3	94	3	--	-	-
17	100	2	3	95	-	-	-	-
	500	< 5	< 5	95	-	-	-	-

Notes: DDR = Dry Density Ratio in %; MDD = Maximum Dry Density in tonnes per cubic metre; K = Permeability in m/s, Site 74 DDR is a remoulded sample.

**5.5 GENERAL SOIL CHARACTERISTICS**

5.5.1 Surface Infiltration Rates.

The *in situ* infiltration rate of surface soils was investigated by constant head infiltrometer. The results are highly variable but given the sandy nature of the surface soils at Dongara, not surprising. The highest infiltration rate, 3,420mm per hour was recorded in the Eastern Ferricrete/clay Unit at Site 37 and the lowest, 72mm per hour, was recorded in the Western Relict Palaeo Lake Unit at Site 55. There was no indication at any site tested that water infiltration was impeded at the surface. Results of the on-site testing are set out in Table 9.

**TABLE 9**

**Surface Rainfall Infiltration Rates**

<b>Location Site</b>	<b>Soil Landscape</b>	<b>I<sub>r</sub> [mm/h]</b>
37	Eastern Ferricrete	3,420
38	Eastern Ferricrete	1,980
53	Central Sand Plain	223
35	Central Sand Plain	1,698
32	Central Sand Plain	1,600
55	Relict Palaeo Lakes	72
4	Relict Palaeo Lakes	160
51	Relict Palaeo Lakes	300

### 5.5.2 Soil Chemistry

General soil chemical parameters were analysed for selected soil horizons and the results are set out in Table 10.

**TABLE 10**

**Soil Chemical Data**

<b>Location (Site No.)</b>	<b>pH</b>	<b>EC (dS/m)</b>	<b>Org. Carbon (%)</b>	<b>(NO<sub>3</sub>)N (mg/kg)</b>	<b>P (mg/kg)</b>	<b>K (mg/kg)</b>	<b>Amm. (mg/kg)</b>
88	6.1	0.059	0.1	2	1	57	1
32	6.5	0.021	0.05	2	1	261	1
9	6.3	0.021	0.05	2	1	75	1
54	6.5	0.01	0.09	2	1	24	1
66	6.2	0.019	0.1	2	1	86	1
26	6.3	0.01	0.09	2	1	20	1
27	6.1	0.018	0.21	2	1	44	1
53	6.5	0.01	0.12	2	1	22	1
12	6.4	0.019	0.12	2	1	44	1
38	6.5	0.02	0.1	1	2	24	1

**TABLE 10 (Continued)**

**Soil Chemical Data**

<b>Location (Site No.)</b>	<b>S (mg/kg)</b>	<b>Fe (mg/kg)</b>	<b>Exc Ca (meq/ 100g)</b>	<b>Exc Mg (meq/ 100g)</b>	<b>Exc Na (meq/ 100g)</b>	<b>Exc K (meq/ 100g)</b>	<b>Al (meq/ 100g)</b>
88	4.3	251	0.13	0.08	0.07	0.13	0
32	1	383	0.29	0.18	0.08	0.71	0
9	1	275	0.12	0.07	0.06	0.13	0
54	1.1	260	0.33	0.1	0.06	0.07	0
66	1.6	779	0.33	0.15	0.07	0.14	0.04
26	1.2	88	0.12	0.06	0.06	0.07	0
27	1.3	41	0.33	0.1	0.07	0.08	0.03
53	1.1	74	0.2	0.09	0.07	0.09	0
12	1.2	153	0.32	0.1	0.06	0.08	0
38	5	333	0.28	0.15	0.08	0.08	0

The data presented in Table 10 above, indicate that the soils generally are all slightly acid, are non saline, and all have low organic carbon contents which will impact in turn on moisture availability and nutrient availability. Phosphorus levels are very low and sulphur levels are also low.

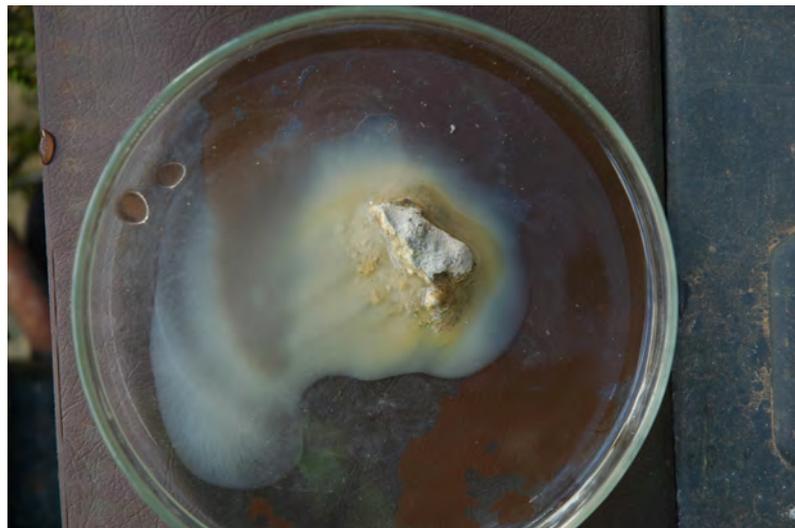
## 6.0 DISCUSSION

### 6.1 PHYSICAL CHARACTERISTICS

#### 6.1.1 Aggregate Stability

The data presented in Tables 3 and 6 show that all the surface soils tested for aggregate stability demonstrated strongly flocculated soil aggregates, with aggregate stability classes of 5, 6 and 8. Class 8 aggregates are aggregates that remain unchanged when they are placed in water, *i.e.* they neither slake nor swell. The author identified dispersive material on the surface at Site 39 but laboratory analyses did not identify dispersion. Such an apparent discrepancy is not surprising and due in part to the nature of the outwash fans present and the presence of spatially discrete soils dominated by Na ions on the exchange complex. This phenomenon is similar to that present at both Cooljarloo and Falcon (Blandford, 2000,2006).

An aggregate stability analysis was also carried out on drill residue left on the surface at a number of sites where the depth of origin of the drill residue was well below the depth excavated for the soil test pit. This material invariably demonstrated dispersion to some degree and both slaking and dispersion occurred within minutes of commencing the test. Typical dispersion characteristics are shown in Plate 12 below. The type and nature of the dispersion present indicates that current management practices for the control of dispersive soils can be adopted and implemented.



**Plate 12:** Typical dispersion characteristics from drill residue remaining at the surface, but the depth of this sediment is unknown. The response here shows an Ec 2(2).

#### 6.1.2 Surface Infiltration Rates

Surface infiltration rates were determined *in situ* using a constant head infiltrometer. The rate of rainfall infiltration across the Dongara project area is highly variable from a high of 3,420mm/h to a low of 72mm/h. The highest rate was recorded at Site 37 in the Eastern Ferricrete Soil Landscape. The profile at this site was sand to 1.8m below ground level but the top 0.7m comprised a strongly gritty sand. The lowest infiltration rate recorded was at Site 55 in the northern end of the Western Relict Palaeo Lake system where the upper 0.7m of the profile comprised “crumb structured” pedogenic silica.

As a general rule, infiltration is not uniform as demonstrated by the upper profile at Site 85. This inspection pit, which was excavated approximately 12 hours after a brief rainfall event, clearly shows differential penetration of rainfall into the soil. The reasons for this are many and varied but hydrophobicity of surface sands will strongly influence penetration patterns, as will the presence of macro-porosity as well as micro textural differences and the effect this has on pore space connectivity. The spatially discrete penetration pattern shown in Plate 13 is significant in that the moisture content of the 'wet' soil on the left was 4% and that of the 'dry' soil on the right was 0.1% (both results presented as gravimetric moisture content). This is a very large discrepancy in soil moisture content and a satisfactory explanation may invoke the application of the percolation theory. It is possible that the 'wet' soil is hydrophilic and the 'dry' soil is hydrophobic. For such an argument to progress, it implies that the water repellent nature of the surface sands has penetrated the profile as indicated. Pursuing such detail was beyond the scope of this investigation

The water in the 'wet' lobe will not move into the dry lobe unless further significant rainfall is received. Conversely, evaporation will rapidly reduce the soil moisture content to that of the adjacent dry sand. Vegetation with roots penetrating the area of the wet soil will benefit from the increase in soil moisture availability, adding to the complexity of spatially discrete patches of non-stressed vegetation.



**Plate 13:** A lobe of wet soil exposed in the soil inspection pit at Site 85.

### 6.1.3 Induration and Moisture Retention

As a general rule, the profiles examined in the Dongara project area demonstrated high levels of induration. While this may, in part, be due to the greater age of the sediments, it is also partly due to the presence of iron oxides present in the soil resulting from the transport of high iron content materials from the Gingin Scarp onto the plain and to eluviation. The presence of the remnants of

weathered ferricrete debris is ubiquitous throughout the Eastern Ferricrete Landscape and soil profiles in this landscape demonstrated high degrees of competence in terms of strength.

This trend of competent sand profiles continued into the Central Sand Plain and most profiles examined showed strong fabric development at depth. The high levels of fabric development and the degree of induration present suggest that these materials will have elevated moisture retention capabilities. Field evidence indicated high soil moisture contents in many of the soils at depths of 1.5 to 2m below the surface.

The areas demonstrating the least competent materials occurred in the Western Relict Palaeo Lake landscape where the subsurface sediments examined tended to be very clean and well sorted sand, often very fine grained. Side-wall collapse often prevented excavation to greater depths.

## 6.2 THE WESTERN RELICT PALAEO LAKE SYSTEM

This landscape, within the Dongara project area, is a continuation of a much larger system that extends both north and south of the project area as a discrete narrow, elongated landscape. It is shown as Quaternary age swamp and lacustrine deposits (Mory, 1995). Field evidence collected during this survey does not support the concept of swamps and no evidence was found to indicate old swamp deposits (peat) present to the depths inspected. Further, the surface expression of this system is not continuous but rather a series of palaeo deposits now separated by tracts of sheet sand.

Within the project area, the relict lakes that have a distinct 'wetland' air photo pattern, due in part to vegetation colour and density have no external drainage. Under the present climatic influences, the system has all internal drainage and field evidence suggests that this has been the case for the past few thousand years.

The vegetation present does not reflect any permanence of surface water, nor extended periods of waterlogging within the boundaries of individual units of this landscape. The only water input appears to be meteoric. Characteristics in the profiles examined indicate that the upper 1.5 m (at least) is above the water table and that seasonal fluctuations of this water table do not impact on the soils present nor does any capillary rise.

### 6.2.1 Classification Issues

In her classification of 'land based' wetland systems, Semeniuk (1987) defined seven common wetland types based on water permanence and surface form. These are:

- permanently inundated basin (lake)
- seasonally inundated basin (sumpland)
- seasonally waterlogged basin (dampland)
- permanently inundated channel (river)
- seasonally inundated channel (creek)
- seasonally inundated flat (Floodplain)
- seasonally waterlogged flat (palusplain)

The units of the western palaeo lakes do not fit easily into this classification. As Hill *et al.* (1996) point out, water is the feature that defines the wetland habitat from non-wetland habitats. Further, the presence of water will strongly impact on the species present and the characteristics of the soil profile subject to water effects. Neither the vegetation species nor soil profile characteristics support any of the above classification for wetlands.

Precipitation, evaporation, evapotranspiration, and high surface infiltration rates directly impact the permanence of surface water within this landscape. Under present climatic regimes, we suggest that

none of the units within this landscape are subject to extended hydro-periods. Rather, the hydro-period is governed in the first instance by the amount of rain that is received and then by the rate of infiltration. Apart from roadways where compaction is excessive, field evidence indicates limited periods of surface waterlogging and all the profiles examined indicate high rates of internal drainage.

The presence of both wetlands and probably wet lands, beyond the boundaries of this survey area imply a need to define these units to comply with an overall classification system. Such a classification then, must take account of meteoric input only, high rates of infiltration, high permeability (based on texture), and good internal drainage. As most of the units are relatively flat lying, or have gentle surface gradients, and all have very limited hydro-periods, we propose that the term intermittent palusplain be applied until additional data indicate that this classification needs to up-graded, or indeed, removed.

### 6.2.2 Profile Characteristics and the Dominance of Silica

There is abundant evidence that these ‘intermittent palusplains’ were once part of a dynamic lake system in geologically recent time(>30,000ybp). Each profile examined within this landscape contained features that were not common to other profiles. However, the presence of silica, both biogenic and pedogenic, links the individual units geomorphologically in both time and space, and as Twidale *et al.* (1970) point out, silcretes have important associations with palaeo surfaces.

The various profiles examined within the Western Relict Palaeo Lake Landscape tended to contain an admixture of macro forms in addition to partial silcrete *per se*. The mass of cemented pedogenic silica (Plate 14) is typical of macro-forms present.



**Plate 14:** Pedogenic silica at Site 21A, 0.7m below the surface. The dark lines are roots and old root lines. The surface (arrowed) comprises secondary silica cementation.

The detail in micro-morphology indicates a prolonged period of geomorphic stability and constancy of process, as is typified by the development of a concentric layering of a ‘silica ‘skin’ (a micro capping structure) on an already existing mass of pedogenic silica (Plate 15) and the ‘in profile’ precipitation of thin platy, silica horizons (Plate 16). The features noted within high silica profiles mirror, to some extent, the characteristics of profiles present in the Eromanga Basin (Milnes & Thiry, 1992) with nodules, pendants, crude vertical columnar structure, and dark bluish purple crumb-structured pedogenic silica.

This latter material, which almost certainly derived its colour from Titania, can be readily mistaken for a crumb-structured clay loam but the silica aggregates simply break down to smaller aggregates under force. This makes any PSD analyses of this material meaningless as it would be possible to get a material of 100% clay (size). Silica columns (Plate 17) and silica stalagmites (Plate 18) are common features of many of the profiles examined.



**Plate 15:** A competent and highly laminated secondary skin (micro capping structure) of precipitated silica (arrowed) forming a very hard thin surface layer over a (pseudo-breccia) silica mass.



**Plate 16:** Globular to massive pedogenic silica towards the base of this profile with silica skins forming discrete thin platy structures below a granular to nodular silica horizon.



**Plate 17:** A large porous silica stalagmitic column from Site 15 with roots penetrating the very porous structure.



**Plate 18:** A competent silica stalagmite from Site 80.

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## **APPENDICES**

<b>APPENDIX I</b>	<b>SOIL PROFILES</b> <b>Part A Sites 1 to 28</b> <b>Part B Sites 31 to 50</b> <b>Part C Sites 51 to 88</b>
<b>APPENDIX II</b>	<b>TABLE OF SOIL DATA</b>
<b>APPENDIX III</b>	<b>PARTICLE SIZE DISTRIBUTION CURVES</b>
<b>APPENDIX IV</b>	<b>DRY DENSITY RATIOS</b>
<b>APPENDIX V</b>	<b>PERMEABILITY</b>
<b>APPENDIX VI</b>	<b>AGGREGATE STABILITY CHEMISTRY</b>
<b>APPENDIX VII</b>	<b>SOIL CHEMISTRY</b>

## **APPENDIX I**

**Part A – Sites 1-28**  
**Part B – Sites 31-50**  
**Part C – Sites 51-88**

# APPENDIX I

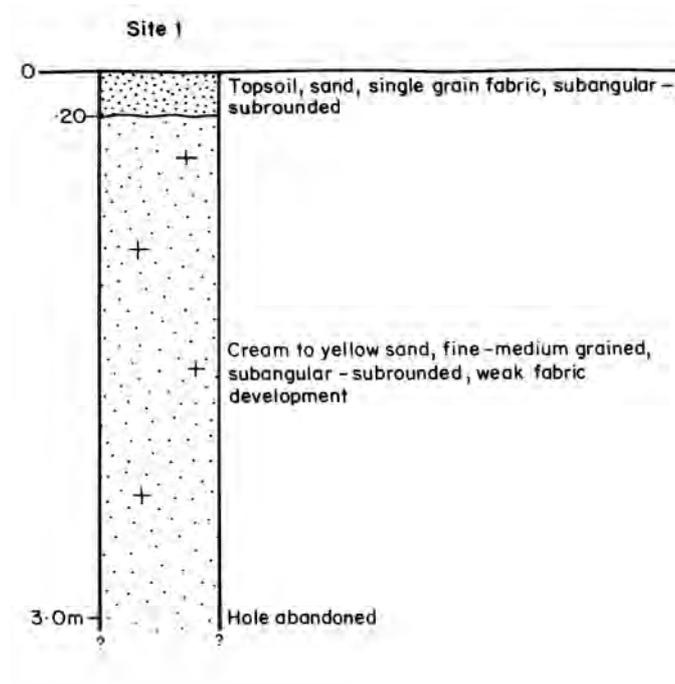
## PART A: SITES 1 - 28

### SOIL PROFILES & VEGETATION RELATIONSHIPS

*“At the time of the survey, vegetation throughout the area was exhibiting moderate to severe drought stress responses including, chlorosis of foliage, leaf drop and partial to whole of plant death”.*

(A.Harris, *pers comm.*)

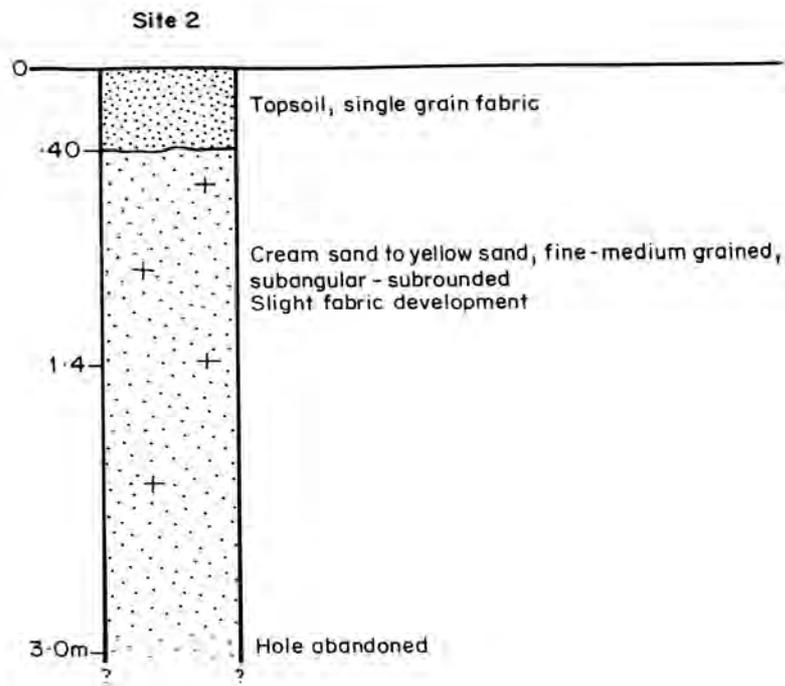
## SITE 1



316154 E  
6734266 N

The site has been recently burnt (<1yr) therefore, no vegetation structure can be described. Species observed to be regenerating include, scattered *Xylomelum angustifolium* trees to 4m, *Banksia attenuata*, *Eremaea beaufortioides* var. *microphylla* (), *Calothamnus blepharospermus* and *Hakea polyanthema* P3 to 1.8m, *Melaleuca leuropoma* and *Scholtzia involucrata* to 1m. Sedges common to the area include *Ecdeiocola monostachya* and *Chordifex sinuosus*.

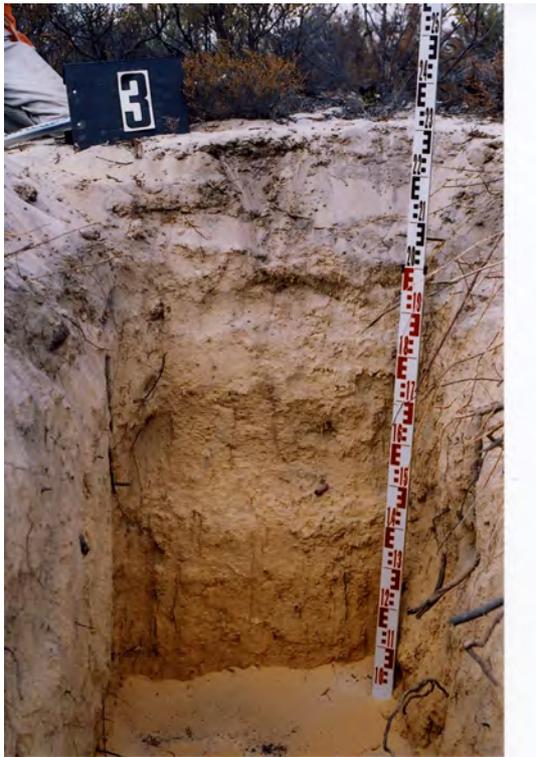
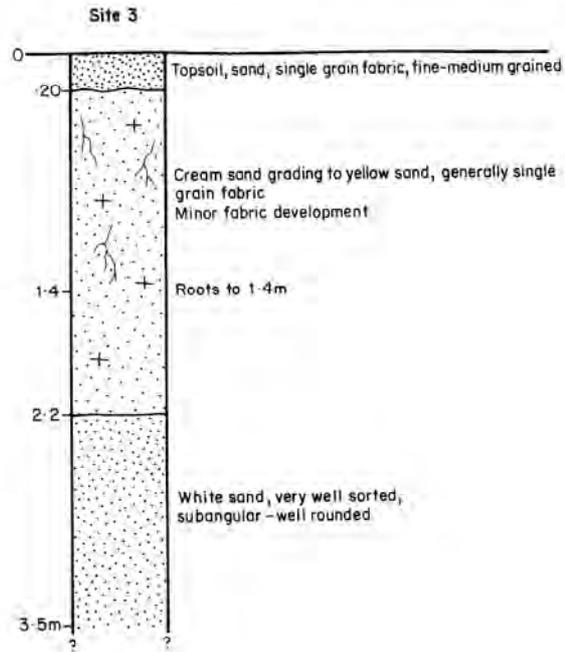
## SITE 2



317298 E  
6734270 N

The site has been recently burnt (<1 yr) therefore, no vegetation structure can be described. Species observed to be regenerating include, emergent *Banksia menziesii* trees to 3.5m, *Banksia attenuata*, *Eremaea beaufortioides* var. *microphylla* (ID pending) and *Hakea polyanthema* P3 to 1.7m, *Melaleuca leuropoma* and *Scholtzia involucrata* to 1m.

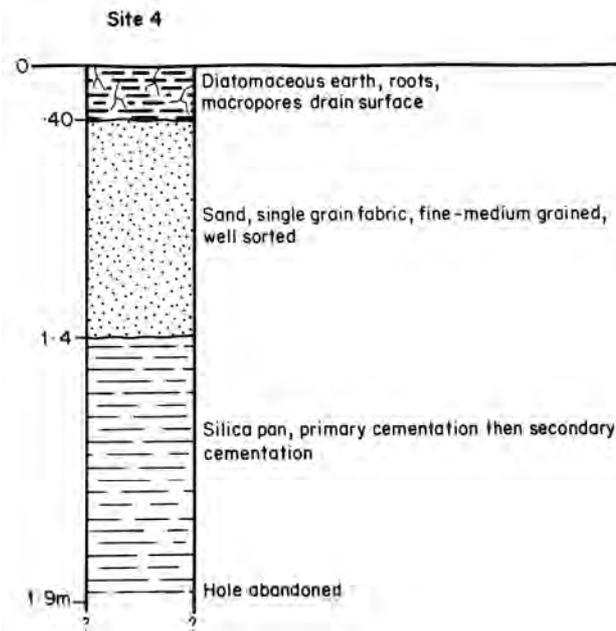
## SITE 3



319194 E  
6734279 N

Heath to 1.8m dominated by *Banksia attenuata*, *Eremaea beaufortioides* var. *microphylla* (ID pending) and *Scholtzia involucrata* over Dwarf Scrub to 1m dominated by *Calytrix/Beyeria* D3-1 (ID pending) and *Stirlingia latifolia*. Isolated *Banksia menziesii* trees occur in the area.

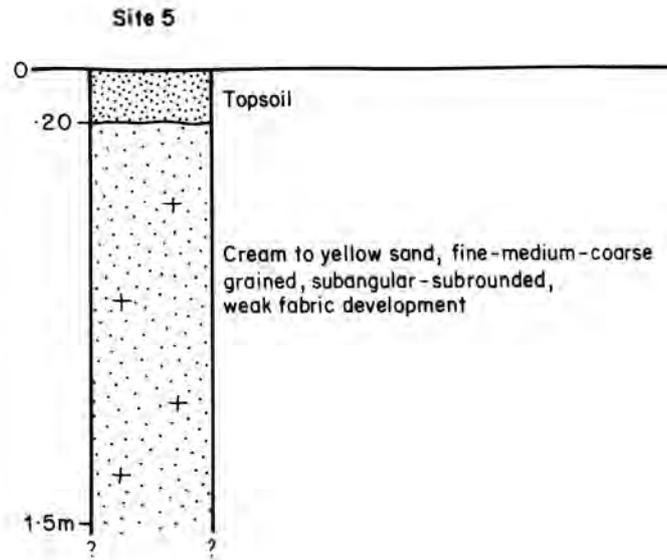
## SITE 4



319805 E  
6734278 N

Heath to 1.65m dominated by *Hakea trifurcata*, *Banksia leptophylla* D4-2 (ID pending) and *Xanthorrhoea drummondii* over Dwarf Scrub to 0.6m dominated by *Calothamnus hirsutus* and *Kunzea micrantha* with scattered *Actinostrobilus pyramidalis*. Isolated *Eucalyptus todtiana* occur in the area.

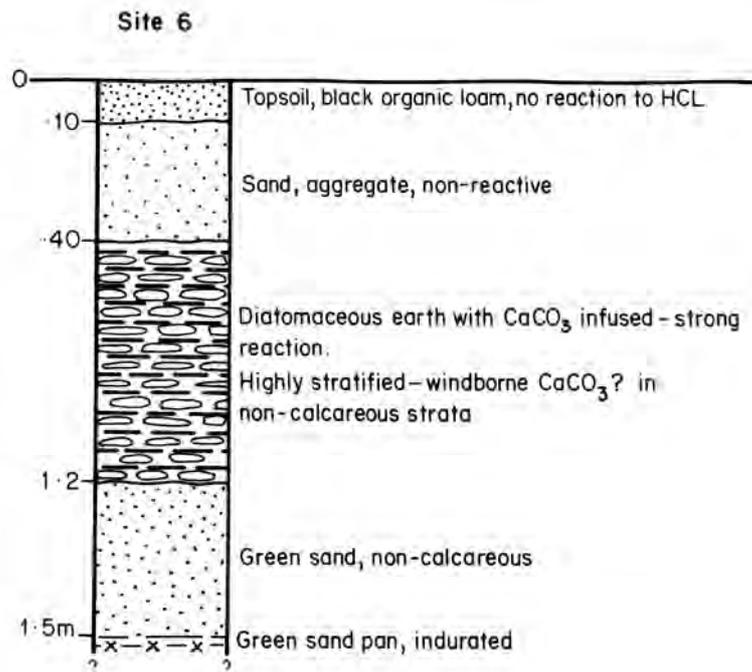
## SITE 5



317090 E  
6735371 N

The site has been recently burnt (2-3 months) therefore, no vegetation structure can be described. Species observed to be regenerating include, scattered *Banksia menziesii* and *Xylomelum angustifolium* trees to 3.0m, *Banksia attenuata*, and *Hakea polyanthema* P3 to 1.6m, *Beaufortia elegans* to 1m.

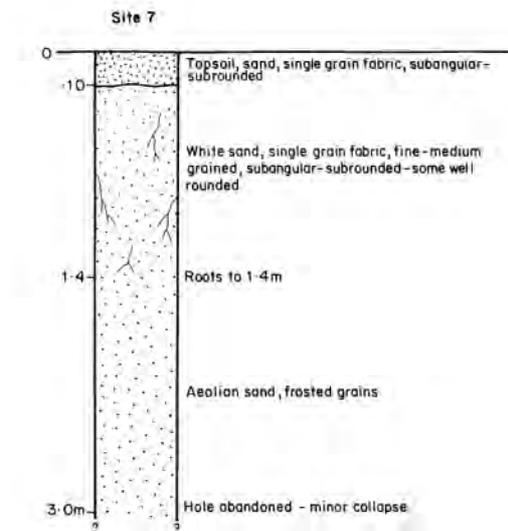
## SITE 6



318542 E  
6735404 N

Thicket to 3m of *Melaleuca huegelii*, *Allocasuarina campestris* and *Santalum acuminatum* over Low Scrub dominated by *Actinostrobos pyramidalis* and *Hakea trifurcata* over *Baumea juncea* D6-3 (ID pending) Tall Sedges. The Priority 4 species, *Banksia elegans* grows at this site. Traveling east from the base of the depression at this site up a 9% slope, the vegetation changes through narrow transitional 'zones' of different species from Thicket to Heath to Very Open Woodland on the elevated dune sands.

## SITE 7



319246 E  
6735418 N

*Banksia menziesii* Open Low Woodland to 5.5 m over *Actinostrobilus pyramidalis* Open Scrub to 2.5m over Low Scrub to 1.8m dominated by *Banksia attenuata* over Dwarf Scrub to 1 m dominated by *Beaufortia elegans* and *Stirlingia latifolia* over *Chordifex sinuosus* Low Sedges to 0.5m. Isolated *Eucalyptus todtiana* and *Nuytsia floribunda* trees occur in the area. The Priority 4 species, *Banksia elegans* also occurs at this site. There is a high level of drought stress exhibited by understorey vegetation at this site

**LOCATION  
BETWEEN SITE 7 AND 8**



319858 E  
6735334 N

Dense Heath to 1.8m dominated by *Banksia leptophylla*, *Beaufortia elegans* and *Hakea polyanthema* P3. Scattered patches of *Eucalyptus todtiana* to 10 m with associated *Acacia scirpifolia* shrubs to 3.5m also occur in the area.

This site is a small, localised and well-defined vegetation community within an elevated depression.

(Photo: A. Harris)

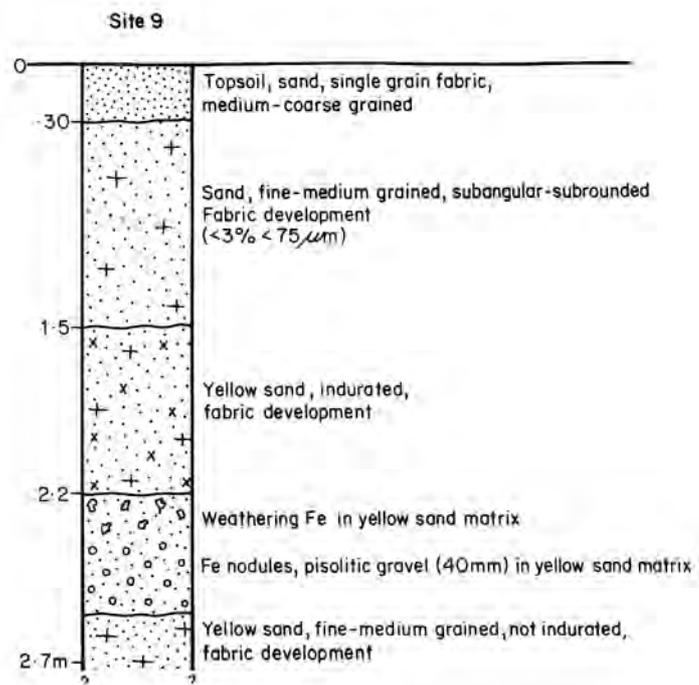
## SITE 8



320465 E  
6735448 N

Heath to 1.7m dominated by *Banksia hookeriana* and *Banksia attenuata* over Dwarf Scrub to 1m dominated by *Beaufortia elegans* and *Calothamnus blepharospermus* over Very Open Tall Sedges to 0.6m. Isolated *Eucalyptus todtiana* and *Xylomelum angustifolium* trees occur in the area. The Priority 3 species, *Hakea polyanthema* grows at this site.

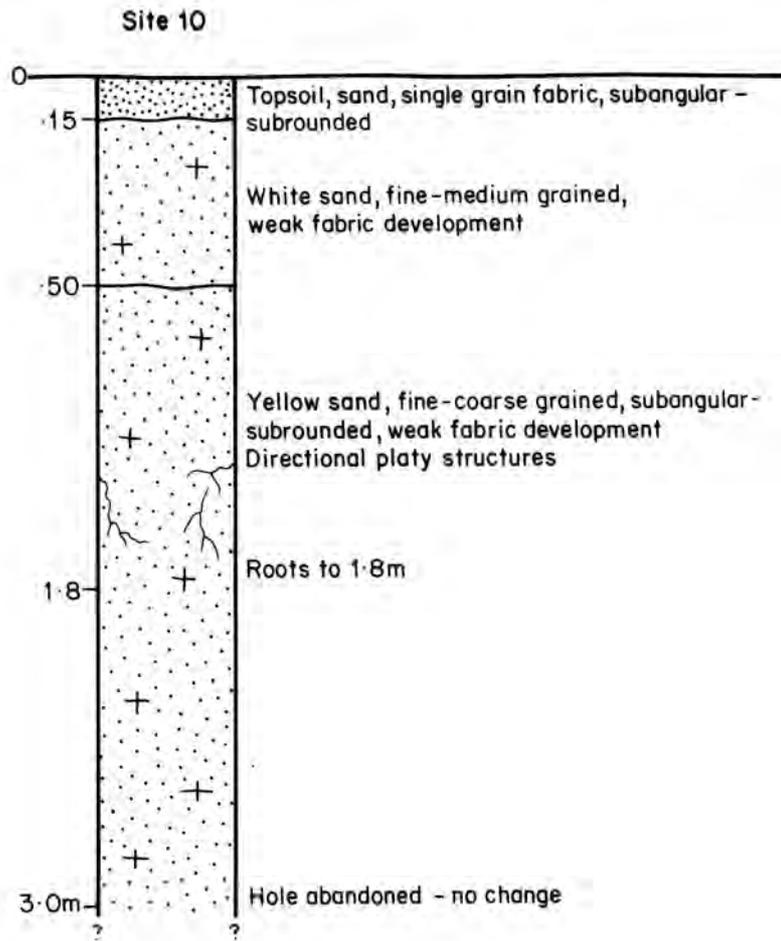
## SITE 9



320263 E  
6736943 N

Heath to 1.1m dominated by *Beaufortia elegans* and *Hakea polyanthema* P3 over Dwarf Scrub to 1m dominated by *Leucopogon* small leaves (ID pending) and *Dryandra shuttleworthiana* over *Ecdeiocolea monostachya* Very Open Low Sedges to 0.5m. The Priority 3 species, *Isopogon tridens* grows at this site.

## SITE 10

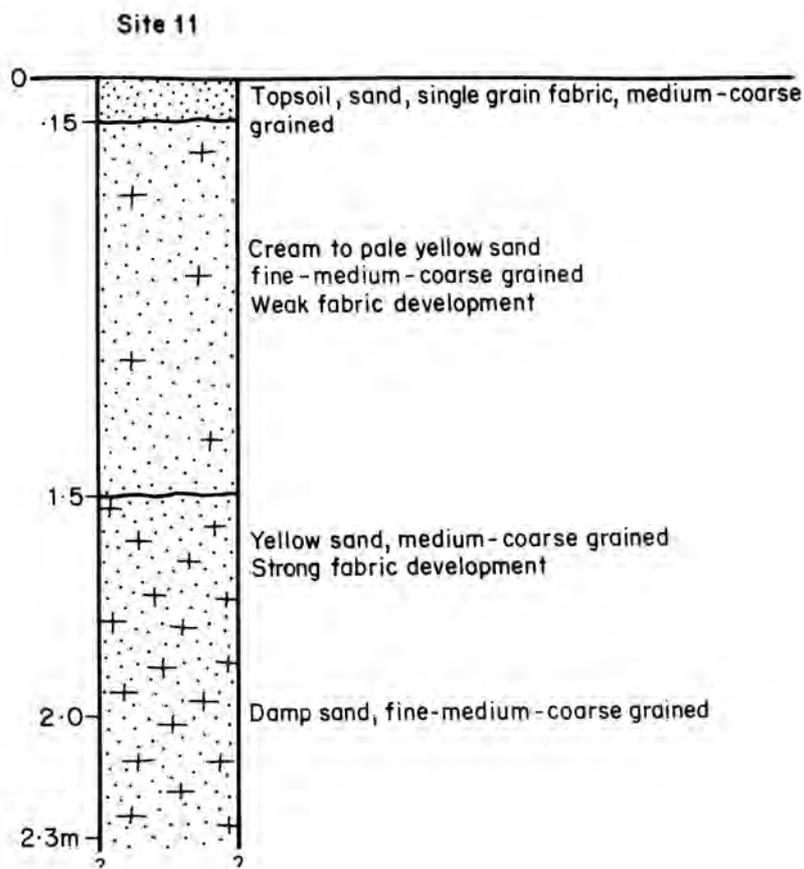


320249 E  
6737246 N

Heath to 1.6m dominated by *Banksia hookeriana*, *Hakea polyanthema* P3 and *Banksia attenuata* over Dwarf Scrub to 1 m dominated by *Daviesia benthamii*, *Leucopogon* small leaves (ID pending) over *Ecdeiocolea monostachya* Open Tall Sedges to 0.7m.

The Priority 3 species, *Isopogon tridens* grows at this site.

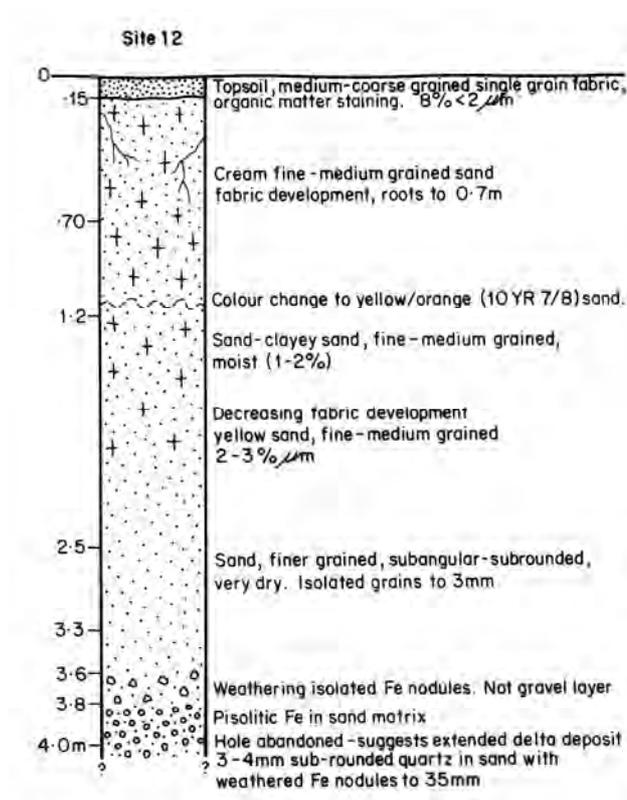
## SITE 11



321591 E  
6737269 N

Heath to 1.5m dominated by *Banksia candolleana*, *Hakea polyanthema* P3 and *Beaufortia elegans* over Dwarf Scrub to 0.9m dominated by *Melaleuca leuropoma* and *Dryandra shuttleworthiana* over *Ecdeiocolea monostachya* Open Tall Sedges to 0.6m. Scattered patches of *Xylomelum angustifolium* trees to 4m and isolated *Eucalyptus todtiana* to 3.5m occur in the area.

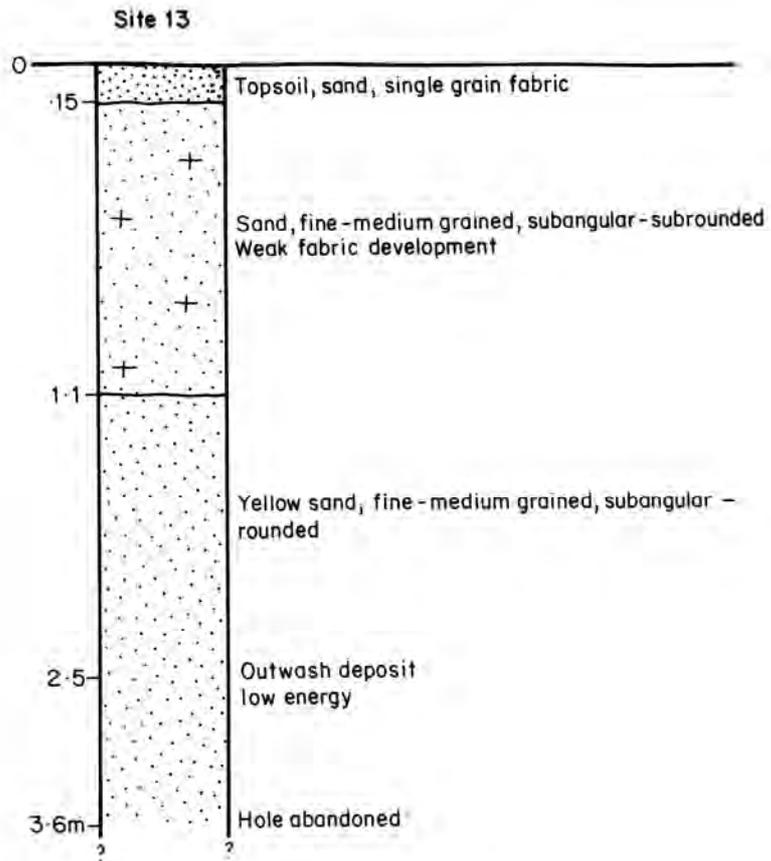
## SITE 12



321791 E  
6736353 N

Heath to 1.6m dominated by *Eremaea beaufortoides* var. *microphylla* (ID pending) and *Banksia attenuata* over Dwarf Scrub to 0.8m dominated by *Beaufortia elegans* and *Hakea polyanthema* P3 over *Ecdeiocolea monostachya* Low Sedges to 0.5m. Isolated patches of *Xylomelum angustifolium* occurs in the area. The Priority 3 species, *Isopogon tridens* grows at this site.

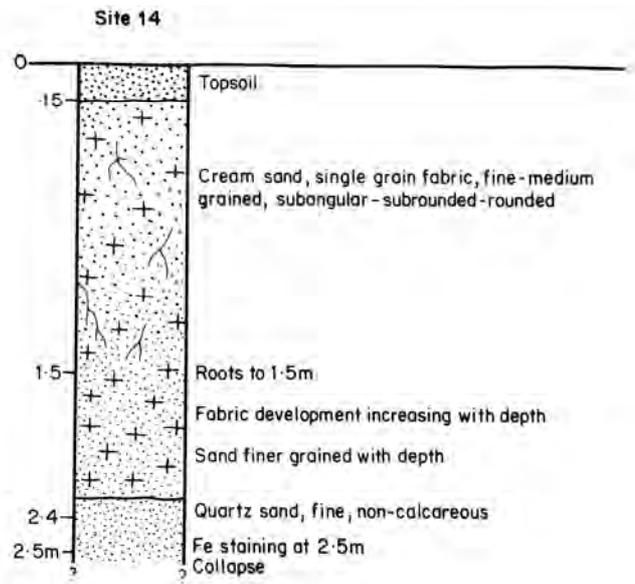
## SITE 13



321470 E  
6736354 N

Low Scrub to 1.6m dominated by *Hakea polyanthema* P3 and *Banksia attenuata* over Low Heath to 1m dominated by *Beaufortia elegans* and *Banksia candolleana* over *Ecdeiocolea monostachya* Open Low Sedges.

