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Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

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Summary

The aim of the study was to provide soils information for the development and the planning of field experiments at the Kojaneerup annex of the Mt Barker Research Station. The annex has been established to develop stable farming systems and lies approximately 15 km south of the eastern end of the Stirling Ranges in the south-west of Western Australia. Soils on the annex were identified and mapped using a combination of grid and free survey methods. The soil map boundaries are accurate to within 50 metres either side of the boundary.

Based on a number of CSIRO soil surveys in the region four duplex series, with one major variant and, one uniform sand, were identified as occurring on the annex. The duplex series include: Waychinicup (solonetzic or Dy4.42 with columnar B horizons), Napier (mottled, yellow or gley duplex - Dy5 and Dg4), Napier with a continuous sesquioxide pan (Dy5.42 and Dy5.85), Bangalup (yellow duplex with brown and brownish A horizons - Dy5 and Dy4) and a calcareous soil (Dy4.83). The Napier, Waychinicup and Bangalup soil series all have ferruginous segregations (lateritic gravels) in a sandy textured A horizon which overlies the clay B horizon.

In contrast with the duplex series, the uniform sands or Kojaneerup soil series (Uc2.2l) are characterized by loamy sand and sand textures throughout the solum, a bleached A2 and a colour B horizon. Kojaneerup soils occur typically on the dunes, but they may also occur on the flats overlying buried duplex profiles.

All the soils have low chemical fertility. The Napier, Waychinicup and Kojaneerup series have hydrophobic surfaces and are also highly susceptible to wind erosion. It is hypothesized that the soil physical properties controls production particularly, the depth of sand and nature of the clay B horizons. The Waychinicup soil type with B horizons near the surface are likely to be the most productive on the annex, and the Kojaneerup series the least productive. The Napier soil type with a continuous sesquioxide pan may be best suited to shallow rooting subterranean clover pastures.

1. Introduction

1.1 Location

A soil survey of the Kojaneerup annex of the Mt Barker research station was undertaken following a request by the Albany District Office of the Western Australian Department of Agriculture. The annex is located on the western fringe of the south coast sandplain approximately 95 km north-east of Albany (Fig. 1.1). It has been established to develop stable farming systems for the sandplain, where currently, farming systems include sheep, cereal and lupin rotations.

Three paddocks (herein referred to as north, central and south paddocks) of Plantagenet location no. 6548, which are collectively called the Kojaneerup annex, have been leased for five years. The total area of the three paddocks is 283.26 ha.

1.2 Climate and Physiography

The Kojaneerup region has a mediterranean climate that has a small summer rainfall component. The winter months are the wettest and although some rain falls during the summer months they can frequently be rainless (Fig. 1.2). The on-set of the winter rain is unreliable; the season can break from as early as February to as late as July or August, with false starts to the season a common occurrence.

The topography of the area is a level to gently undulating sand plain with an internal relief of up to 5 m. The plain, which was originally covered by mallee, has many lakes and swamps that have been cut into the land surface. Aeolian dunes which cover the plain are aligned in a general northwest-southeast direction. The sandplain is poorly drained and has no well defined watercourses with lakes and swamps acting as the drainage sumps for the area.

1.3 Objectives

The primary objective was to describe the soil morphology in each paddock, classify the soils and map their distribution. However, soils classified in this way might not correspond to their agricultural potential. Therefore, a secondary objective was to map the soils based on physical parameters which may influence plant growth.

The Albany Office staff recommended that the following parameters should be used to identify soils with different agronomic potential:

(i) Depth to ferruginous segregations (lateritic gravels) in excess of 20 per cent.

(ii) Depth to clay.

(iii) Colour changes in the A and the B horizons.

(iv) Drainage characteristics.

(v) Surface texture and consistence.

(vi) pH changes.

In addition to these requirements, the advisors and research officers believed that any classification applied to the annex should be compatible with previous soil series descriptions used in the area, e.g. Kojaneerup and Bangalup (Smith, l950b). These terms would be more familiar to farmers and so would facilitate extension advise and its acceptance.

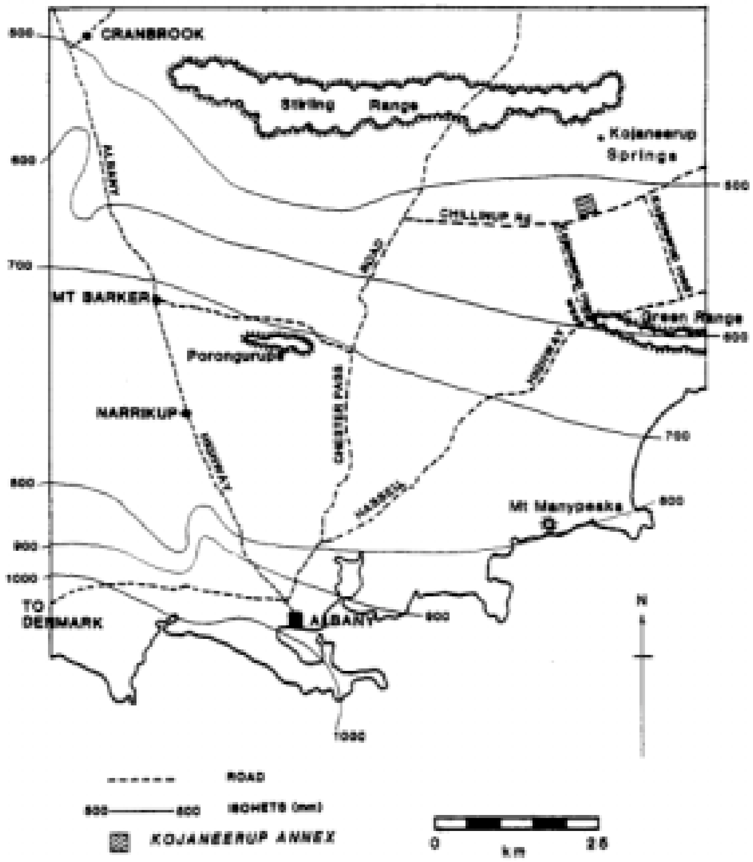
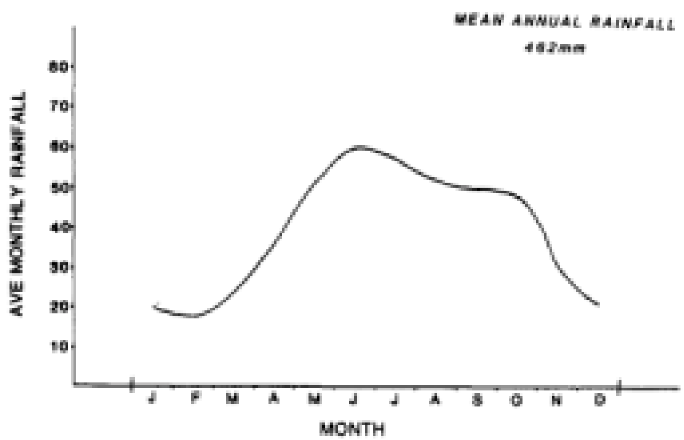


Figure 1.1. Rainfall distribution in the vicinity of the Kojaneerup annex.



AVE NO WET DAYS	J	F	M	A	M	J	J	A	S	O	N	D
	4	4	5	6	11	13	15	14	12	11	7	5

Figure 1.2. Meteorological data for Kojaneerup Springs, located 11 kilometres north of the annex (Fig 1.1). (Bureau of Meteorology).

2. Previous Surveys

There have been many soil surveys at various scales in the vicinity of the Kojaneerup annex. The Kojaneerup research annex itself has been mapped at a smaller scale than reported her-e and similar soils have been described in other soil surveys adjacent to the annex. Specifically, two reconnaissance style surveys have covered the Kojaneerup region; one 'The Atlas of Australian Soils' (Northcote et al.., 1967) at a scale of 1:2,000,000, and the other by Churchwood et al..i. (1988) extends from Northcliffe to Many Peaks at a scale of 1:100,000.

In 'The Atlas of Australian Soils' the annex is found within soil map unit WD 7, on sheet 5. The topography of this map unit is described as "a flat to gently undulating plain with few depressions, swamps, lakes and dunes". The soils are sandy with yellow, mottled clayey B horizons (Dy5.81 and Dy5.84) and minor areas of well drained flats (Dy5.42); poorly drained flats (Dy5.43); depressions (Dg4.42 and Dg4.43); and dunes (Uc2.2 and Uc2.3).

In Churchwood et al.. (1988) descriptions of the landforms and soils are similar to Northcote et al.. (1967). They mapped the annex in the Chillinup map unit which has a landform of a flat to broadly undulating plain with lakes, swamps and dunes. The soils found in this map unit are an association of yellow duplex lateritic soils on the plain, yellow duplex solonetzic soils in the depressions and podzols in sands on hummocks and dunes. Site 79 (Appendix 1) in Churchwood's survey is only 2km from the annex and provides some useful chemical data.