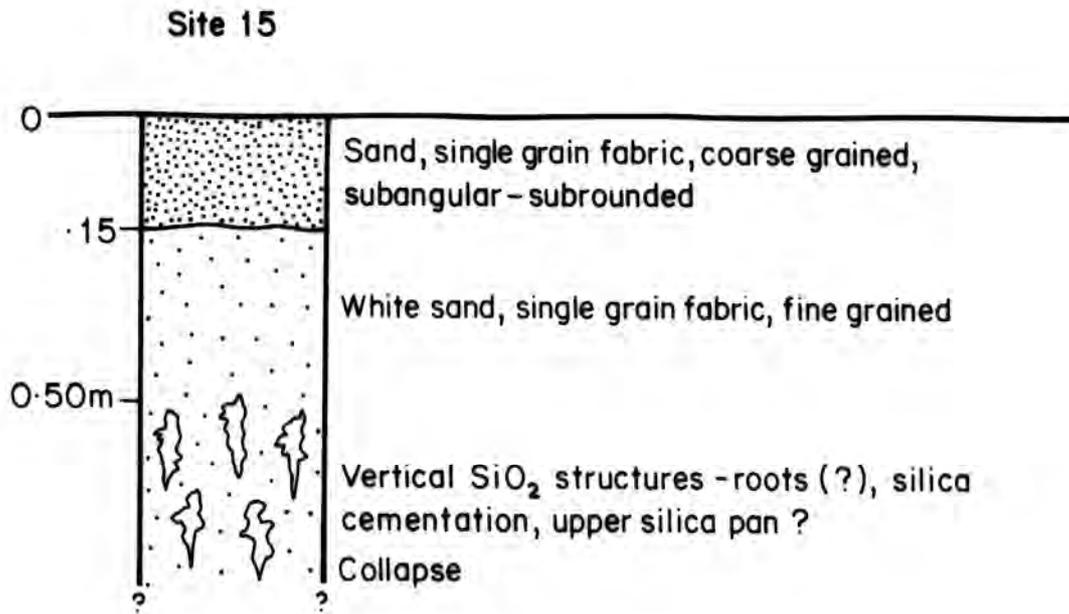
## SITE 14



319033 E  
6737235 N

Open Low Woodland to 2.5m of *Banksia menziesii* over Heath to 1.7m dominated by *Banksia attenuata* and *Eremaea beaufortioides* var. *microphylla* (ID pending) over Dwarf Scrub to 0.6m dominated by *Astroloma xerophyllum* and *Melaleuca leuropoma* over Very Open Low Sedges to 0.3m of *Mesomelaena pseudostygia*. Scattered patches of *Eucalyptus todtiana* to 3.4m with associated *Acacia scirpifolia* shrubs occur in the area. The Priority 3 species, *Hakea polyanthema* grows at this site

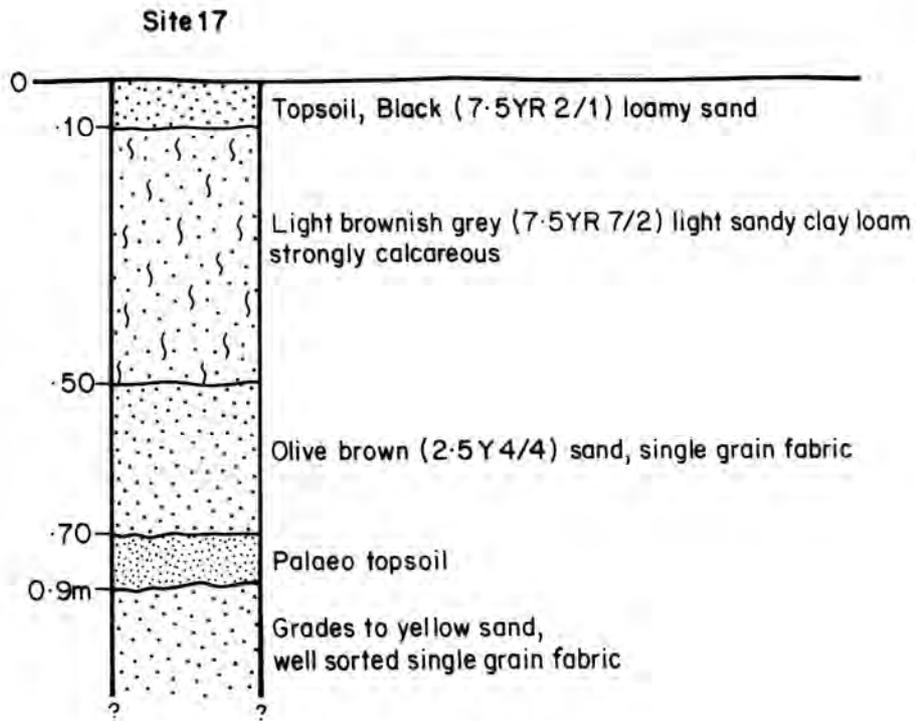
SITE 15



317727 E  
6737215 N

Scrub to 2.8m of *Acacia scirpifolia* over Heath to 1.9m dominated by *Allocasuarina campestris* and *Calothamnus quadrifidus* over *Verticordia densiflora* Dwarf Scrub to 1m.

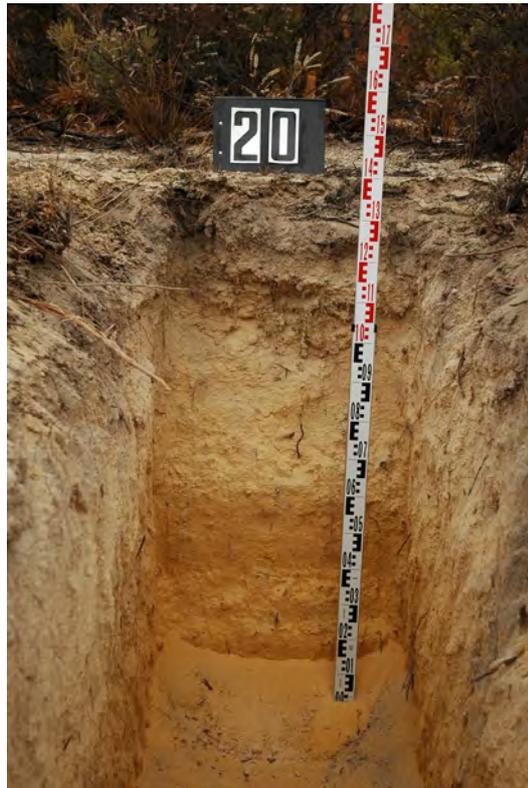
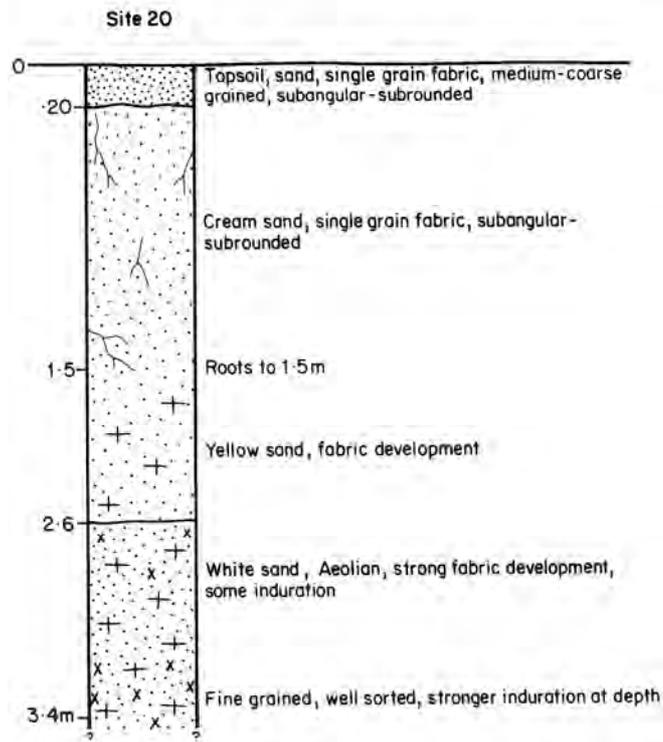
SITE 17



316704 E  
6737188 N

Low Scrub to 1.7m of *Grevillea eriostachya* over Heath to 0.9m dominated by *Melaleuca systema* and *Acacia lasiocarpa* var. *lasiocarpa* over *Desmocladius asper* Very Open Low Sedges to 0.1m. Scattered trees to 3 m and numerous dead stags to 4.5m of *Banksia prionotes* occur in the area. Repeated fires appear to have changed the vegetation structure from an Open Woodland. The vegetation here is under extreme stress with much leaf drop occurring.

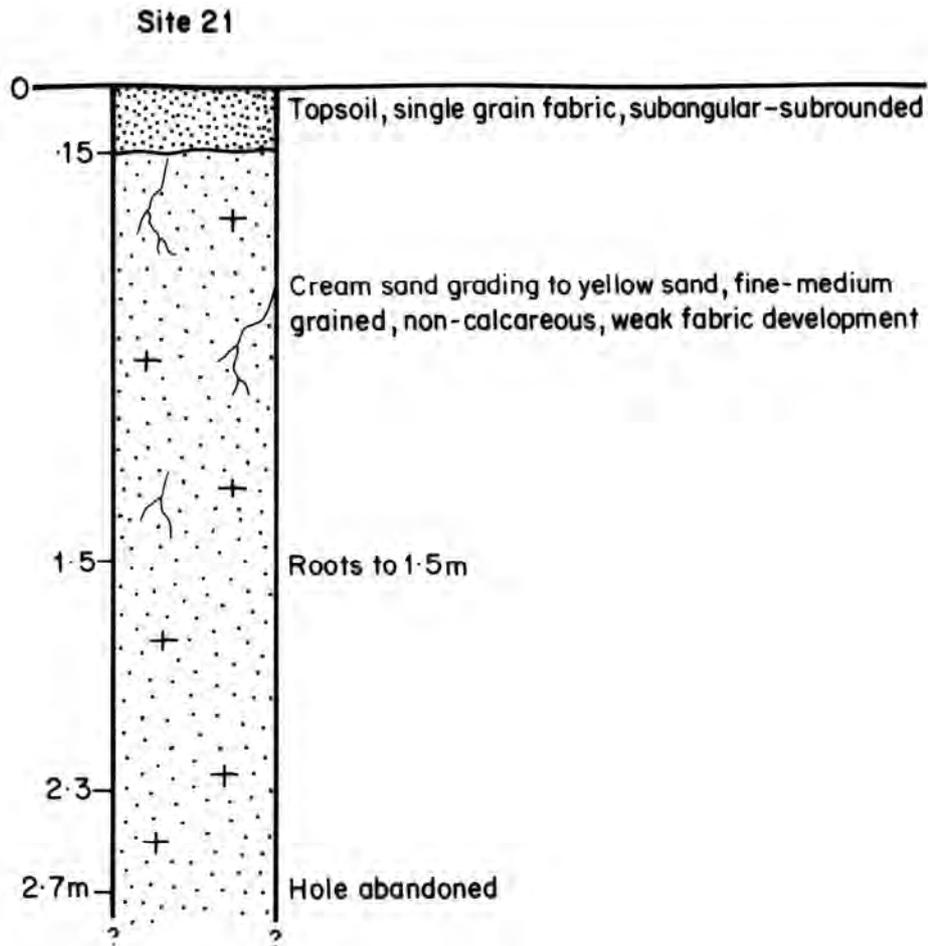
## SITE 20



316157 E  
6737789 N

Heath to 1.8m dominated by *Banksia attenuata* and *Banksia hookeriana* over Open Dwarf Scrub to 1m dominated by *Melaleuca leuropoma* over *Mesomelaena pseudostygia* Very Open Low Sedges to 0.3m. Isolated *Banksia menziesii* trees occur in the area. The Priority 4 species, *Banksia elegans* grows at the site.

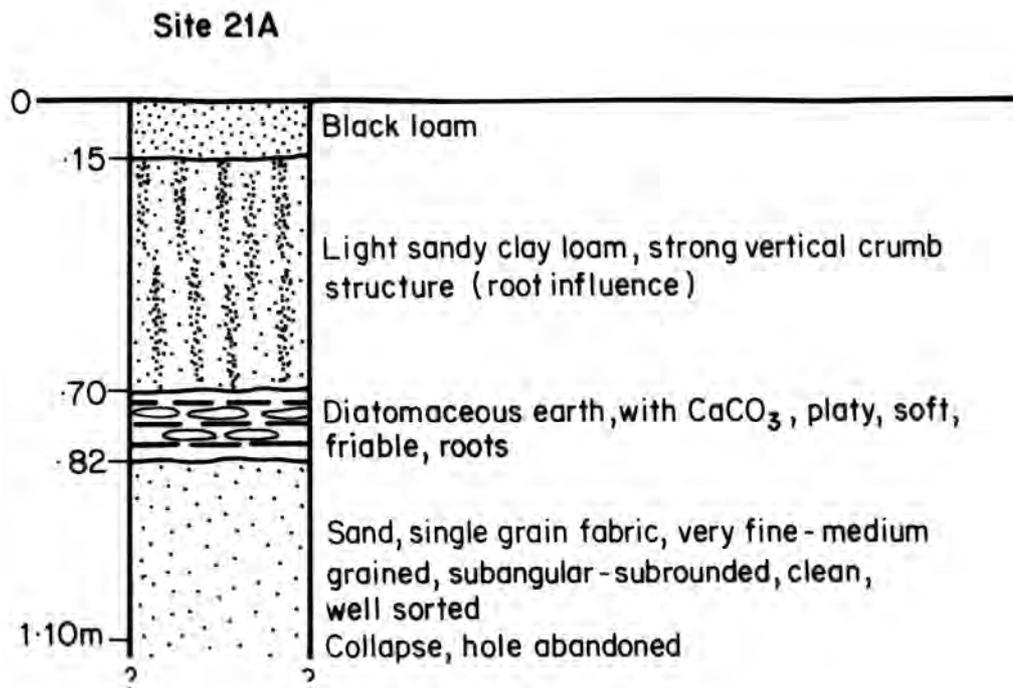
## SITE 21



316300 E  
6738129 N

Heath to 1.9m dominated by *Banksia hookeriana* and *Banksia attenuata* over Dwarf Scrub to 0.9m dominated by *Hakea polyanthema* P3 over Open Tall Sedges to 0.6m dominated by *Ecdeiocolea monostachya*. Isolated *Banksia menziesii* trees occur in the area. There are many recent, medium and old dead *Banksia hookeriana* at the site. Possibly due to drought stress.

SITE 21A

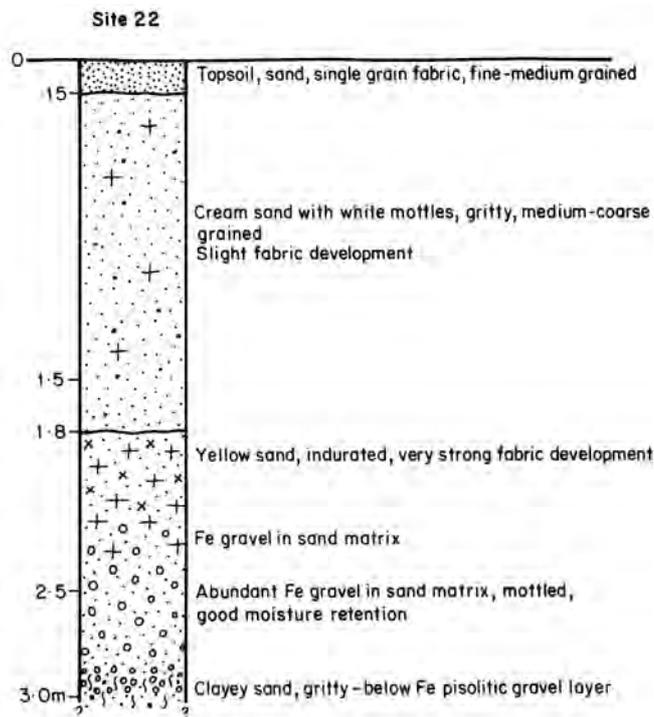


316972 E  
6738147 N

Heath to 18 m dominated by *Calothamnus quadrifidus* and *Melaleuca systena* over Open Dwarf Scrub to 0.4m dominated by *Acacia lasiocarpa* var. *lasiocarpa*. Scattered trees of *Banksia prionotes* to 8m, *Nuytsia floribunda* to 5m and *Melaleuca preissiana* to 3.5m, occur in the area.

Drought stress is evident in the understorey at this site .

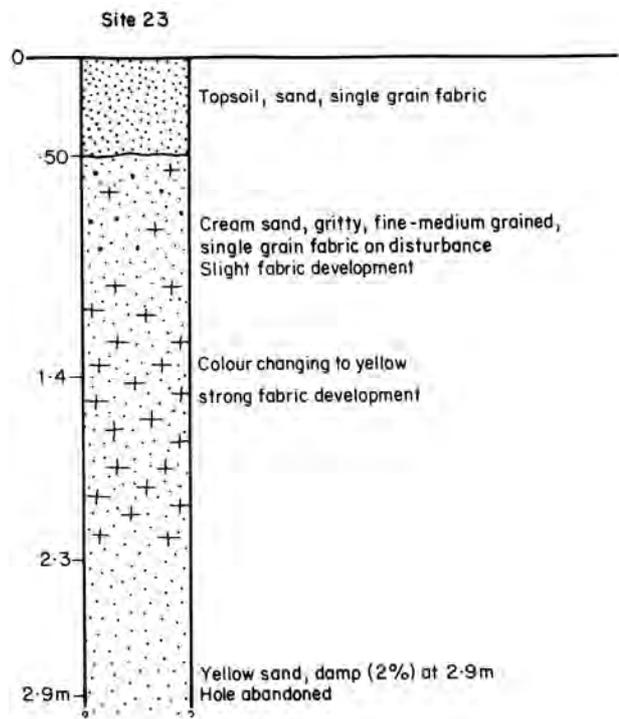
## SITE 22



322702 E  
6737287 N

Heath to 1.6m dominated by *Hakea polyanthema* P3 and *Calothamnus blepharospermus* over Dwarf Scrub to 0.9m dominated by *Dryandra shuttleworthiana* and *Melaleuca leuropoma* over Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya*. Scattered patches of *Eucalyptus todtiana* trees to 6m occur in the area.

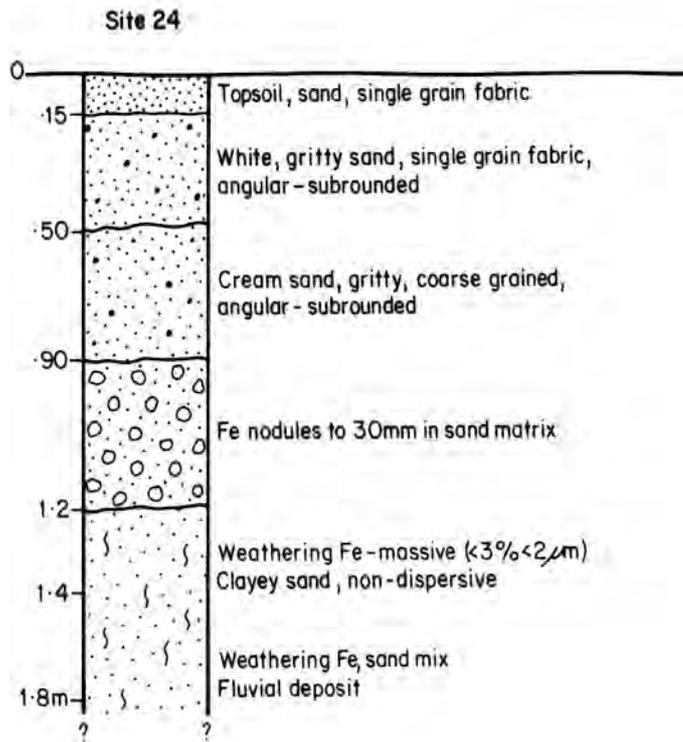
## SITE 23



323635 E  
6737302 N

Heath to 1.5m dominated by *Hakea polyanthema* P3 and *Calothamnus blepharospermus* over Dwarf Scrub to 1m dominated by *Dryandra shuttleworthiana* and *Banksia candolleana* over Open Low Sedges dominated by *Ecdeiocolea monostachya*. Scattered *Xylomelum angustifolium* trees to 4.5m occur in the area.

## SITE 24

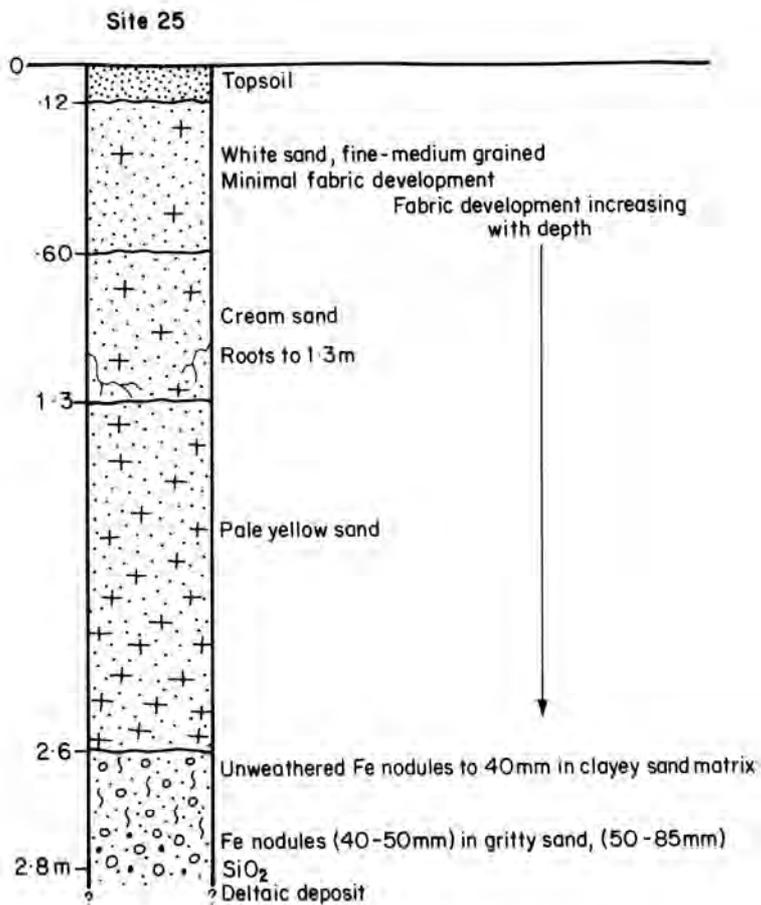


324900 E  
6737321 N

Open Low Scrub to 1.2m dominated by *Hakea polyanthema* P3 over Low Heath to 1m dominated by *Beaufortia elegans* and *Banksia lanata* over Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya*. Isolated patches of *Eucalyptus todtiana* mallee to 3.4m occur on rises in the general area.

The Priority 3 species, *Isopogon tridens* grows at this site.

## SITE 25

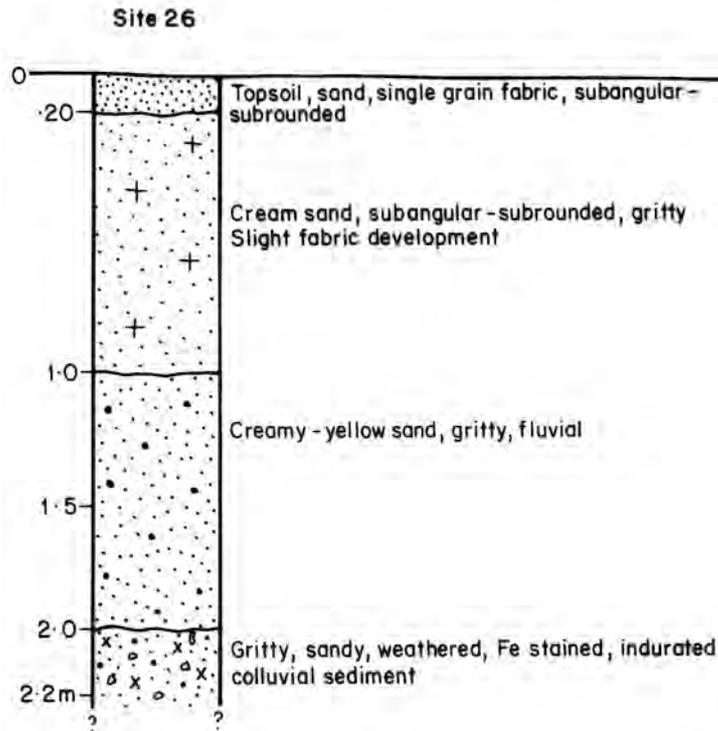


322741 E  
 6738133 N

Low Scrub to 1.6m dominated by *Hakea polyanthema* P3, *Banksia attenuata* and *Banksia candolleana* over Dwarf Scrub to 0.8m dominated by *Melaleuca leuropoma* and *Dryandra shuttleworthiana* over Low Sedges dominated by *Ecdeiocolea monostachya* and *Chordifex sinuosus*. Scattered *Eucalyptus tottiana* trees to 3.5m with *Lomandra hastilis* sedge occurs in the area.

The Priority 3 species, *Isopogon tridens* grows at this site.

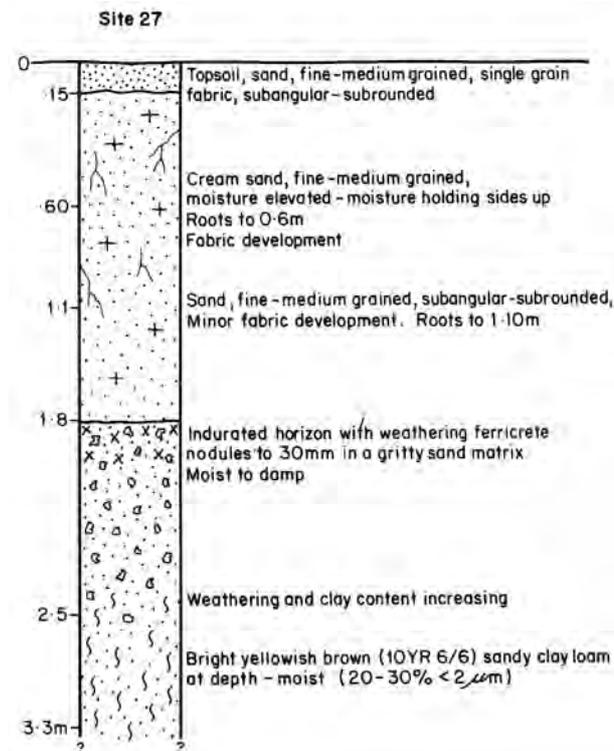
SITE 26



323448 E  
6738238 N

Open Low Woodland to 4.5m of *Eucalyptus todtiana* over Heath to 1.6m dominated by *Beaufortia elegans* and *Hakea polyanthema* P3 over Dwarf Scrub to 0.8m dominated by *Banksia candolleana*. Isolated *Xylomelum angustifolium* trees to 4m occur in the area.

## SITE 27

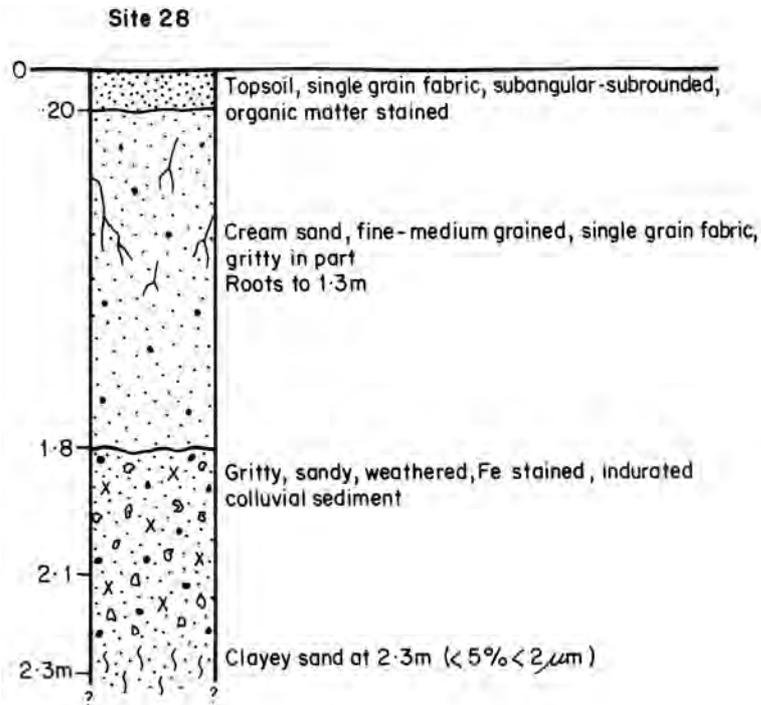


322735 E  
6738865 N

Heath to 1.7m dominated by *Beaufortia elegans* and *Hakea polyanthema* P3 over Dwarf Scrub dominated by *Hibbertia hypericoides* over Low Sedges dominated by *Chordifex sinuosus*.

The Priority 3 species, *Isopogon tridens* grows at this site.

## SITE 28



322714 E  
6739276 N

Heath to 1.6m dominated by *Hakea polyanthema* P3 and *Beaufortia elegans* over Dwarf Scrub to 1m dominated by *Melaleuca leuropoma* and *Eremaea beaufortoides* var. *microphylla* (ID pending) over *Ecdeiocolea monostachya* Tall Sedges to 0.8m. Scattered *Eucalyptus todtiana* trees to 4m occur in the area.

The Priority 3 species, *Isopogon tridens* grows at the site.

## APPENDIX I

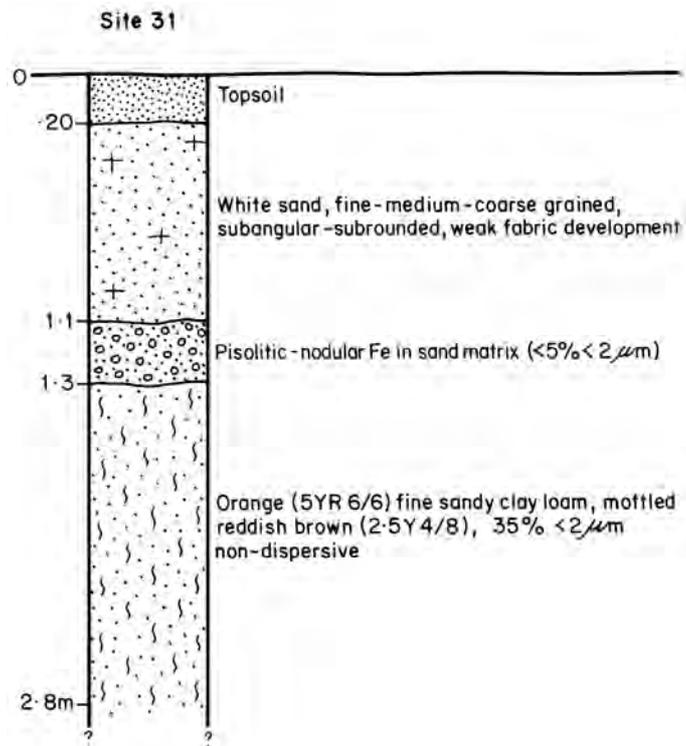
### PART B: SITES 31 - 50

#### SOIL PROFILES, VEGETATION RELATIONSHIPS,

*“At the time of the survey, vegetation throughout the area was exhibiting moderate to severe drought stress responses including, chlorosis of foliage, leaf drop and partial to whole of plant death”.*

*(A.Harris, pers comm..)*

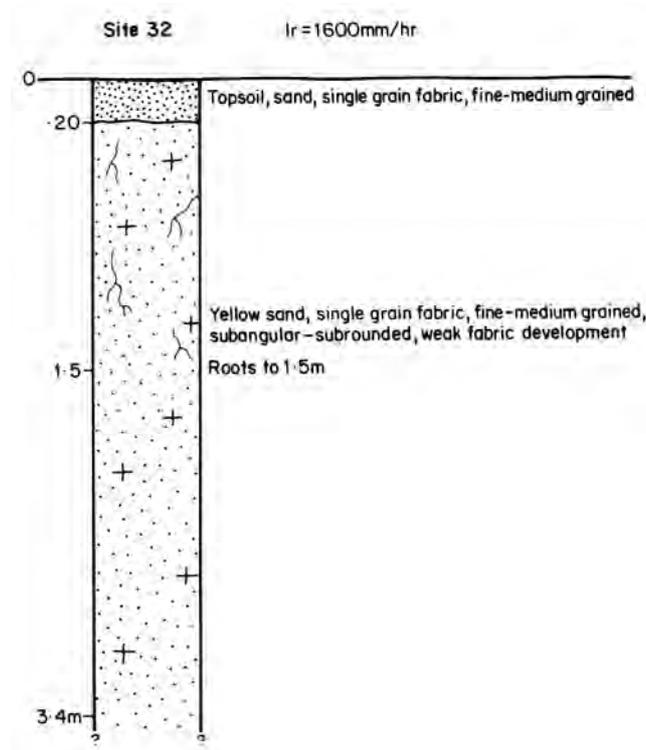
## SITE 31



322665 E  
6741030 N

Low Scrub to 1.5m dominated by *Leptospermum erubescens* and *Hakea polyanthema* P3 over Dwarf Scrub to 1m dominated by *Melaleuca leuropoma* and *Scholtzia involucrata* over *Mesomelaena pseudostygia* Very Open Low Sedges. Scattered patches of *Eucalyptus todtiana* and *Xylomelum angustifolium* trees to 6 m occur in the area.

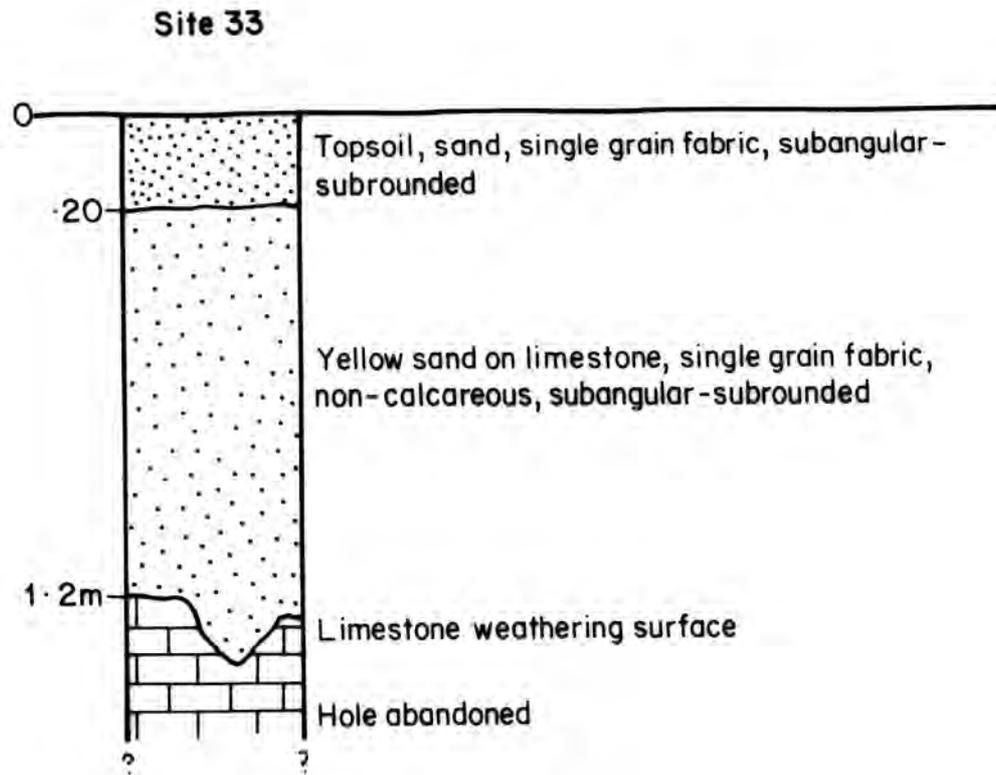
## SITE 32



319942 E  
6742140 N

Heath to 2m dominated by *Banksia attenuata*, *Calothamnus blepharospermus* and *Banksia candolleana* over Dwarf Scrub to 0.9m dominated by *Hakea polyanthema* P3 and *Daviesia benthamii* (ID pending) over Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*. Isolated *Eucalyptus todtiana* to 4.5m also occur in the area.

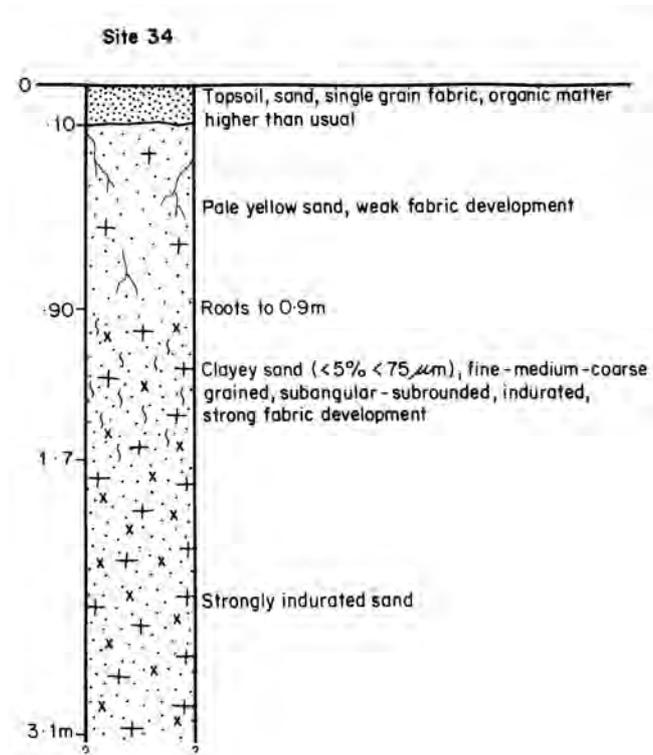
## SITE 33



319535 E  
6742213 N

Low Woodland to 8m of *Banksia prionotes* over Scrub to 2.3m of *Allocasuarina campestris* over Low Scrub to 1.6m dominated by *Calothamnus* D33-1 (ID pending) and *Calothamnus blepharospermus* over *Ecdeiocolea monostachya* Low Sedges.

## SITE 34

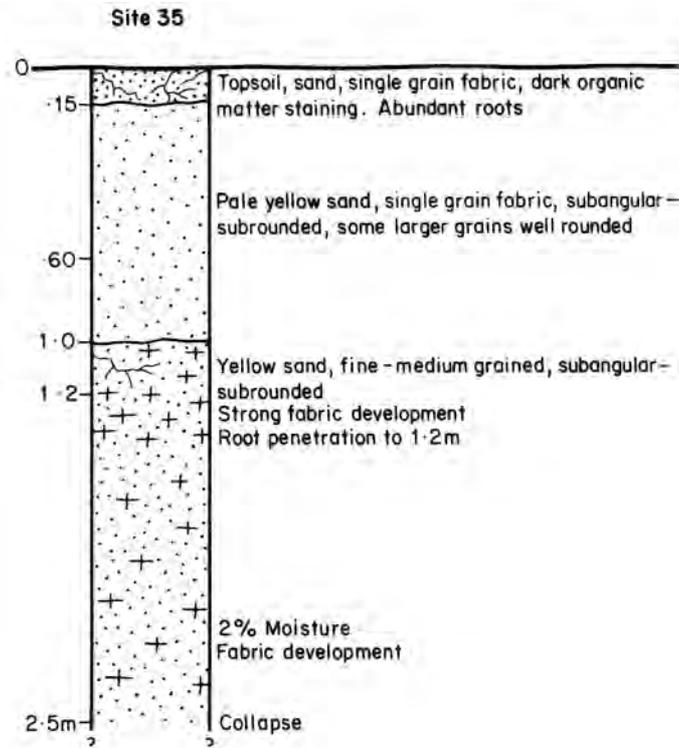


322644 E  
6742677 N

Open Low Scrub to 1.3m of *Eremaea beaufortioides* var. *microphylla* (ID pending) and *Banksia attenuata* over Low Heath to 1m dominated by *Melaleuca leuropoma* and *Calothamnus blepharospermus* and *Dryandra shuttleworthiana* over Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*. Very isolated patches of *Eucalyptus todtiana* are in the area.

The Priority 3 species, *Hakea polyanthema* and *Isopogon tridens* grow at this site.

## SITE 35



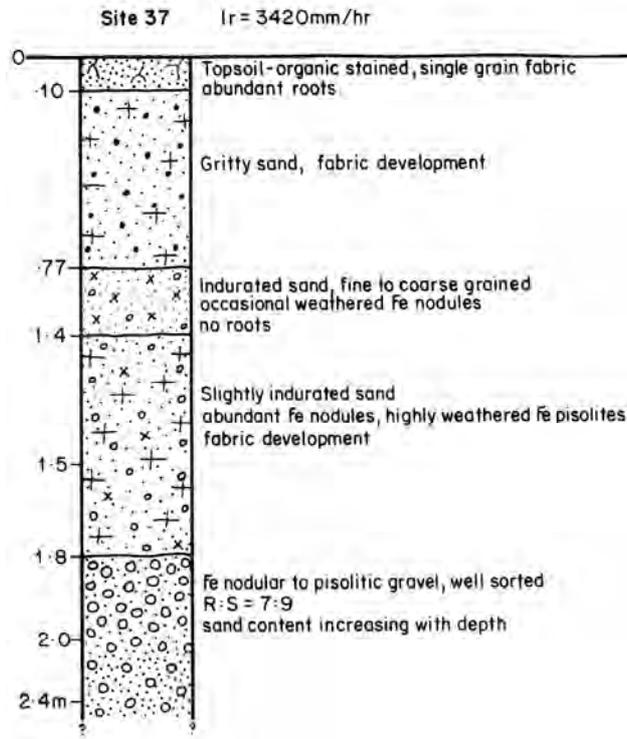
319802 E  
6742749 N

Low Scrub to 1.8m dominated by *Banksia attenuata* and *Banksia hookeriana* over Low Heath to 1m dominated by *Eremaea beaufortioides* var. *microphylla* (ID pending), *Melaleuca leuropoma* and *Calothamnus blepharospermus* over Open Tall Sedges dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*.