Smith (1950b) mapped the soils of the south and south-east Stirling area which includes the research annex, at a scale of 1:63,360. The survey covered 1400 square kilometres and described 14 soil associations using the soil association names from earlier surveys. The map units which cover the annex are the Waychinicup, Napier, Kojaneerup and Bangalup associations.

Four other surveys were conducted in the vicinity of the research annex:

1. Teakle (1946) mapped the soils in the Many Peaks district at a scale of 1:15,840. Twelve soil series were identified and of these, the Waychinicup soil series is the only one common to the annex.

2. Bettenay and Poutsma (1962) mapped the soils of the north Many Peaks district centred approximately 10 km south of the annex at a scale of 1:126,720. This survey described nine soil associations. The Napier, Sleeman, Waychinicup and Moulyup associations contained the Napier and Waychinicup series as dominant or subdominant soils, which are the two main soils found at the annex.

3. Further to the south-west Smith (1950a) mapped the soils of the east Narrikup region at 1:15,840. Ten soil series were described, including the Napier, Waychinicup and Bangalup series.

4. Boehm and Pym (1950) surveyed the soils of the Denbarker area at 1:63 360, and reported three soil associations and seven soil series. The Bangalup series was the only soil type of this survey found at the annex.

The relationship between soil associations and the series within the associations is summarized in Table 2.1. We have also included in Table 2.2 the relationship between the soil series and the soil types or map units used in this report. The definitions of soil types adopted by previous surveyors have not been used in this report.

Teakie's (1946) original description of the Waychinicup series does not include columnar structure; Teakle refers to soils with columnar B horizons as Yilberup. However, subsequent workers have all classified soils with columnar B horizons as Waychinicup soils. To avoid confusion we have continued to use the columnar B horizons as a diagnostic feature of Waychinicup series.

Table 2.1 Relationship between soil associations and soil series from previous surveys

Soil associations	Dominant series	Associated series	Reference
Bangalup	Bangalup	Frankland, Kwildalup and/or Yeriminup	Boehm & Pym (1950) (1950)
Waychinicup	Waychinicup	Napier Yate soils Salina soils	Smith (1950b)
Napier	Napier	Waychinicup Willbay Yeriminup	
Bangalup	Bangalup	Yeriminup Willbay	
Kojaneerup	Kojaneerup	Waychinicup Yate soils Salina soils	
Napier	Napier	Sleeman	Bettenay & Poutsma (1962)
Waychinicup	Waychinicup	Yilberup	
Moulyup	Moulyup	Waychinicup	
Sleeman	Sleeman	Napier and Corimup	

Table 2.2 Comparison between soil series from previous surveys and the map units (soil types) described at the annex

Soil series*	Churchwood et al	Annex map units
Napier	Yellow, duplex lateritic soils	la, 1b, 3
Waychinicup	Yellow, duplex solonetzic soils	2a, 2b, 2c
Kojaneerup	Podzols	6
Bangalup	-	4

* from the above references

3. Soil Mapping Procedure

An aerial photograph of the property taken in December 1985 was enlarged from a scale of 1:50,000 to 1:5,000. A plan was compiled at 1:5,000 by digitizing fencelines and other features in the paddocks.

The field work for the survey was undertaken from May to June, 1987. The annex was surveyed using a combination of grid and free survey methods (McDonald, 1975). Initially, soils were described along transects in each paddock every 100 to 200 metres. Preliminary boundaries were then drawn, and further soil observations made to accurately locate the soil boundaries.

The soil profile was examined at each site by digging a small pit to the top of the clay subsoil or to a depth of 1.2 metres on the deep sandy soils. Profiles within the clay subsoil were described from auger borings. The soil properties were described according to McDonald et al. (1984). These descriptions are on the Division of Resource Management's WARIS databank. In the field, the profiles were classified to their Principle Profile Form (Northcote, 1979), and also into one of the soil series described by Smith (1950b). The Napier and Waychinicup soils of Smith (1950b) were subdivided using the depth to ferruginous segregations and clay as criteria.

Each site was located on the map by taking three compass bearings to points which could be identified on the paddock plans. A total of 174 soil profiles were examined and described in the three paddocks. This gave a density of 1 site per 1.5 ha and is within the range recommended by McDonald (1975) of 1 site per 0.5 ha to 1 site per 2 ha when mapping at scales of 1:5,000. Essentially, a profile was described every 100 metres, and therefore map units are accurate to within 50 metres either side of the soil boundary. Researchers seeking to use the paddocks for experiments should be cognisant of the mapping accuracy and describe additional profiles where necessary. The position and number of each site is shown on the soil map. The map is also available on the Division of Resource Management's geographic information system. Additional maps display the depth to ferruginous segregations exceeding 20 per cent, the depth to clay, and the pH of the Al horizon.

4. Soils

4.1 Overview

All soils show evidence of being intensely weathered and strongly leached. Surface horizons have textures of sand or sandy loam and are usually underlain by a bleached A2. Because these soils have been strongly leached, they are naturally chemically infertile and are deficient in all the macro nutrients (Appendix 1). Their physical properties, however, appear to be the main factor controlling plant production. In particular, clay and, to a lesser degree, gravel layers which act as physical barriers to root and water movement, appear to account for differences in production between soils in the region. The leased area is covered by two physically distinct soils, 1) duplex, sand over clay and 2) uniform coarse textured sands.

4.2 Duplex Soils

The dominant duplex soils on the leased block are Napier (Plate 4.1) and Waychinicup (Plate 4.2) covering 60 per cent of the total area. Napier soils with a continuous sesquioxide pan between the A and the B horizon cover 10 per cent of the area. The Bangalup soils and a calcareous duplex soil not previously described, cover only 0.6 per cent of the area.

Plate 4.1. A typical Napier soil series profile (site 171) showing the bleached A2 horizon and a layer of ferruginous segregatiosis overlying a mottled gley clay B horizon (Map Unit 1a and 1b).

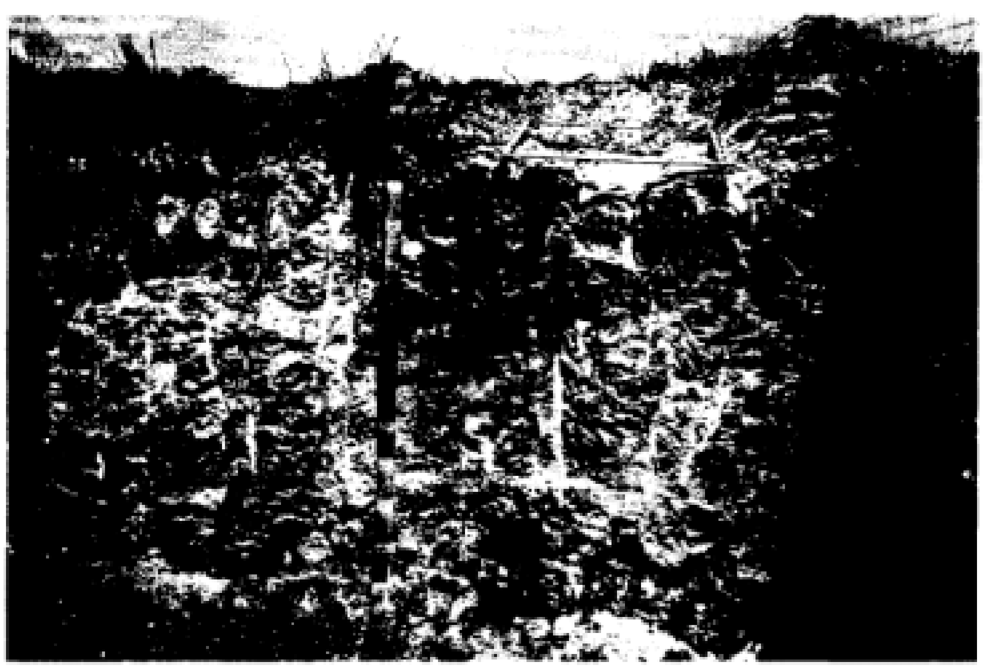


Plate 4.2. A typical Waychinicup soil series profile (site 172) showing the bleached A2 and the ferruginous segregations overlying the columnar (domes) structure of the B horizon (Map Units 2a, 2b and 2c).

Plate 4.3. Columnar (domed) structure of the Waychinicup soil series (site 172).

Plate 4.4. A typical Kojaneerup soil series profile (site 170) showing a bleached A2 horizon overlying a soft (loose) colour B horizon (Map Unit 6).

The A horizons of both the Napier and Waychinicup series are similar. Textures are sand to sandy loam. They have single grained structure, and are loose or weakly coherent. The A2 horizons are conspicuously bleached. In both soils a layer of ferruginous segregations occurs in the part of the A2 horizon. These are either discrete nodules ranging in size of up to 60mm and in excess of 20 per cent of the A2 horizon, or are cemented to form a continuous pan. The ferruginous segregations overlie the clay B horizon.

The B horizons of the Waychinicup series have a characteristically columnar structure (Plate 4.3) thus distinguishing them from the Napier series with subangular blocky or apedal B horizons. The columns are greater than 100 mm across and are recognised by distinctive domes. A layer of bleached sand is often found between the segregations in the A2 and above the domes. The bleached sand may even extend down between the columns of the B horizon. Some of the soils mapped as Waychinicup have weak to strong colour development in or above the segregations, qualifying as a colour B horizon with a Principle Profile Form of Uc2.21; they are pedologically similar to the Kojaneerup series, but they do not have the same depth of sand.

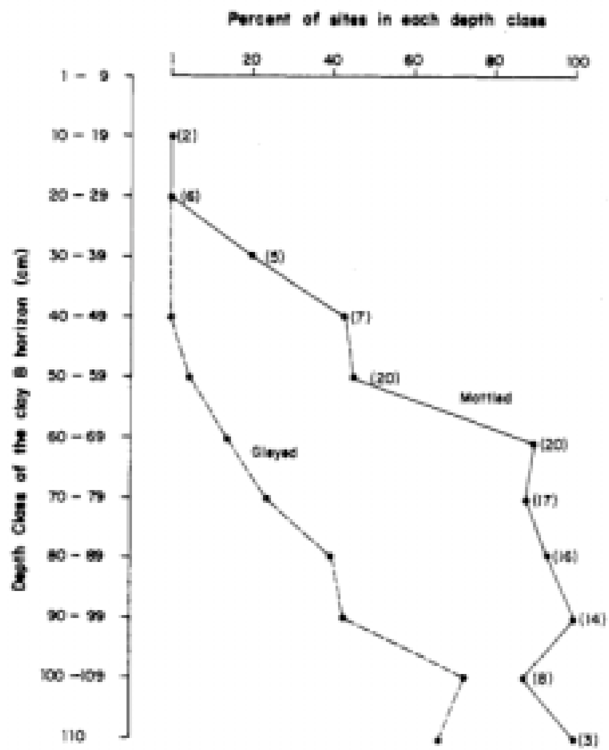


Figure 4.1. Relationship between the depth of the clay B horizons of Napier and Waychinicup profiles and, (1) the percentage of profiles exceeding 10 per cent mottling in the upper 15 cm of the B horizon and, (2) the percentage of profiles with gleyed B horizons. (Numbers in brackets refer to the number of observations in each depth class.)

Table 4.1. B horizon characteristics of the Napier and Waychinicup map units

	Soil map unit				
	Napier		**Waychinicup**		
	< 40 cm to FS*	**> 40 cm to FS***	**<45 cm to clay**	**> 45 cm to clay and < 40 cm to FS***	**> 45 cm to clay and > 40 cm to FS***
Whole coloured (%)	13	0	94	58	0
Mottled (%)	87	100	6	42	100
Gleyed (%)	20	76	0	4	48
Yellow (%)	80	24	100	96	52

* (FS = ferruginous segregations).

The percentage of profiles with mottles, exceeding 20 per cent or, gleying, in the upper 15 centimetres of the clay B horizon increased with the depth of the B horizon (Fig. 4.1). Only 60 per cent of the Waychinicup profiles were mottled compared with the Napier soils at 90 per cent mottling. Usually, the presence of mottles and gleying indicates a seasonal water table. Considering the above and Table 4.1, showing the incidence of mottling and gleying in each of the map units, we have inferred that the Napier profiles have impeded drainage in comparison to the Waychinicup profiles.

Within the Napier series two phases were recognized, (1) those profiles where the depth to ferruginous segregations was less than or equal to 40 cm (Map Unit la) and, (2) those soils where the depth of sand over the layer of ferruginous segregations exceeded 40 cm (Map Unit 1b).

A depth of 40 cm was used to divide the group, because in the district, soils with ferruginous segregations at depths down to 40 to 50 cm, are found to be the most productive. It is likely that the depth to ferruginous segregations is an indicator of the agricultural potential of these soils because the segregations reflect the depth to clay (Fig. 4.2). The clay acts as a hydraulic barrier affecting moisture availability to the plants. In addition, 40 cm was used as a criterion because the profiles described can be divided into two natural groups between 40 and 50 centimetres to depth of ferruginous segregations (Fig. 4.3) and depth to clay between 80 to 90 cm (Figs 4.4 and 4.5).

The Waychinicup series was separated into three map units using both the depth to clay and the depth to the ferruginous segregations; (1) Soils with clay at less than or equal to 45 cm (Map Unit 2a), (2) Soils with clay greater than 45 cm but ferruginous segregations occur at less than or equal to 40 cm (Map Unit 2b), and (3) Soils with clay greater than 45 cm and ferruginous segregations greater than 40 cm (Map Unit 2c).

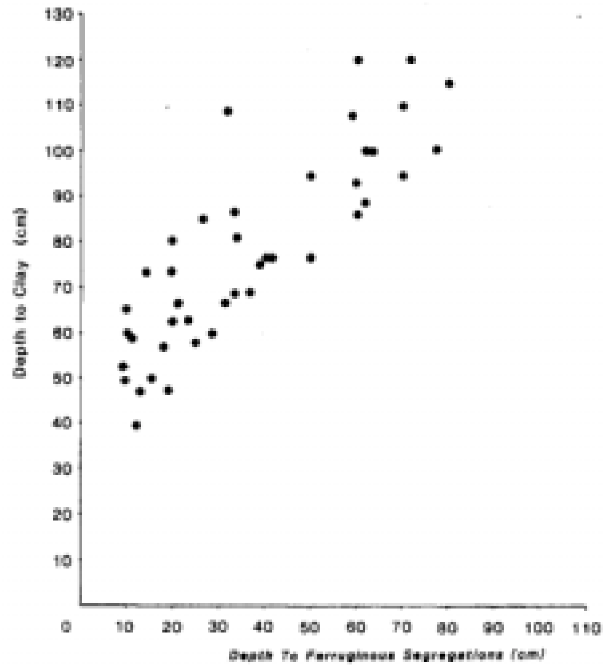


Figure 4.2. Comparison between the depth to clay in Napier profiles and the depth to ferruginous segregations.

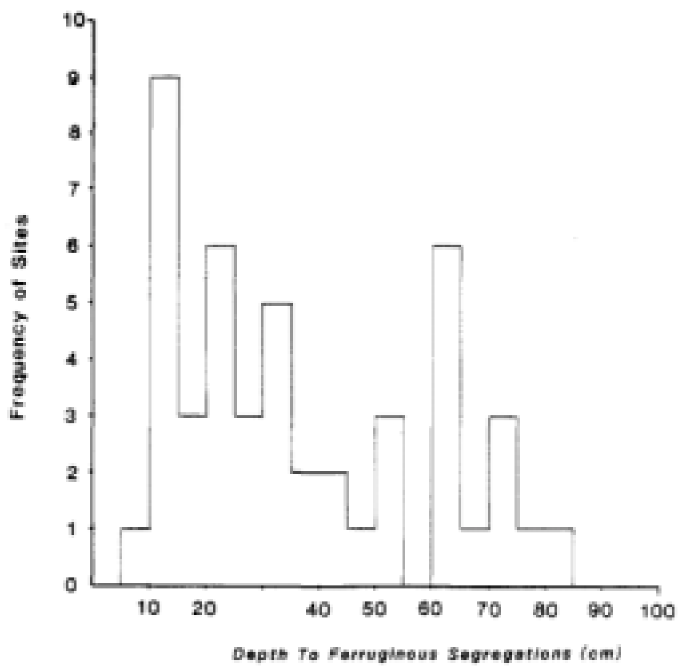


Figure 4.3. Frequency Histogram. Depth to ferruginous segregations exceeding 20 per cent, of 47 Napier profiles.

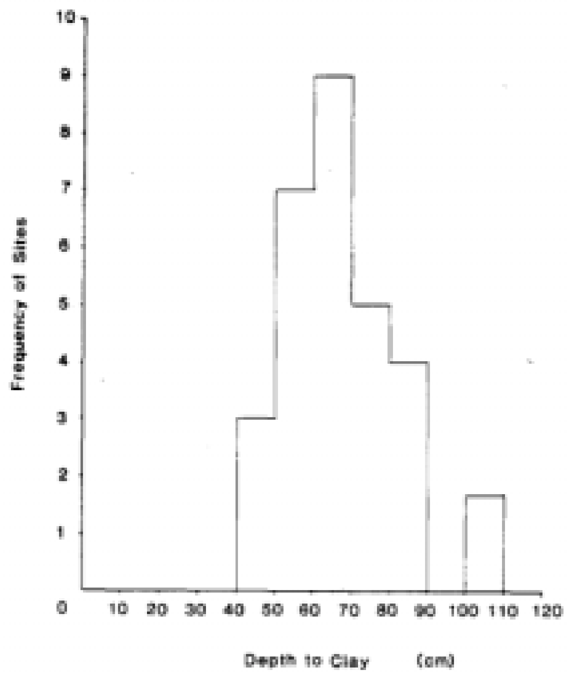


Figure 4.4. Frequency histogram. Depth to clay of 30 Napier profiles. Ferruginous segregations exceeding 20 per cent, at 40 cm or less below the surface.