Scattered trees of *Xylomelum angustifolium* to 5m and *Eucalyptus todtiana* to 3.5m occur in the area.

The Priority 3 species, *Hakea polyanthema* and *Isopogon tridens* grow at this site.

## SITE 37

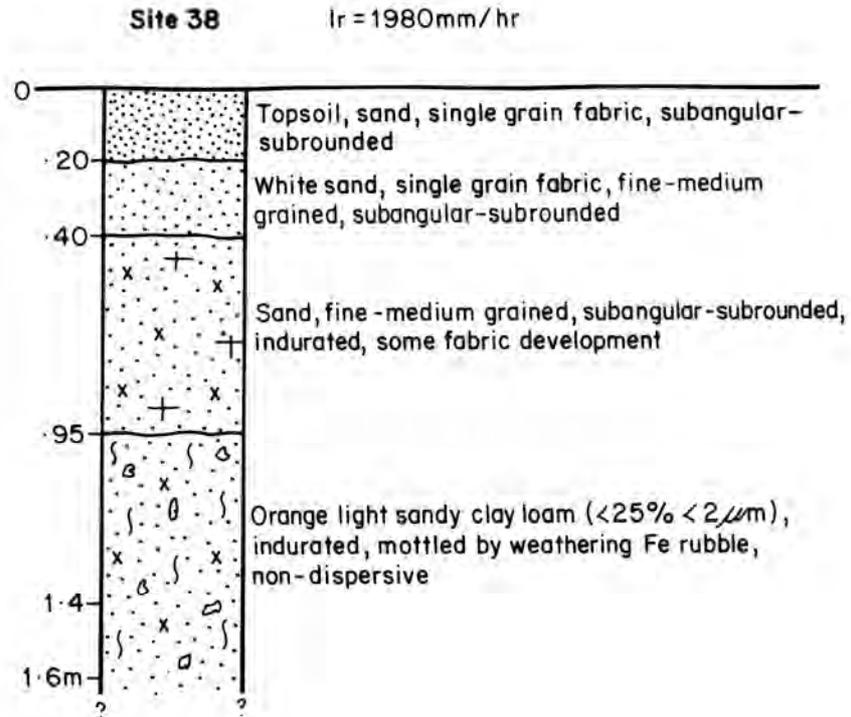


322091 E  
6744037 N

Low Heath to 0.8m dominated by *Hakea polyanthema* P3 and *Dryandra carlinoides* over Open Low Sedges to 0.3m dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*.

The Priority 3 species, *Isopogon tridens* grows at this site.

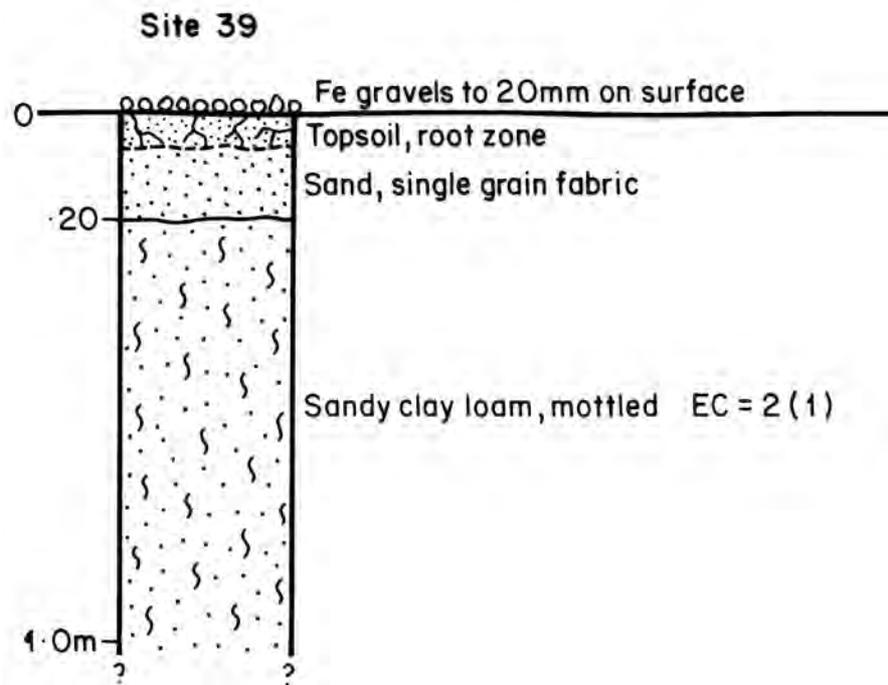
## SITE 38



322439 E  
6744752 N

Dense Low Heath to 0.6m dominated by *Hakea polyanthema* P3, *Melaleuca leuropoma* and *Dryandra shuttleworthiana* over *Ecdeiocolea monostachya* Open Low Sedges to 0.5m.

## SITE 39

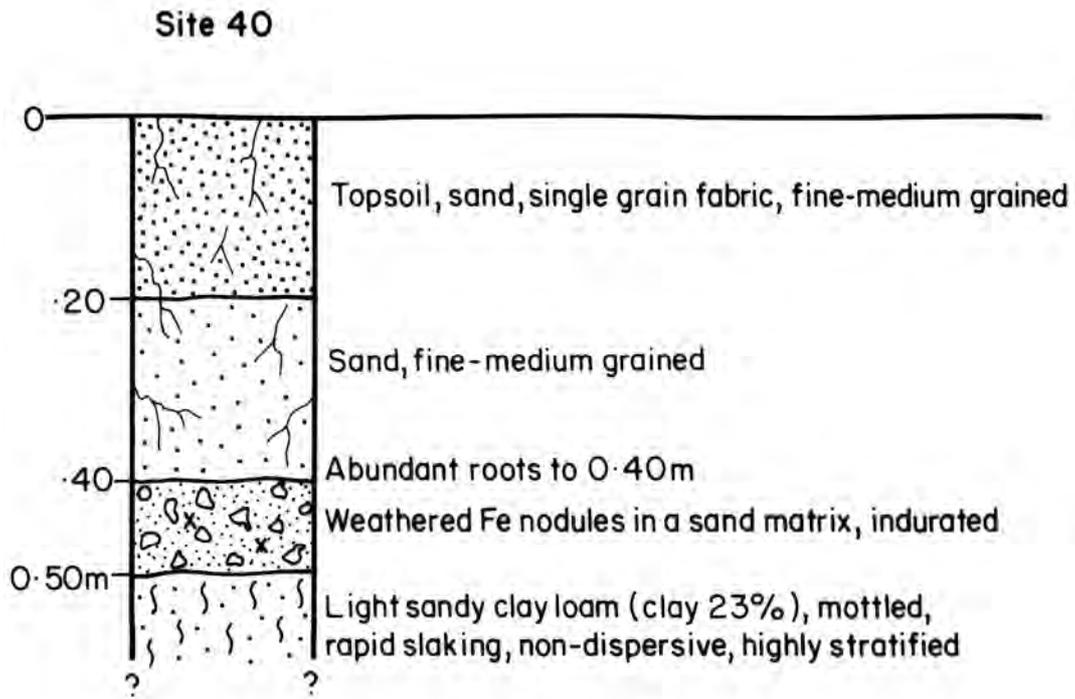


322234 E  
6745343 N

Low Heath to 0.5m dominated by *Melaleuca aspalathoides* and *Dryandra carlinoides* over *Ecdeiocolea monostachya* Very Open Low Sedges to 0.5m.

This site has been burnt within the last 1-2 years. Plants are regenerating well, however the foliar cover is lower than that expected. A number of species present at the site, although not dominant, indicate that (i) seasonal ponding of the surface soils occur and/or (ii) surface soil moisture is held for long periods.

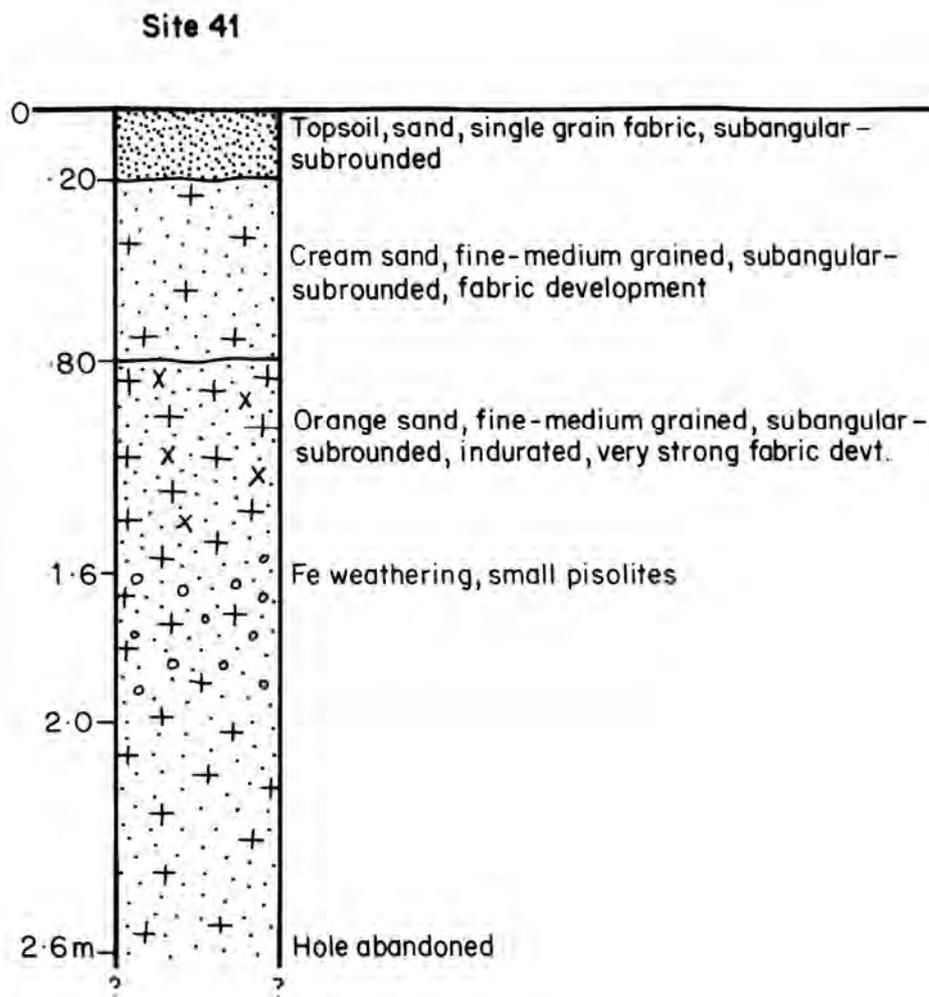
## SITE 40



322625 E  
6745857 N

The site has been recently burnt (<6 months ago) therefore, no vegetation structure can be described. Species observed to be regenerating include, *Dryandra carlinoides*, *Hakea corymbosa*, *Melaleuca aspalathoides*, *Hakea auriculata*, *Hakea varia*, *Calothamnus hirsutus* and the sedges *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*. Vegetation structure is most likely to be a Heath over Open Low Sedges. Isolated *Allocasuarina campestris* trees to 2.5m occur in the area.

## SITE 41

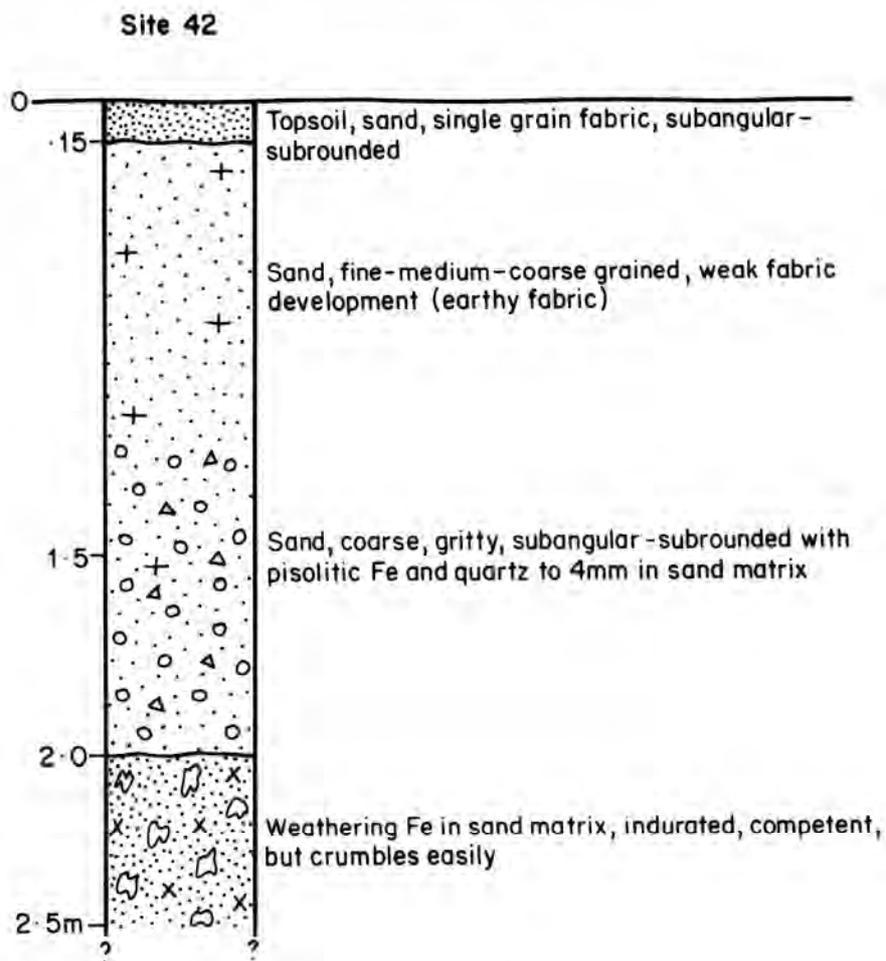


321470 E  
6745435 N

Low Heath to 0.6m dominated by *Conospermum boreale* and *Melaleuca leuropoma* over *Ecdeiocolea monostachya*. Very Open Low Sedges to 0.5m. Scattered *Banksia attenuata* shrubs to 1.6m and isolated *Eucalyptus tottiana* trees to 4m are in the area.

This site has been burnt within the last 1-2 years and although the plants are regenerating, the foliar cover is lower than expected. The Priority species, *Hakea polyanthema* P3 grows at this site.

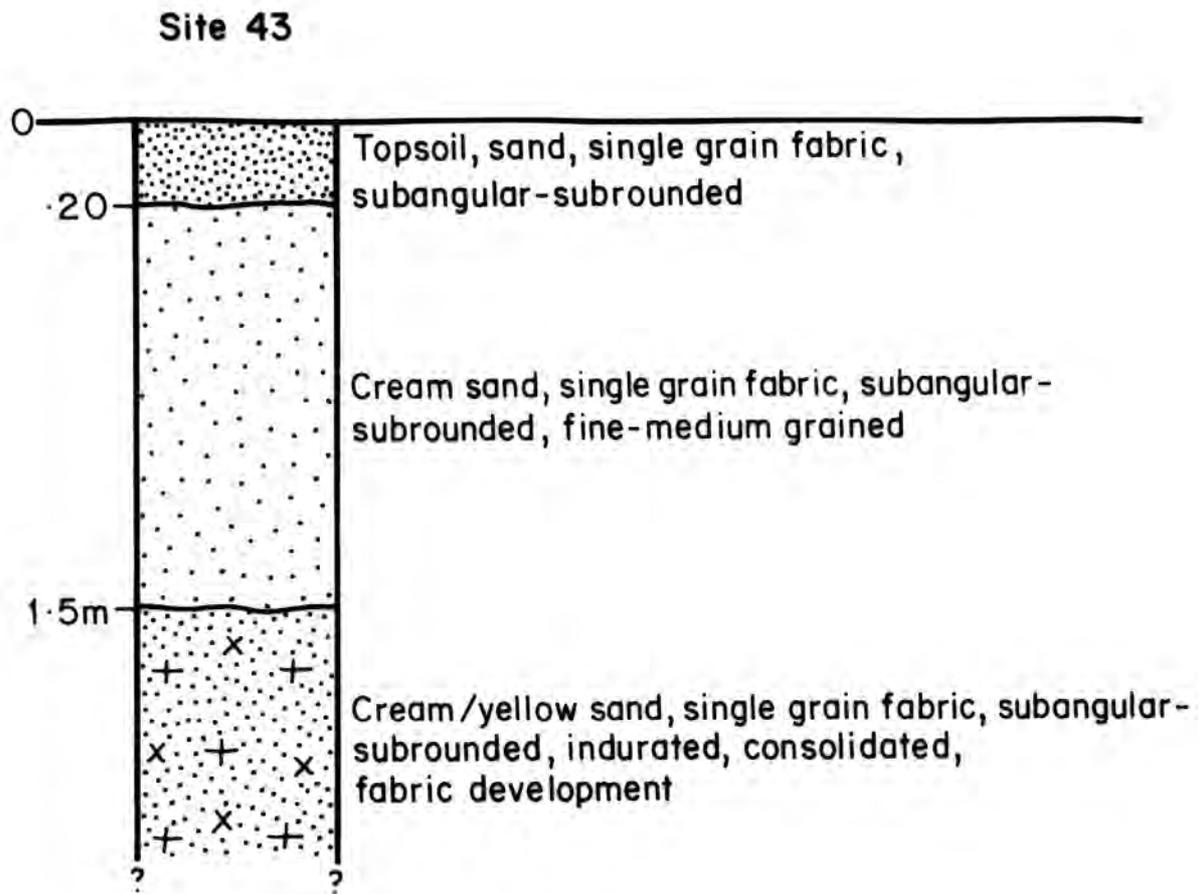
## SITE 42



320874 E  
6745243 N

Thicket to 3m dominated by *Allocasuarina campestris* and *Acacia scirpifolia* over Low Scrub to 1.6m dominated by *Hakea polyanthema* P3 over *Ecdeiocolea monostachya*. Very Open Low Sedges to 0.5m. Scattered *Eucalyptus todtiana* trees to 7m are in the area.

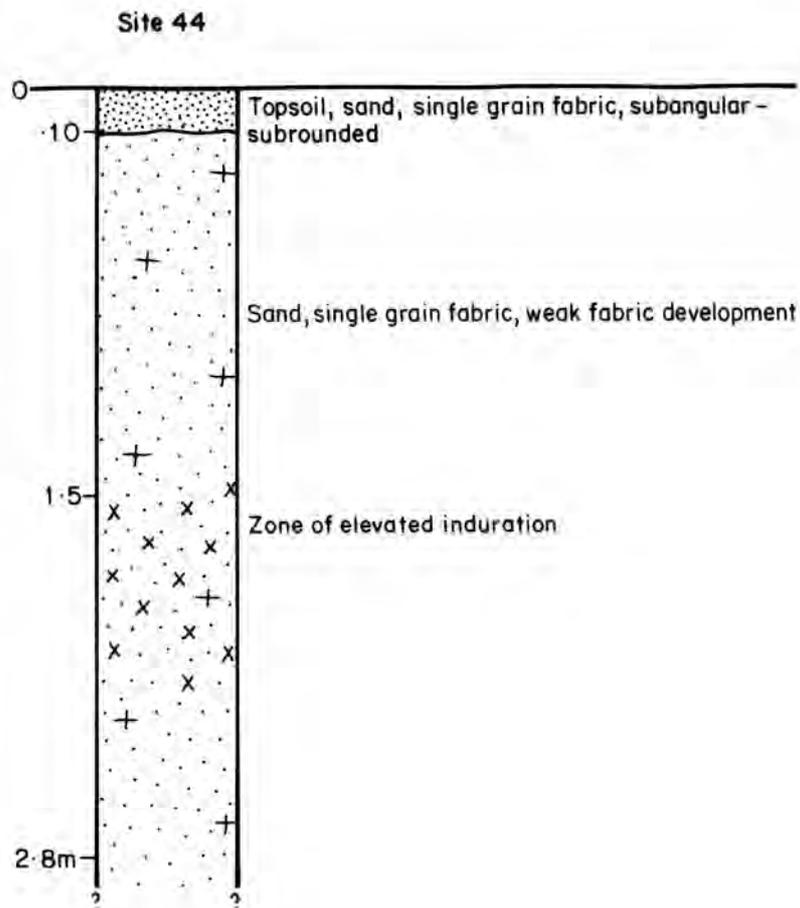
SITE 43



319021 E  
6745427 N

Low Heath to 1m dominated by *Hakea polyanthema* P3, *Banksia candolleana* and *Eremaea beaufortioides* var. *microphylla* (ID pending), over Very Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya*.

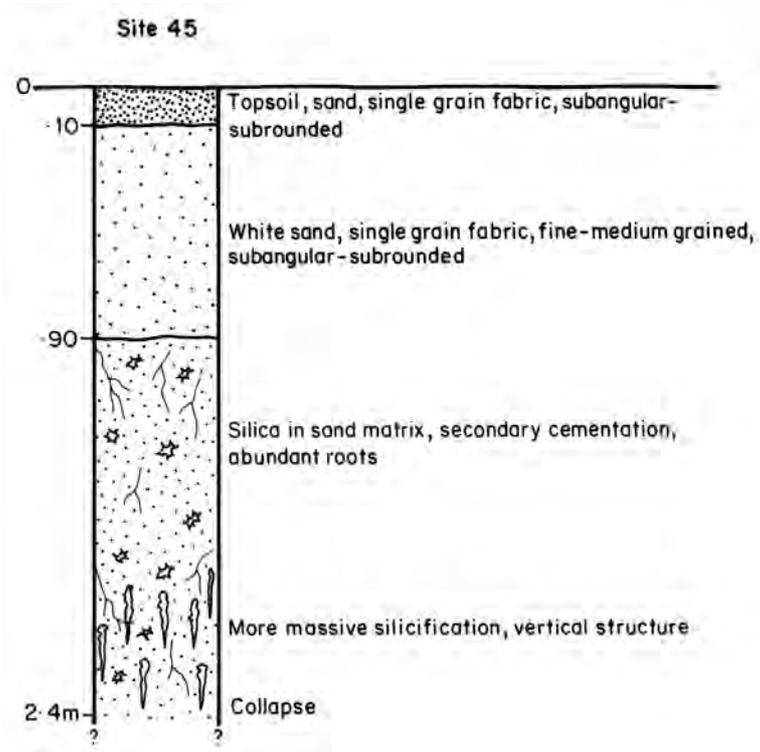
## SITE 44



317942 E  
6745426 N

Heath to 1.6m dominated by *Banksia attenuata* and *Hakea polyanthema* P3 over Low Heath to 1m dominated by *Calothamnus blepharospermus* and *Conospermum boreale* over Open Low Sedges to 0.5m. Isolated *Eucalyptus tottiana* trees to 4m are in the area.

## SITE 45

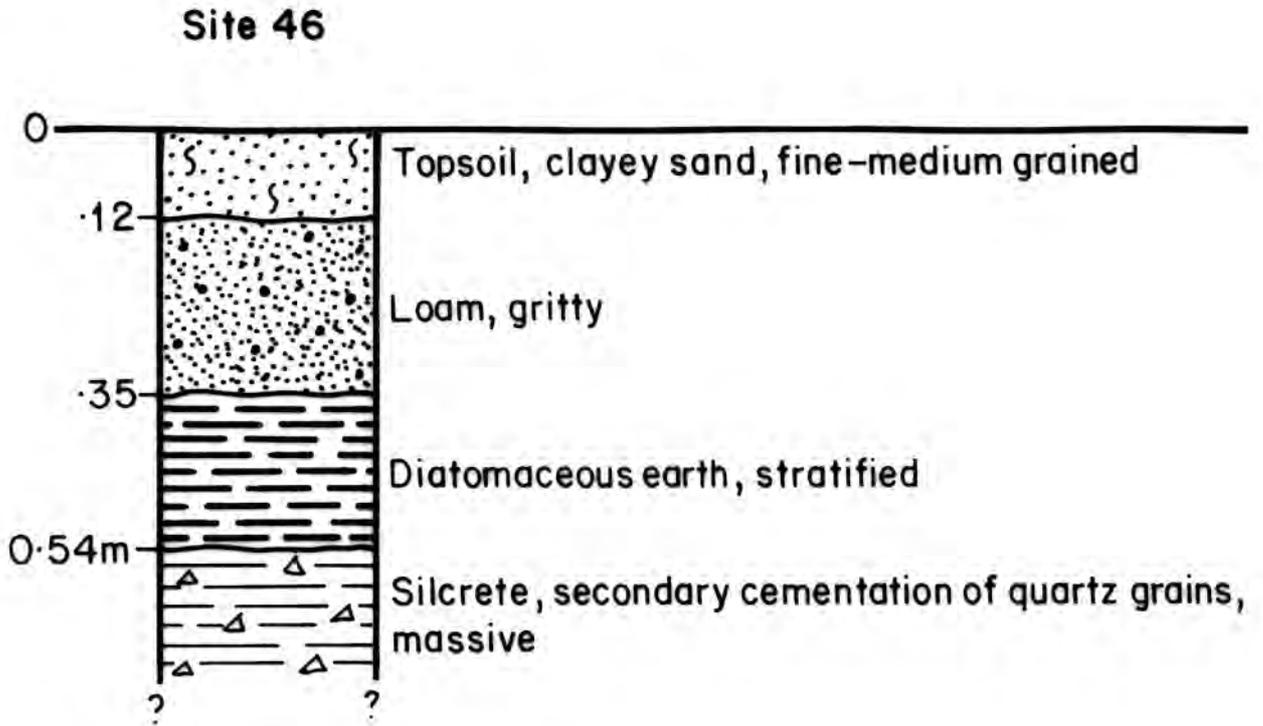


317643 E  
6745428 N

*Acacia scirpifolia* Scrub to 4.5m over Heath to 1.8m dominated by *Verticordia densiflora*, *Calothamnus hirsutus* and *Banksia leptophylla* D63-1 (ID pending). Scattered *Banksia menziesii* trees to 5m and isolated *Eucalyptus todtiana* trees occur in the area.

The Priority 4 species, *Banksia elegans* grows at this site.

SITE 46

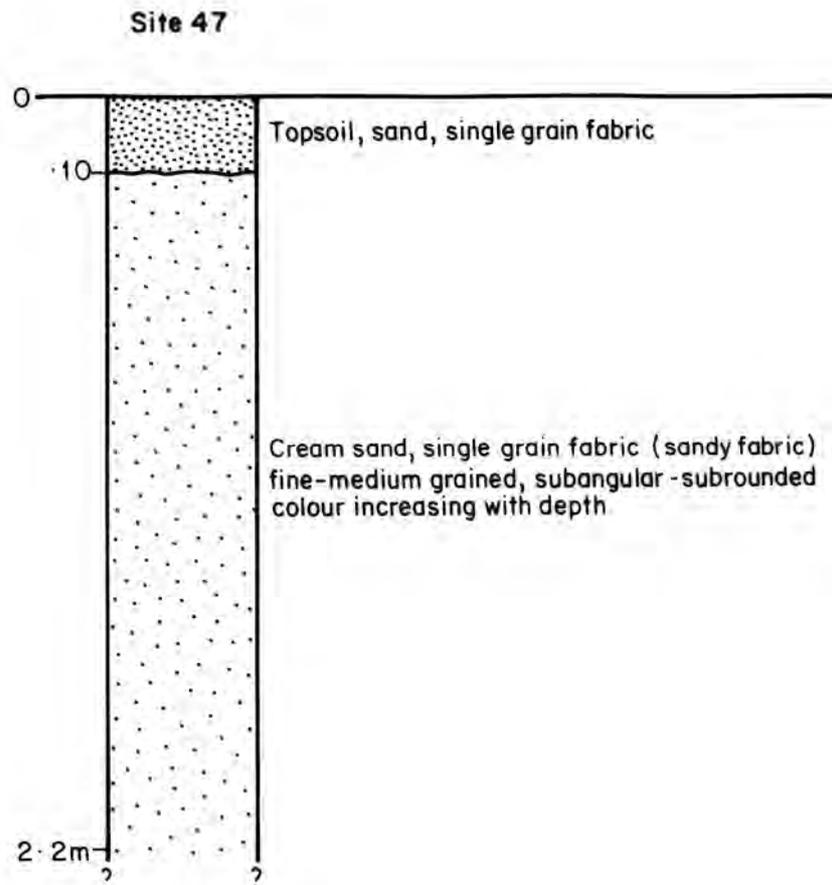


316988 E  
 6745353 N

Open Low Scrub to 1.6m dominated by *Acacia scirpifolia* over Low Heath to 0.9m dominated by *Calothamnus hirsutus* and *Verticordia densiflora*.

Ten metres to the south is the boundary of this community, with a Thicket community, where aeolian sand has formed a low dune. The Low Heath plant association of *Calothamnus hirsutus* and *Verticordia densiflora* indicates that this site seasonally holds high surface soil moisture, however no evidence of water flow nor ponding was observed.

## SITE 47

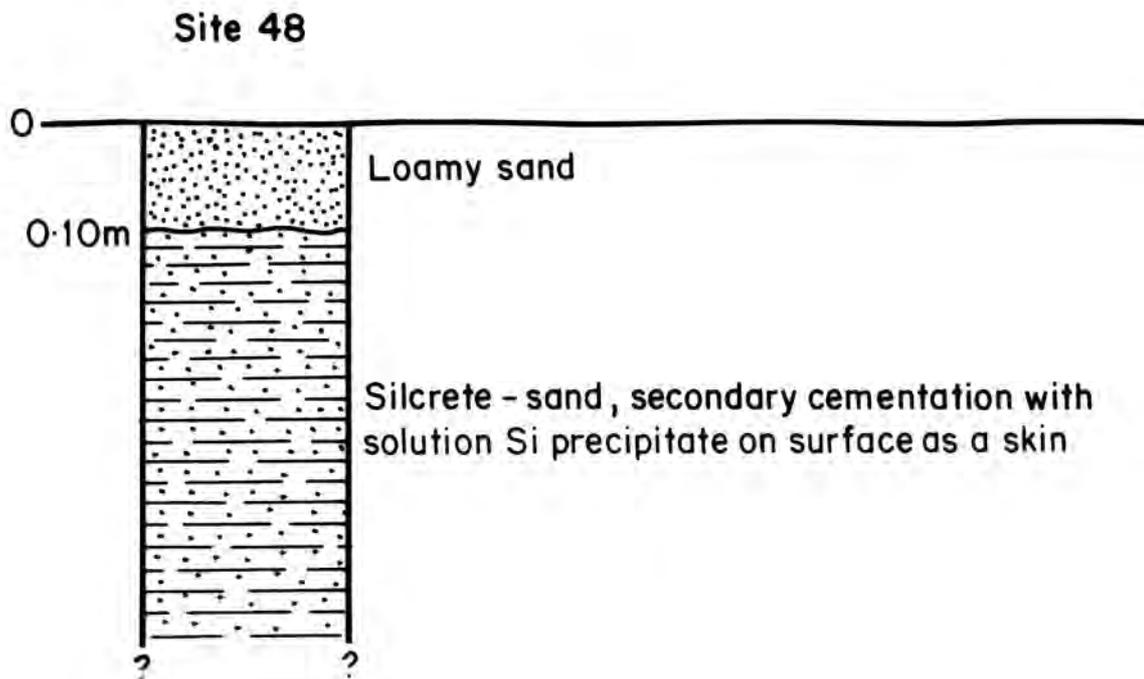


316601 E  
6745443 N

Open Low Scrub to 1.2m of *Banksia elegans* P4 over Low Heath to 1m dominated by *Banksia attenuata*, *Conospermum boreale* and *Calytrix/Beyeria* D3-1 (ID pending). Scattered *Banksia menziesii* trees to 3.5m occur in the area.

Area was burnt ~2 years ago. Regenerating vegetation is still successional.

## SITE 48

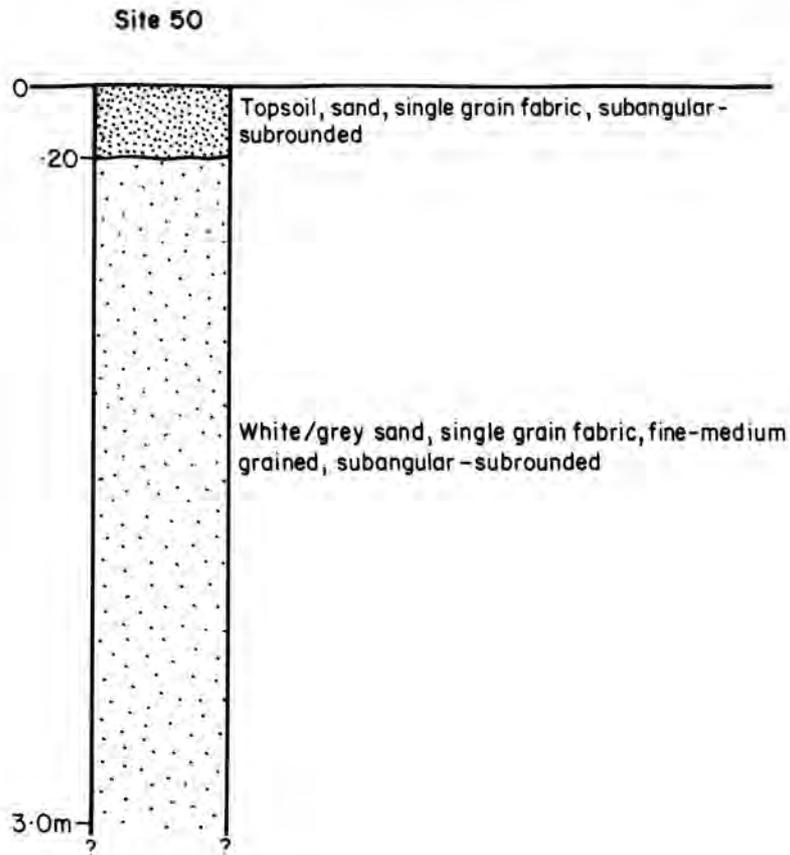


315919 E  
6745446 N

Low Scrub to 1.1m of *Banksia attenuata* over Low Heath to 1m dominated by *Eremaea beaufortioides* var. *microphylla* (ID pending), *Melaleuca leuropoma* and *Calothamnus quadrifidus*. Scattered *Banksia menziesii* trees to 4.5m and isolated *Eucalyptus todtiana* to 3.5m occur in the area.

This site was burnt ~2 years ago. Regenerating vegetation is still successional.

## SITE 50



316975 E  
6746676 N

Open Low Woodland to 3.5m of *Banksia menziesii* over Low Scrub to 1.6m dominated by *Melaleuca leuropoma* and *Scholtzia involucrata* over *Chordifex sinuosus* Open Low Sedges to 0.25m. Isolated *Eucalyptus todtiana* mallee to 4m with associated *Acacia scirpifolia* shrubs to 3m occur in the area.

## APPENDIX I

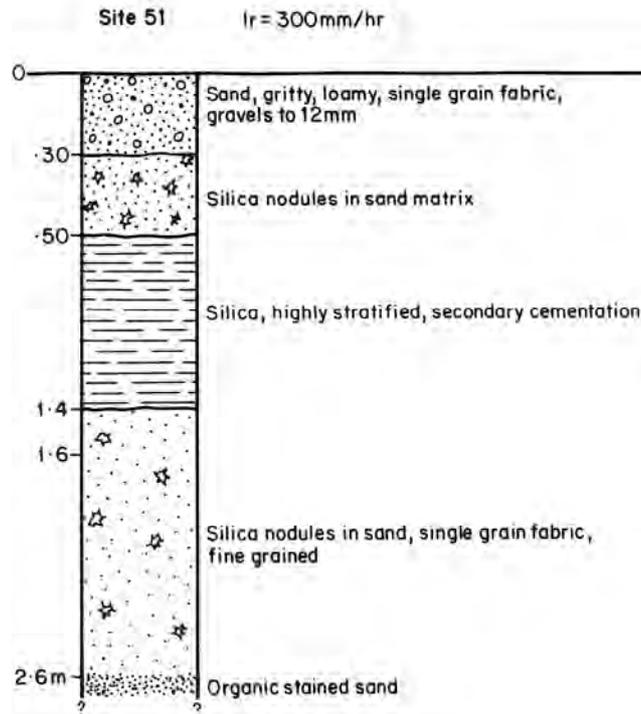
### PART C: SITES 51 - 88

#### SOIL PROFILES, VEGETATION RELATIONSHIPS,

*“At the time of the survey, vegetation throughout the area was exhibiting moderate to severe drought stress responses including, chlorosis of foliage, leaf drop and partial to whole of plant death”.*

*(A.Harris, pers comm..)*

## SITE 51

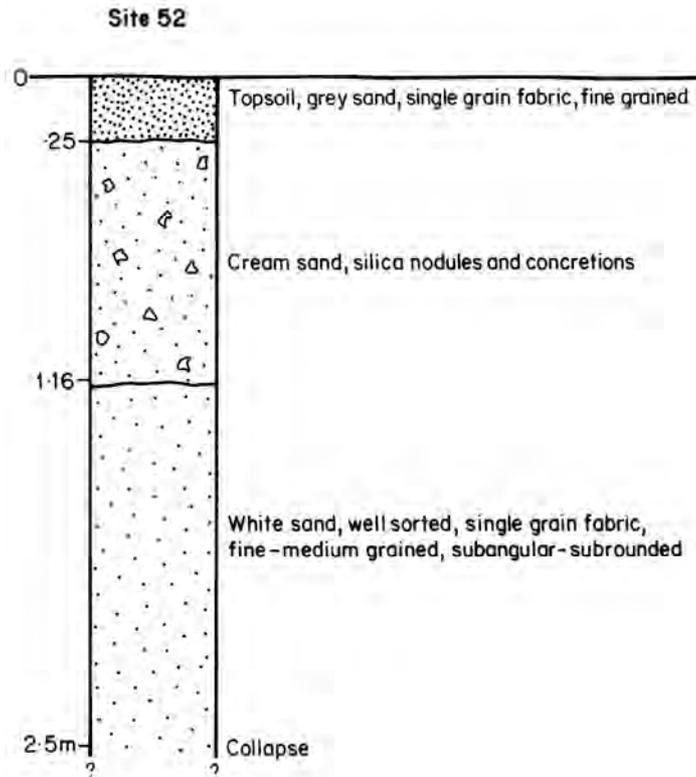


317232 E  
6746593 N

Dense Heath to 1.6m dominated by *Banksia leptophylla* and *Allocasuarina campestris* over Open Dwarf Scrub dominated by *Calothamnus hirsutus* and *Verticordia densiflora*.

This site was burnt ~6 years ago and taller shrubs of *Allocasuarina campestris* and *Acacia saligna* to 2.5m were killed. Vegetation at the site comprises dense regeneration, post-fire, that is still successional. Species recorded indicate that the site experiences seasonally high soil moisture close to the surface.

## SITE 52

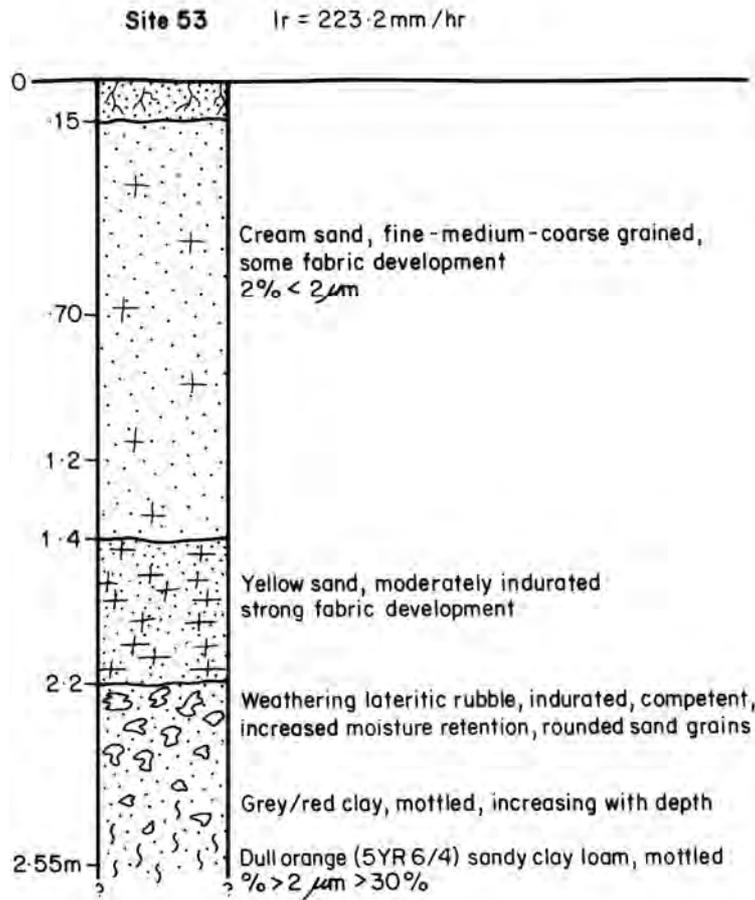


317536 E  
6746657 N

Low Scrub to 1.6m dominated by *Banksia leptophylla* D63-1 (ID pending) over Heath to 0.8m dominated by *Verticordia densiflora*, *Calothamnus hirsutus* and *Beaufortia elegans*. Isolated *Eucalyptus todtiana* and *Banksia menziesii* trees to 4m occur in the area.

*Xanthorrhoea drummondii* plants were a significant proportion of the vegetation at this site, however they are now all dead. Repeated fires, drought stress or disease are likely causes. There is no evidence of water flow or ponding on the surface, however some non-dominant species indicate seasonally high soil moisture may occur.

## SITE 53

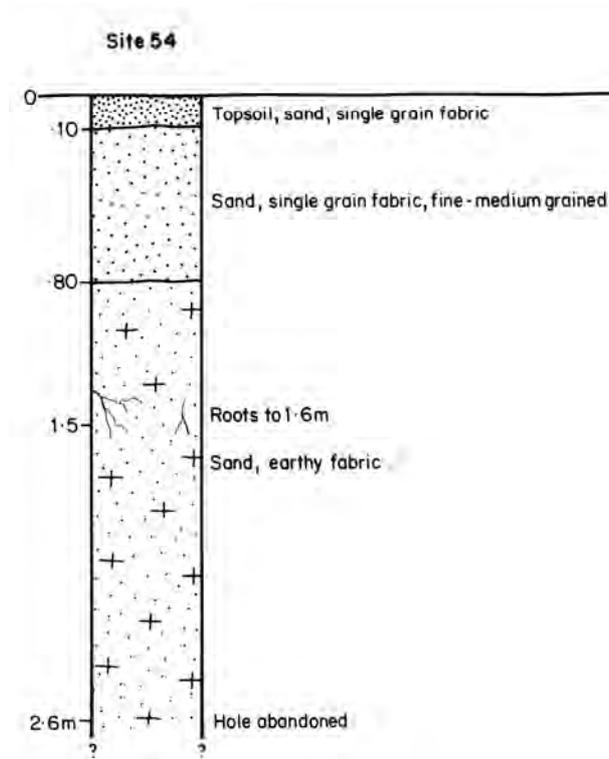


318051 E  
6746655 N

Open Scrub to 4m of *Acacia scirpifolia* over Heath to 1.6m dominated by *Banksia leptophylla* D53-1 (ID pending) and *Banksia attenuata* over Dwarf Scrub dominated by *Eremaea beaufortioides* var. *beaufortioides* and *Melaleuca leuropoma*. Isolated *Eucalyptus todtiana* to 4.5m and *Nuytsia floribunda* trees to 3m occur in the area.