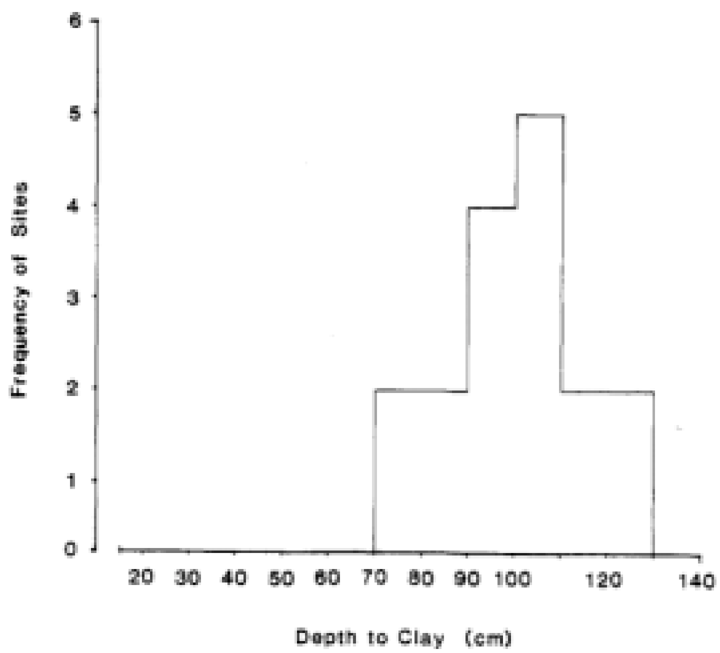


Figure 4.5. Frequency histogram. Depth to clay of 17 Napier profiles. Ferruginous segregations exceeding 20 per cent, below 40 cm.

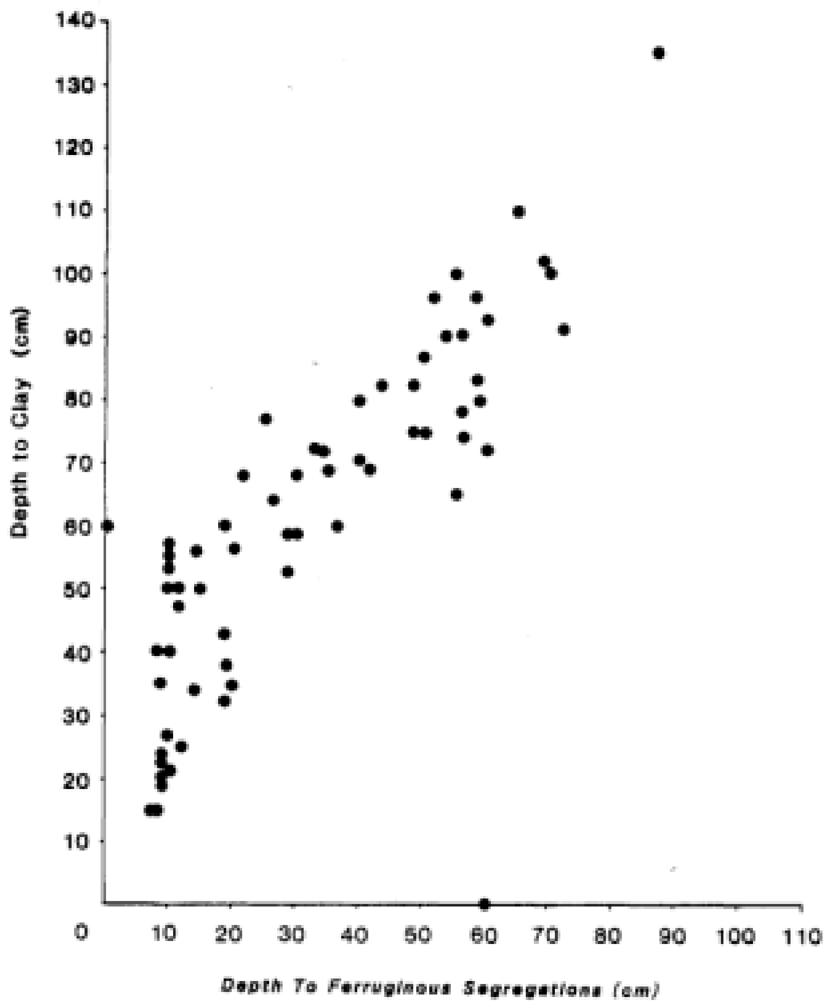


Figure 4.6. Comparison of the depth to clay B horizons of Waychinicup profiles and the depth to ferruginous segregations.

These limits were chosen primarily because of the relevance to plant production and also because the limits conform with the divisions chosen for the Napier series; there were no obvious natural divisions in the depth to segregations or clay with a continuum in the relation between the depth of gravel and the depth of clay (Fig. 4.6). Some evidence exists for a division between two natural groups at 40 to 50 cm depth of clay (Fig. 4.7).

A third soil was identified which is essentially a Napier with a strongly cemented, continuous sesquioxide pan between the sandy A horizon and the clay B horizon (Map Unit 3.). The B horizon is usually apedal or subangular blocky but, may have the distinctive columnar structure of the Waychinicup series (site 71, south paddock).

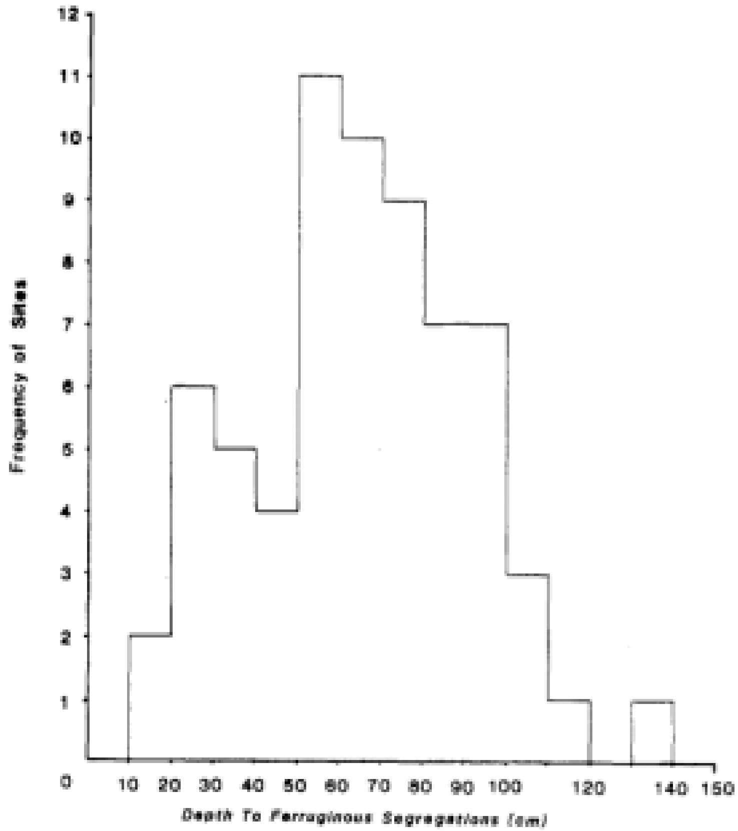


Figure 4.7. Frequency histogram. Depth to clay of 66 Waychinicup profiles.

The minor soils, Bangalup series and Calcareous duplex soils contrast with the Napier and the Waychinicup series. The Bangalup series (Map Unit 4) is distinguished by the grey brown or brownish grey A horizon. An A2 horizon is present but not bleached. The upper 15 cm of the clayey B horizon is mottled, yellow and apedal. Large amounts of ferruginous segregations occur both on the surface and through ..he A horizon and into the B horizon. The brownish greys and the greyish browns of the A horizons and the proximity of these soils to those Napier series with a continuous sesquioxide pan suggests that the Bangalup series may be forming from the weathering of the pan; this may account for the seemingly better agricultural performance of these soils in the district (D. Roe pers. com.).

The calcareous duplex soils are found where there are limestone segregations present on the soil surface. Only one soil profile was described for this soil type because of its very limited distribution. In this one profile a strongly cemented limestone pan occurred between the A and the B horizons. The yellow B horizon was whole coloured and apedal.

4.3 Uniform Soils

Only one soil occurs in this group on the leased area and that is the Kojaneerup soil type which covers 30 per cent of the total area. This soil type was relatively consistent across the three paddocks and was mapped as one soil map unit, although it did occur on two quite different landforms, sand dunes and level plains. Textures are sandy throughout with a conspicuously bleached A2 horizon above yellow colour B horizon.

Where these soils occur on the plains a layer of ferruginous segregations is often found at depth in B horizon. Below this layer a gleyed, mottled clay can occur at depths between 1.2 to 1.5 metres.

5. Wind Erosion

Existing dunes have been eroded, and in many places, the colour B horizon of the Kojaneerup series has almost been exposed. Erosion is particularly noticeable in some areas of the southern paddock. The severity of wind erosion on the Napier and Waychinicup soils is not as apparent. However, at the time of the survey the wind was actively eroding all paddocks; sheets of sand could be seen blowing across the paddocks; soil surfaces were covered by a coarser bleached sand veneer which could easily be distinguished from the underlying sandy Al horizon, darkened by organic matter.