The Priority 3 species, *Hakea polyanthema* grows at this site.

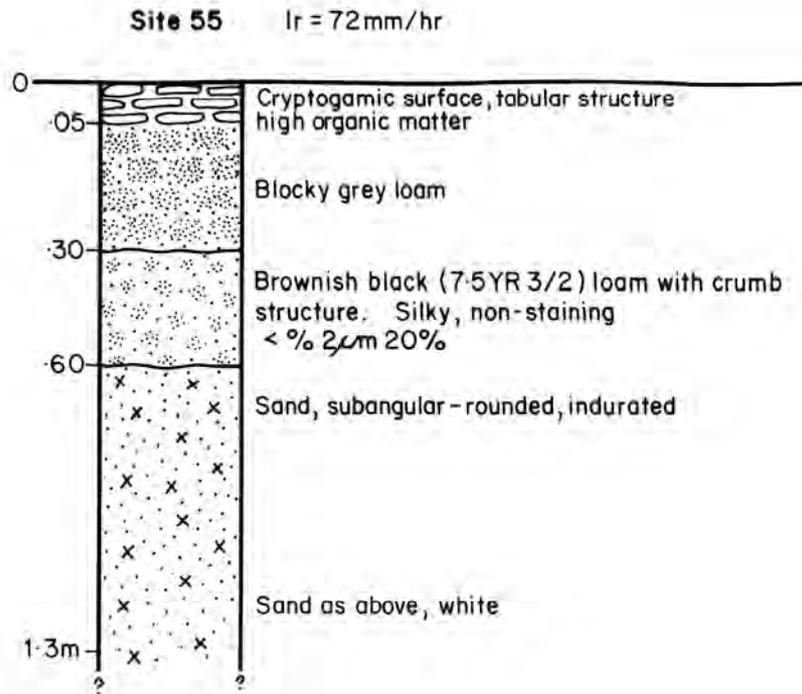
## SITE 54



318424 E  
6746680 N

Heath to 1.5m dominated by *Banksia hookeriana* and *Banksia attenuata* over Dwarf Scrub to 0.8m dominated by *Calothamnus blepharospermus* over *Ecdeiocolea monostachya* Very Open Low Sedges to 0.5m. Scattered patches of *Eucalyptus todtiana* and *Xylomelum angustifolium* trees to 3.5m occur in the area.

## SITE 55



**Note:** 0.05m to 0.6m is titanite stained crumb-structured (ped-sized), opaline pedogenic silica.

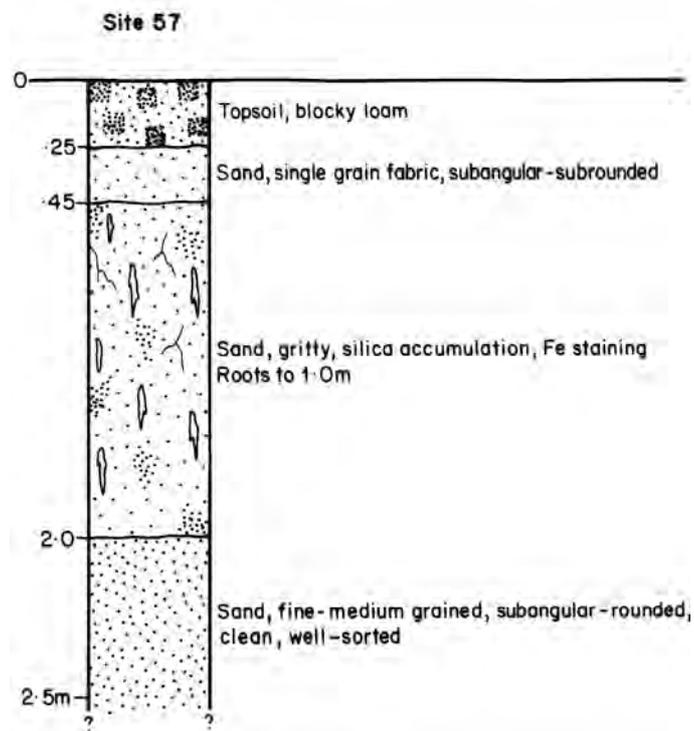


317022 E  
6746946 N

Thicket to 2.8m dominated by *Melaleuca huegelii* and *Acacia blakelyi* D55-1 (ID pending) over Open Low Scrub to 1.6m of *Banksia leptophylla*. There is 70% Cryptogam cover on the soil surface at the site.

Severe drought stress is evident at the site, with 70 to 95% deaths of the vegetation occurring.

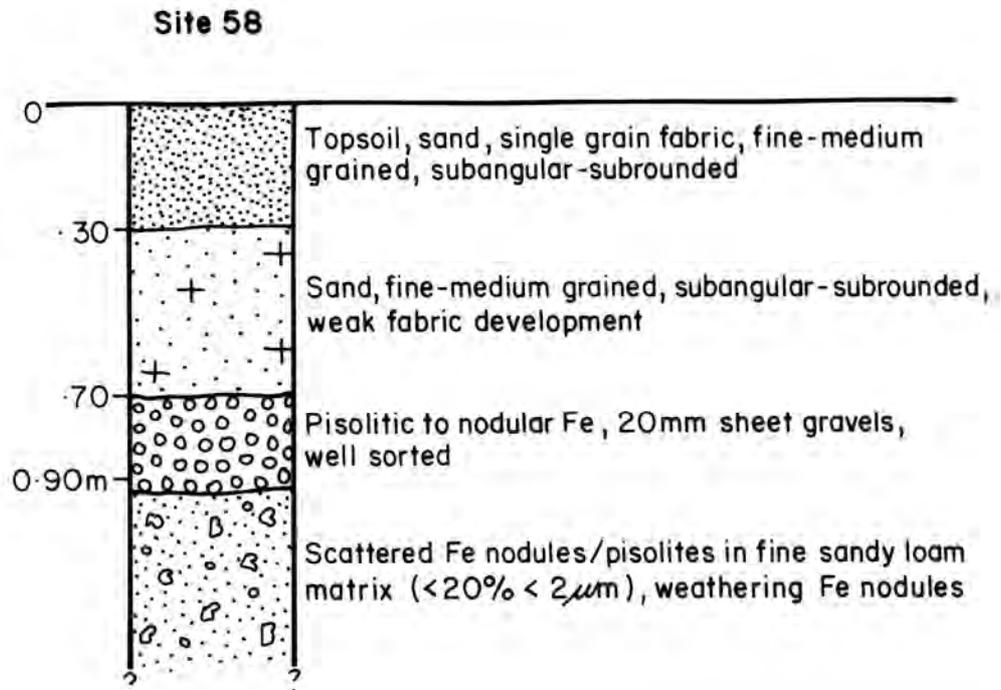
## SITE 57



317058 E  
6748004 N

Dense Thicket to 3m dominated by *Actinostrobos pyramidalis* and *Banksia leptophylla* over Open Low Scrub to 1.6m dominated by *Melaleuca systema* and *Calothamnus quadrifidus*. *Melaleuca huegelii* is a minor component of the vegetation at this site.

## SITE 58

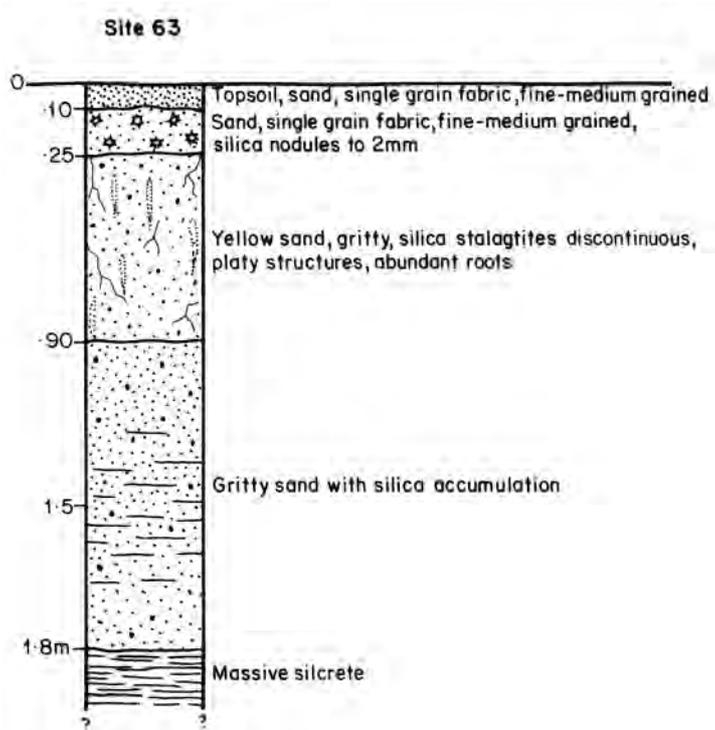


322651 E  
6748450 N

Successional vegetation is at the site of excavation, due to a recent burn, ~1 year ago, with different dominant species recorded to the non-burnt vegetation on the south side of the firebreak. Plants recorded in the burnt area on the north side include, *Hakea varia*, *Hakea candolleana*, *Eremaea beaufortoides* var. *microphylla* (ID pending), *Hakea auriculata*, *Calothamnus sanguineus*, *Baeckea camphorosmae*, and the sedges *Ecdeiocolea monostachya* and *Lyginia imberbis*.

Non-burnt vegetation is a Low Heath to 0.9m dominated by *Eremaea beaufortoides* var. *microphylla* (ID pending), *Dryandra shuttleworthiana* and *Scholtzia involucrata* over Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya*.

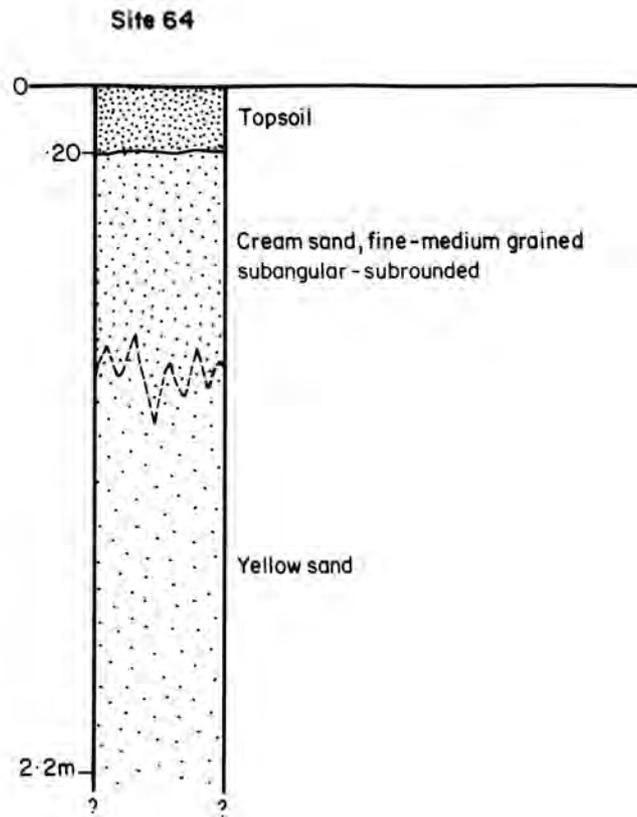
## SITE 63



317532 E  
6749867 N

Open Scrub to 2.5m dominated by *Actinostrobos pyramidalis* and *Allocasuarina campestris* over Heath to 1.6m dominated by *Banksia leptophylla* D63-1 (ID pending) and *Xanthorrhoea drummondii* over Open Dwarf Scrub to 1 m dominated by *Hakea polyanthema* P3 and *Jacksonia hakeoides*. Scattered patches of *Eucalyptus todtiana* to 5m and isolated *Nuytsia floribunda* occur at the site. This site is an area of transitional vegetation, between a low-lying Sand Heath of *Banksia leptophylla* on fine-grained sand and a Heath of *Banksia attenuata* and *Banksia hookeriana* on deep yellow sand.

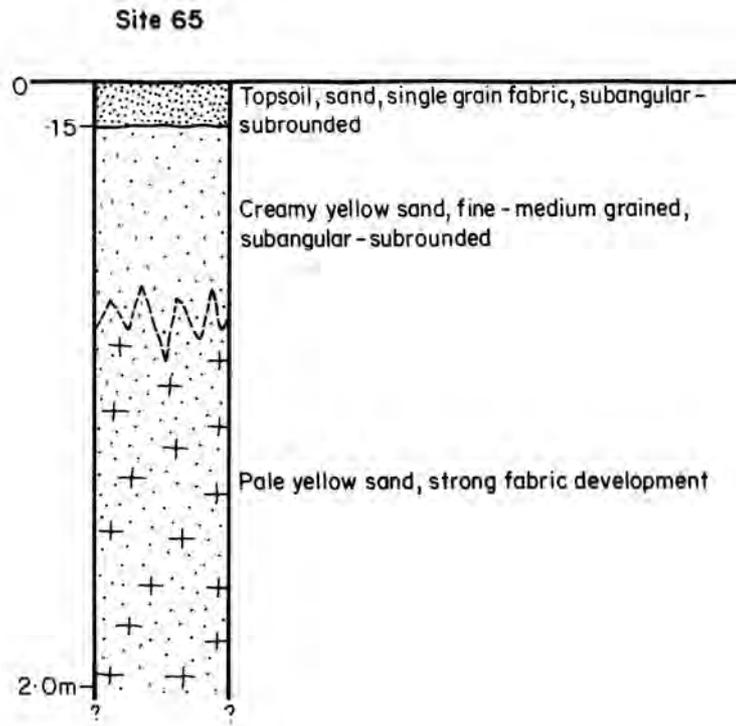
## SITE 64



318601 E  
6749879 N

Scrub to 3m dominated by *Acacia scirpifolia* and *Grevillea eriostachya* over Heath to 1.5m dominated by *Banksia attenuata* and *Eremaea beaufortioides* var. *beaufortioides* over Dwarf Scrub to 0.9m dominated by *Hakea polyanthema* P3 over Very Open Low Sedges to 0.3m dominated by *Mesomelaena pseudostygia*.

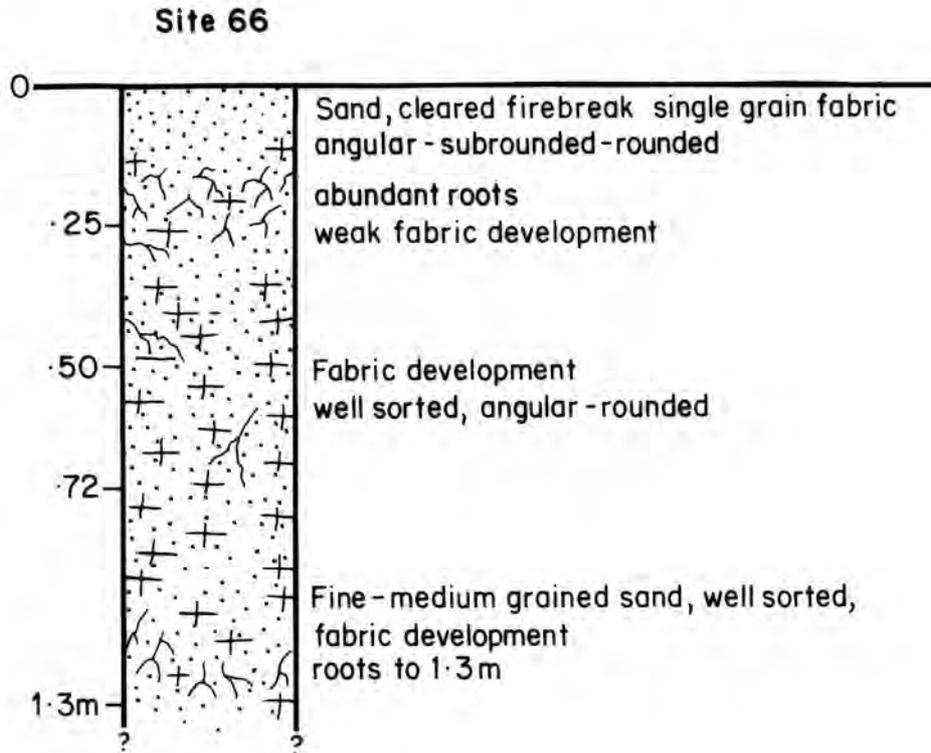
## SITE 65



319061 E  
6749895 N

Heath to 1.8m dominated by *Banksia attenuata* and *Hakea polyanthema* P3 over Dwarf Scrub to 1m dominated by *Calothamnus blepharospermus* and *Melaleuca leuropoma* over Very Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya*.

## SITE 66

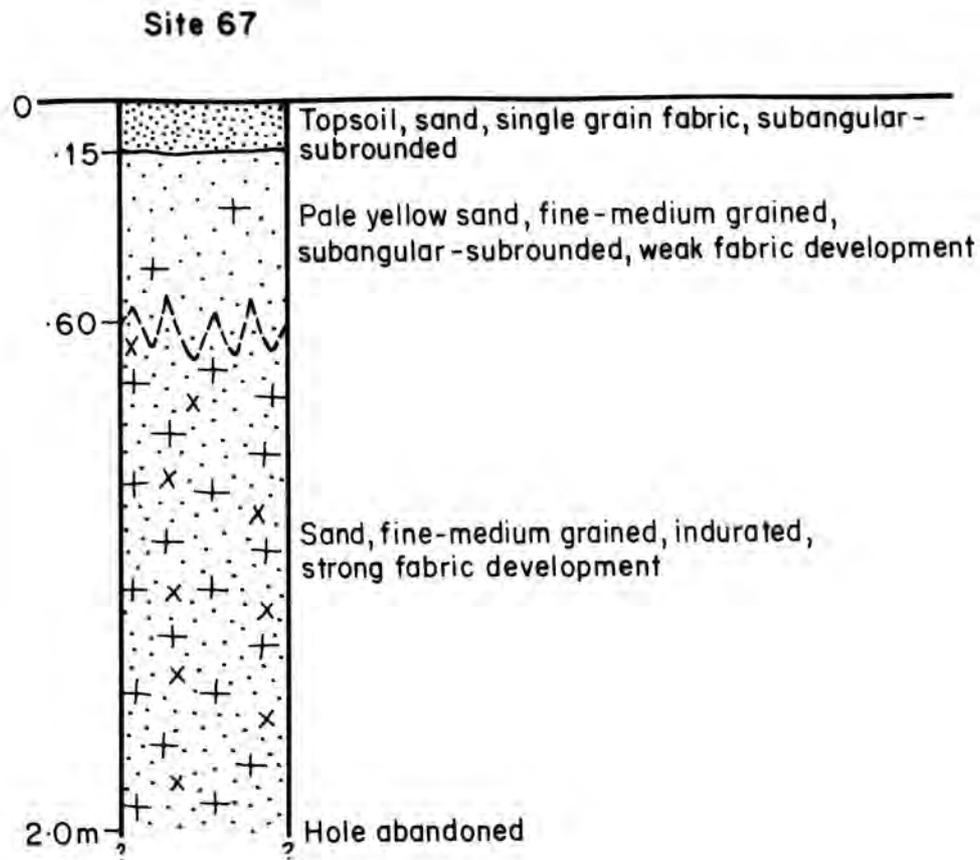


319538 E  
6749884 N

Low Scrub to 1.6m dominated by *Eremaea beaufortioides* var. *microphylla* D66-7 (ID pending) and *Banksia attenuata* over Dwarf Scrub to 0.9m dominated by *Hakea polyanthema* P3 and *Calothamnus blepharospermus* over Open Low Sedges to 0.35m dominated by *Ecdeiocolea monostachya*. Isolated *Banksia prionotes* trees to 4.5m occur in the area.

The Declared Rare Flora, *Stawellia dimorphantha*, grows at this site on the track edge.

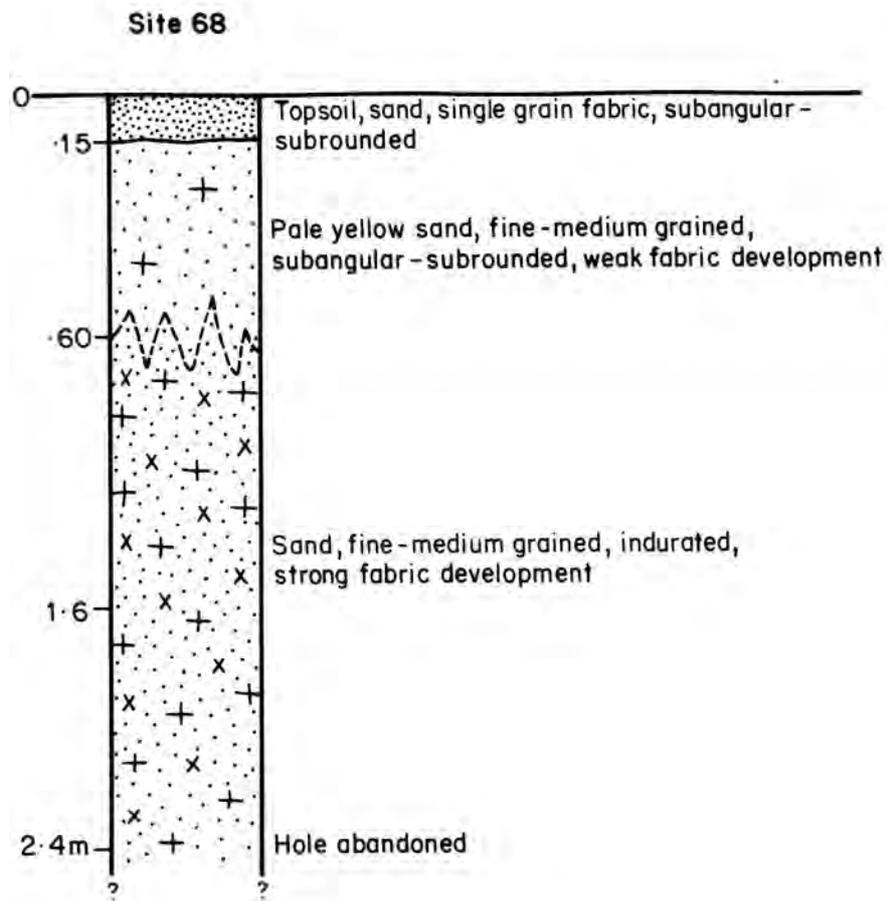
## SITE 67



320232 E  
6749906 N

Low Scrub to 1.3m dominated by *Calothamnus blepharospermus* and *Hakea polyanthema* P3 over Dwarf Scrub to 0.6m dominated by *Melaleuca leuropoma* and *Calytrix/Beyeria* D3-1 (ID pending) over *Ecdeiocolea monostachya* Low Sedges to 0.5m.

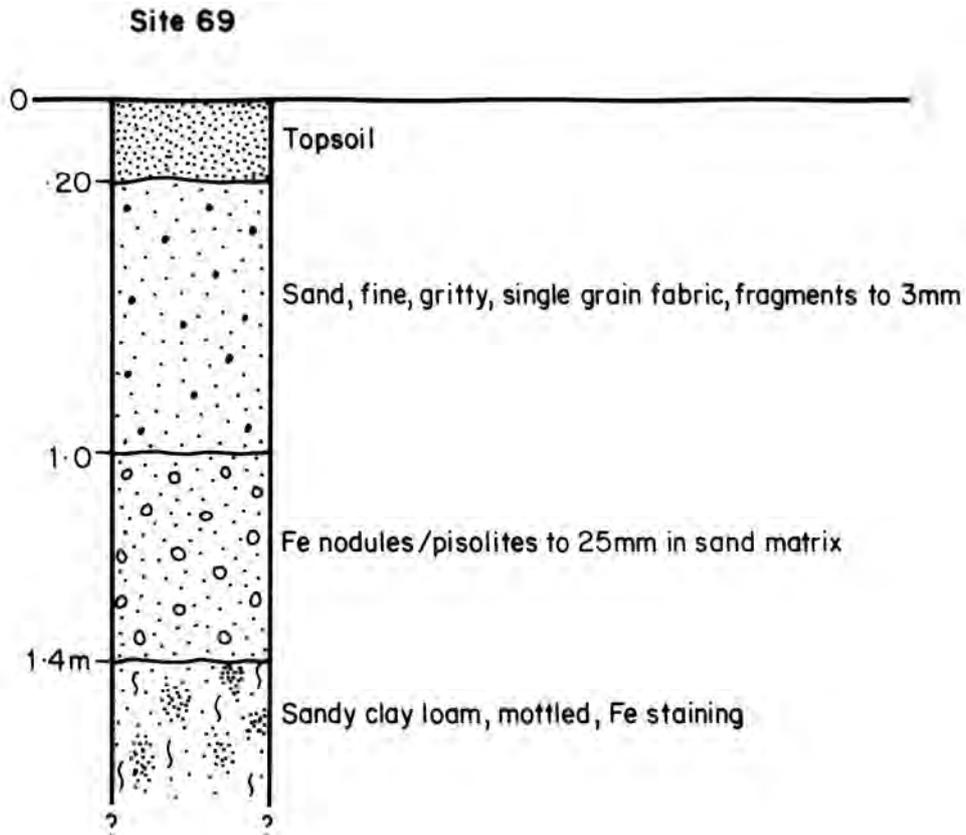
## SITE 68



320836 E  
6749907 N

Open Low Scrub to 2m of *Calothamnus blepharospermus* and *Banksia attenuata* over Low Heath to 0.8m dominated by *Hakea polyanthema* P3 and *Melaleuca leuropoma* over *Ecdeiocolea monostachya* Open Low Sedges to 0.5m.

## SITE 69

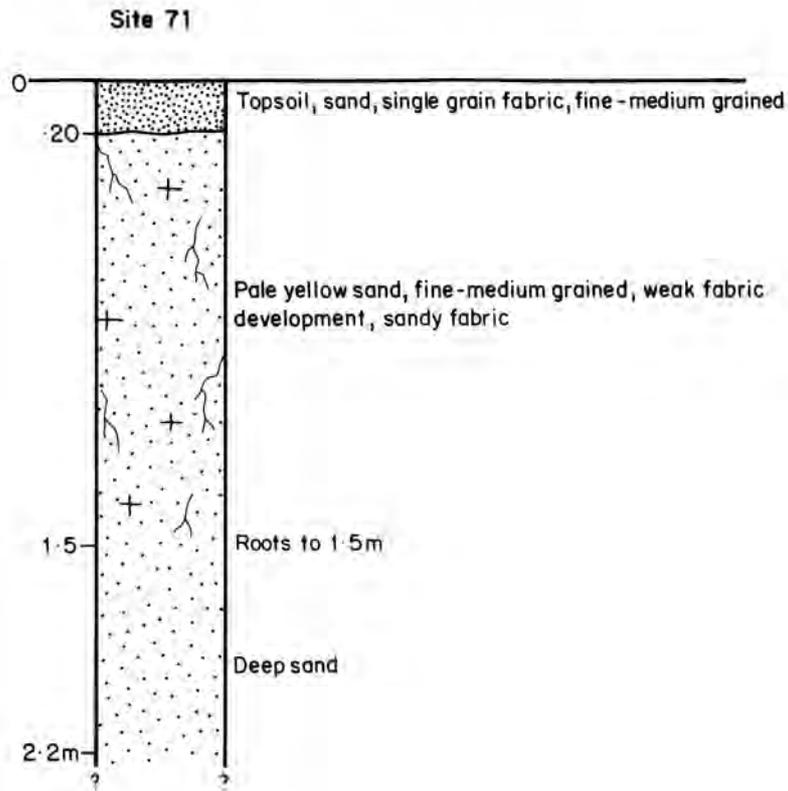


322561 E  
6749586 N

This site has been recently burnt, ~1 year ago, therefore the vegetation structure cannot be described. Regenerating plants recorded include, *Calothamnus quadrifidus*, *Hakea candolleana*, *Scholtzia involucrata*, *Hakea auriculata*, *Eremaea beaufortioides* var. *microphylla*. An isolated patch of *Eucalyptus todtiana* to 5m occurs at the site.

The site is on an old disturbed area located between a firebreak and Tomlinson Road. It is located on a regional drainage line, although there is no drainage channel present. The landform is consistent with the drainage pattern, and significantly taller vegetation occurs here than that in site 58 to the south, where the soil profile is similar. The vegetation also benefits from water drainage off Tomlinson Road.

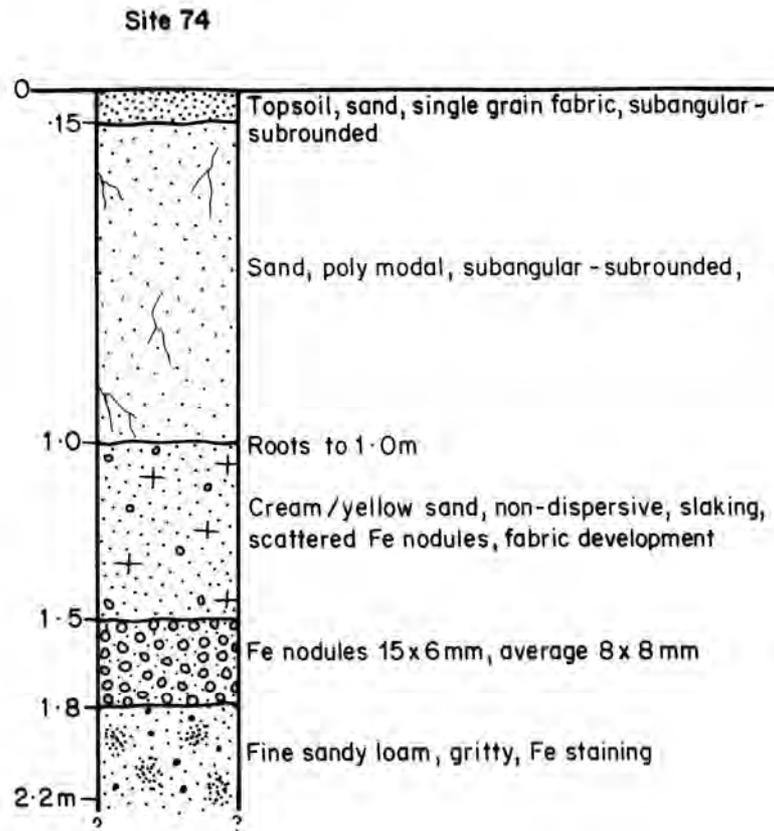
## SITE 71



317874 E  
6749866 N

Heath to 1.5m dominated by *Banksia attenuata*, *Banksia hookeriana* and *Hakea polyanthema* P3 over Dwarf Scrub to 0.9m dominated by *Melaleuca leuropoma* and *Conospermum boreale* over Very Open Low Sedges to 0.5m of *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*. Isolated trees of *Eucalyptus todtiana* to 6m and *Banksia prionotes* to 5m occur in the area.

## SITE 74

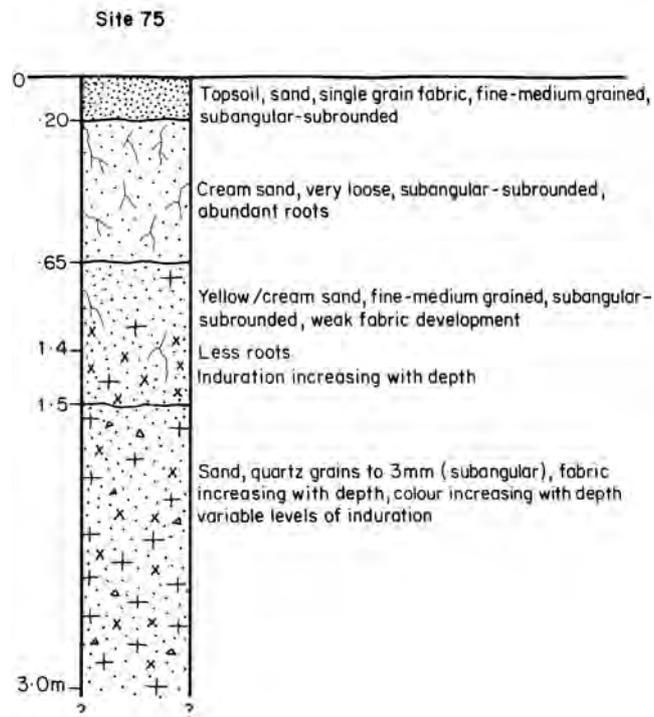


320344 E  
6748782 N

Open Low Scrub to 1.2m of *Eremaea beaufortioides* var. *microphylla* (ID pending) over Low Heath to 0.9m dominated by *Hakea polyanthema* P3 and *Melaleuca leuropoma* over Low Sedges dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*.

The Priority 3 species, *Isopogon tridens* grows at this site.

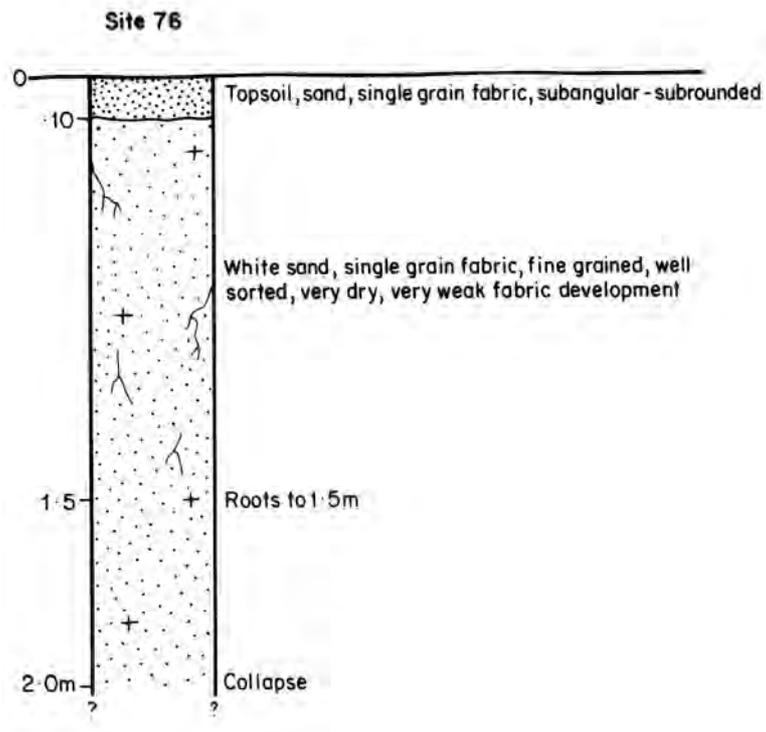
## SITE 75



320460 E  
6748352 N

Open Low Woodland to 6.5m of *Eucalyptus tottiana* over Open Scrub to 3m of *Acacia scirpifolia* and *Grevillea eriostachya* over Low Heath to 1m dominated by *Beaufortia elegans* and *Hakea polyanthema* P3 over *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia* Very Open Low Sedges to 0.5m.

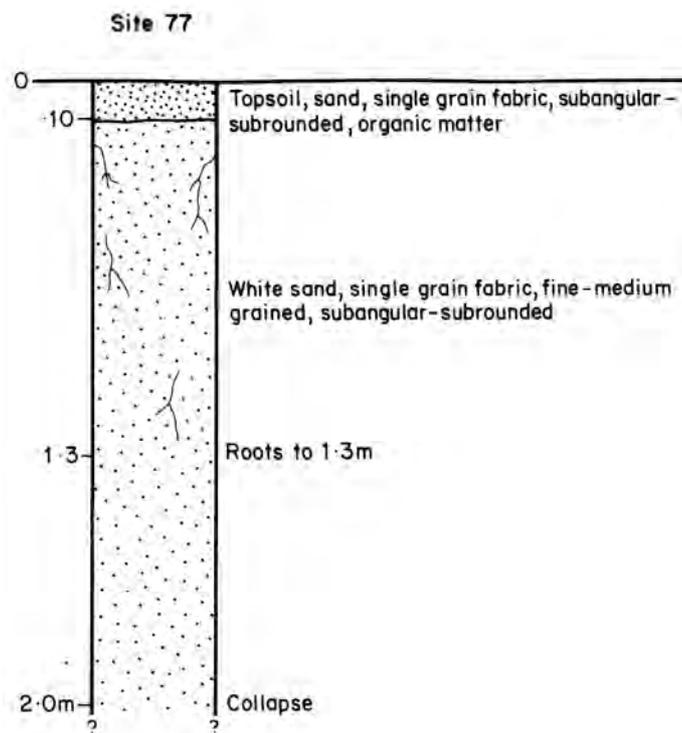
## SITE 76



317479 E  
6739279 N

Heath to 1.7m dominated by *Banksia attenuata* and *Scholtzia involucreta* over Dwarf Scrub to 1m dominated by *Beaufortia elegans* over Open Low Sedges dominated by *Alexgeorgia nitens* and *Lyginia imberbis*. Scattered *Banksia menziesii* trees to 3.5m also occur in the area.

## SITE 77



316522 E  
6740660 N

Open Low Woodland to 4m of *Banksia menziesii* over Heath to 1.7m dominated by *Banksia attenuata* and *Scholtzia involucrata* over Dwarf Scrub to 0.8m dominated by *Melaleuca leuropoma* over Open Low Sedges to 0.3m dominated by *Alexgeorgia nitens* and *Lyginia imberbis*.

The Undescribed species, *Styloidium* sp. nova occurs on the drill line accessing this site.

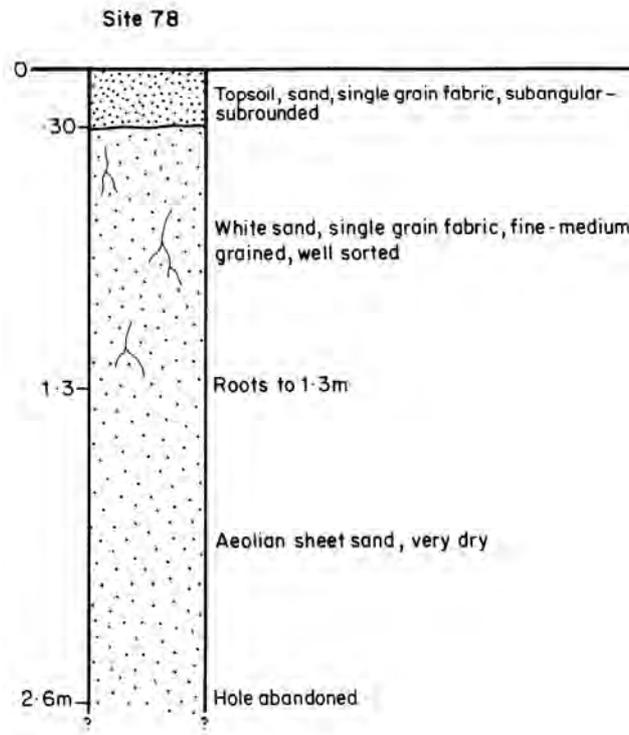
## BETWEEN SITE 77 and 78

Between soil pit sites 77 and 78 (at 316946 East and 6741303 North) there is an interdunal depression (60 x 100 m), with a Heath vegetation structure and iron staining at the soil surface. North of this depression is a widespread area of stressed vegetation.



All the *Eucalyptus tottiana* trees have died back with a few trees regenerating from epicormic buds at the base (coppice growth). *Nuytsia floribunda* and *Banksia menziesii* trees are also affected. The understorey vegetation is severely stressed and the sedge plant *Lomandra hastilis* that normally grows in the shelter of mallee-form *Eucalyptus tottiana* trees are now growing in isolated patches. Repeated fires, as well as drought stress over time is changing this Very Open Woodland into a Heath.

## SITE 78

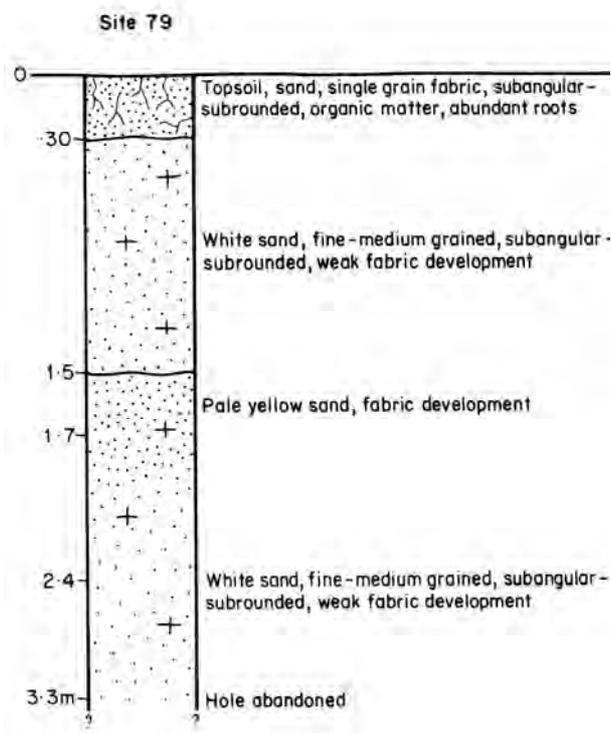


316942 E  
6741885 N

Heath to 1.6m of *Banksia attenuata* over Dwarf Scrub to 1m dominated by *Scholtzia involocrata* and *Stirlingia latifolia* over Open Low Sedges dominated by *Lyginia imberbis* and *Alexgeorgia nitens*. Scattered *Banksia menziesii* trees to 3m also occur in the area.

The *Banksia attenuata* shrubs are very resilient at this site, as the majority of smaller understorey shrubs are either chlorotic or dead from drought stress.