These soils were eroding because sheep, grazing the pastures and stubbles, had detached the soil and removed the surface protection. Nevertheless, while management may have increased the risk of erosion, these soils have developed naturally through wind sorting the surface, forming the dunes and the closely associated Kojaneerup series, and the sandy A horizons of the duplex soils. The loose consistence of the sandy A horizons of all the soils on the leased area means that there is little cohesion between the soil particles and little force is needed to move them. The dominant forces preventing the exposed soil particles from moving are the high fall velocity of the particles and the cohesive forces created by soil moisture.

6. Water Repellency

Soil moisture in this environment is not as effective in bonding the surface grains where the annual rainfall is 462 mm and the soils are hydrophobic (water repellent). In the field all A horizon soils that were dry or slightly moist were strongly hydrophobic and we suspect that all the A horizons are strongly hydrophobic (Table 6.1).

Soils assessed using Molar Ethanol Droplet (MED) test (King, 1981) exceed 2 in two thirds of the soils sampled to 10 centimetres (Appendix 1); on this scale a score 1 or 2 is normal. These values for surface samples are much lower than would be expected from field observations, particularly in the northern paddock, largely because the laboratory sample is a mixture of soil over the first 10 centimetres.

In the field we noticed that clover had germinated and was still green on the calcareous duplex soils in contrast to the other soils which were bare. We believe the differences in clover cover may be due to differences in water repellency. An area of calcareous duplex soil supporting clover (site 51) and an adjacent non-calcareous soil (site 95) were sampled in depth intervals of 10 cm down to 30 cm. The non-calcareous soil was strongly hydrophobic, using molar enthanol droplet test but, the calcareous soil was hydrophilic (Table 6.1). As could be expected the calcareous soil was less acid and had a higher level of soluble salts (measured using electrical conductivity).

Table 6.1. A comparison of the hydrophobic nature and acidity of a non-calcareous soil (N/C) site 95, and a calcareous soil (C) site 51, and the level of soluble salts in each soil

	Analyses					
Depth	**pH (0.01 M CaCl2)**		**Soluble salt (EC 1: 5 mS/rn)**		**Repellency (MED Test)**	
(cm)	**N/C**	**C**	**N/C**	**C**	**N/C**	**C**
0-10	4.7	6.2	3.4	10.6	3.5	1.0
10-20	4.9	6.4	2.6	8.9	2.5	2.5
20-30	5.0	7.2	2.7	18.6	1.5	0.0

The non-calcareous soil is not acid enough to affect clover, but the difference in repellency would be sufficient to produce the observed differences in clover growth. The hydrophilic nature of the calcareous soil may be due to an increase in charge in the soils caused by calcium salts and the smaller particles increasing the charge per unit area.

7. Agronomic Potential

An objective of the annex is to ascertain the agronomic potential of the soils. Some assessment of this can be made by comparing the performance of the soils on the annex with that of soils on neighboring farms and by examining existing chemical data and the inherent physical properties of the soils on the annex. All the major soils, Napier, Waychinicup and Kojaneerup, have a low agricultural capability as a result of the combination of low chemical fertility, severe hydrophobic surfaces and low and unreliable rainfall. Nevertheless, there are differences in production between the soils described.

The shallow Waychinicup soils are considered to be the most productive of the soils on the annex (D. Roe, pers. corn.). Although these soils are well drained, as indicated by the whole coloured B horizons, water may be perched above the clay, in the root zone, for sufficient time to allow plant establishment. In wet years or in areas of higher rainfall to the south, similar soils will be waterlogged during the growing season. Even though the soils have relatively shallow A horizons the rooting depth is unlikely to limit plant growth because the clay B horizons are strongly structured.

The shallow Napier and the moderately deep Waychinicup soils are most likely to be the better producing soils in wet years. Water would be retained close to the surface but not too close to cause water-logging. There is sufficient sand above the clay to allow development of shallow rooting plants.

The Kojaneerup, deep Napier and deep Waychinicup soils, although pedologically different, are agronomically similar because the root zone is sufficiently well drained to cause water stress. All these soils are highly susceptible to wind erosion because of the difficulty in maintaining sufficient ground cover. In wet years, where these soils occur in drainage depressions or, receive run-on, they will be waterlogged.

The Napier soil with the strongly cemented, continuous sesquioxide pan is different both morphologically and agriculturally from the shallow Napier and the moderately deep Waychinicup soils. The pan severely limits the root development for nearly all agricultural crops and pastures. Field observations showed that plant roots were only able to penetrate the pan through cracks and holes. This soil also has a lower water holding capacity than the other Napier and Waychinicup soils, with the soil moisture storage being restricted to the gravelly sands overlying the pan. This results in the soil drying off more rapidly at the end of the growing season with the onset of warmer weather. Consequently this map unit is best suited to the shallower rooted subterranean clover pasture, and preferably an early maturing cultivar that would set seed while moisture was still available (J. Lemon pers. com.).

8. Description of Soil Map Units

8.1 Soil Map Unit 1a

8.1.1 Soils general

Shallow-gravelly, mottled yellow duplex. (CSIRO soil series: Napier).

This texture contrasting profile consists of A horizons of dark greyish brown (1OYR 4/2) fine loamy sands over a bleached A2 horizon of light brownish grey (1OYR 6/2, 1OYR 7/2, dry) fine sand. These overlie a whole coloured to mottled brownish yellow (1OYR 6/6) to light grey (5.OY 7/1) clayey B horizon. Ferruginous segregations exceeding 20 per cent occur in a dense layer above the B horizon and less than 40 cm below the surface. The sands are single grain of a loose coherence and the clay B horizons are weakly to strongly pedal.

Area:	48.77 ha
No. of sites:	35
Dominant PPF5:	Dy5.42 (45%)*, Dy5.82 (15%), Dg4.42 (15%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Poorly drained
Permeability:	Slow

8.1.2 Profile description - Site no. 21

Map reference: E622768m, N618l23Om (2528-I, Green Range)

Principal profile form: Dy5.42

Horizon	Depth (cm)	Description
Ap	0-10	Dark greyish brown (1OYR 4/2); fine loamy sand; moderately moist; single grain; sandy; loose; pH 6.0; sharp boundary to -
A21cb	10-20	Light brownish grey (1OYR 6/2) light grey (1OYR 7/2 dry); fine sand; moderately moist; single grain; sandy; loose; pH 6.5; abrupt boundary to -
A22cb	20-65	Pale yellow (2.5Y 7/4), white (2.5Y 8/2 dry); fine sand; moderately moist; single grain; sandy; loose; > 50%, 20-60 mm, subrounded, ferruginous segregations; pH 7.0; sharp boundary to -
B2	65-80	Brownish yellow (1OYR 6/6); medium clay; moderately moist; moderate pedality, subangular blocky, 2-5 mm; smooth; moderately firm; 20 - 50%, medium, distinct, yellow mottles; pH 8.0.

* Percentage of profiles described with this PPF (Appendix 2).

8.2 Soil Map Unit 1b

8.2.1 Soil general

Deep-gravelly mottled gley duplex. (CSIRO soil series: Napier).

Texture contrasting profiles with A horizons of dark greyish brown (1OYR 4/2) fine loamy sands with a deeper bleached A2 horizon of very pale brown (1OYR 7/3) fine sands overlie mottled, gleyed (5GY 7/1) to brownish yellow (1OYR 6/8) clayey B horizons. A layer of ferruginous segregations exceeding 20 per cent occurs below 40 cm and above the B horizon. Occasionally some colour development (1OYR 7/4) occurs in the layer of ferruginous segregations or, just above it. The sands are single grain of a loose consistence and the B horizons are massive to moderately structured.

Area:	16.54 ha
No. of sites:	16
Dominant PPF5:	Dg4.42 (25%)*, Dg4.82 (25%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Poorly drained
Permeability:	Slow

8.2.2 Profile description - Site no. 55

Map reference: E621472m, N6178725m (2528-I, Green Range)

Principal profile form: Dg4.42

Horizon	Depth (cm)	Description
Ap	0-12	Dark greyish brown (1OYR 4/2); fine loamy sand; moderately moist, single grain; sandy; loose; pH 7.5; sharp boundary to -
A2lcb	12-62	Very pale brown (1OYR 7/3), white (10 YR 8/1, dry); fine sand; moderately moist; single grain; sandy; loose; pH 7.0; abrupt boundary to -
A22cb	62-90	Light yellowish brown (2.5Y 6/4), light grey (1OYR 7/2 dry); fine clayey sand; moderately moist; single grain; sandy; loose; > 50%, 6 - 20 mm, subrounded ferruginous segregations; pH 7.0; abrupt boundary to -
B2	90-120	Light grey (5.OY 7/1); medium clay; moist; moderate pedality, 10-20 mm, subangular blocky; smooth; moderately weak; 20 - 50%, coarse, prominent, brown mottles; pH 7.0.

* Percentage of profiles described with this PPF (Appendix 2).

8.3 Soil Map Unit 2a

8.3.1 Soil general

Shallow yellow duplex with columnar B horizons. (CSIRO soil series: Waychinicup).