## SITE 79

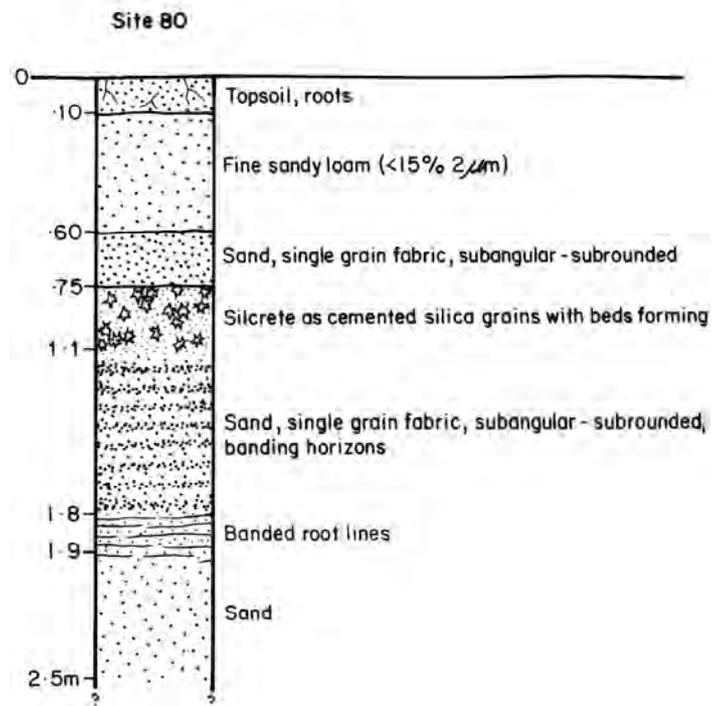


317453 E  
6741886 N

Heath to 1.6m of *Banksia attenuata* over Dwarf Scrub to 0.6m dominated by *Melaleuca leuropoma*, *Jacksonia hakeoides* and *Stirlingia latifolia* over Very Open Low Sedges to 0.25m dominated by *Lyginia imberbis*. Isolated *Banksia menziesii* trees to 3.5m also occur in the area.

The Priority 4 species, *Banksia elegans* grows at this site. The vegetation structure is also changing to the west from this site through repeated fires and drought stress, from a Very Open Woodland to a Heath.

## SITE 80



317804 E  
6741869 N

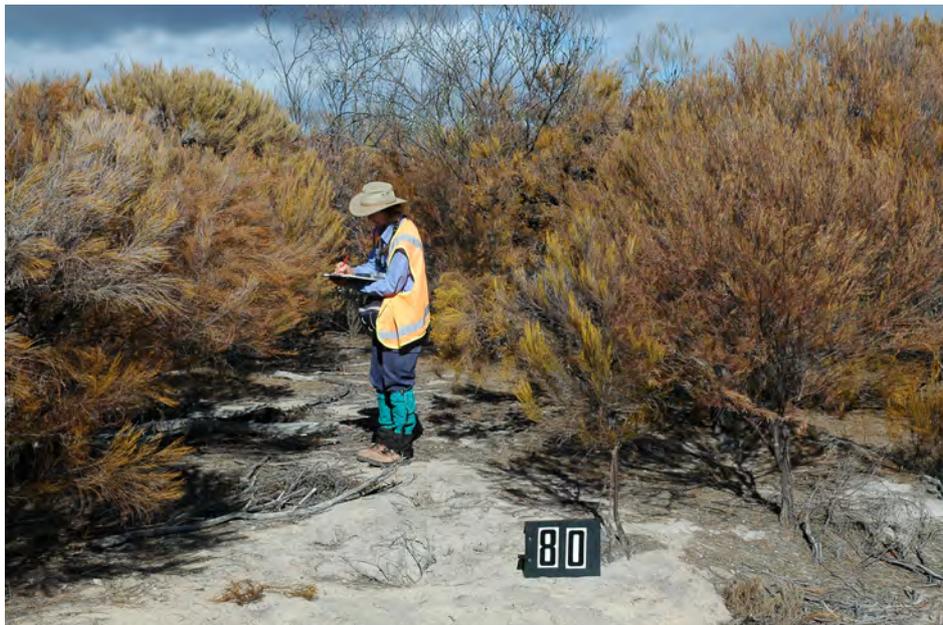
Thicket to Dense Thicket dominated by *Allocasuarina campestris* to 3m with scattered *Acacia scirpifolia* to 3.5m and *Acacia saligna* (ID pending) to 3.5m over occasional *Jacksonia hakeoides*.

## SITE 80 (Continued)

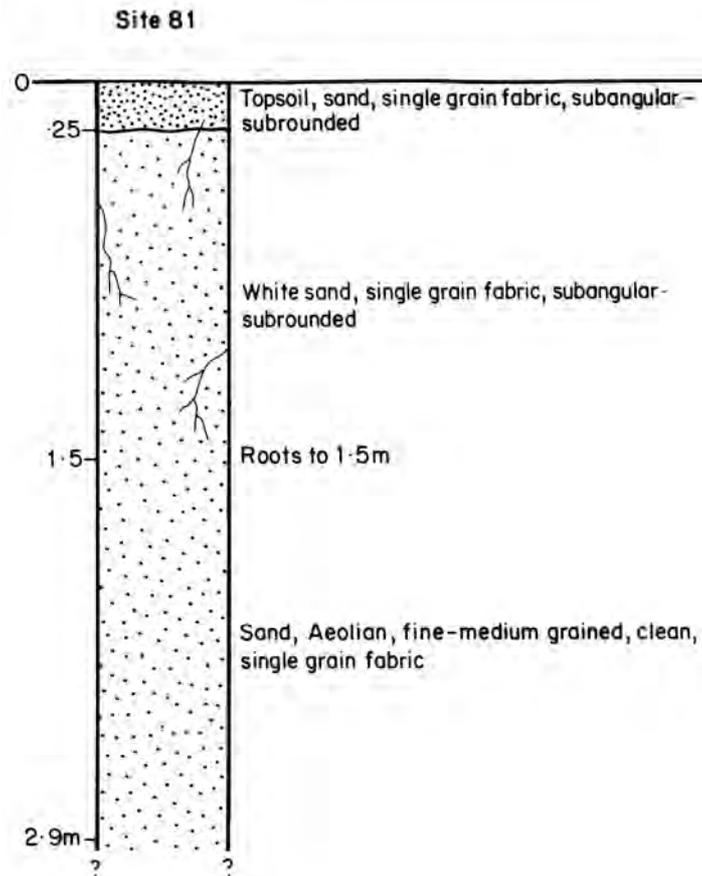
Vegetation structure in this community varies from 40% vegetation cover over 50% litter cover and 10% bare ground to 90% vegetation cover over 100% litter cover. There is no small shrub or sedge layer here, which may indicate that the soils are inhospitable to shallow root systems, with little soil water availability to plants at the surface. Ground surface is very uneven with sinkholes where soil is collapsing inwards. Dry low density, grey friable soil, is present on the surface. Vegetation is exhibiting a severe drought stress response with 99% chlorosis and 70 to 95% death of vegetation at the site.



The soil pit is ~30 m east of a vegetation change boundary to a 1.6 m Heath of *Banksia attenuata* with very stressed scattered *Banksia menziesii* trees to 3.5 m. The Priority 4 species, *Banksia elegans* grows in higher numbers on the track edges and in the vegetation from ~200 m and continues east.



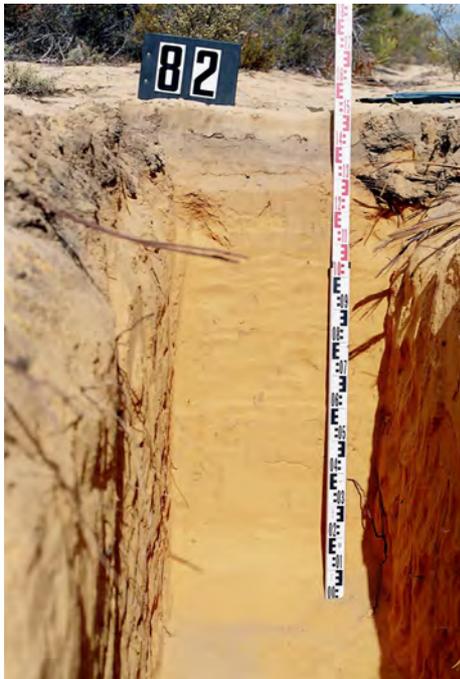
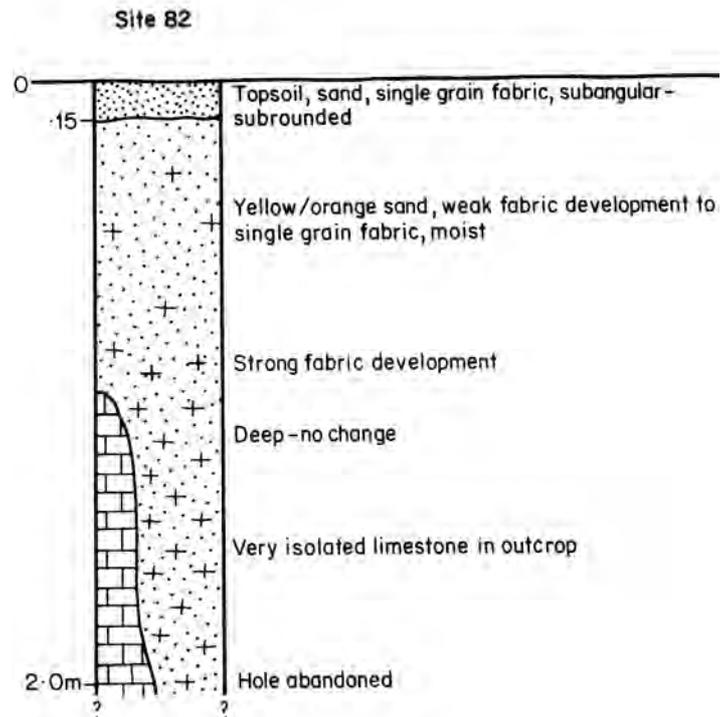
## SITE 81



318382 E  
6741861 N

Heath to 1.7m dominated by *Scholtzia involucrata* and *Banksia attenuata* over Open Dwarf Scrub to 1m dominated by *Melaleuca leuropoma* and *Stirlingia latifolia* over Very Open Low Sedges dominated by *Lyginia imberbis*. Scattered trees to 3m of *Banksia menziesii* and *Banksia elegans* P4 occur in the area.

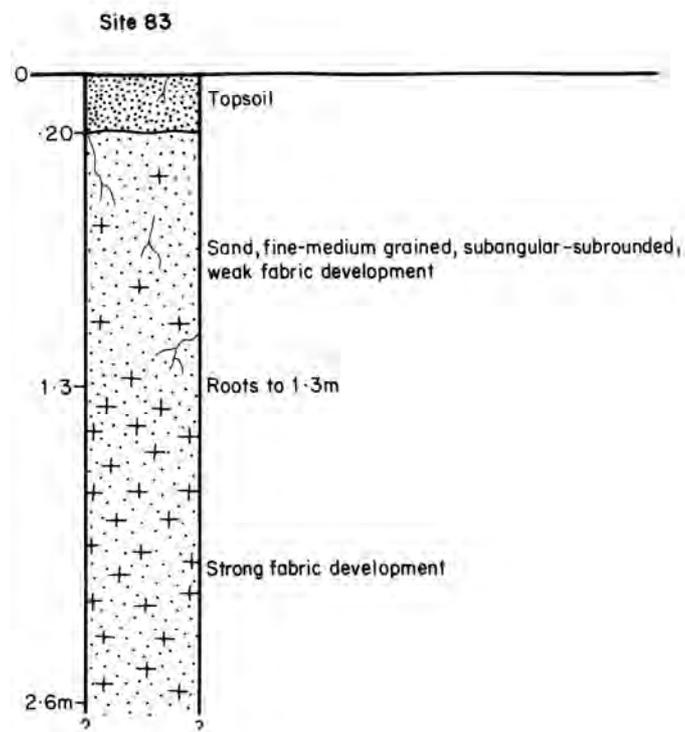
## SITE 82



319392 E  
6741862 N

Low Woodland to 9m of *Banksia prionotes* over Open Scrub to 4m dominated by *Allocasuarina campestris* and *Acacia spathulifolia* over Low Scrub to 1.65m dominated by *Calothamnus blepharospermus* over Open Dwarf Scrub dominated by *Hibbertia hypericoides* over *Ecdeiocolea monostachya* Open Low Sedges to 0.5m. Isolated patches of *Eucalyptus todtiana* to 6m also occur in the area.

## SITE 83

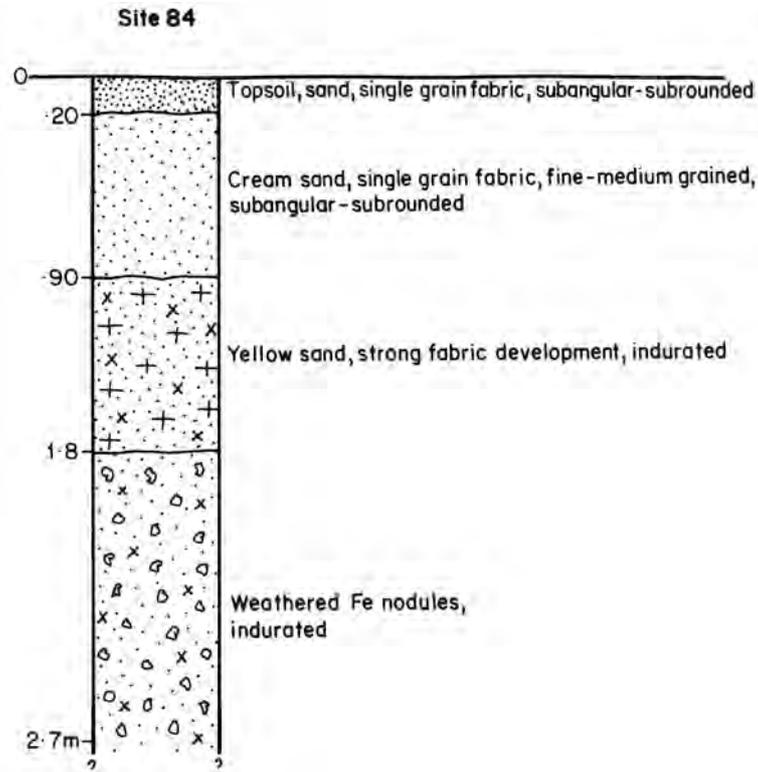


321818 E  
6743557 N

Low Heath to 1m dominated by *Hakea polyanthema* P3, *Calothamnus blepharospermus* and *Eremaea beaufortioides* var. *microphylla* (ID pending) over Open Tall Sedges to 0.6m dominated by *Ecdeiocola monostachya* and *Mesomelaena pseudostygia*.

The Priority species, *Isopogon tridens* grows at this site.

## SITE 84

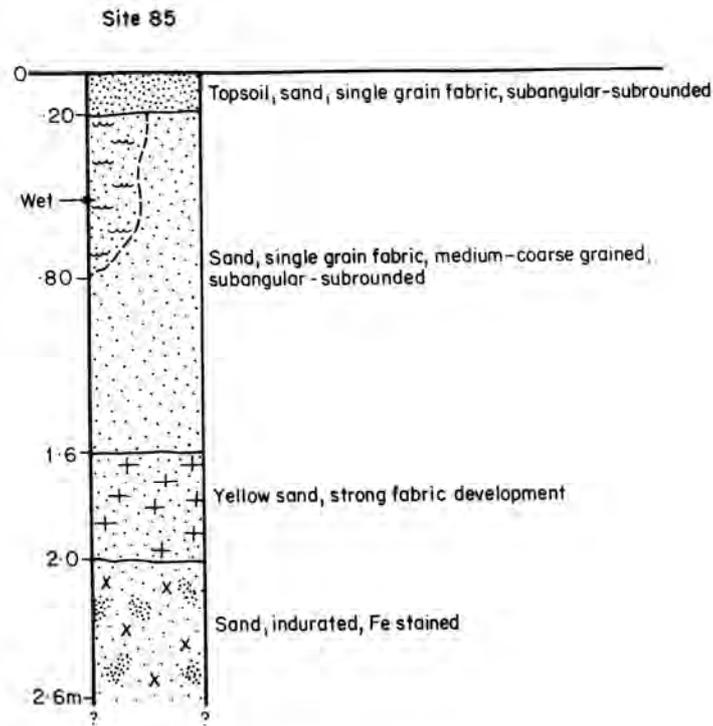


321289 E  
6743558 N

Low Heath to 1m dominated by *Hakea polyanthema* P3, *Hakea circumalata*, *Darwinia pauciflora* and *Beaufortia elegans* over Open Tall Sedges to 0.6m dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*. *Eucalyptus todtiana* mallee-form seem to follow 'on contour' gentle rises throughout the landscape and Low Heath community in this area.

The Priority species, *Isopogon tridens* grows at this site.

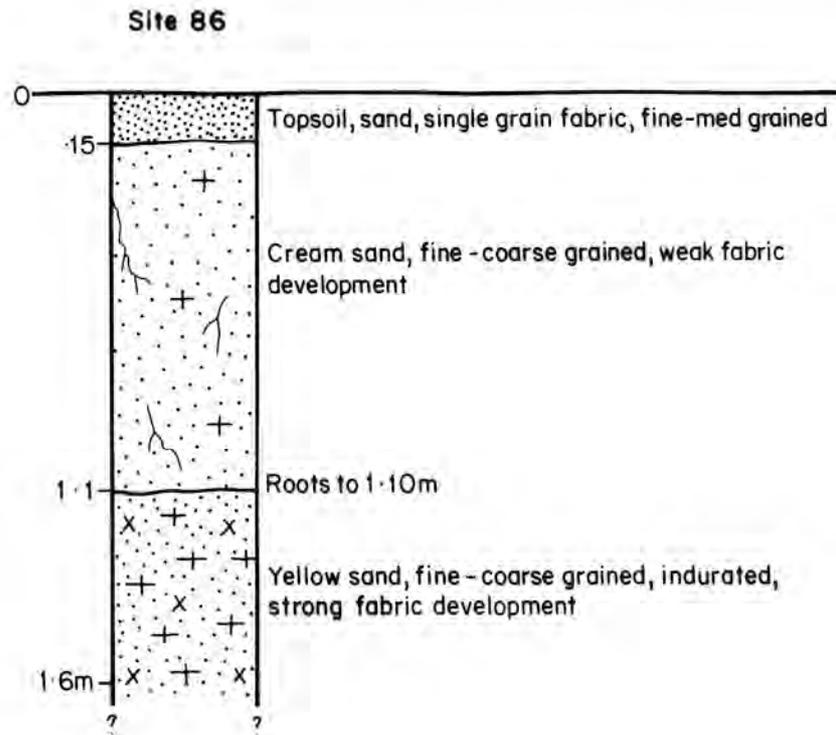
## SITE 85



321291 E  
6744515 N

Heath to 1.6m dominated by *Hakea polyanthema* P3 over Low Heath to 1m dominated by *Isopogon tridens* P3 and *Melaleuca leuropoma* over Open Low Sedges to 0.5m dominated by *Ecdiocollea monostachya*. Scattered patches of *Eucalyptus todtiana* also occur in the wider area.

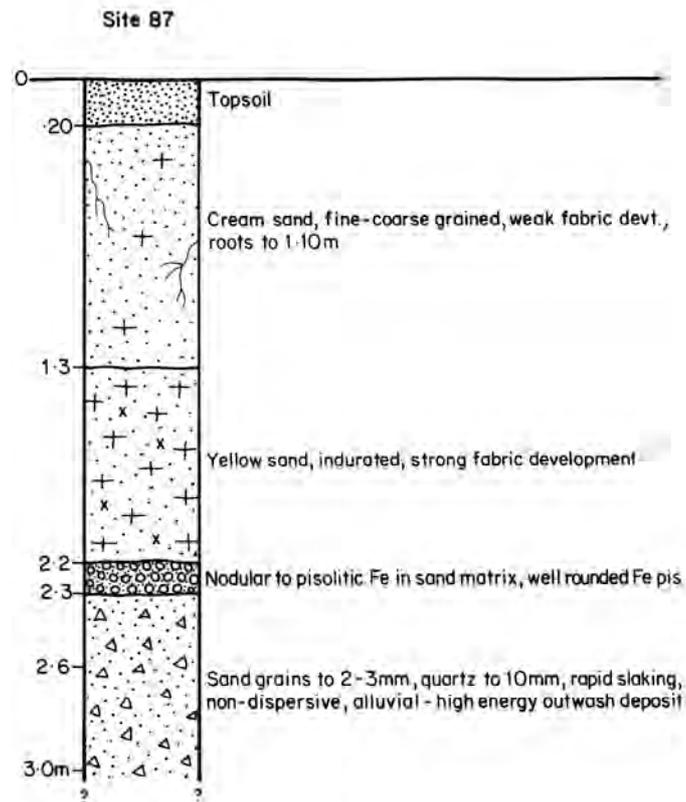
## SITE 86



320710 E  
6747153 N

Low Heath to 1m dominated by *Calothamnus blepharospermus*, *Banksia candolleana* and *Hakea polyanthema* P3 over Open Low Sedges to 0.5m of *Ecdeiocolea monostachya*. Scattered patches of *Eucalyptus tottiana* to 4m and *Xylomelum angustifolium* trees to 3.5m also occur in the area.

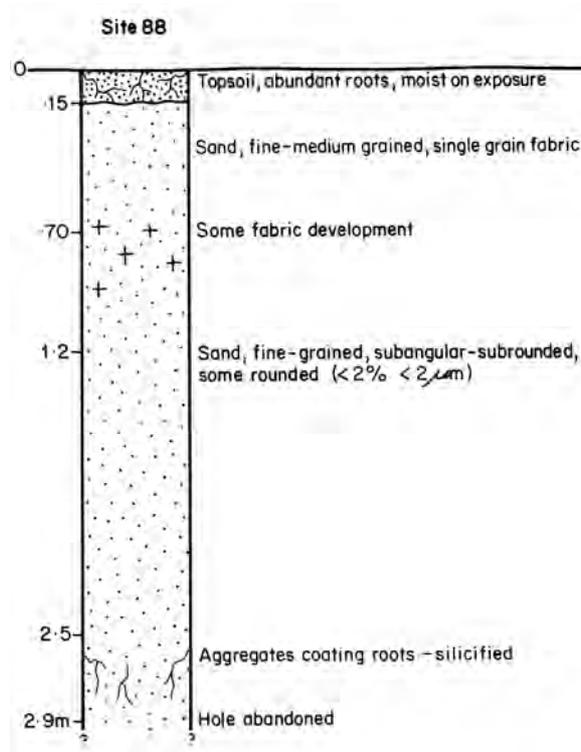
## SITE 87



321158 E  
6747159 N

Open Low Woodland to 5m of *Eucalyptus tottiana* and *Xylomelum angustifolium* over Heath to 1.3m dominated by *Hakea polyanthema* P3, *Calothamnus blepharospermus* and *Calothamnus quadrifidus* over Open Low Sedges to 0.5m dominated by *Ecdeiocolea monostachya* and *Mesomelaena pseudostygia*.

## SITE 88



317667 E  
6744514 N

Open Low Woodland to 6.5m of *Eucalyptus todtiana* and *Banksia menziesii* over Low Scrub to 1.8m dominated by *Banksia attenuata* and *Hakea polyanthema* P3 over Dwarf Scrub to 0.8m dominated by *Melaleuca leuropoma* and *Andersonia heterophylla* over Very Open Low Sedges to 0.25m of *Mesomelaena pseudostygia*.

**APPENDIX II**  
**TABLE OF SOIL DATA**

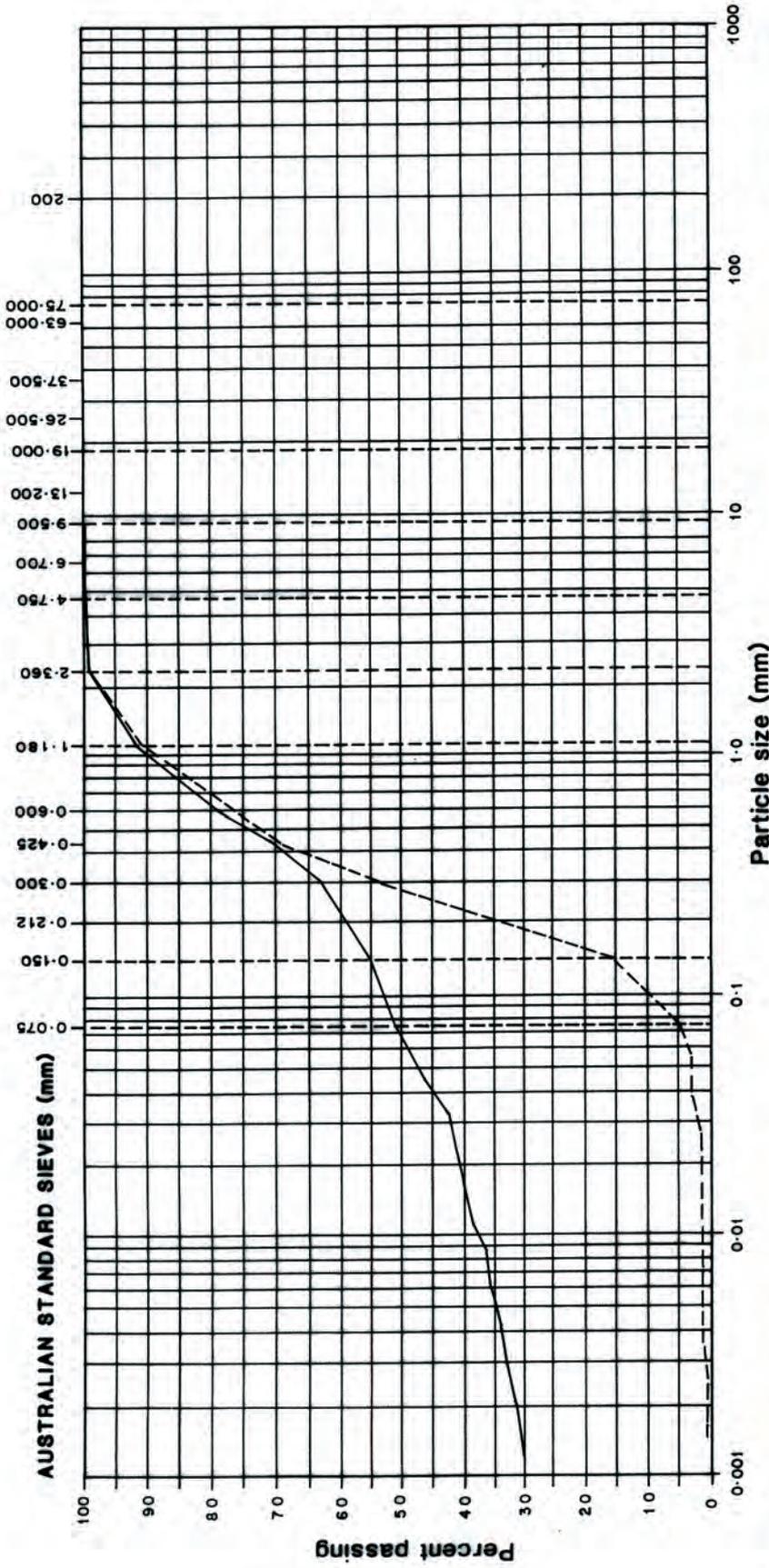
## SOIL DATA

Where: Site test pit site number  
 PD is profile description  
 P photo of profile  
 V vegetation description  
 PSD particle size distribution  
 DDR dry density ratio  
 K permeability  
 C chemistry  
 EAT Emmerson aggregate test  
 ESP exchangeable sodium percentage  
 IR surface infiltration rate  
 x data available

SITE	PD	P	V	PSD	DDR	K	C	EAT	ESP	IR
1	x		x							
2	x	x	x							
3	x	x	x							
4	x	x	x	x						x
5	x	x	x							
6	x	x	x							
7	x	x	x							
8		x	x							
9	x	x	x				x			
10	x		x							
11	x		x							
12	x	x	x	x			x	x	x	
13	x		x	x						
14	x	x	x							
15	x	x	x							
17	x	x	x	x	x					
20	x	x	x							
21	x		x							
21A	x	x	x	x						
22	x	x	x							
23	x	x	x							
24	x	x	x							
25	x		x	x						
26	x	x	x	x			x			
27	x	x	x	x	x		x			
28	x	x	x							
31	x	x	x							
32	x	x	x	x		x	x			x
33	x		x							
34	x	x	x							
35	x		x	x						x
37	x	x	x	x	x	x		x	x	x
38	x	x	x				x			x
39	x	x	x							
40	x		x	x				x	x	
41	x		x							
42	x		x							
43	x		x					x	x	
44	x		x							
45	x	x	x							

Site	PD	P	V	PSD	DDR	K	C	EAT	ESP	IR
46	x	x	x							
47	x		x							
48	x		x							
50	x		x							
51	x	x	x							x
52	x		x							
53	x		x	x	x		x	x	x	x
54	x	x	x	x	-		x			
55	x	x	x	x	-					x
57	x	x	x							
58	x	x	x							
63	x	x	x	x						
64	x		x							
65	x		x							
66	x		x	x	x		x			
67	x		x							
68	x		x							
69	x		x							
71	x	x	x							
74	x	-	x	x	x	x				
75	x	x	x							
76	x	x	x							
77	x	x	x							
78	x		x							
79	x	x	x							
80	x	x	x							
81	x		x							
82	x	x	x							
83	x	x	x							
84	x		x							
85	x	x	x							
86	x		x							
87	x		x					x	x	
88	x	x	x	x	x		x			

**APPENDIX III**  
**PARTICLE SIZE DISTRIBUTION CURVES**



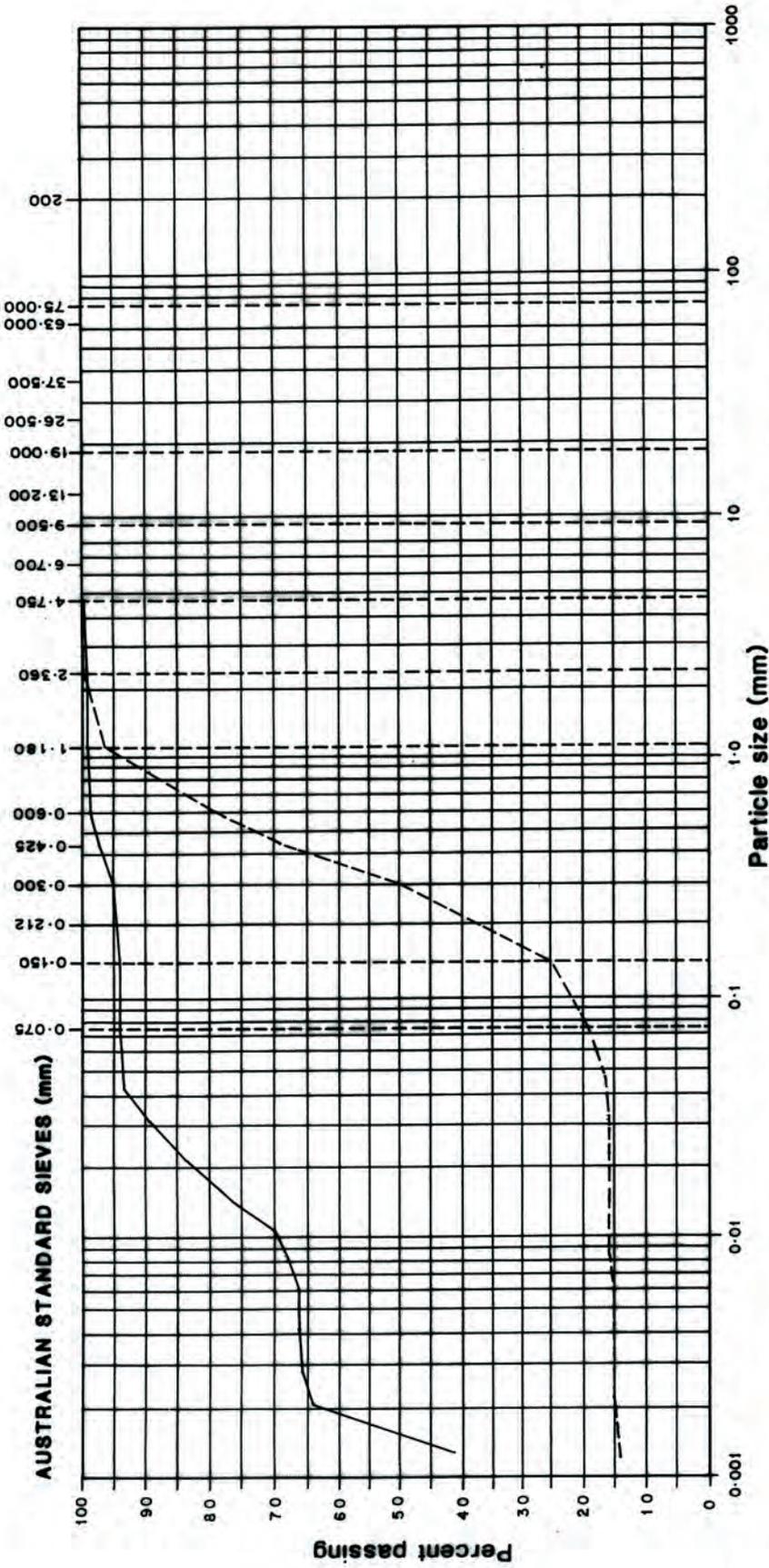
**AS 1289(1977) PARTICLE SIZE LIMITS**

CLAY	Fine	Medium	Coarse	SILT	SAND	Fine	Medium	Coarse	GRAVEL	COBBLES	BOULDERS

### Particle Size Distribution

Sites 40 & 63

- 40 - depth 600mm ———
- 63 - depth 250mm - - - - -



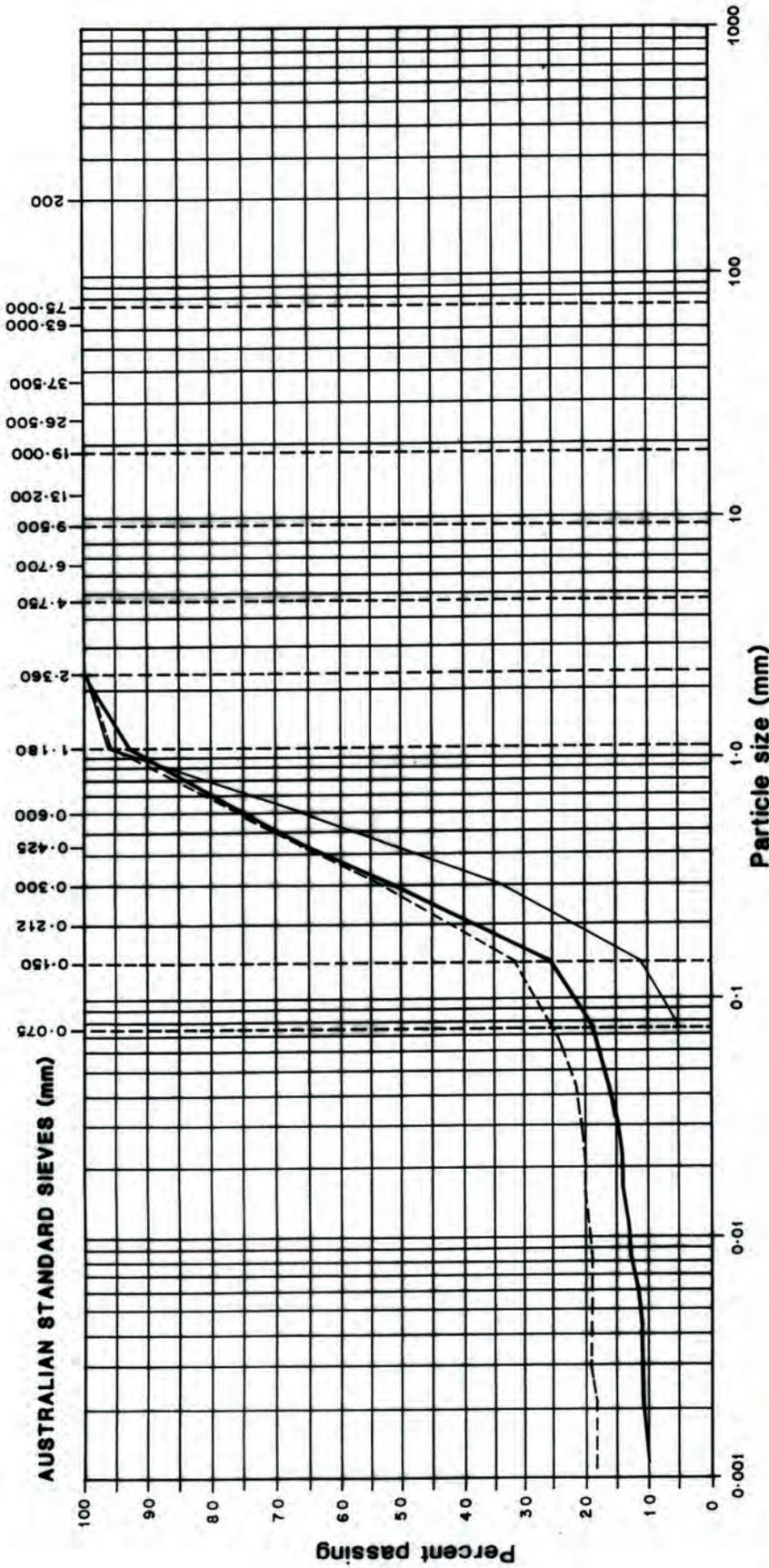
**AS 1289(1977) PARTICLE SIZE LIMITS**

CLAY	Fine	Medium	Coarse	SILT	Fine	Medium	Coarse	SAND	Fine	Coarse	GRAVEL	Medium	Coarse	COBBLES	BOULDERS

**Particle Size Distribution**

Sites 21A & 74

- 21A - depth 400mm ———
- 74 - depth 1200mm - - - - -

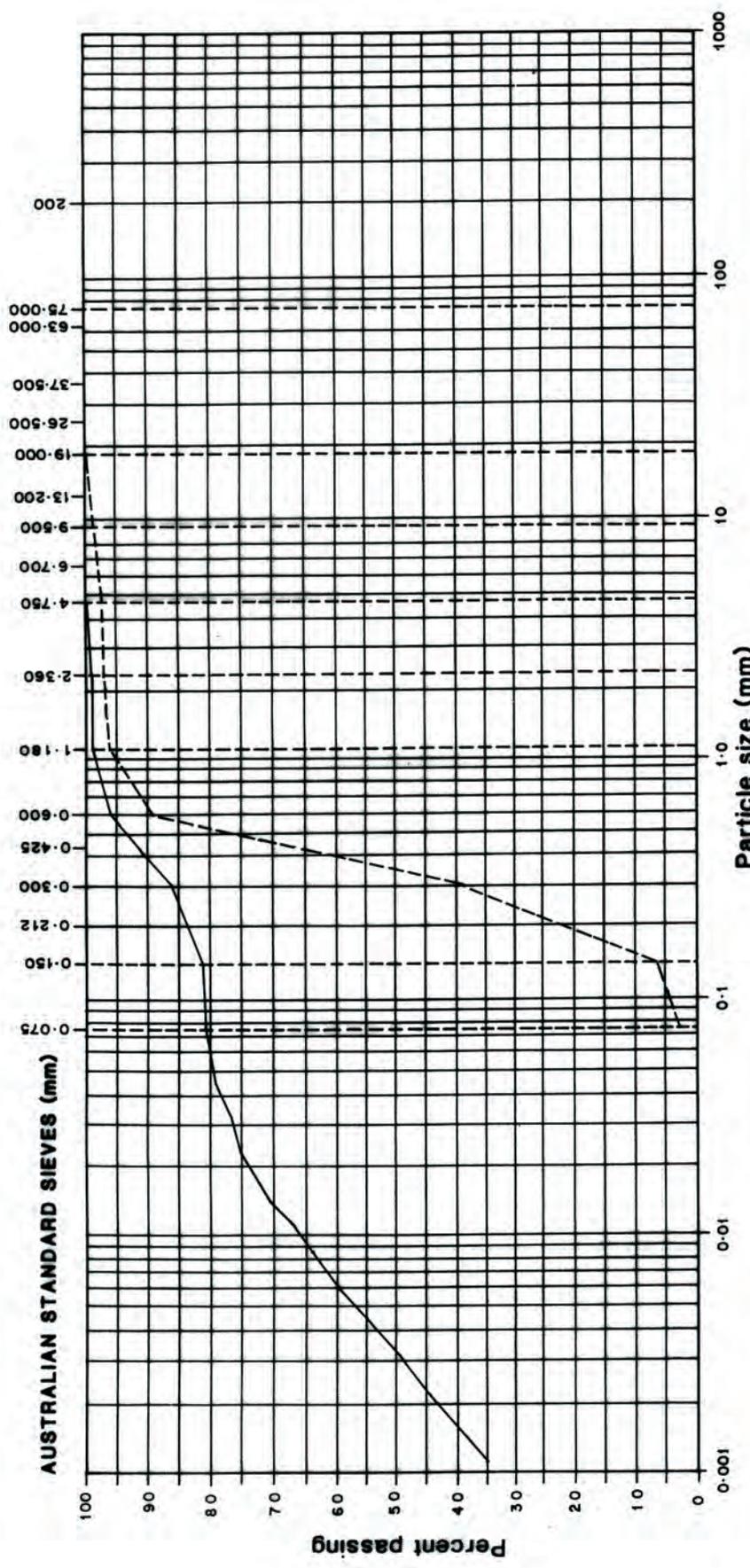


AS 1289(1977) PARTICLE SIZE LIMITS

Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
SILT			SAND			GRAVEL				

37A - depth 100mm ———  
 37B - depth 900mm - - - - -  
 37C - depth 1580mm ———

**Particle Size Distribution**  
 Site 37



AS 1289(1977)  
PARTICLE SIZE LIMITS

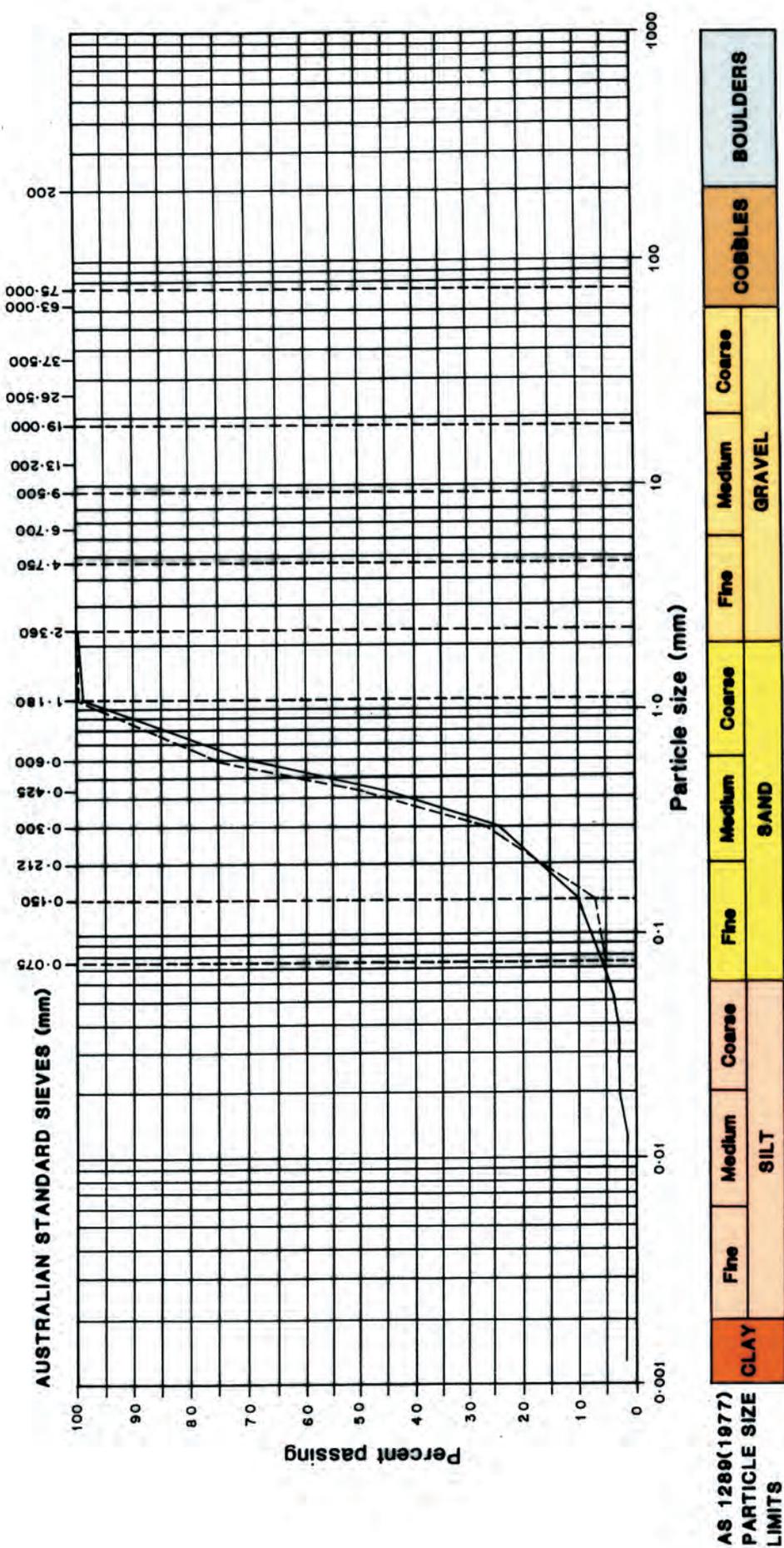
CLAY	Fine	SILT		SAND		GRAVEL	COBBLES	BOULDERS
		Fine	Medium	Coarse	Medium			