This texture contrasting profile is characterized by brownish yellow (10 YR 6/8) to yellowish brown (10 YR 5/6) columnar structured clayey B horizon which is overlain by texture contrasting A horizons. The A horizon consists of dark brownish grey (1OYR 4/2) fine loamy sand Al and a bleached A2 horizon of very pale brown (1OYR 7/3) fine sands. The A2 horizon is occasionally a pale yellow (2.5Y 7/4) and extends down between the columns. Ferruginous segregations are found in the A horizon, usually in a layer above the B horizon.

Area:	29.92 ha
No. of sites:	16
Dominant PPF5:	Dy4.42 (80%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Moderately well drained
Permeability:	Moderate

8.3.2 Profile description Site no. 16

Map reference: E622l67m, N5l8].008m (2528-I, Green Range)

Principal profile form: Dy4.42

Horizon	Depth (cm)	Description
Ap	0-10	Dark greyish brown (1OYR 4/2); fine loamy sand; dry; single grain; sandy; loose; 5%, 6-20 mm. subrounded, ferruginous segregations; pH 6.0; sharp boundary to
A2cb	10-25	Very pale brown (1OYR 7/4), white (1OYR 8/2, dry); fine sand; dry single grain; sandy; loose;) 50%, 6-20 mm, subrounded, ferruginous segregations; pH 6.5; sharp, wavy boundary to
B2	25-60	Yellowish brown (1OYR 5/6); medium clay; moderately moist; strong primary pedality, 2-5 mm, subangular blocky, strong secondary pedality, columnar, 100-200 mm; smooth; very firm; 2-10 %, fine, faint, pale mottles and < 2%, fine, distinct, red mottles; pH 7.5.

* Percentage of profiles described with this PPF (Appendix 2).

8.4 Soil Map Unit 2b

8.4.1 Soil general

Moderately deep yellow duplex with columnar B horizons. (CSIRO soil series: Waychinicup).

This texture contrasting profile has a depth to the clay subsoil of between 45 to 65 cm, which is 30 cm deeper than soil map unit 2a. The A horizons comprise an organic stained surface layer; very dark greyish brown (1OYR 3/2) fine loamy sand over a bleached A2 horizon of a pale brown (1OYR 6/3 M, 1OYR 7/2 dry) fine sand which contains a distinct layer of ferruginous segregations. These layers overlie a texture contrasting clayey B horizon that is yellowish brown (1OYR 5/8) to brownish yellow (1OYR 6/8) and is mottled to whole coloured and has a columnar structure.

Area:	27.78 ha
No. of sites:	26
Dominant PPF5:	Dy5.42 (45%)*, Dy4.42 (40%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Poorly drained
Permeability:	Slow

8.4.2 Profile description - Site no. 38

Map reference: E622493m, N61812l2m (2528-I, Green Range)

Principal profile form: Dy5.42

Horizon	Depth (cm)	Description
Ap	0-10	Dark greyish brown (1OYR 4/2); fine loamy sand; dry; single grain; sandy; loose; pH 6.5; sharp boundary to -
A2lcb	10-35	Pale brown (1OYR 6/3), light grey (1OYR 7/2, dry); fine sand; moderately moist; single grain; sandy; loose;, 50%, 20-60 mm, subrounded, ferruginous segregations; pH 7.0; gradual boundary to -
A22cb	35-50	Brown (1OYR 5/3), light grey (1OYR 7/2 Dry); fine sand; moderately moist; single grain; sandy; loose; 50%, 6-20 mm, subrounded, ferruginous segregations; pH 7.0; sharp, irregular boundary to -
B2l	50-100	Yellowish brown (1OYR 5/8); light clay; moderately moist; strong primary pedality, 5-10 mm, polyhedral, strong secondary structure, 100-200 mm, columnar; smooth; moderately weak; 20-50%, medium, distinct, yellow mottles; pH 8.0.

* Percentage of profiles described with this PPF (Appendix 2).

8.5 Soil Map Unit 2c

8.5.1 Soil general

Deep-gravelly yellow duplex with columnar B horizons. (CSIRO soil series: Waychinicup).

This texture contrasting profile represents the deep phase of the Waychinicup soil type with the clay being at least 75 cm deep. The A horizons consist of a dark grey (1OYR 4/1) fine loamy sand over a deep bleached A2 horizon of light grey (1OYR 7/2 M, 1OYR 8/1 dry) fine sand which contains a dense layer of ferruginous segregations in the lower part of this horizon. At times there is a pale yellow (2.5Y 7/4) colour development in and just above the ferruginous segregations, These layers overlie a texture contrasting clayey B horizon that has a columnar structure. The height of the columns is between 10 to 30 cm and the clay is brownish yellow (1OYR 6/8) to light gray (5.OY 7/1) and is usually mottled.

Area:	39.70 ha
No. of sites:	27
Dominant PPF5:	Dy5.42 (45%)*, Dy4.42 (35%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Poorly drained
Permeability:	Slow

8.5.2 Profile description Site no. 78

Map reference: E621378m, N6l7879lm (2528-I, Green Range)

Principal profile form: Dy5.42

Horizon	Depth (cm)	Description
Ap	0-10	Dark grey (1OYR 4/1); fine loamy sand; dry; single grain; sandy; loose; pH 6.0; abrupt boundary to -
A2lcb	10-50	Light grey (1OYR 7/2), white (1OYR 8/1, dry); fine sand; moderately moist; single grain; sandy; loose; pH 6.0; abrupt boundary to -
A22cb	50-80	Light brownish grey (1OYR 6/2), light grey (1OYR 7/2, dry); fine sand; moist; single grain; sandy; loose; 20-50%, 6-20 mm, subrounded, ferruginous segregations; pH 7.5; abrupt, wavy boundary to -
B2	80-100	Brownish yellow (1OYR 6/6); light medium clay; moist; strong primary pedality, 5-10 mm, subangular blocky, strong secondary pedality, 50-100 mm, columnar; smooth; moderately weak; 20-50%, coarse, distinct, grey mottles; pH 7.5.

* Percentage of profiles described with this PPF (Appendix 2).

8.6 Soil Map Unit 3

8.6.1 Soil general

Yellow duplex with sesquioxide pan. (CSIRO soil series: Napier).

This texture contrasting profile has A horizons of very dark greyish brown (1OYR 3/2) fine loamy sands with a bleached A2 horizon of pale brown (1OYR 6/3) fine sand which Sometimes contains a layer of ferruginous segregations overlies a yellowish brown (1OYR 6/4) to brownish yellow (1OYR 6/6) mottled clayey B horizon. A strongly cemented, continuous massive sesguioxide pan is present above the B horizon. The clay subsoil is massive to strongly structured.

Area:	28.03 ha
No. of sites:	18
Dominant PPF5:	Dy5.42 (45%)*, Dy5.85 (35%)
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Poorly drained
Permeability:	Slow

8.6.2 Profile description - Site no. 54

Map reference: E621856m, N6178878m (2528-I, Green Range)

Principal profile form: Dy5.42

Horizon	Depth (cm)	Description
Ap	0-15	Very dark greyish brown (1OYR 3/2); fine loamy sand; moist; single grain; sandy; loose; pH 6.0; sharp boundary to -
A2cb	15-30	Brown (1OYR 5/3), light grey (1OYR 7/2, dry); fine sand; moderately moist; single grain; sandy; loose; pH 7.0; sharp boundary to -
PAN	30-95	Strongly cemented, sesquioxide pan, continuous, nodular; sharp boundary to -
B2	95-120	Light yellowish brown (2.5Y 6/4); medium clay; moist; moderate pedality, 10-20 mm, subangular blocky; smooth; moderately firm; 10-20%, fine, distinct yellow mottles and < 2%, fine, prominent, red mottles; pH 8.0.

* Percentage of profiles described with this PPF (Appendix 2).

8.7 *Soil Map Unit 4*

8.7.1 Soil general

Gravelly yellow duplex with brown and brownish A horizons. (CSIRO soil series: Bangalup).

These texture contrasting profiles have A horizons with very dark greyish brown (1OYR 3/2) loamy sands grading into dark yellowish brown (1OYR 4/4) clayey sands to brownish yellow (1OYR 6/6) clayey sands containing a distinct layer of ferruginous segregations. These layers overlie a yellow (2.5Y 7/6) mottled clayey subsoils that have a weak to moderate structure.

Area:	1.4 ha
No. of sites:	3
Dominant PPF5:	Dy5.63, Dy4.23, Dy4.43
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Imperfectly drained
Permeability:	Moderate

8.7.2 Profile description - Site no. 127

Map reference: E62984m, N61809O1m (2528-I, Green Range)

Principal profile form: Dy5.63

Horizon	Depth (cm)	Description
Ap	0-10	Very dark greyish brown (1OYR 3/2); fine loamy sand; moderately moist; single grain; sandy; loose; pH 6.5; sharp boundary to -
A2l	10-20	Dark yellowish brown (1OYR 4/4), yellowish brown (1OYR 5/4, dry) fine clayey sand; moderately moist; single grain; sandy; loose; 2-10%, 2 mm, rounded, ferruginous segregations; pH 7.0; diffuse boundary to
A22	20-45	Yellowish brown (1OYR 5/4), yellow (1OYR 7/8, dry); fine clayey sand; moderately moist; single grain; sandy; loose; > 50%, 20-60 mm, subrounded, ferruginous segregations; pH 7.5; diffuse boundary to
A23	45-80	Light yellowish brown (2.5Y 6/4), yellow (2.5Y 8/6, dry); fine sand; moderately moist; single grain; sandy; loose; 20-50%, 20-60 mm, subrounded, ferruginous segregations; pH 8.0; clear boundary to -

Horizon	**Depth (cm)**	**Description**
B2	80-100	Yellow (2.5Y 7/6); light medium clay; moderately moist; weak pedality, 2-5 mm, subangular blocky; smooth; moderately weak; 20-50%, medium, distinct, yellow mottles; 2-10%, 6-20 mm, rounded and 2-10%, 2-6 mm, subangular ferruginous segregations; pH 8.5.

8.8 Soil Map Unit 5

8.8.1 Soil general

Calcareous duplex. (CSIRO soil series: Unnamed).

This soil is of very limited extent in the south paddock and is recognized by surface outcrops of limestone nodules. It consists of a surface organic layer of dark grey (1OYR 4/1) loamy sands over a bleached A2 horizon of pale brown (1OYR 6/3) to very pale brown (1OYR 7/4) fine sands. These layers overlie a massive, calcareous, brownish yellow (1OYR 6/6) clayey B horizon which contains a strongly cemented, continuous, massive calcrete pan.

Area:	0.2 ha
No. of sites:	1
Dominant PPF5:	Dy4.83
Landform element:	Plain
Run-off:	Very Slow
Internal drainage:	Moderately well drained
Permeability:	Moderate

8.8.2 Profile description - Site no. 51

Map reference: E621204m, N6l7892lm (2528-I, Green Range)

Principal profile form: Dy4.83

Horizon	Depth (cm)	Description
Ap	0-15	Dark grey (1OYR 4/1); fine loamy sand; dry; single grain; sandy; loose; pH 7.5; sharp boundary to
A2lcb	15-65	Pale brown (1OYR 6/3), light gray (1OYR 7/2, dry); fine sand; moderately moist; single grain; sandy; loose; pH 8.5; diffuse boundary to
A22cb	65-100	Very pale brown (].OYR 7/4), very pale brown (1OYR 8/3, dry; fine sand; moderately moist; single grain; sandy; loose; pH 8.5; abrupt boundary to
B21	100-120	Brownish yellow (1OYR 6/6); sandy clay; moderately moist; massive; earthy; moderately weak; whole coloured; pH 8.5; sharp boundary to
PAN	120-140	Strongly cemented, massive, continuous, calcrete pan.
2B	140-160	Brownish yellow (1OYR 6/6); heavy clay; moist; weak pedality, 2-5 mm, subangular blocky; smooth; very firm; 10-20%, fine, faint, grey mottles; pH 8.5.

8.9 Soil Map Unit 6

8.9.1 Soil general

Deep uniform sand with yellow B horizons. (CSIRO soil series: Kojaneerup).

Uniform coarse textured sandy soils with a surface organic layer of grey (1OYR 5/1) fine loamy sand over a bleached A2 horizon of light grey (1OYR 7/1, 1OYR 8/1, dry) fine sand. This grades into a light yellowish brown (1OYR 6/4) to yellowish (10 YR 7/6) colour B horizon for Uc2.21 soils, to a pale yellow (2.5 Y 7/4) for Uc5.ll soils where the colour development is not strong enough to qualify as a colour B horizon. A layer of ferruginous segregations is often encountered at depths of 80 to 100 cm which in turn overlies a deep clay layer, between 100 and 150 cm, suggesting that the upper horizons comprise a more recent soil which has buried a former Napier or Waychinicup soil.

Area:	83.57 ha
No. of sites:	32
Dominant PPF5:	Uc2.21 (85%)*
Landform element:	Sand dune and plain
Run-off:	No run off
Internal drainage:	Rapidly drained
Permeability:	Highly permeable

8.9.2 Profile description - Site no. 53

Map reference: E621407m, N6178914m (2528-I, Green Range)

Principal profile form: Uc2.2l

Horizon	Depth (cm)	Description
Ap	0-10	Greyish brown (1OYR 5/2); fine loamy sand; moderately moist; single grain; sandy; loose; pH 6.0; sharp boundary to
A2cb	10-80	Light brownish grey (1OYR 6/2), light grey (1OYR 7/1 dry); fine sand; moderately moist; single grain; sandy; loose; pH 6.5; gradual boundary to
B2	80-130	Yellow (1OYR 7/6); fine sand; moderately moist; single grain; sandy; loose; pH 7.0; abrupt boundary to
2A2b or B22	130-150	Pale yellow (2.5Y 7/4); fine sand; moderately moist; single grain; sandy; loose; 20 50%, 6-20 mm, subrounded, ferruginous segregations; pH 7.0

* Percentage of profiles described with this PPF (Appendix 2).

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Appendix 1

Laboratory analyses

In a preliminary investigation of the annex in April 1987 by Mr R. Glencross, soils samples were taken from the areas shown in Fig. Al. At each location soils were sampled by taking twenty, 2 cm cores to a depth of 10 cm. Samples were bulked, air dried, and analysed for concentrations of nitrate, ammonium, phosphorus, potassium, organic carbon and the results are presented in Table Al. In selected areas soils were also sampled at 10 to 20 centimetres, 20 to 30 centimetres, and greater than 30 centimetres. On all samples the pH (both 1:5 water and 0.O1M $CaCl_2$), electrical conductivity, and water repellency were measured (Table A2). The methods of analysis are described below.

Methods of analysis

Nitrate-nitrogen (N03):	Aluminium sulphate solution added to a water extract and measured with a specific-ion electrode.
Ammonium-nitrogen (NH4+):	Potassium chloride extract measured colorimetrically.
Phosphorus (P):	Sodium bicarbonate extract measured colorimetrically (Colwell method).
Potassium (K):	Sodium bicarbonate extract measured by atomic absorption.
Organic carbon (C%):	Soil/acid dichromate solution measured colorimetrically (Walkley-Black method).
Soil reaction (pH):	1:5 soil water suspension and where noted with 0.01 M calcium chloride.
Electrical conductivity (EC):	On the 1:5 soil water suspension.

Table A1. Concentrations of Nitrogen, Phosphorous, Potassium and Carbon in the top 10 cm of soil at locations lA to 3D shown on Figure Al

Location	**NO3- ppm**	**NH4+ ppm**	**P ppm**	**K ppm**	**C%**	**Map unit**
lA	5	6	27	110	1.0	2b
lB	5	6	23	118	1.4	2a
1C	5	6	17	104	1.1	2a
1D	3	7	13	133	0.9	la
lE	3	6	15	62	1.0	6
lF	2	6	22	78	1.0	la
2A	3	4	10	53	0.6	6
2B	3	6	7	77	1.1	la
2C	3	5	6	60	1.0	3
2D	4	12	6	99	0.9	2b
2E	4	12	7	127	1.0	la
2F	3	5	6	51	0.6	2c
3A	6	11	8	107	1.1	3
3B	11	9	8	111	1.0	2b
3C	6	8	7	75	0.9	6
3D	3	10	8	104	0.7	2c
Mean	4.3	7.4	11.9	91.8	0.96	
Standard deviation	2.2	2.6		26.7	0.2	
Standard error of mean	0.5	0.6	1.7	6.7	0.05	
± C*	1.0	1.0	3.0	10	0.1	
x**	20	27	21	29	16	

* ± C confidence interval with 95% confidence limits.
**x sample size to achieve confidence interval.

Size of sample

The chemical analyses in Tables Al and A2 can be used to obtain an estimate of the sample size in soil testing programmes at the annex. The methods should be similar to those used above. The investigation must first decide upon an acceptable confidence interval ± C. The number of samples with 95 per cent confidence limit is given by

$$x = \frac{4\ ^{2}}{C^{2}}$$

where is the population standard deviation which is estimated by s the sample standard deviation (Snedecor and Cochran, 1967). Estimates of x for selected values of c are included with the means and standard deviations at the foot of Tables Al and A2.