### Particle Size Distribution

Site 55

55A - depth 200 mm —————

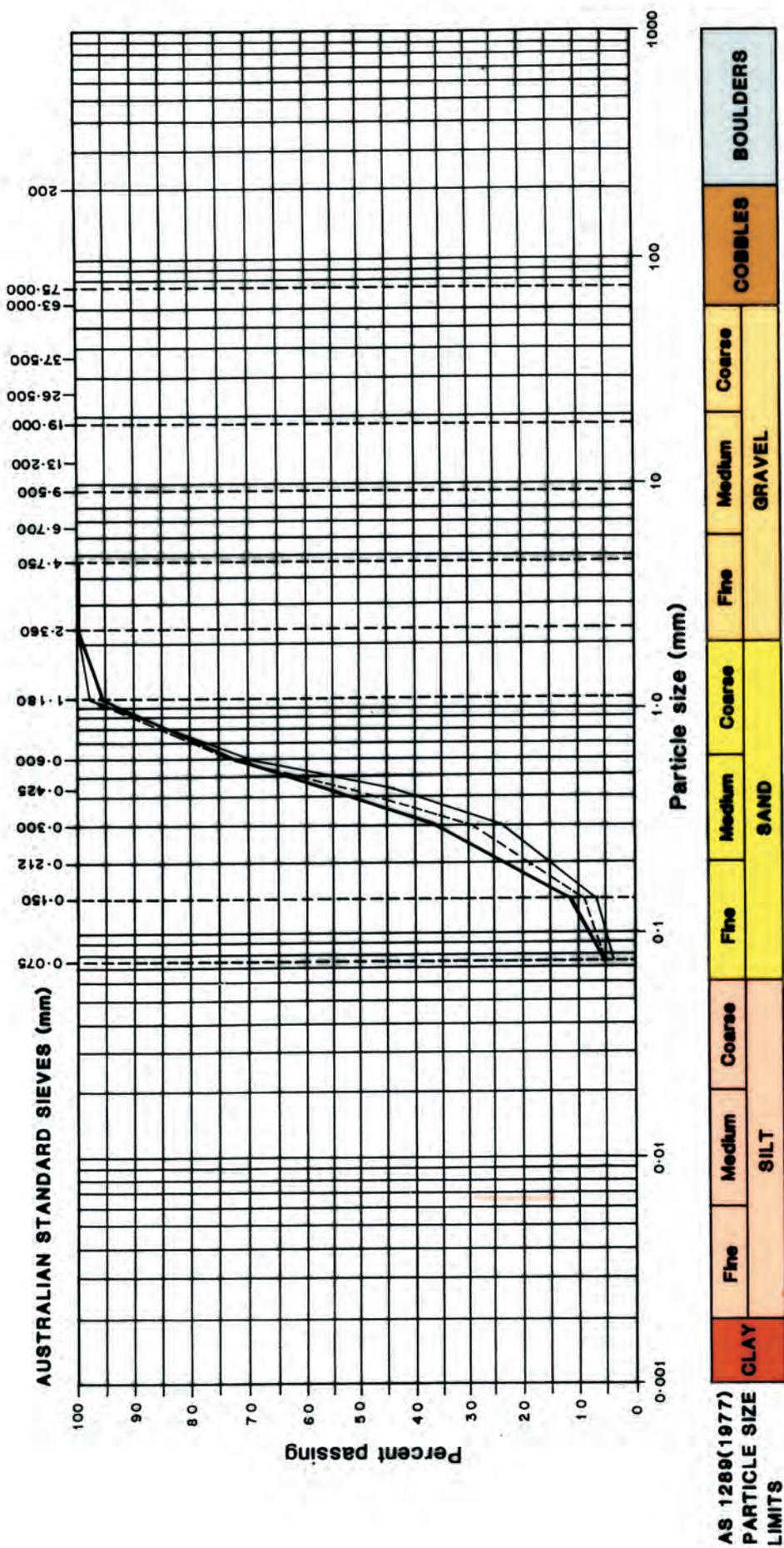
55B - depth 700 mm - - - - -



**Particle Size Distribution**

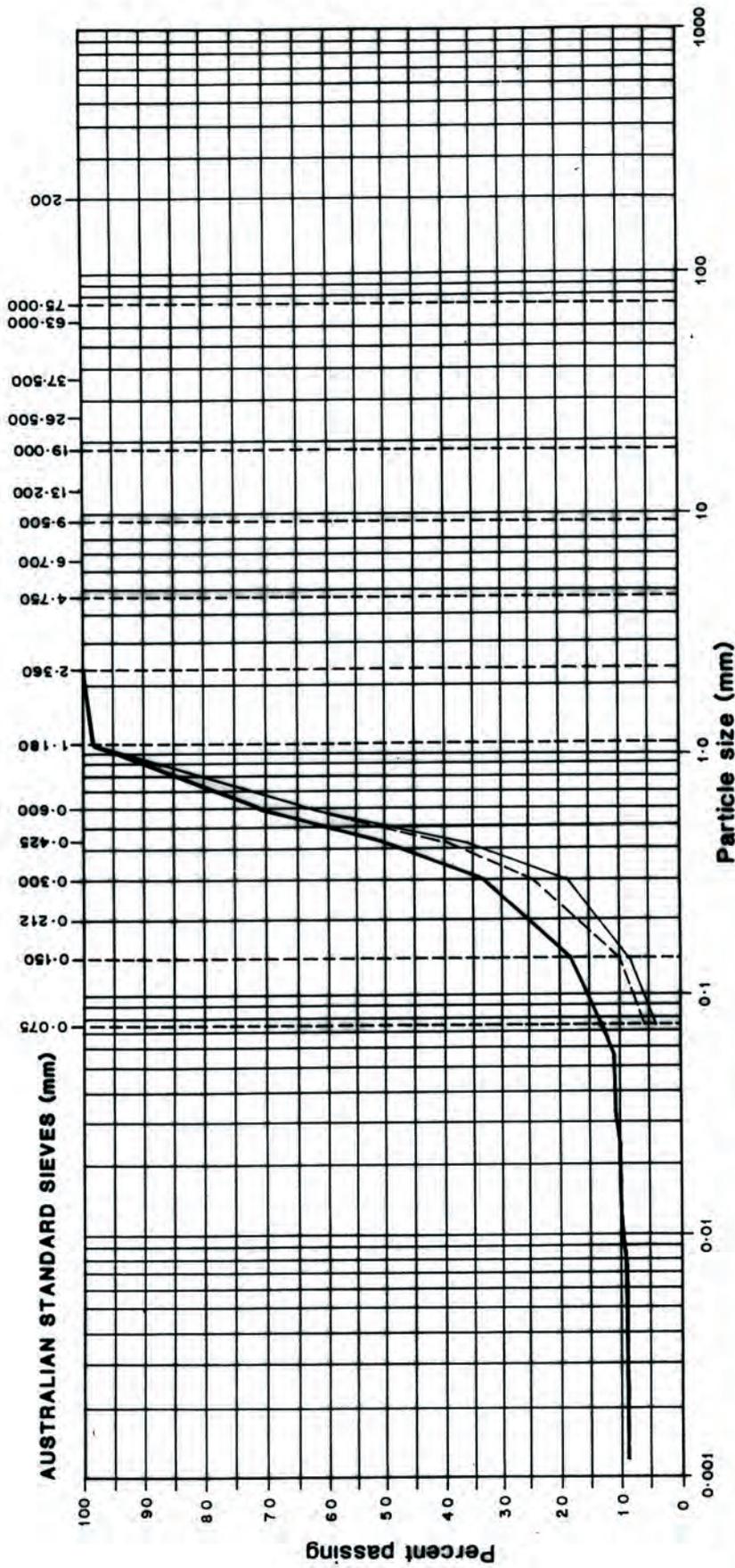
Site 17

17A - depth 100mm —————  
 17B - depth 500mm - - - - -



**Particle Size Distribution**

Site 27



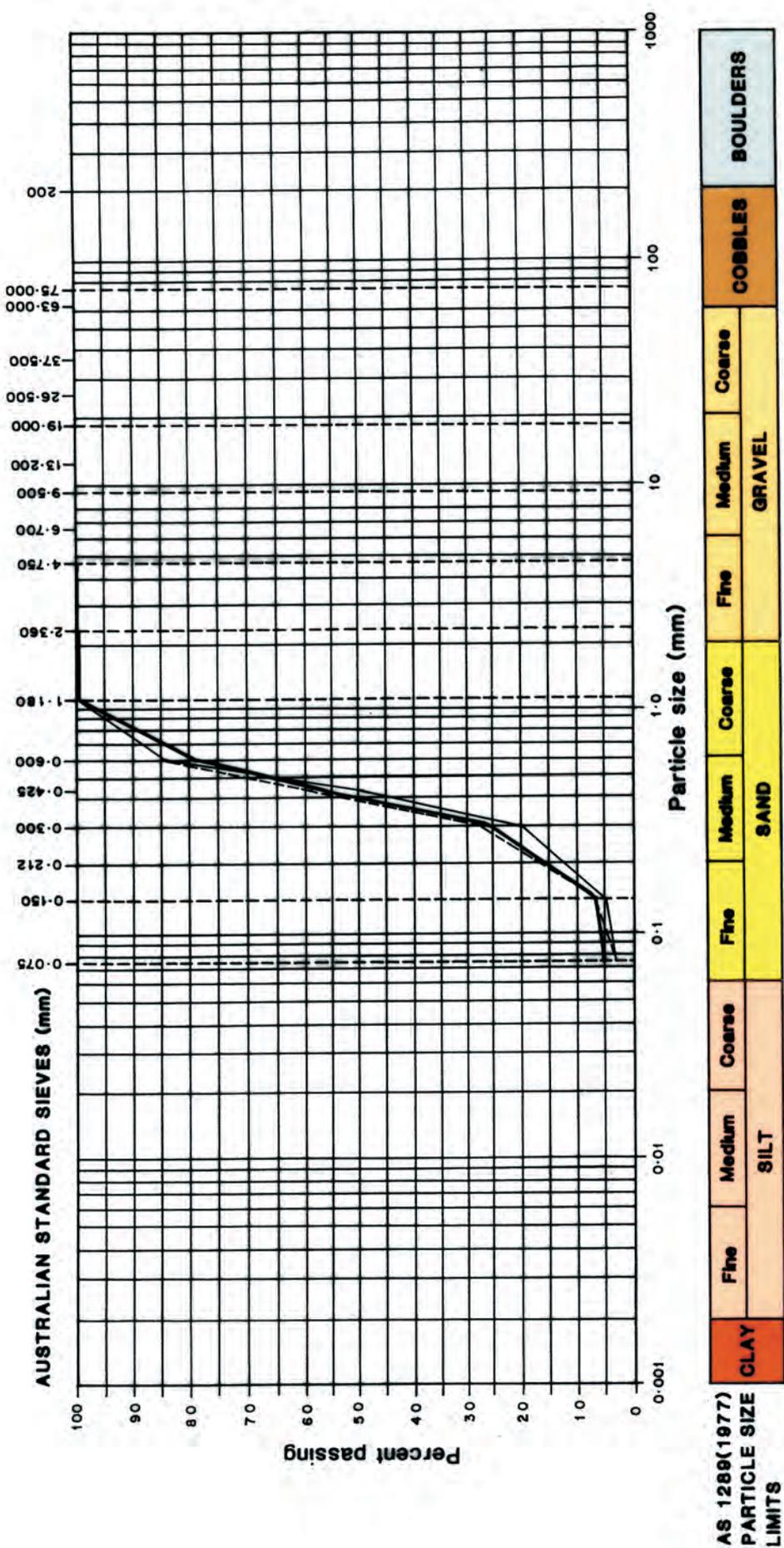
**AS 1289(1977) PARTICLE SIZE LIMITS**

CLAY	Fine	Medium	Coarse	SILT	Fine	Medium	Coarse	SAND	Fine	Medium	Coarse	GRAVEL	Coarse	COBBLES	BOULDERS

**Particle Size Distribution**

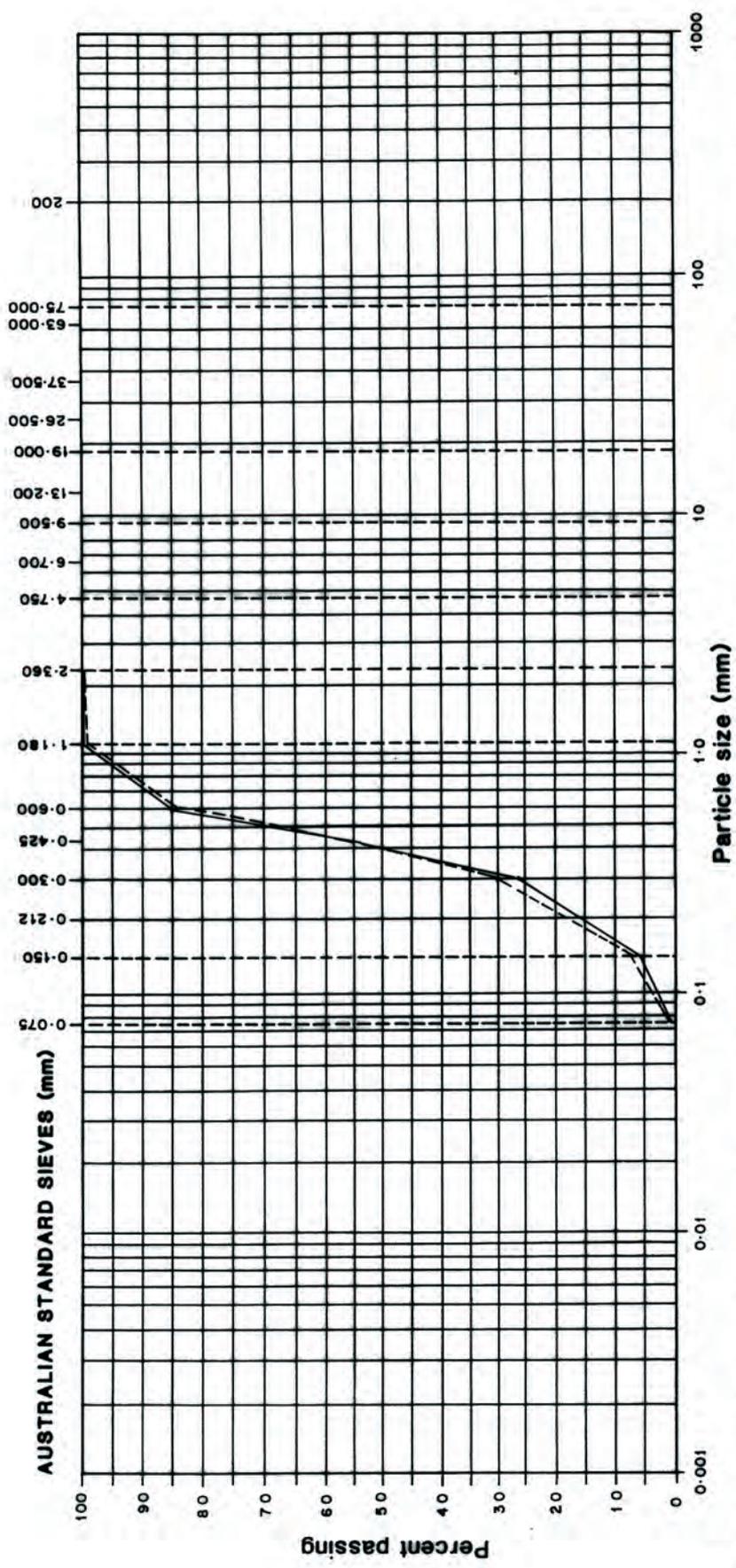
Site 12

- 12A - depth 200mm ———
- 12B - depth 730mm - - - - -
- 12C - depth 1200mm ———



**Particle Size Distribution**

Site 35



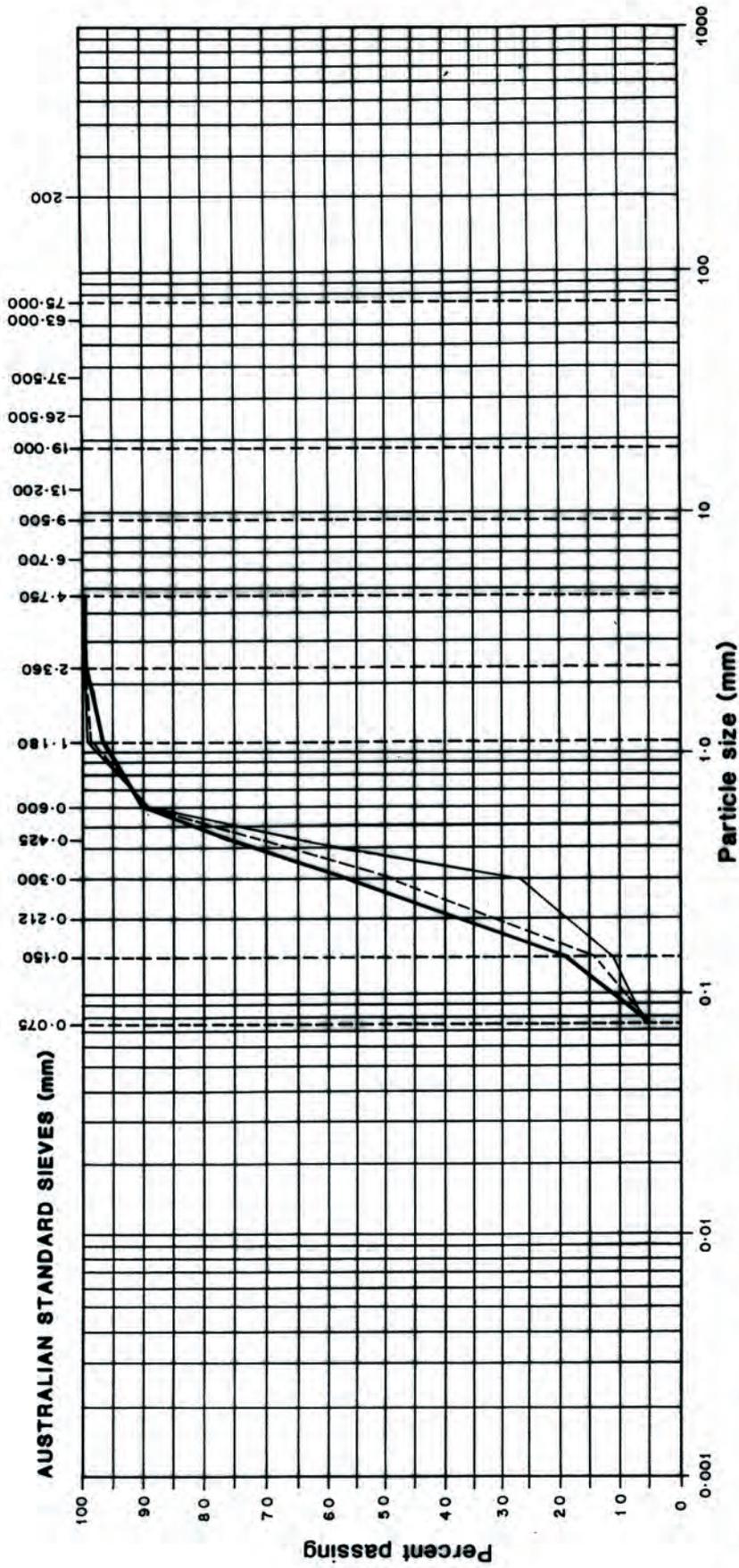
AS 1289(1977)  
**PARTICLE SIZE LIMITS**

CLAY	Fine	Medium	Coarse	SAND	Fine	Medium	Coarse	GRAVEL	Coarse	BOULDERS	
	SILT				SAND				GRAVEL		
	SILT				SAND				GRAVEL		

88A - depth 280mm ———  
 88B - depth 800mm - - - - -

**Particle Size Distribution**

Site 88



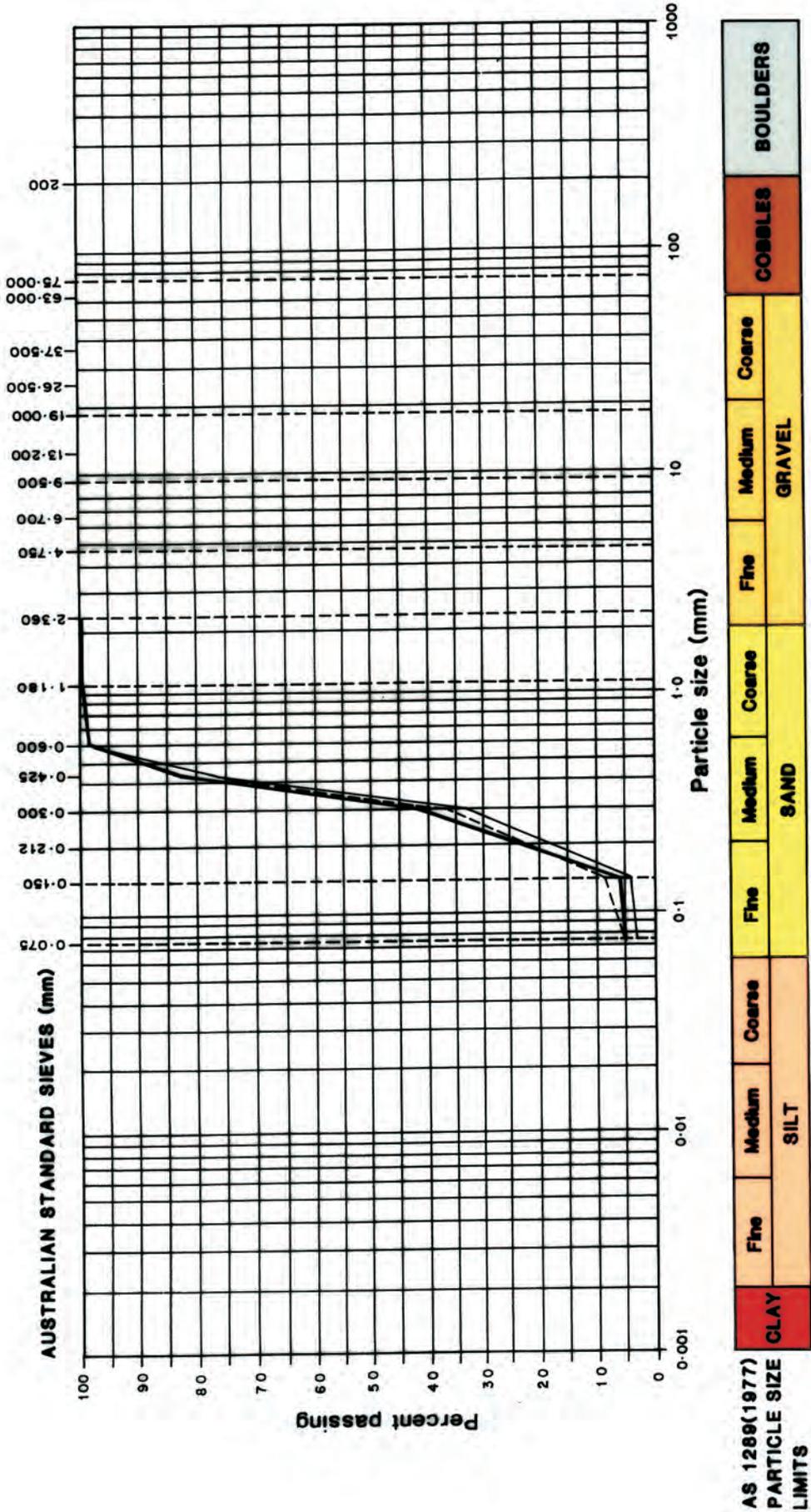
**AS 1289(1977) PARTICLE SIZE LIMITS**

CLAY	Fine	Medium	Coarse	SILT	Fine	Medium	Coarse	SAND	Fine	Medium	Coarse	GRAVEL	COBBLES	BOULDERS

- 53A - depth 200mm ———
- 53B - depth 700mm - - - - -
- 53C - depth 1100mm ———

**Particle Size Distribution**

Site 53



**Particle Size Distribution**

Site 66

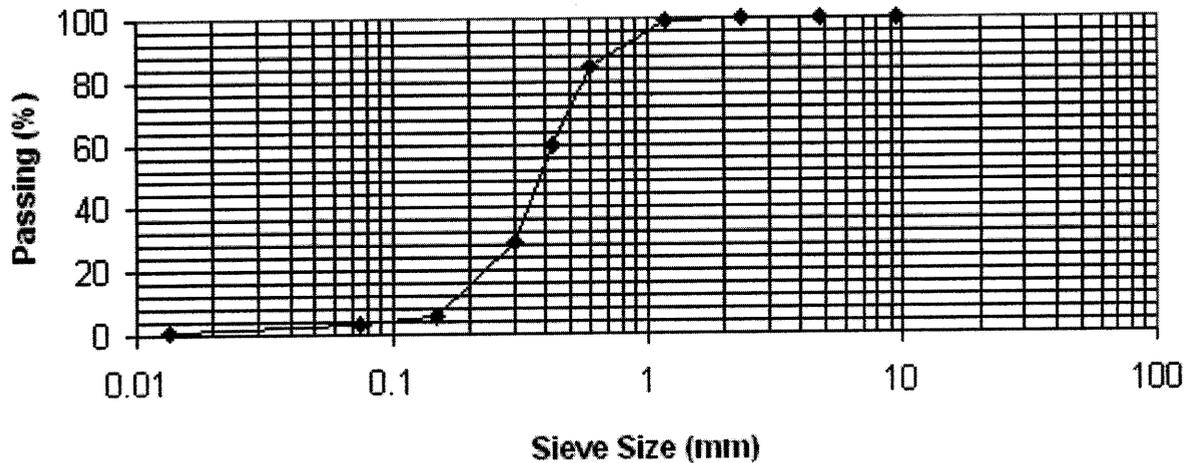
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3343  
 Sample ID: Dong - 4 1.0m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution



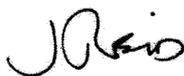
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	99
53.0		0.600	84
37.5		0.425	60
26.5		0.300	29
19.0		0.150	6
9.50	100	0.075	3
4.75	100	0.0135	1

% Retained

Largest Sieve - 1% at 1.18 mm:

Note: Sample supplied by client.

Approved Signatory:



(J.Reid)

Date: 31/05/2007



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Western Geotechnics Group  
 PO Box 219 Bentley WA 6982  
 36 Railway Parade  
 Welshpool WA 6106



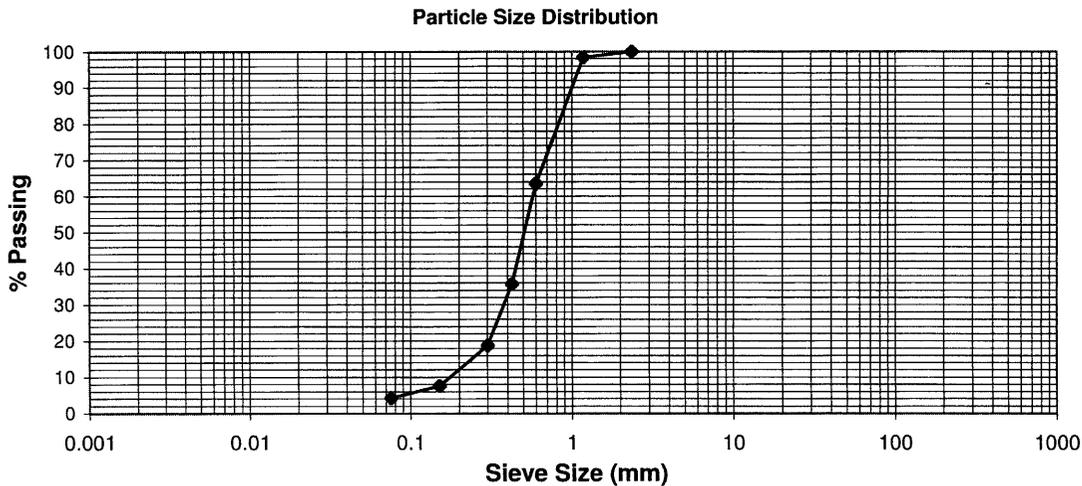
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 12 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1859  
 Depth: 200mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	98
		0.600	63
		0.425	36
		0.300	19
		0.150	8
		0.075	4

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1859 / S301

Approved Signatory: \_\_\_\_\_ ( M.Matthews ) Date: 9/05/2007



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 PO Box 219 Bentley WA 6982  
 36 Railway Parade  
 Welshpool WA 6106



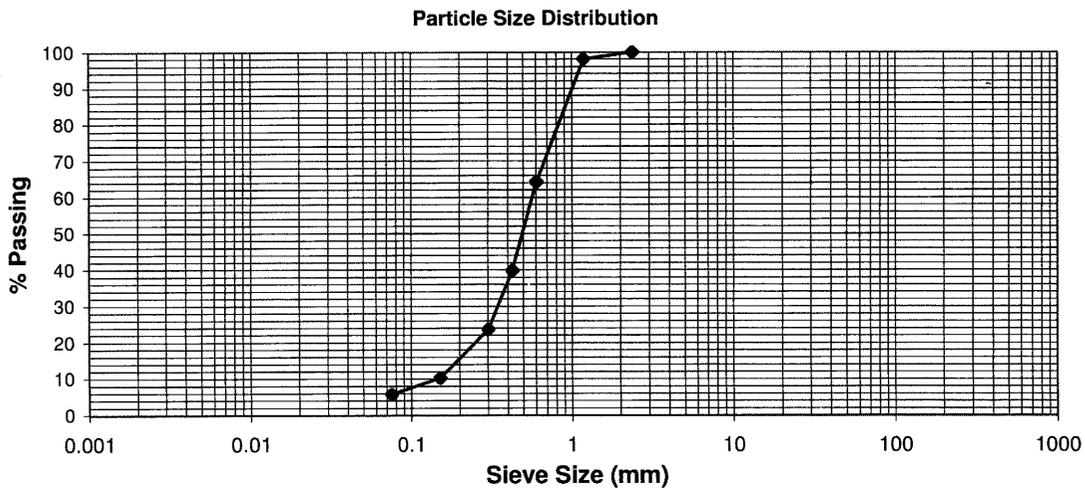
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 12 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1860  
 Depth: 730mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	98
		0.600	64
		0.425	40
		0.300	24
		0.150	10
		0.075	6

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1860 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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 Welshpool WA 6106



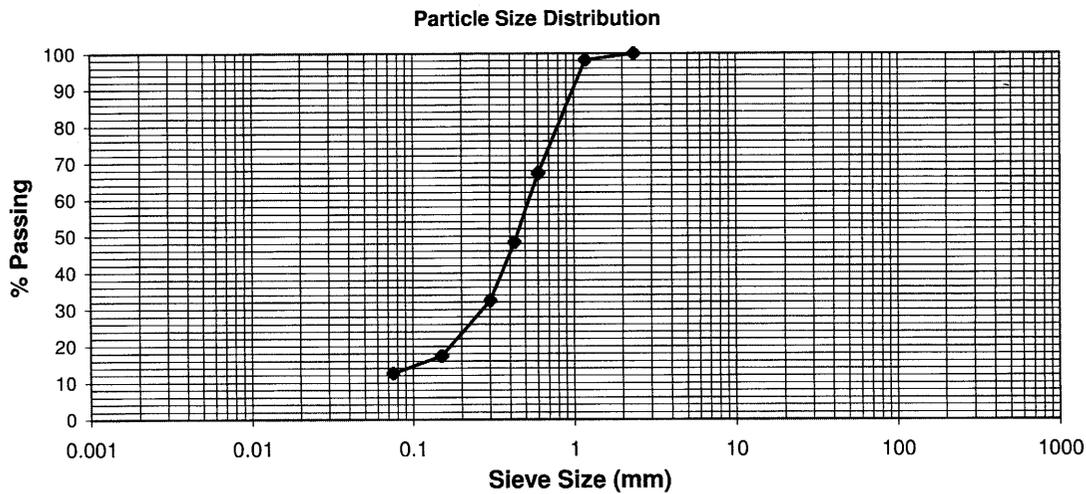
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 12 - C

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1861  
 Depth: 1200mm

#### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	98
		0.600	67
		0.425	48
		0.300	33
		0.150	17
		0.075	13

Notes:  
 Sample supplied by client

Certificate No.:07-WG-1861 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

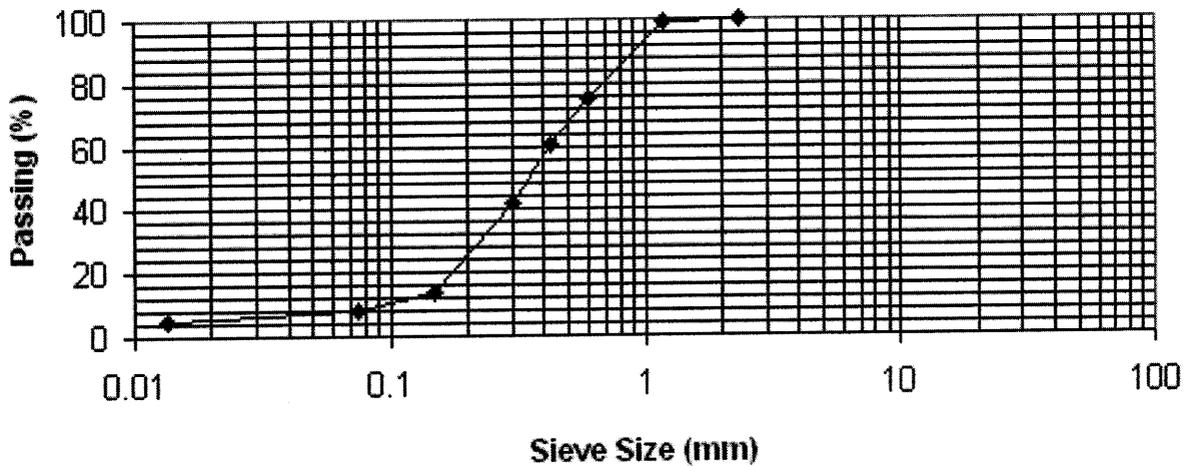
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3344  
 Sample ID: Dong - 13 3.6m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution



Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	99
53.0		0.600	75
37.5		0.425	61
26.5		0.300	42
19.0		0.150	14
9.50		0.075	8
4.75		0.0135	5

% Retained

Largest Sieve - 1% at 1.18 mm:

Note: Sample supplied by client.

Approved Signatory:  (J.Reid)

Date: 31/05/2007



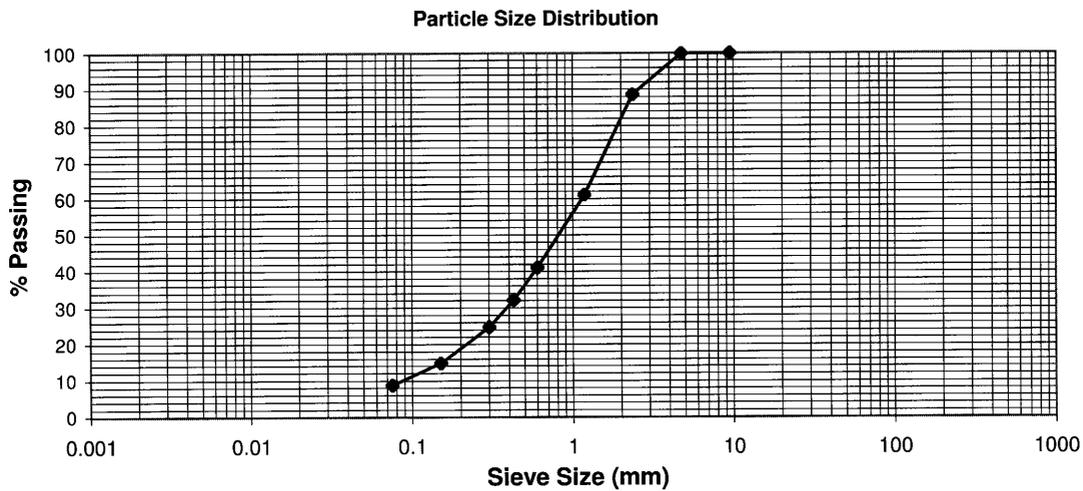
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### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 17 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1857  
 Depth: 100mm

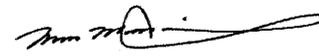
### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	89
		1.18	61
		0.600	41
		0.425	32
		0.300	25
9.5	100	0.150	15
4.75	100	0.075	9

Notes:  
 Sample supplied by client

Certificate No.:07-WG-1857 / S301

Approved Signatory:  ( M.Matthews ) Date: 9/05/2007



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Western Geotechnics Group  
 PO Box 219 Bentley WA 6982  
 36 Railway Parade  
 Welshpool WA 6106



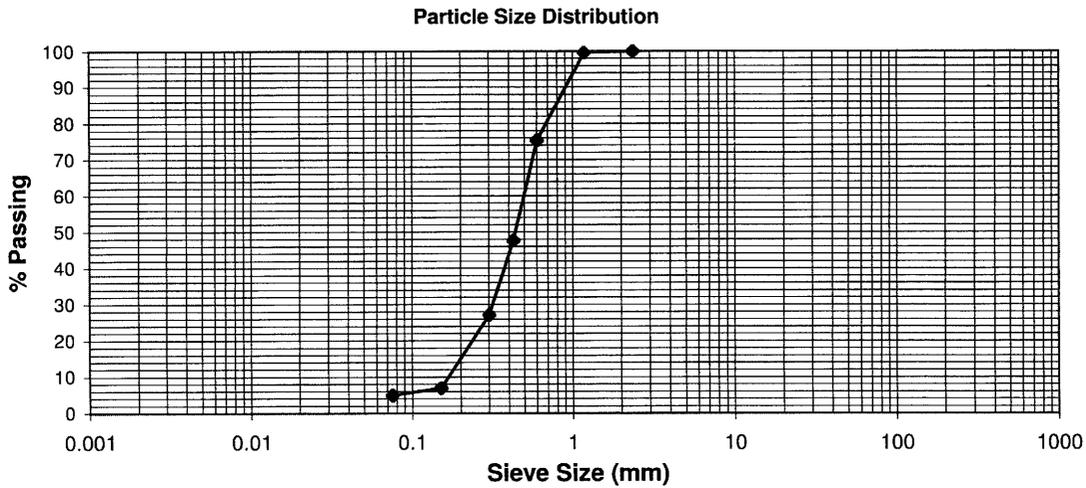
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 17 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1858  
 Depth: 500mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	100
		0.600	75
		0.425	48
		0.300	27
		0.150	7
		0.075	5

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1858 / S301

Approved Signatory:

( M.Matthews )

Date:

9/05/2007



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# TEST CERTIFICATE

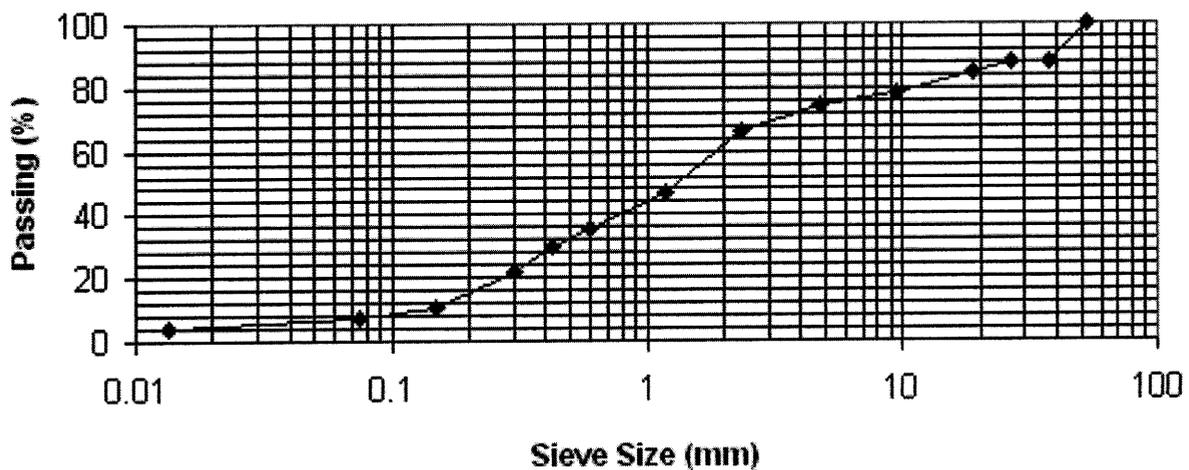
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3346  
 Sample ID: Dong - 25 2.8m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution

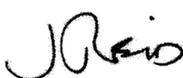


Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	66
75.0		1.18	46
53.0	100	0.600	36
37.5	88	0.425	30
26.5	88	0.300	22
19.0	85	0.150	11
9.50	78	0.075	7
4.75	74	0.0135	4

% Retained

Largest Sieve - 12% at 37.5 mm:

Note: Sample supplied by client.