Table A2. pH (1:5 water and 0.OlM $CaCl_2$), water repellency (MED test) and EC1:5 of soils sampled at various depths from areas lA to 3D shown on Figure Al

Location	**Sample**	**Depth (cm)**	**pH (H_20)**	**pH (0.01 M $CaCl_2$)**	**MED test**	**E.C. (mS/rn)**
lA	2.11	0-10	6.2	4.9	1.0	8.7
lB	2.12	0-10	6.3	4.9	2.5	8.7
lC	2.21	0-10	6.3	5.1	2.0	7.2
	2.22	20-30	6.4	5.2	1.0	7.4
	2.23	> 30	6.8	5.5	0	6.2
lD	*	0-10	5.6	5.0	1.5	11.3
lE	2.31	0-10	5.5	4.6	1.5	12.1
	2.32	20-30	6.8	6.1	0	5.2
	2.33	30-40	7.1	6.0	0	5.9
1F	*	0-10	6.2	5.2	2.0	11.8
2A	4.11	0-10	7.1	5.0	2.5	8.4
	4.12	10-20	6.3	4.5	1.0	3.].
	4.13	20-30	6.5	5.6	0	4.6
	4.14	60-70	7.0	5.8	0	6.6
2B	4.lc	0-10	6.8	5.3	3.0	8.3
2C	4.21	0-10	6.1	5.1	3.0	9.3
	4.22	10-20	7.0	5.2	0.5	2.2
	4.23	50-60	7.2	5.4	0	5.0
2D	4.31	0-10	6.1	5.3	3.0	13.7
	4.32	10-20	7.1	5.6	1.0	5.7
	4.33	20-30	6.5	5.3	0	2.5
2E	4.3lc	0-10	6.5	5.2	3.0	15.7
2F	4.41	0-10	6.6	5.2	2.5	7.7
3A	4.31	0-10	6.6	5.5	3.0	9.2
	4.32	20-30	7.2	4.9	1.0	4.0
38	4.3llc	0-10	6.3	5.2	2.5	9.0
3C	4.321	0-10	6.7	5.2	3.5	10.7
3D	4.331	0-10	7.0	5.1	3.5	7.8
Mean (Samples 0-10 cm)			6.5	5.2	1.6	7.8
Standard deviation			0.5	0.4	1.2	3.3
Standard error of mean			0.09	0.07	0.2	0.6
± C[1]			0.2	0.2	0.5	2
x^2			25	16	23	11

* missing sample number

1 ±C confidence interval with 95% confidence limits.

2 x sample size to achieve confidence interval.

A Waychinicup profile

The detailed chemical and physical analysis of a Waychinicup profile, described by Churchwood et al.. (1988) is given in Table 3A. The analytical methods are described in Churchwood et al. (1988).

Table A3. Waychinicup profile description and Analytical data from Churchwood et al.. (1988) site 79, 1 km north-east of the annex

Profile: 79

Classification: Yellow duplex (solonetzic) soil Dy5.43

Reference: P41; Waychinicup sand (Smith (1950)

Location: Coopers Road, 2.5 km north of Chillinup Road. 34°31'S; 1l8°18E

Mapping Unit: Chillinup

Number	Depth (cm)	Description
1	0-3	Grey-brown fine sand with organic matter
2	3-18	Light grey-brown fine sand; low gravel
3	18-45	Brown, yellow-brown and reddish brown mottled sandy clay; columnar
4	45-71	Yellow-brown and grey-brown mottled sandy clay; low gravel
5	71-107	Grey-brown and yellow-brown mottled sandy clay; rock fragments
	107	Spongelite and chert

Analytical Data

No	Reaction pH	Loss on ignition %	Total salts %	Organic carbon %	Nitrogen %	Gravel %	Silt %	Clay %	Total	Exchangeable cations (m-equiv./100g soil)			
										Ca	Mg	K	Na
1	6.0	1.3	0.01	0.5	0.02	<1	3	2	1.8				
2	6.0	0.8	0.01	0.4	0.02	6	4	0	1.4				
3	7.3	3.2	0.07	0.4	0.03	2	2	27	11.2	1.0	4.5	0.8	1.7
4	9.4	5.8	0.32	0.1	0.01	9	2	39					
5	9.3	6.4	0.44	0.1	0.01	26	0	42					

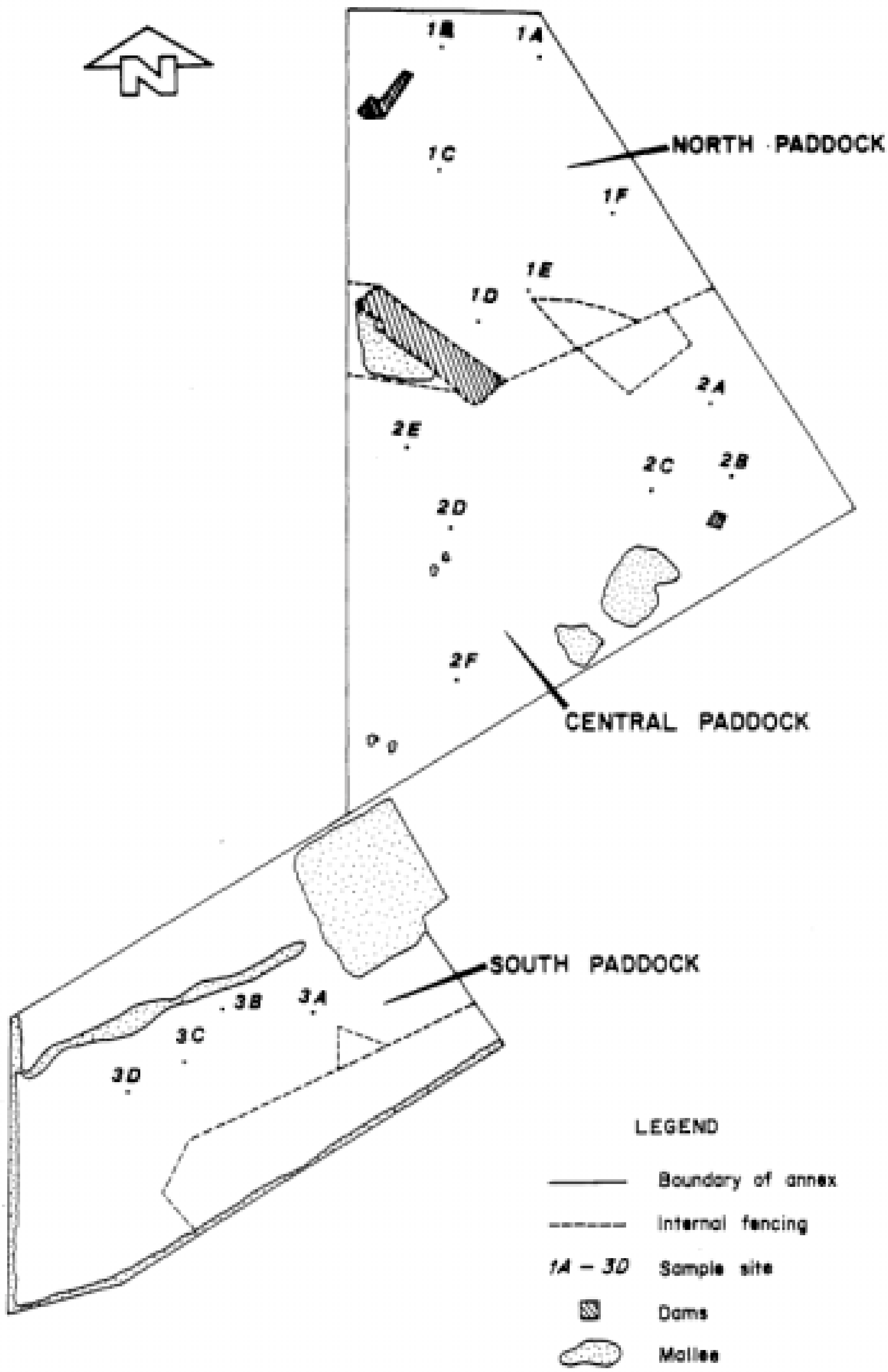

Figure A1. Areas sampled by Mr R. Glencross during April 1987 for a preliminary assessment of the annex. The results of the analyses are given in Tables Al and A2.

Appendix 2

List of Principal Profile Forms (PPF) described and frequency of occurrence.

Map unit	PPF	No.	Per cent of profiles classified
1a	Dy5.42	14	44
	Dg4.42	5	16
	Dy5.82	4	12
	Dg4.82	2	6
	Dy4.82	2	6
	Dy4.42	1	3
	Dy4.43	1	3
	Dg4.43	1	3
	Dy5.43	1	3
	Dy5.83	1	3
	Unclassified	3	-
	TOTAL	35	
1b	Dg4.82	4	27
	Dg4.42	4	27
	Dg4.83	3	20
	Dy5.82	3	20
	Uc5.ll	1	6
	Unclassified	1	-
	TOTAL	16	
2a	Dy4.42	13	81
	Dy4.43	2	12.5
	Dy5.43	1	6.5
	TOTAL	16	
2b	Dy5.42	12	46
	Dy4.42	10	38
	Dy5.43	1	4
	Dy4.43	1	4
	Dg4.42	2	8
	TOTAL	26	

Map unit	PPF	No.	Per cent of profiles classified
2c	Dy5.42	12	45
	Dg4.42	9	33
	Uc2.2l	6	22
	TOTAL	27	
3	Dy5.42	4	45
	Dy5.85	3	33
	Dy4.42	1	11
	Dg4.82	1	11
	Unclassified	9	-
	TOTAL	18	
4	Dy4.43	1	33.3
	Dy4.23	1	33.3
	Dy5.63	1	33.3
5	Dy4.83	1	100
6	Uc2.21	26	81
	Uc5.11	5	16
	Uc1.11	1	3
	Total	32	