Approved Signatory:  (J.Reid)

Date: 31/05/2007

# TEST CERTIFICATE

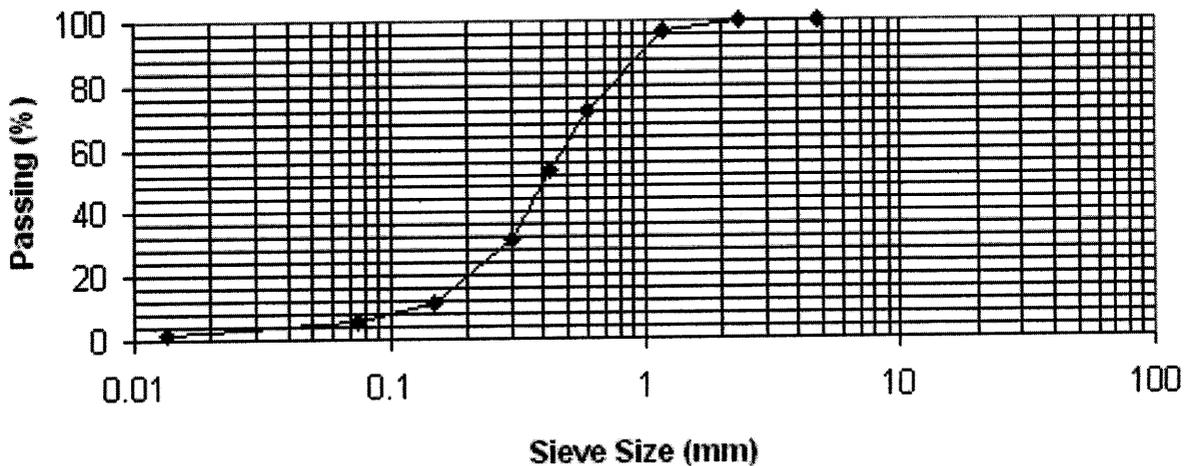
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3347  
 Sample ID: Dong - 26 1.0m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

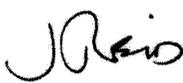
### Particle Size Distribution



Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	97
53.0		0.600	72
37.5		0.425	53
26.5		0.300	32
19.0		0.150	11
9.50		0.075	6
4.75	100	0.0135	1

% Retained  
 Largest Sieve - 3% at 1.18 mm:

Note: Sample supplied by client.

Approved Signatory:  (J.Reid)

Date: 31/05/2007



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# TEST CERTIFICATE

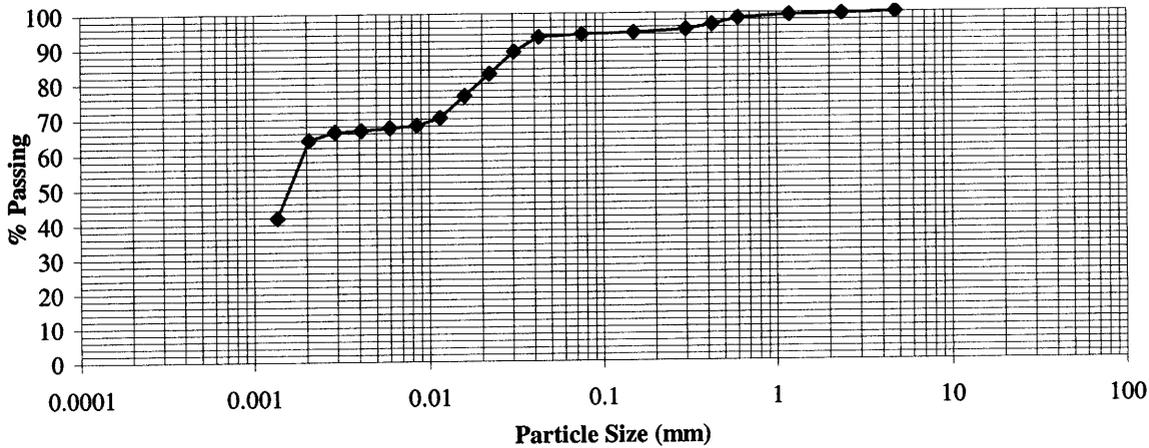
## PARTICLE SIZE DISTRIBUTION TEST RESULTS - according to AS 1289 3.6.2



Page 1 of 1

**CLIENT:** TIWEST Joint Venture  
**PROJECT:** Dongara Survey  
**LOCATION:** Dongara  
**Sample No.:**  
**Sample Id.:** Dong - 21A

**JOB NO.:** 07-01-594  
**Client Job No.:**  
**Lab Ref No.:** 07-WG-3345  
**Date Tested:** 25/05/07  
**Depth (m):** 0.4m



**SIEVING**

Sieve Size (mm)	Passing (%)
37.5	
19.0	
9.5	
4.75	100
2.36	99
1.18	99
0.600	98
0.425	97
0.300	95
0.150	94
0.075	94

**HYDROMETER**

Particle Diameter (mm)	Finer (%)
0.0425	93
0.0305	89
0.0221	83
0.0159	76
0.0115	70
0.0085	68
0.0060	67
0.0041	67
0.0029	66
0.0021	64
0.0014	42

**Note:** Sample supplied by client  
 An assumed specific gravity of 2.7 has been used in the calculation of this test.

Approved Signatory: J Reid (J.Reid)

Certificate No.: 07-WG-3345 / S303  
 Date: 31/05/2007



Accreditation No. 2418

SN 2411

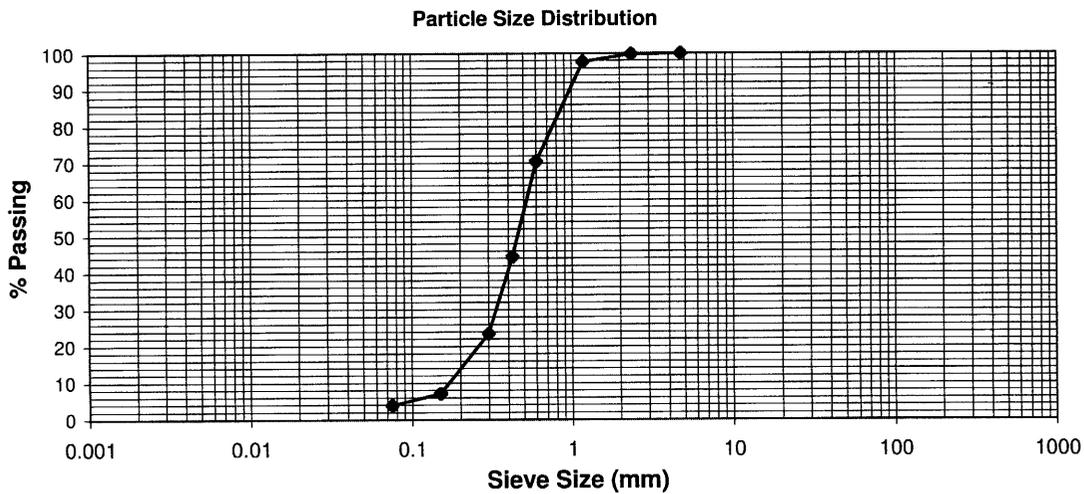
This document is issued in accordance with NATA's accreditation requirements

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 27 - A

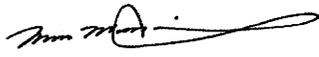
Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1862  
 Depth: 150mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	98
		0.600	70
		0.425	44
		0.300	23
		0.150	7
4.75	100	0.075	4

Notes:  
 Sample supplied by client



Certificate No.:07-WG-1862 / S301

Approved Signatory:

( M.Matthews )

Date: 9/05/2007



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 Welshpool WA 6106



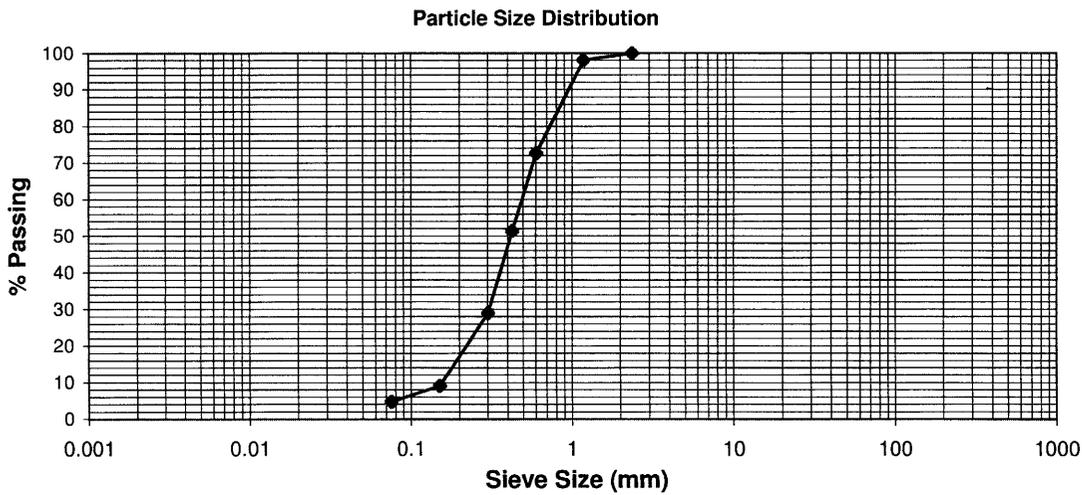
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 27 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1863  
 Depth: 600mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	98
		0.600	73
		0.425	51
		0.300	29
		0.150	9
		0.075	5

Notes:  
 Sample supplied by client

Approved Signatory:

( M. Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1863 / S301



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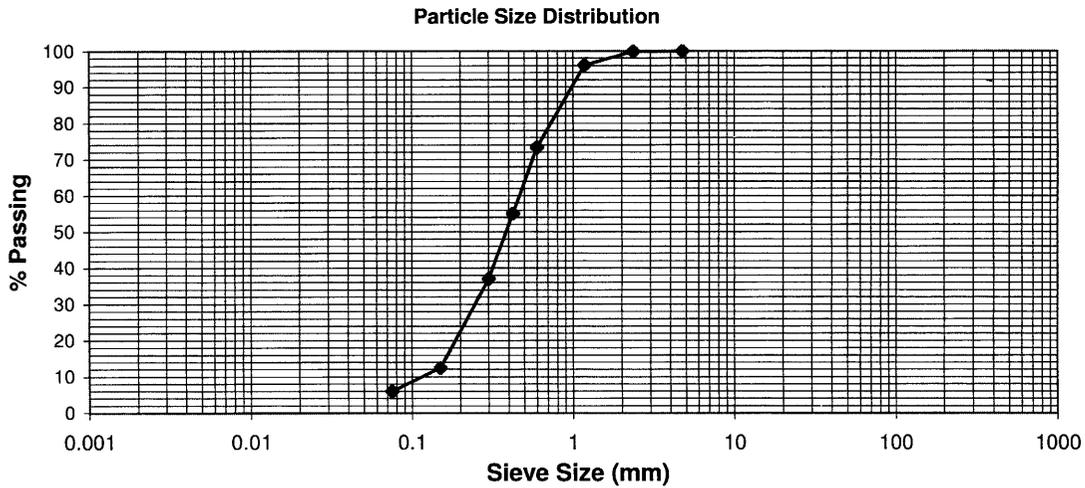
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 27 - C

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1864  
 Depth: 1100mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
4.75	100	2.36	100
		1.18	96
		0.600	73
		0.425	55
		0.300	37
		0.150	12
		0.075	6

Notes:  
 Sample supplied by client

Certificate No.:07-WG-1864 / S301

Approved Signatory:

( M.Matthews )

Date: 9/05/2007



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# TEST CERTIFICATE

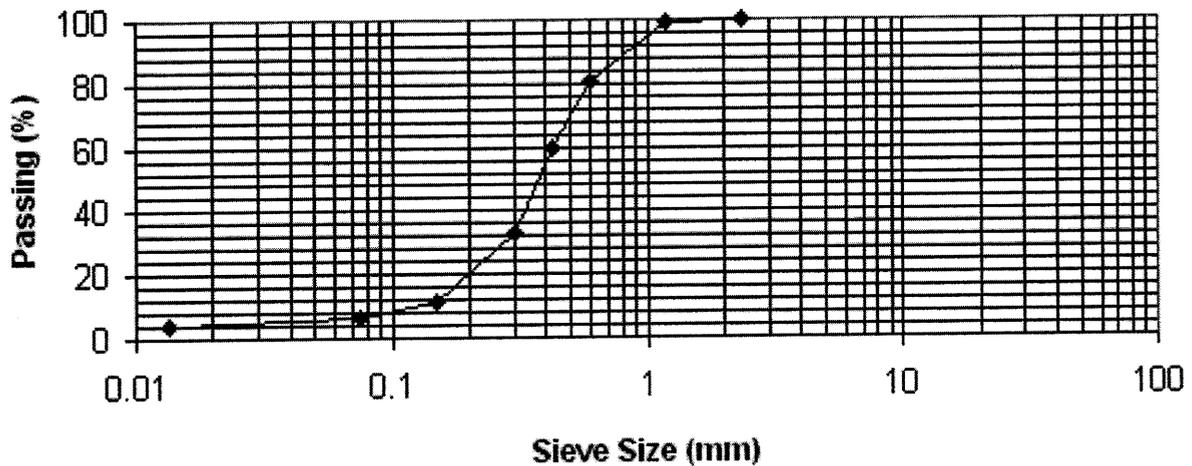
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3348  
 Sample ID: Dong - 32 1.0m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution



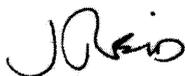
Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	99
53.0		0.600	80
37.5		0.425	60
26.5		0.300	33
19.0		0.150	11
9.50		0.075	6
4.75		0.0135	4

% Retained

Largest Sieve - 1% at 1.18 mm:

Note: Sample supplied by client.

Approved Signatory:



(J.Reid)

Date: 31/05/2007



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perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

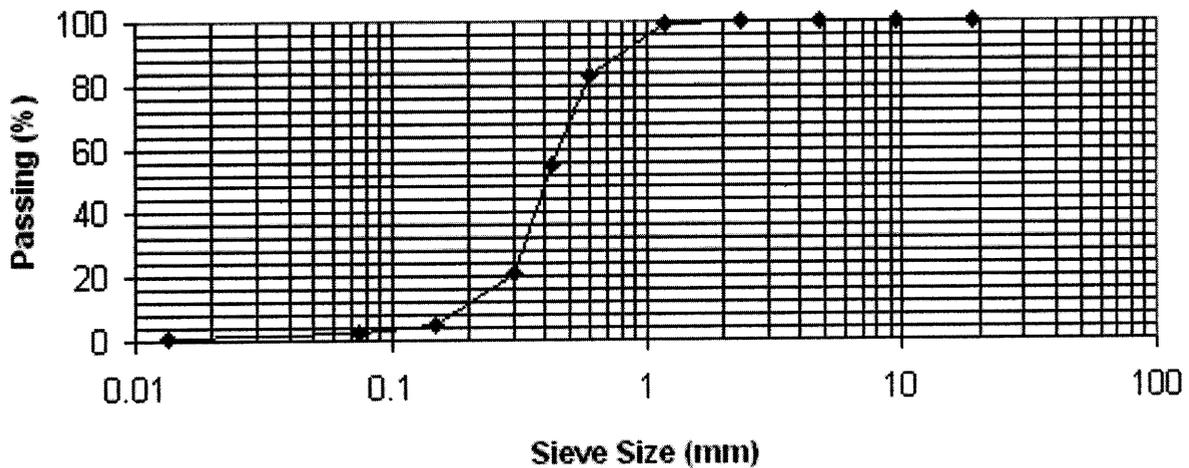
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3349  
 Sample ID: Dong - 35 0.3m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution



Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	99
53.0		0.600	83
37.5		0.425	55
26.5		0.300	21
19.0	100	0.150	4
9.50	100	0.075	3
4.75	100	0.0135	1

% Retained  
 Largest Sieve - 1% at 1.18 mm:

Note: Sample supplied by client.

Approved Signatory:  (J.Reid)

Date: 31/05/2007



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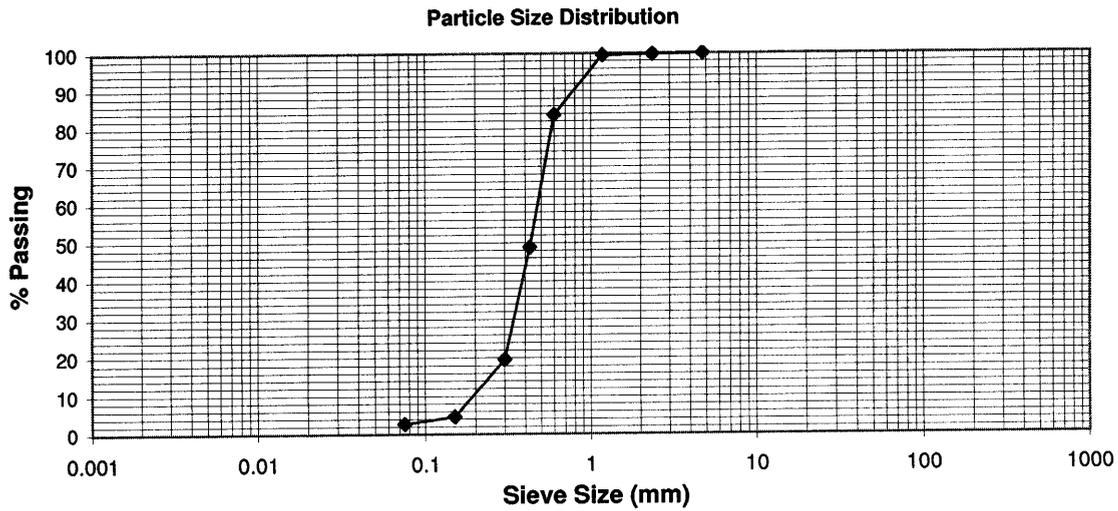
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 35 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1854  
 Depth: 180mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	100
		0.600	84
		0.425	49
		0.300	20
		0.150	5
4.75	100	0.075	3

Notes:  
 Sample supplied by client

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1854 / S301



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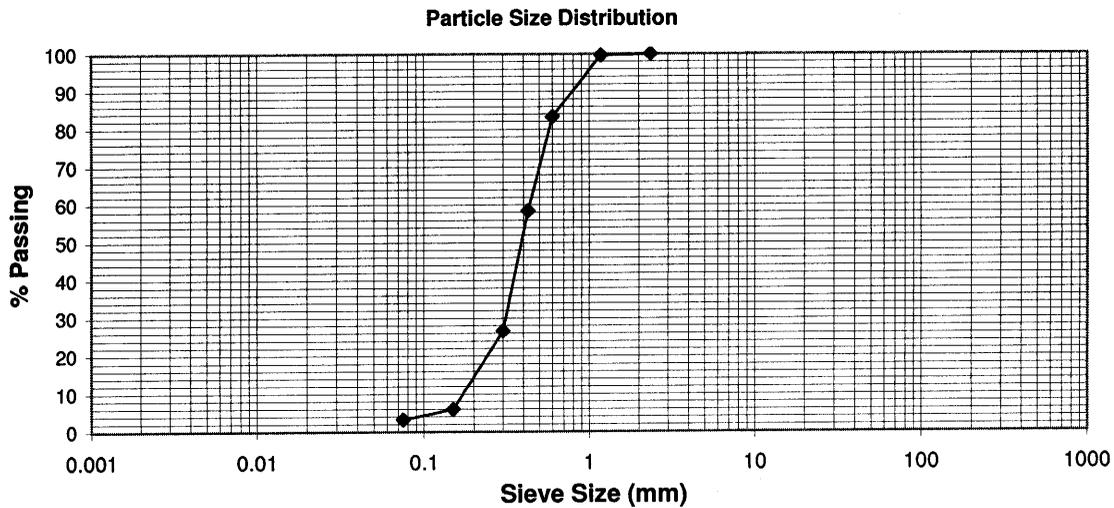
SN 2411

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 35 - B

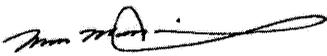
Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1855  
 Depth: 680mm

#### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	100
		0.600	83
		0.425	58
		0.300	27
		0.150	6
		0.075	3

Notes:  
 Sample supplied by client



Approved Signatory:

( M.Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1855 / S301



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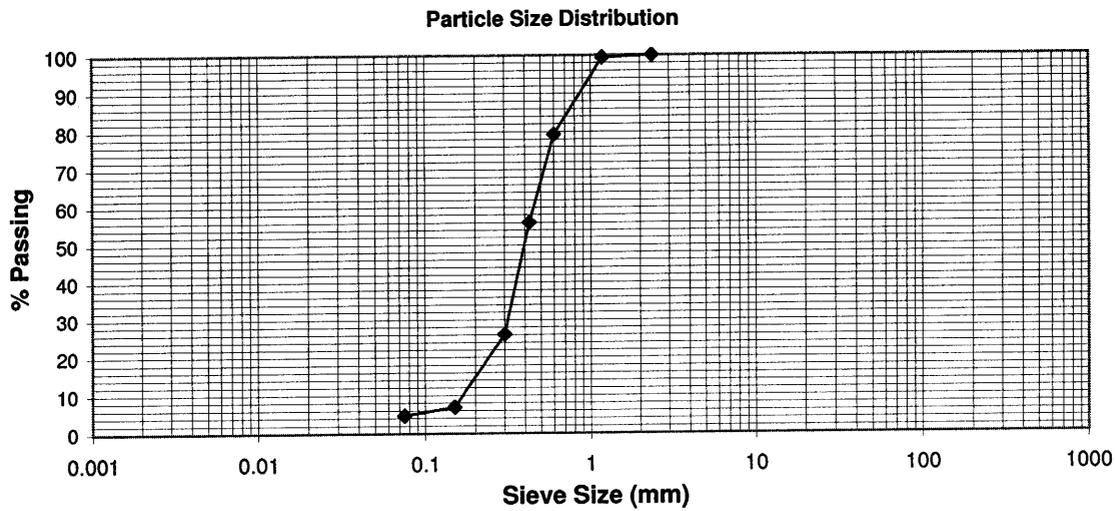
### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 35 - C

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1856  
 Depth: 1200mm

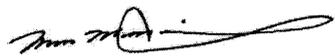
### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION

-acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	99
		0.600	79
		0.425	56
		0.300	26
		0.150	7
		0.075	5

Notes:  
 Sample supplied by client



Approved Signatory: \_\_\_\_\_ ( M.Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1856 / S301



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# TEST CERTIFICATE



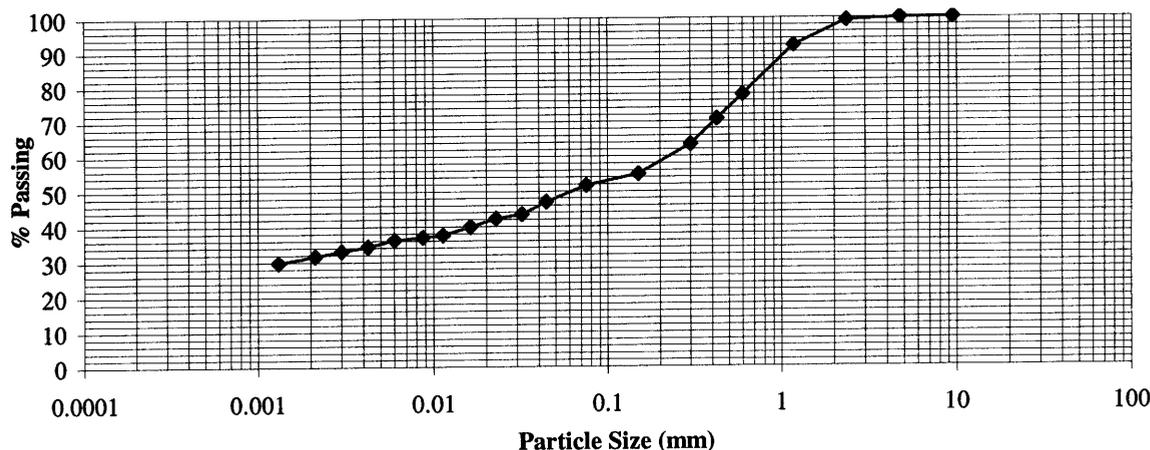
## PARTICLE SIZE DISTRIBUTION TEST RESULTS

- according to AS 1289 3.6.2

Page 1 of 1

**CLIENT:** TIWEST Joint Venture  
**PROJECT:** Dongara Survey  
**LOCATION:** Dongara  
**Sample No.:**  
**Sample Id.:** Dong - 40

**JOB NO.:** 07-01-594  
**Client Job No.:**  
**Lab Ref No.:** 07-WG-3351  
**Date Tested:** 25/05/07  
**Depth (m):** 0.6m



SIEVING	
Sieve Size (mm)	Passing (%)
37.5	75
19.0	65
9.5	58
4.75	52
2.36	48
1.18	45
0.600	42
0.425	38
0.300	35
0.150	32
0.075	30

HYDROMETER	
Particle Diameter (mm)	Finer (%)
0.0441	47
0.0319	43
0.0227	42
0.0163	40
0.0113	38
0.0087	37
0.0060	36
0.0042	34
0.0030	33
0.0021	32
0.0013	30

**Note:** Sample supplied by client  
 An assumed specific gravity of 2.7 has been used in the calculation of this test.

Approved Signatory:  (J.Reid)

Date: 31/05/2007 Certificate No.: 07-WG-3351 / S303



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# TEST CERTIFICATE



perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

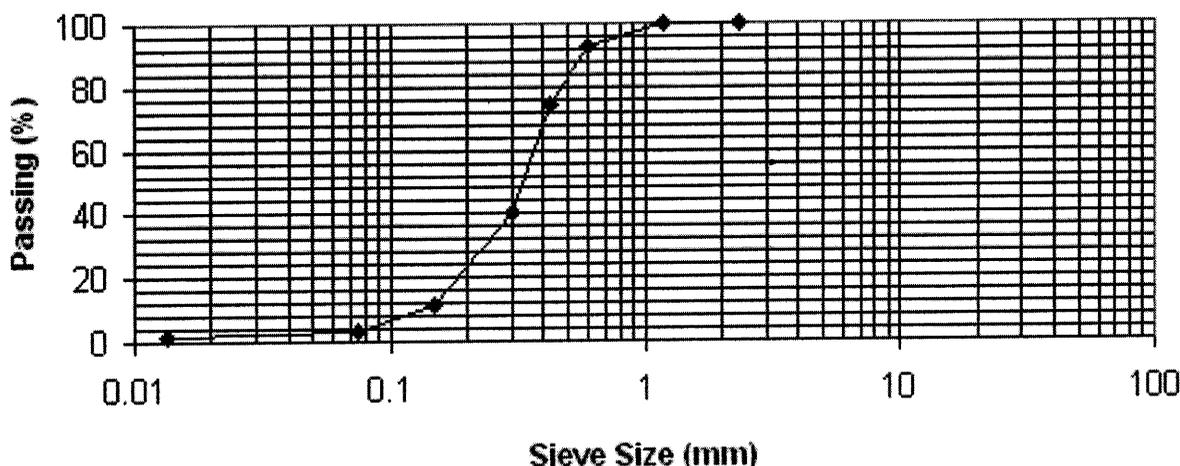
Client: TIWEST Joint Venture  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-3352  
 Sample ID: Dong - 54 0.7m

Client Job No:  
 Order No: CZ6224  
 Tested Date: 23/05/2007  
 WG Job Number: 07-01-594  
 Lab: Welshpool

## PSD: PARTICLE SIZE DISTRIBUTION

WA115.1 Decantation & sieving

### Particle Size Distribution



Sieve Size (mm)	Passing (%)	Sieve Size (mm)	Passing (%)
150.0		2.36	100
75.0		1.18	100
53.0		0.600	93
37.5		0.425	74
26.5		0.300	41
19.0		0.150	11
9.50		0.075	4
4.75		0.0135	2

% Retained

Largest Sieve - 7% at 0.6 mm:

Note: Sample supplied by client.

Approved Signatory:

(J.Reid)

Date: 31/05/2007



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 Welshpool WA 6106



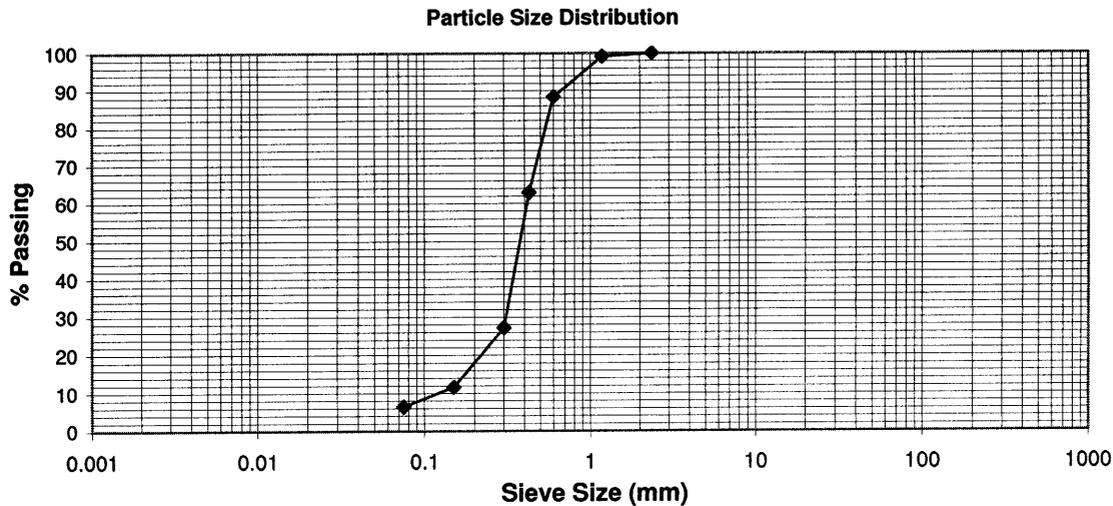
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 53 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1849  
 Depth: 200mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	99
		0.600	88
		0.425	63
		0.300	27
		0.150	12
		0.075	6

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1849 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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 Welshpool WA 6106



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 ph: 1300 781 744  
 fx: (08) 9458 3700

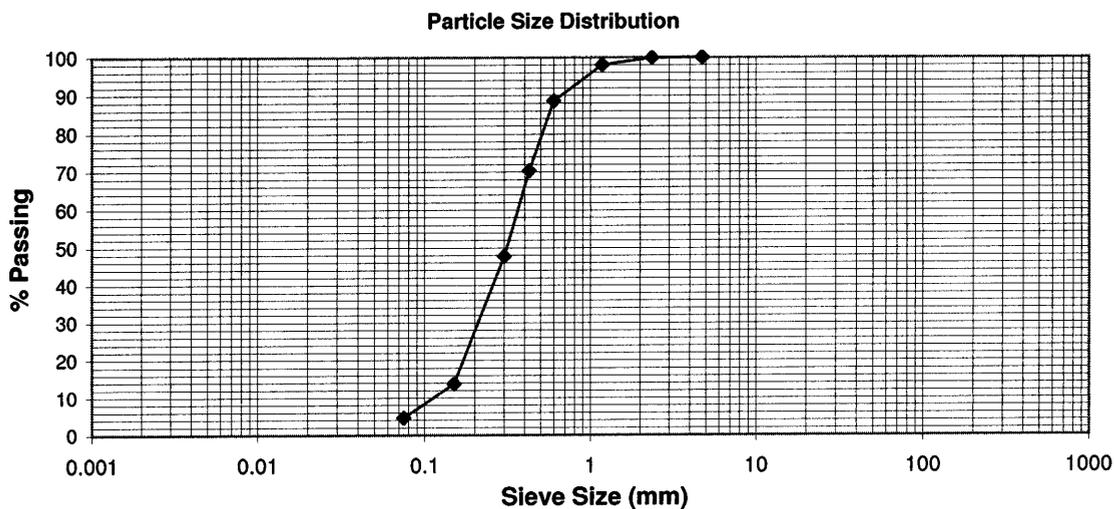
### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 53 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1850  
 Depth: 700mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION

-acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
4.75	100	0.075	5
		0.150	14
		0.300	48
		0.425	70
		0.600	89
		1.18	98
		2.36	100

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1850 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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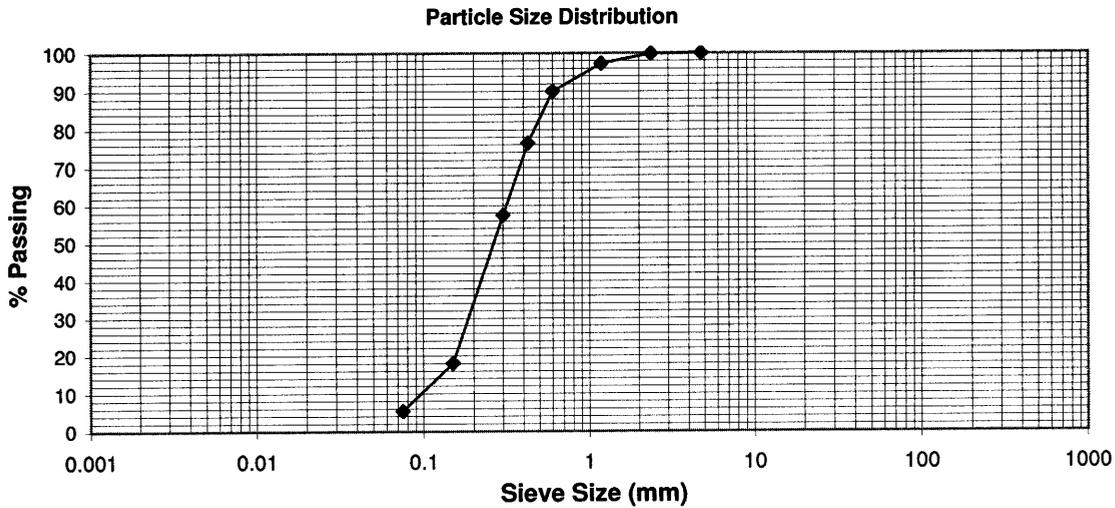
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

**TEST CERTIFICATE**

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 53 - C

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1851  
 Depth: 1100mm

**METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION**  
 -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
4.75	100	2.36	100
		1.18	97
		0.600	90
		0.425	76
		0.300	57
		0.150	18
		0.075	5

Notes:  
 Sample supplied by client

Approved Signatory:

( M.Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1851 / S301



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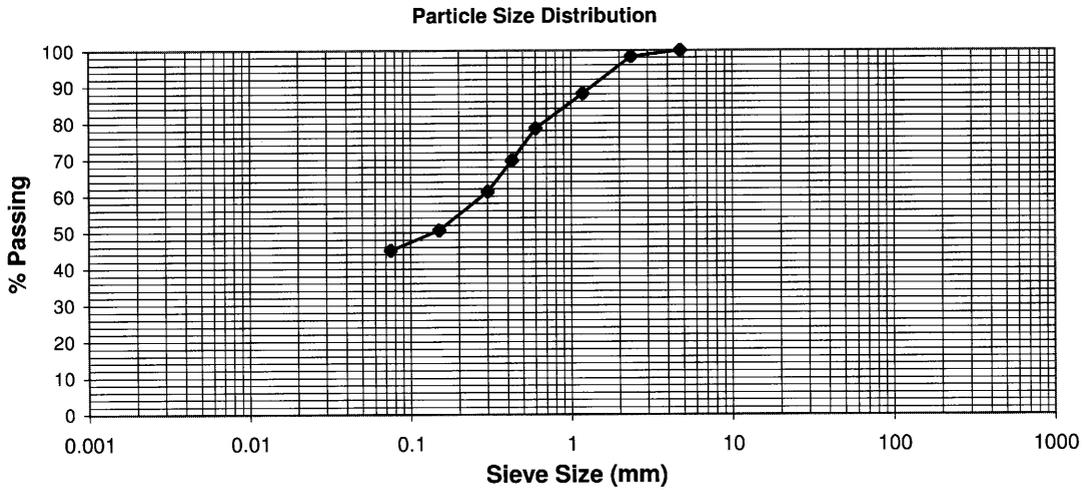
SN 2411

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 55 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1847  
 Depth: 200mm

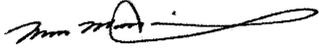
### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	98
		1.18	88
		0.600	79
		0.425	70
		0.300	61
		0.150	51
4.75	100	0.075	45

Notes:  
 Sample supplied by client

Certificate No.:07-WG-1847 / S301

Approved Signatory:  ( M.Matthews ) Date: 9/05/2007



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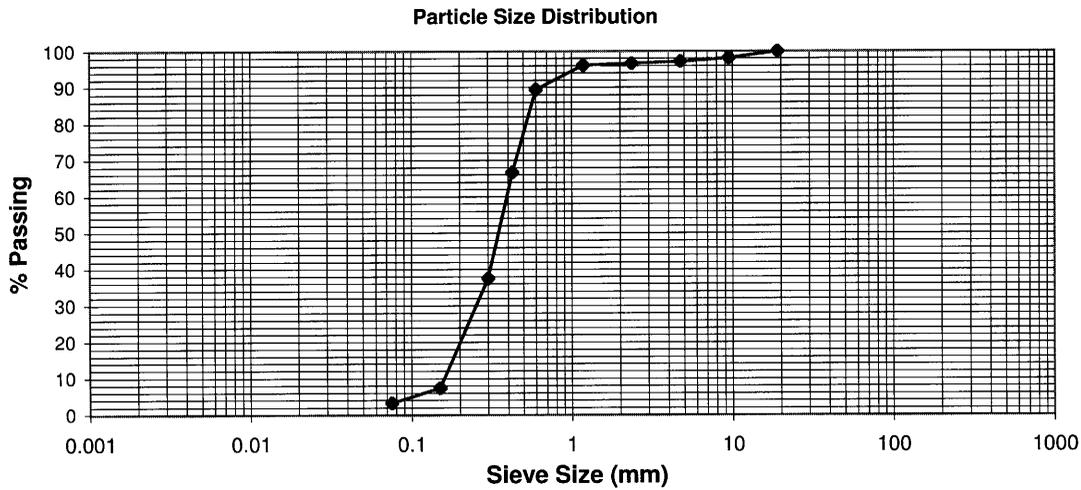
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 55 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1848  
 Depth: 700mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	97
		1.18	96
		0.600	89
		0.425	67
19.0	100	0.300	38
9.5	98	0.150	7
4.75	97	0.075	3

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1848 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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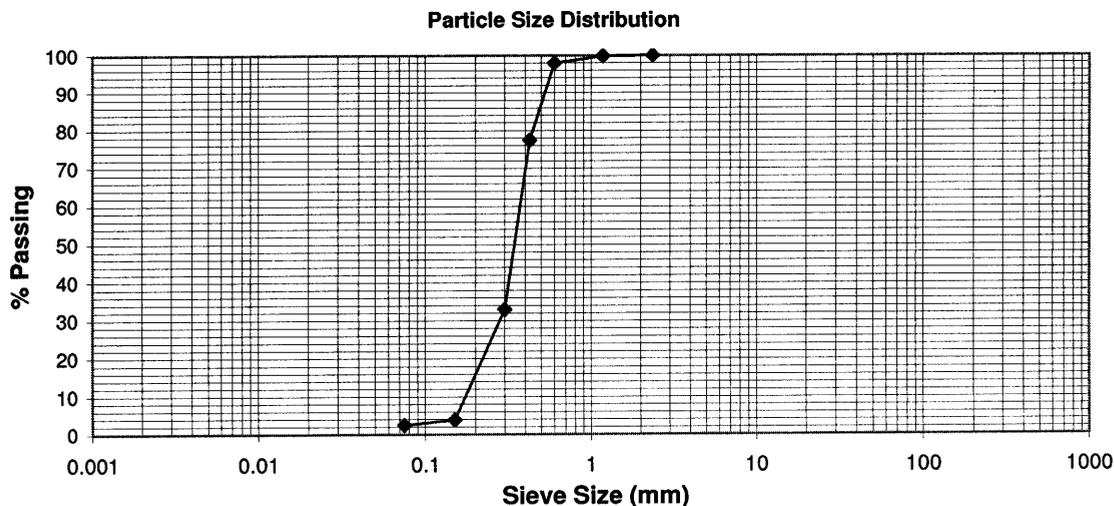
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 66 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1844  
 Depth: 250mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
2.36	100		
1.18	100		
0.600	98		
0.425	77		
0.300	33		
0.150	4		
0.075	3		

Notes:  
 Sample supplied by client

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1844 / S301



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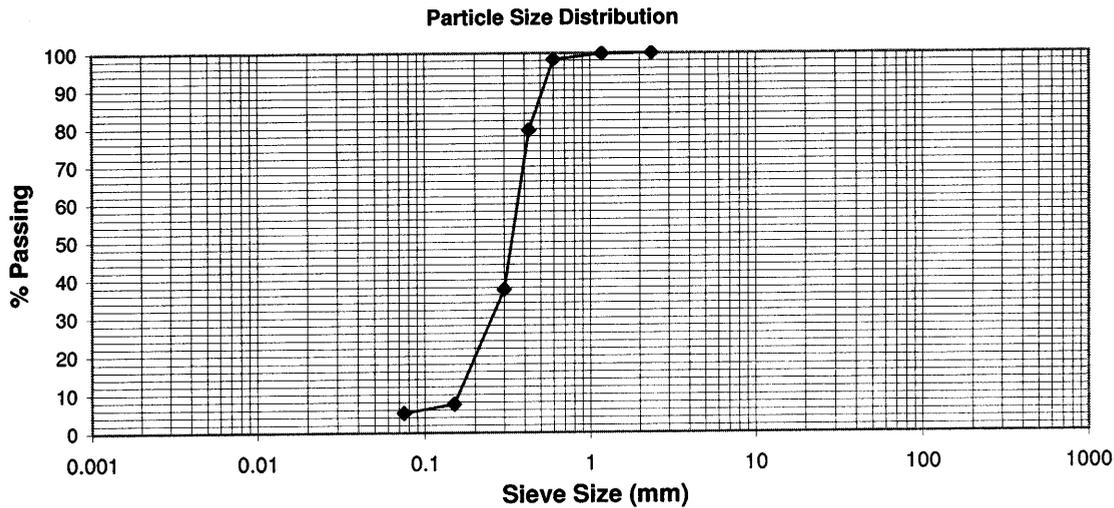
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 66 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1845  
 Depth: 720mm

#### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
2.36	100		
1.18	100		
0.600	98		
0.425	80		
0.300	37		
0.150	8		
0.075	5		

Notes:  
 Sample supplied by client

Approved Signatory: \_\_\_\_\_ ( M. Matthews )

Date: 9/05/2007

Certificate No.:07-WG-1845 / S301



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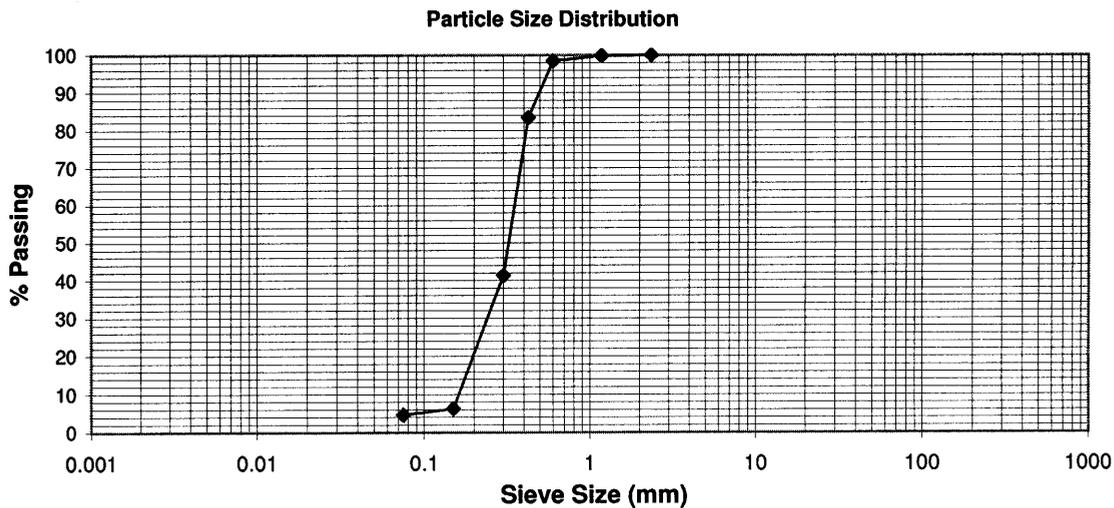
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 66 - C

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1846  
 Depth: 1300

#### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	100
		0.600	98
		0.425	83
		0.300	41
		0.150	6
		0.075	5

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1846 / S301

Approved Signatory: \_\_\_\_\_

( M.Matthews )

Date: 9/05/2007



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Western Geotechnics Group  
 PO Box 219 Bentley WA 6982  
 36 Railway Parade  
 Welshpool WA 6106



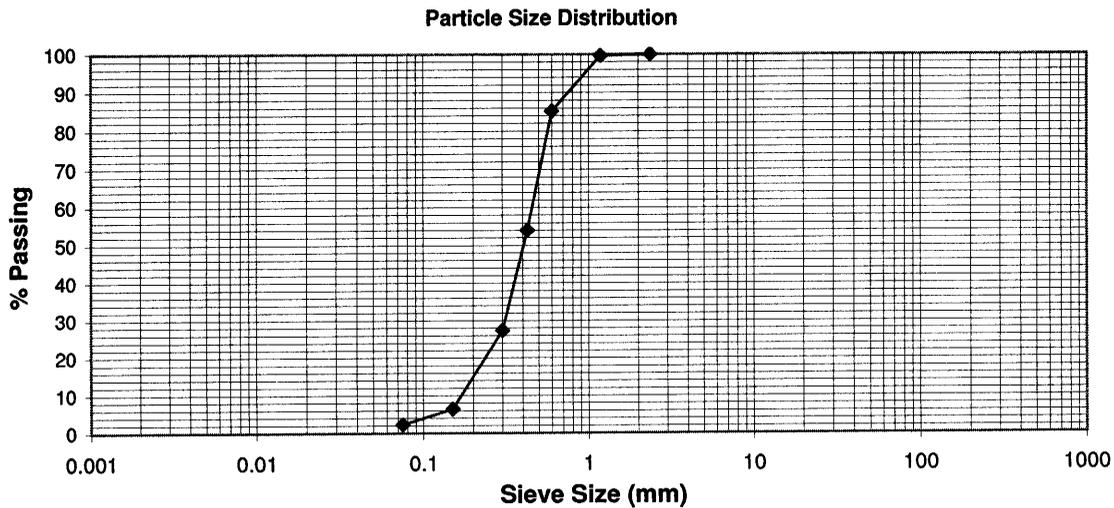
perth@westerngeo.com.au  
 ABN 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 88 - A

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1852  
 Depth: 280mm

### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
		2.36	100
		1.18	100
		0.600	85
		0.425	54
		0.300	27
		0.150	6
		0.075	2

Notes:  
 Sample supplied by client

*(Signature)*

Certificate No.:07-WG-1852 / S301

Approved Signatory:

( M.Matthews )

Date: 9/05/2007



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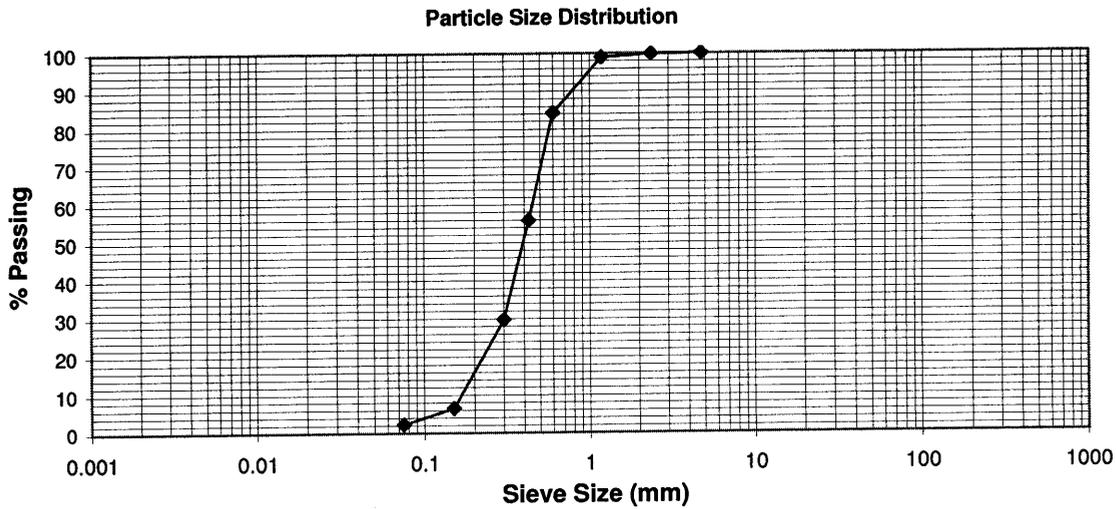
SN 2411

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 88 - B

Client Job No.:  
 Test Date: 30/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1853  
 Depth: 800mm

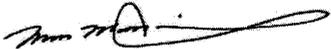
### METHOD FOR DETERMINATION OF PARTICLE SIZE DISTRIBUTION -acc to AS 1289.3.6.1



Sieve Size (mm)	% Passing	Sieve Size (mm)	% Passing
4.75	100	2.36	100
		1.18	99
		0.600	84
		0.425	56
		0.300	30
		0.150	7
		0.075	2

Notes:  
 Sample supplied by client

Certificate No.:07-WG-1853 / S301

Approved Signatory:  ( M.Matthews ) Date: 9/05/2007



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**APPENDIX IV**  
**DRY DENSITY RATIOS**

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.  
Sample ID.: Site 12 - A

Client Job No.: CZ6224  
Order No.:  
Test Date:  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1859

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	A	B	C
Location	Site 12	Site 12	Site 12
	-200mm	-730mm	-1200mm
Lift/Course:			
Mode (mm):	100	250	300
Field Wet Density ( $t/m^3$ )	1.71	1.68	1.72
Field Dry Density ( $t/m^3$ )	1.71	1.67	1.68
Field Moisture Content (%): (AS 1289.2.1.1)	0.5	0.5	2.0

#### TEST RESULTS

Variation of Moisture (%):

Wet/Dry  
opt moist

Moisture Ratio (%):

Dry Density Ratio (%):

(AS 1289.5.4.1) (Note: Calculated from Rounded data)

#### LABORATORY COMPACTION DATA

(AS 1289.5.2.1)

Laboratory Sample No.:

Optimum Moisture Content (%):

Maximum Dry Density ( $t/m^3$ ):

Retained + 19.0mm (Wet)

Retained + 19.0mm (Dry)

Notes: Test location Details provided by Client. Field Dry Densities Only as requested by client.

Approved Signatory:

( M.Matthews )

Certificate No.:07-WG-1859 / S409

Date: 9/05/2007



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## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.:  
Sample ID.: Site 17 - A

Client Job No.: CZ6224  
Order No.:  
Test Date:  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1857

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	A	B
Location	Site 17	Site 17
	-100mm	-500mm
Lift/Course:		
Mode (mm):	250	200
Field Wet Density (t/m <sup>3</sup> )	1.17	1.61
Field Dry Density (t/m <sup>3</sup> )	<b>0.93</b>	<b>1.58</b>
Field Moisture Content (%): (AS 1289.2.1.1)	<b>26.0</b>	<b>2.0</b>

#### TEST RESULTS

Variation of Moisture (%):

Wet/Dry  
opt moist

Moisture Ratio (%):

Dry Density Ratio (%):

(AS 1289.5.4.1) (Note: Calculated from Rounded data)

#### LABORATORY COMPACTION DATA

(AS 1289.5.2.1)

Laboratory Sample No.:

Optimum Moisture Content (%):

Maximum Dry Density (t/m<sup>3</sup>):

Retained + 19.0mm (Wet)

Retained + 19.0mm (Dry)

Notes: Test location Details provided by Client. Field Dry Densities Only as requested by client.

Certificate No.:07-WG-1857 / S409

Approved Signatory:

( M.Matthews )

Date: 9/05/2007



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## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.  
Sample ID.: Site 27 - A

Client Job No.: CZ6224  
Order No.:  
Test Date:  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1862

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	A	B	C
Location	Site 27	Site 27	Site 27
	-150mm	-600mm	-1100mm
Lift/Course:			
Mode (mm):	200	300	250
Field Wet Density (t/m <sup>3</sup> )	1.65	1.60	1.64
Field Dry Density (t/m <sup>3</sup> )	<b>1.64</b>	<b>1.59</b>	<b>1.63</b>
Field Moisture Content (%): (AS 1289.2.1.1)	<b>0.5</b>	<b>0.5</b>	<b>0.5</b>

#### TEST RESULTS

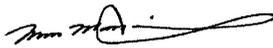
Variation of Moisture (%):  
Wet/Dry  
opt moist

Moisture Ratio (%):  
Dry Density Ratio (%):  
(AS 1289.5.4.1) (Note: Calculated from Rounded data)

#### LABORATORY COMPACTION DATA (AS 1289.5.2.1)

Laboratory Sample No.:  
Optimum Moisture Content (%):  
Maximum Dry Density (t/m<sup>3</sup>):  
Retained + 19.0mm (Wet)  
Retained + 19.0mm (Dry)

Notes: Test location Details provided by Client. Field Dry Densities Only as requested by client.



Approved Signatory:

( M. Matthews )

Certificate No.: 07-WG-1862 / S409

Date: 9/05/2007



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## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.  
Sample ID.: Site 35

Client Job No.: CZ6224  
Order No.:  
Test Date: 26/04/07  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1854

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	A	B	C
Location	Site 35	Site 35	Site 35
	-180mm	-680mm	-1200mm
Lift/Course:			
Mode (mm):	300	200	300
Field Wet Density ( $t/m^3$ )	1.53	1.64	1.65
Field Dry Density ( $t/m^3$ )	1.53	1.63	1.62
Field Moisture Content (%): (AS 1289.2.1.1)	0.5	0.5	1.5

#### TEST RESULTS

Variation of Moisture (%):	12.5	12.0	11.0
Wet/Dry opt moist	Dry 13.0	Dry 12.5	Dry 12.5
Moisture Ratio (%):	4.0	5.5	13.5
Dry Density Ratio (%): (AS 1289.5.4.1) (Note: Calculated from Rounded data)	89.0	90.5	89.5

#### LABORATORY COMPACTION DATA

(AS 1289.5.2.1)

Laboratory Sample No.:	1854	1855	1855
Optimum Moisture Content (%):	13.1	12.4	12.4
Maximum Dry Density ( $t/m^3$ ):	1.72	1.81	1.81
Retained + 19.0mm (Wet)			
Retained + 19.0mm (Dry)			

Notes: Test location Details provided by Client.

Certificate No.: 07-WG-1854 / S409

Approved Signatory:

( M.Mathews )

Date: 9/05/2007



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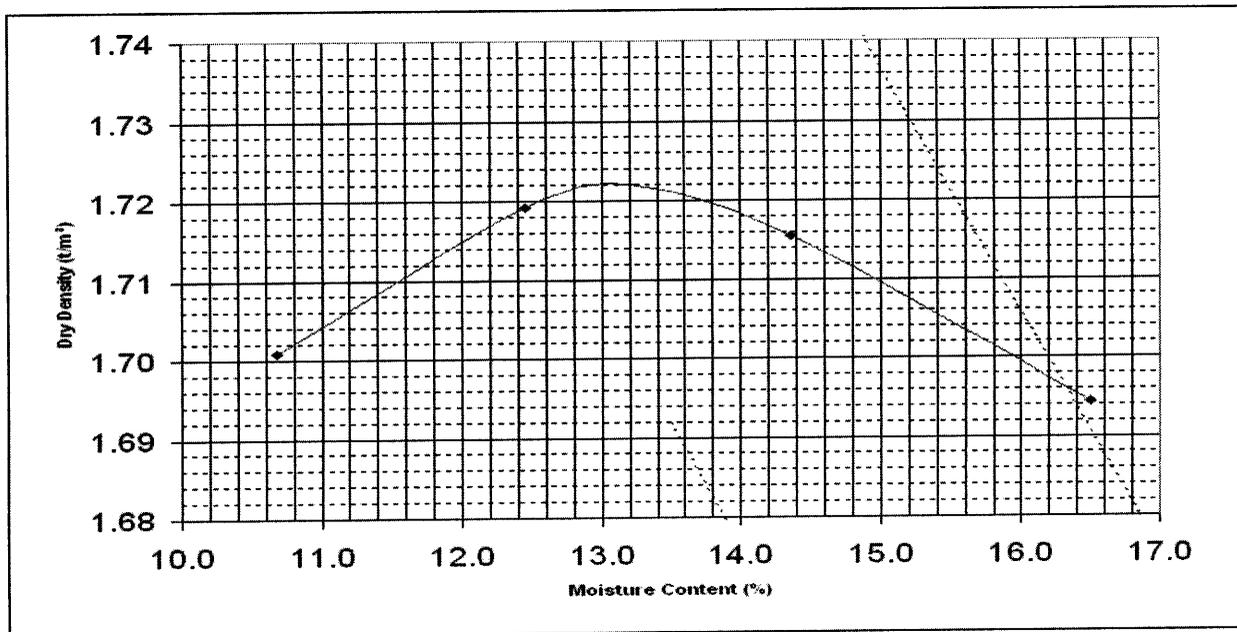
# TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-1854  
Sample ID: Site 35 - A 180mm

Client Job No:  
Order No: CZ6224  
Tested Date: 28/05/2007  
WG Job Number: 07-01-368  
Lab: Welshpool

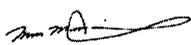
## COMPACTION TEST: MODIFIED

AS 1289.5.2.1



Modified Effort	
<b>Maximum Dry Density (t/m<sup>3</sup>)</b>	<b>1.72</b>
<b>Optimum Moisture Content (%)</b>	<b>13.0</b>
% Retained 19.0mm	0
% Retained 37.5mm	0

Note: Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 28/05/2007



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Cert No.: 07-WG-1854-S402  
Page: 1

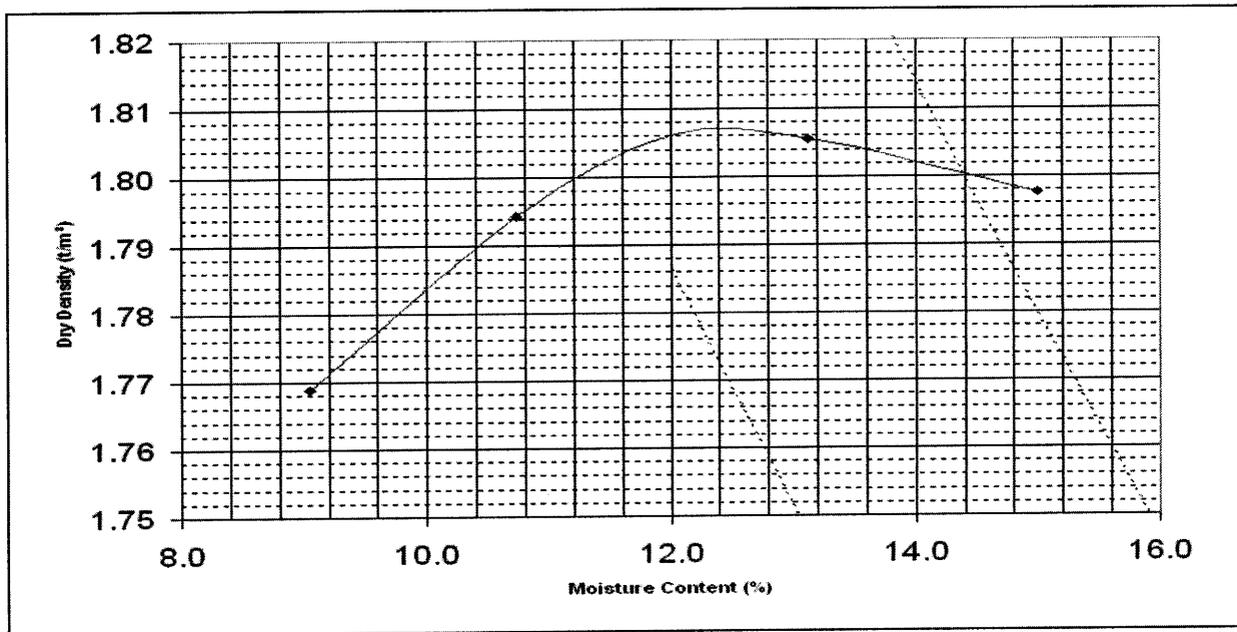
# TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-1855  
Sample ID: Site 35 - B 680mm

Client Job No:  
Order No: CZ6224  
Tested Date: 28/05/2007  
WG Job Number: 07-01-368  
Lab: Welshpool

## COMPACTION TEST: MODIFIED

AS 1289.5.2.1



Modified Effort	
<b>Maximum Dry Density (t/m<sup>3</sup>)</b>	<b>1.81</b>
<b>Optimum Moisture Content (%)</b>	<b>12.5</b>
% Retained 19.0mm	0
% Retained 37.5mm	0

Note: Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 28/05/2007



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Page: 1

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.:  
Sample ID.: Site 53

Client Job No.: CZ6224  
Order No.:  
Test Date: 25/04/07  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1849

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	B	C
Location	Site 53	Site 53
	-700mm	-1100mm
Lift/Course:		
Mode (mm):	200	300
Field Wet Density ( $t/m^3$ )	1.67	1.68
Field Dry Density ( $t/m^3$ )	1.66	1.67
Field Moisture Content (%): (AS 1289.2.1.1)	0.5	0.5
TEST RESULTS		
Variation of Moisture (%):	13.0	13.0
Wet/Dry	Dry	Dry
opt moist	13.5	13.5
Moisture Ratio (%):	3.0	5.5
Dry Density Ratio (%):	95.0	95.5
(AS 1289.5.4.1) (Note: Calculated from Rounded data)		

#### LABORATORY COMPACTION DATA (AS 1289.5.2.1)

Laboratory Sample No.:	1849	1849
Optimum Moisture Content (%):	13.7	13.7
Maximum Dry Density ( $t/m^3$ ):	1.75	1.75
Retained + 19.0mm (Wet)		
Retained + 19.0mm (Dry)		
MEAN	Max. Dry Density $t/m^3$ : 1.75	Opt. Moisture Cont. (%): 13.5

Notes: Test location Details provided by Client.

Certificate No.:07-WG-1849 / S409

Approved Signatory:

( M.Mathews )

Date: 9/05/2007



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# TEST CERTIFICATE



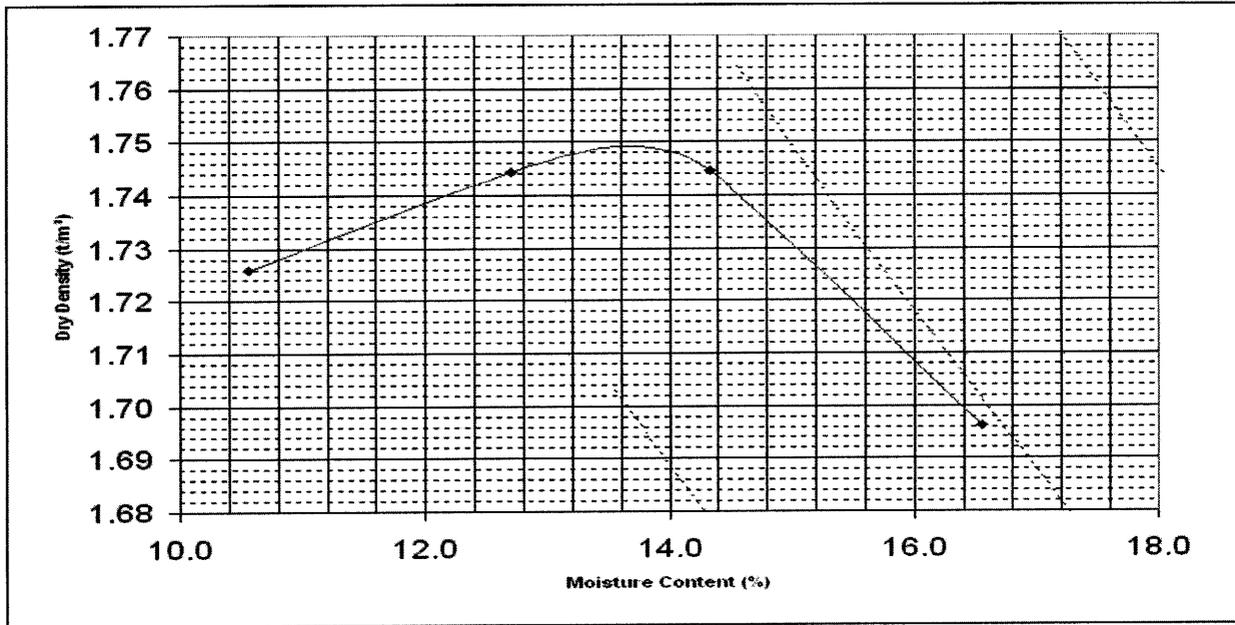
perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-1849  
 Sample ID: Site 53 - A 200mm

Client Job No:  
 Order No: CZ6224  
 Tested Date: 28/05/2007  
 WG Job Number: 07-01-368  
 Lab: Welshpool

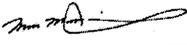
## COMPACTION TEST: MODIFIED

AS 1289.5.2.1



Modified Effort	
<b>Maximum Dry Density (t/m<sup>3</sup>)</b>	<b>1.75</b>
<b>Optimum Moisture Content (%)</b>	<b>13.5</b>
% Retained 19.0mm	0
% Retained 37.5mm	0

Note: Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 28/05/2007



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Western Geotechnics Group  
PO Box 219 Bentley WA 6982  
36 Railway Parade  
Welshpool WA 6106

**WgeoG**  
Western  
geotechnics  
Group  
perth@westerngeo.com.au  
ABN 91105324436  
ph: 1300 781 745  
fx: (08) 9458 3701

### TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.:  
Sample ID.: Site 55 - A

Client Job No.: CZ6224  
Order No.:  
Test Date:  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1847

#### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD -acc to AS 1289.5.8.1

TEST DATA

Location	A Site 55 -200mm
Lift/Course:	
Mode (mm):	100
Field Wet Density (t/m <sup>3</sup> )	1.31
Field Dry Density (t/m <sup>3</sup> )	1.15
Field Moisture Content (%): (AS 1289.2.1.1)	13.5

TEST RESULTS

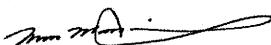
Variation of Moisture (%):  
Wet/Dry  
opt moist

Moisture Ratio (%):  
Dry Density Ratio (%):  
(AS 1289.5.4.1) (Note: Calculated from Rounded data)

#### LABORATORY COMPACTION DATA

Laboratory Sample No.:  
Optimum Moisture Content (%):  
Maximum Dry Density (t/m<sup>3</sup>):  
Retained + 19.0mm (Wet)  
Retained + 19.0mm (Dry)

Notes: Test location Details provided by Client. Field Dry Densities Only as requested by client.

Approved Signatory:  (M. Matthews) Date: 9/05/2007

Certificate No.: 07-WG-1847 / S409



Accreditation No. 2418

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## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No.:  
 Sample ID.: Site 66

Client Job No.: CZ6224  
 Order No.:  
 Test Date: 25/04/07  
 WG Job No.: 07-01-368  
 Lab No.: 07-WG-1844

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

	A	B	C
Location	Site 66	Site 66	Site 66
	-250mm	-720mm	-1300mm
Lift/Course:			
Mode (mm):	200	200	200
Field Wet Density (t/m <sup>3</sup> )	1.67	1.62	1.66
Field Dry Density (t/m <sup>3</sup> )	1.66	1.60	1.64
Field Moisture Content (%): (AS 1289.2.1.1)	1.0	1.0	1.0

#### TEST RESULTS

Variation of Moisture (%):	11.5	11.5	11.5
Wet/Dry	Dry	Dry	Dry
opt moist	12.5	12.5	12.5
Moisture Ratio (%):	7.0	8.5	8.5
Dry Density Ratio (%): (AS 1289.5.4.1) (Note: Calculated from Rounded data)	94.0	91.0	93.0

#### LABORATORY COMPACTION DATA

(AS 1289.5.2.1)

Laboratory Sample No.:	1844	1844	1844
Optimum Moisture Content (%):	12.4	12.4	12.4
Maximum Dry Density (t/m <sup>3</sup> ):	1.76	1.76	1.76
Retained + 19.0mm (Wet)			
Retained + 19.0mm (Dry)			

MEAN Max. Dry Density t/m<sup>3</sup>: 1.76 Opt. Moisture Cont. (%): 12.5

Notes: Test location Details provided by Client.

Certificate No.: 07-WG-1844 / S409

Approved Signatory:

(M. Matthews)

Date: 9/05/2007



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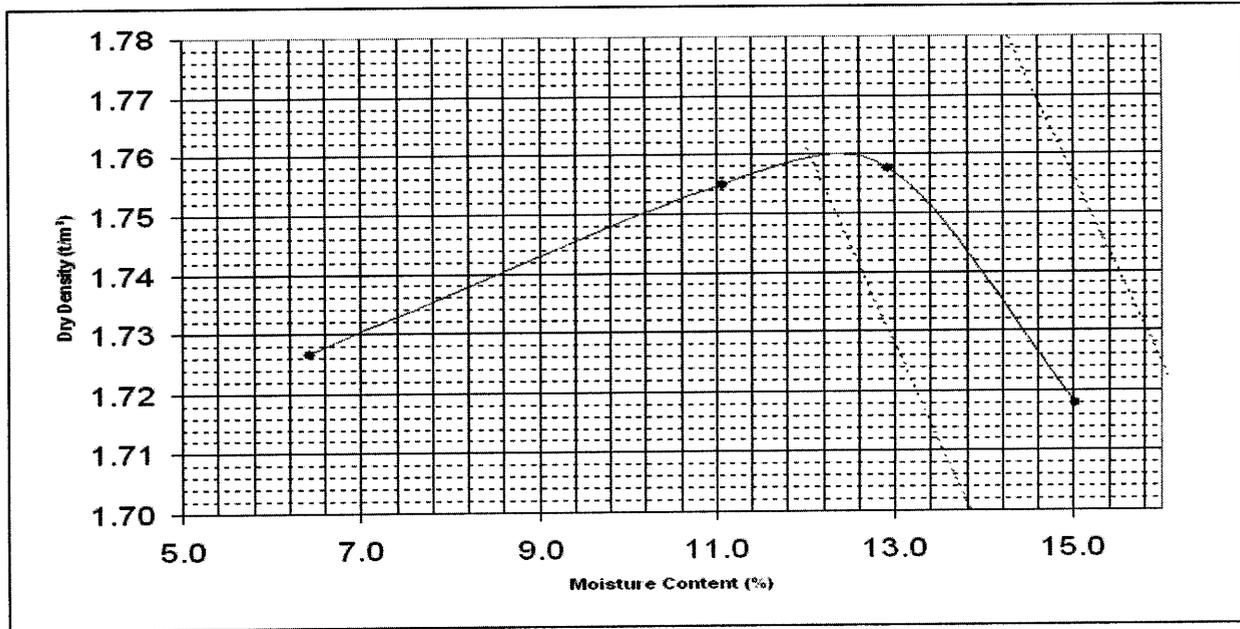
perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-1844  
 Sample ID: Site 66 - A 250mm

Client Job No:  
 Order No: CZ6224  
 Tested Date: 28/05/2007  
 WG Job Number: 07-01-368  
 Lab: Welshpool

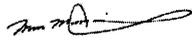
## COMPACTION TEST: MODIFIED

AS 1289.5.2.1



Modified Effort	
<b>Maximum Dry Density (t/m<sup>3</sup>)</b>	<b>1.76</b>
<b>Optimum Moisture Content (%)</b>	<b>12.5</b>
% Retained 19.0mm	0
% Retained 37.5mm	0

Note: Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 28/05/2007



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 Page: 1

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No.:  
Sample ID.: Site 88 - A

Client Job No.: CZ6224  
Order No.:  
Test Date: 26/04/07  
WG Job No.: 07-01-368  
Lab No.: 07-WG-1852

### SUMMARY OF COMPACTION CONTROL TESTS NUCLEAR DENSITY METER METHOD

-acc to AS 1289.5.8.1

#### TEST DATA

Location A  
Site 88  
-280mm

Lift/Course:

Mode (mm): 300

Field Wet Density ( $t/m^3$ ) 1.58

Field Dry Density ( $t/m^3$ ) 1.57

Field Moisture Content (%) 0.5  
(AS 1289.2.1.1)

#### TEST RESULTS

Variation of Moisture (%) 14.0

Wet/Dry Dry

opt moist 14.5

Moisture Ratio (%) 4.0

Dry Density Ratio (%) 90.5

(AS 1289.5.4.1) (Note: Calculated from Rounded data)

#### LABORATORY COMPACTION DATA

(AS 1289.5.2.1)

Laboratory Sample No.: 1852

Optimum Moisture Content (%) 14.3

Maximum Dry Density ( $t/m^3$ ): 1.74

Retained + 19.0mm (Wet)

Retained + 19.0mm (Dry)

MEAN Max. Dry Density  $t/m^3$ : 1.74 Opt. Moisture Cont. (%): 14.5

Notes: Test location Details provided by Client.

Certificate No.: 07-WG-1852 / S409

Approved Signatory:

(M. Matthews)

Date: 9/05/2007



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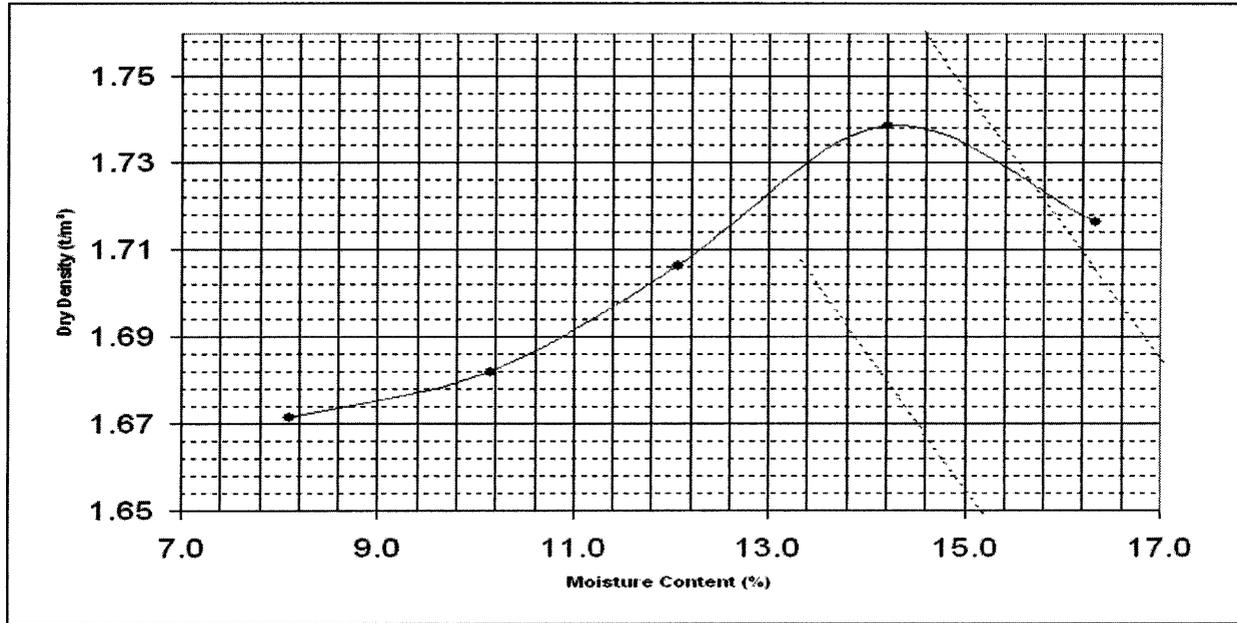
perth@westerngeo.com.au  
 ABN: 91105324436  
 ph: 1300 781 744  
 fx: (08) 9458 3700

Client: D.C. Blandford & Associates Pty Ltd  
 Project: Dongara Survey  
 Location: Dongara  
 Sample No: 07-WG-1852  
 Sample ID: Site 88 - A 280mm

Client Job No:  
 Order No: CZ6224  
 Tested Date: 28/05/2007  
 WG Job Number: 07-01-368  
 Lab: Welshpool

## COMPACTION TEST: MODIFIED

AS 1289.5.2.1



Modified Effort	
<b>Maximum Dry Density (t/m<sup>3</sup>)</b>	<b>1.74</b>
<b>Optimum Moisture Content (%)</b>	<b>14.5</b>
% Retained 19.0mm	0
% Retained 37.5mm	0

Note: Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 28/05/2007



Accreditation No.: 2418

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 Cert No.: 07-WG-1852-S402  
 Page: 1

**APPENDIX V**  
**PERMEABILITY**

## TEST CERTIFICATE

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-1841  
Sample ID: Site 37 - A 100mm

Client Job No:  
Order No: CZ6224  
Tested Date: 7/05/2007  
WG Job Number: 07-01-368  
Lab: Welshpool

### PERMEABILITY: CONSTANT HEAD

AS1289.6.7.1 Undisturbed sample

Dry Density (t/m<sup>3</sup>): 1.55

Field Moisture Content (%): 2.5

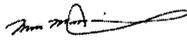
Hydraulic Gradient (mm) 1335

#### COEFFICIENT OF PERMEABILITY

m/s at 20 degrees C 1.1 x 10<sup>-4</sup>

Note: Deviation from standard method: Sample not remoulded, tested in undisturbed (as collected) state.

Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 9/05/2007

Site No.: 2411  
Cert No.: 07-WG-1841-S803  
Page: 1

Western Geotechnics Group  
PO Box 219 Bentley WA 6982  
36 Railway Parade  
Welshpool WA 6982

## TEST CERTIFICATE



perth@westerngeo.com.au  
ABN: 91105324436  
ph: 1300 781 744  
fx: (08) 9458 3700

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-1841  
Sample ID: Site 37 - A 100mm

Client Job No:  
Order No: CZ6224  
Tested Date: 7/05/2007  
WG Job Number: 07-01-368  
Lab: Welshpool

### PERMEABILITY: CONSTANT HEAD

AS1289.6.7.1 Undisturbed sample

Dry Density (t/m<sup>3</sup>): 1.55

Field Moisture Content (%): 2.5

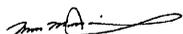
Hydraulic Gradient (mm) 1335

#### COEFFICIENT OF PERMEABILITY

m/s at 20 degrees C 1.1E-04

Note: Deviation from standard method: Sample not remoulded, tested in undisturbed (as collected) state.

Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 9/05/2007

Site No.: 2411  
Cert No.: 07-WG-1841-S803  
Page: 1

Western Geotechnics Group  
PO Box 219 Bentley WA 6982  
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## TEST CERTIFICATE



perth@westerngeo.com.au  
ABN: 91105324436  
ph: 1300 781 744  
fx: (08) 9458 3700

Client: D.C. Blandford & Associates Pty Ltd  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-1842  
Sample ID: Site 37 - B 900mm

Client Job No:  
Order No: CZ6224  
Tested Date: 7/05/2007  
WG Job Number: 07-01-368  
Lab: Welshpool

### PERMEABILITY: CONSTANT HEAD

AS1289.6.7.1 Undisturbed sample

Dry Density (t/m<sup>3</sup>): 1.49

Field Moisture Content (%): 2.5

Hydraulic Gradient (mm): 1330

#### COEFFICIENT OF PERMEABILITY

m/s at 20 degrees C 5.6 x 10<sup>-5</sup>

Note: Deviation from standard method: Sample not remoulded, tested in undisturbed (as collected) state.  
Sampled by WgeoG according to AS 1289.1.2.1.6.5 (insitu)

Approved Signatory:  (M. Matthews)

Date: 9/05/2007

Site No.: 2411  
Cert No.: 07-WG-1842-S803  
Page: 1

# TEST CERTIFICATE



Client: TIWEST Joint Venture  
Project: Dongara Survey  
Location: Dongara  
Sample No: 07-WG-3354  
Sample ID: Dong - 74 1.2m

Client Job No:  
Order No: CZ6224  
Tested Date: 28/05/2007  
WG Job Number: 07-01-594  
Lab: Welshpool

## PERMEABILITY: CONSTANT HEAD

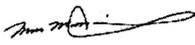
AS1289.6.7.1 Remoulded sample

Max. Dry Density (t/m <sup>3</sup> )	1.60
Optimum Moisture Content (%)	7.0
Dry Density (t/m <sup>3</sup> )	1.63
Dry Density Ratio (%)	101.7
Moisture Content (%)	5.0
Moisture Ratio (%)	72.0
Surcharge (kPa)	0.0
Hydraulic Gradient (mm)	1,343
Percentage Retained	0
Sieve Size (mm)	4.75
Compactive Effort	Max Dry Density (t/m <sup>3</sup> ):

### COEFFICIENT OF PERMEABILITY

m/s at 20 degrees C **1.0E-04**

Note: Sample supplied by client.

Approved Signatory:  (M. Matthews)

Date: 29/05/2007

Site No.: 2411  
Cert No.: 07-WG-3354-S802  
Page: 1

**APPENDIX VI**  
**AGGREGATE STABILITY CHEMISTRY**

**SOIL AND WATER TESTING LABORATORY**  
Scone Research Centre

Report No: SCO07/149R1  
Client Reference: N Sibbel  
Tiwest Joint Venture  
PO Box 31  
Dandaragan WA 6507

Lab No	Method Sample Id	C1A/4	C5A/3 CEC & exchangeable cations (me/100g)				C2A/3		F8A/2			F9B/2	
		EC (dS/m)	CEC	Na	K	Ca	Mg	pH	ESP (%)	D%	EAT		
1	Dongara 12 0-2	<0.01	4.2	<0.1	<0.1	0.7	0.2	6.8	<2	0	5		
2	Dongara 37 100-300	<0.01	4.4	<0.1	<0.1	0.7	0.2	7.1	<2	0	8/5		
3	Dongara 39 0-5	0.88	6.1	0.5	0.1	1.5	1.6	6.7	8	0	6		
4	Dongara 40 0-6	0.04	7.8	0.1	0.1	2.2	1.5	7.1	1	5	6		
5	Dongara 42 2.7m	<0.01	6.0	<0.1	0.1	1.4	0.8	7.1	<2	26	8/5		
6	Dongara 53 0.7	<0.01	4.5	<0.1	<0.1	0.3	0.1	6.6	<2	67	5		
7	Dongara 87 2.5m	<0.01	5.8	0.1	<0.1	1.2	0.9	6.6	2	32	6		

*[Handwritten signature]*

END OF TEST REPORT

**APPENDIX VII**  
**SOIL CHEMISTRY**

# Analytical Report

Job No: 073215

Lab Id Units LQL	External Idents	NITRATEN mg/kg 1	AMMONIUM mg/kg 1	PHOS mg/kg 1	POTASSIUM mg/kg 1	SULPHUR mg/kg 0.1	ORGCARBON % 0.01	IRON mg/kg 1	CONDUCTY dS/m 0.001
073215-001	88	2	1	1	57	4.3	0.1	251	0.059
073215-002	32	2	1	1	261	1	0.05	383	0.021
073215-003	9	2	1	1	75	1	0.05	275	0.021
073215-004	54	2	1	1	24	1.1	0.09	260	0.01
073215-005	99	2	1	1	86	1.6	0.1	779	0.019
073215-006	26	2	1	1	20	1.2	0.09	88	0.01
073215-007	27	2	1	1	44	1.3	0.21	41	0.018
073215-008	53	2	1	1	22	1.1	0.12	74	0.01
073215-009	12	2	1	1	44	1.2	0.12	153	0.019
073215-010	Dong 38	1	1	2	24	5	0.1	333	0.02

# Analytical Report

Job No : 073215

Lab Id Units LQL	External Idents	PH_CACL2 pH 0.1	PH_H2O pH 0.1	EXC_CA meq/100g 0.01	EXC_MG meq/100g 0.01	EXC_NA meq/100g 0.01	EXC_K meq/100g 0.01	EXC_AL meq/100g 0.01
073215-001	88	5.6	6.1	0.13	0.08	0.07	0.13	0
073215-002	32	5.9	6.5	0.29	0.18	0.08	0.71	0
073215-003	9	5.5	6.3	0.12	0.07	0.06	0.13	0
073215-004	54	5.9	6.5	0.33	0.1	0.06	0.07	0
073215-005	99	5.4	6.2	0.33	0.15	0.07	0.14	0.04
073215-006	26	5.6	6.3	0.12	0.06	0.06	0.07	0
073215-007	27	5.3	6.1	0.33	0.1	0.07	0.08	0.03
073215-008	53	5.6	6.5	0.2	0.09	0.07	0.09	0
073215-009	12	5.7	6.4	0.32	0.1	0.06	0.08	0
073215-010	Dong 38	5.5	6.5	0.28	0.15	0.08	0.08	0