RESEARCH PROJECT SERIES

SOIL AND LAND SURVEY OF THE

STATE RESEARCH FARM WERRIBEE

BY

J.M. MAHER AND J.J MARTIN

NOTE FOR READERS
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The authors extend sincere thanks to all these people.

SECTION 1 - PURPOSE OF SURVEY

The aims of the survey were:

(a) to identify and classify the soils of the State Research Farm (S.R.F) Werribee;

(b) to delineate map units homogeneous in terms of soil profile;

(c) to determine if any relationships between soils and topography exist;
and

(d) to construct a provisional land capability map from the data obtained.

SECTION 2 - BACKGROUND

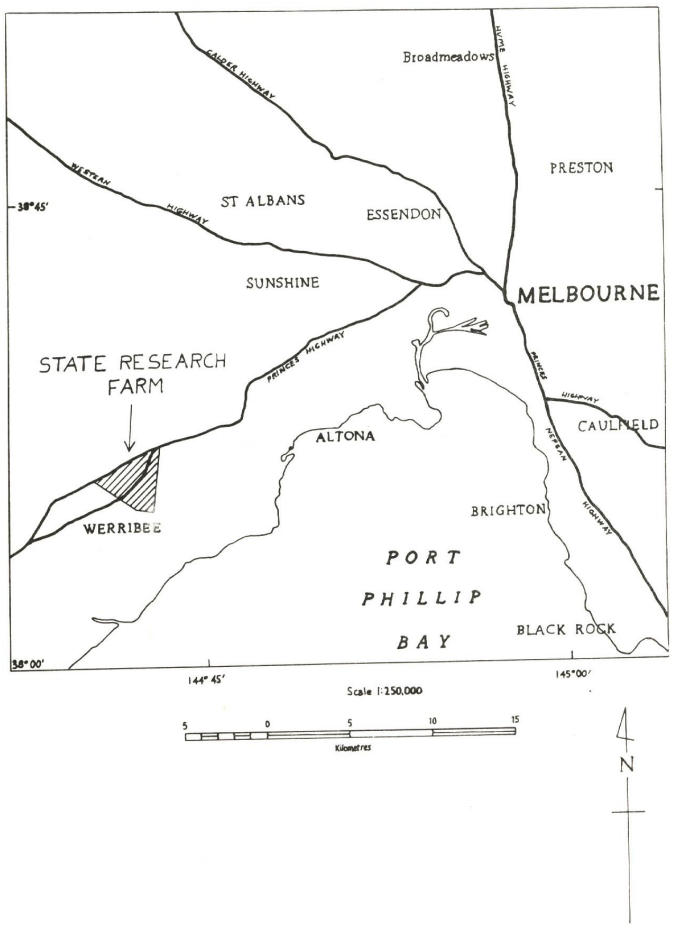
2.1. Philosophic Basis for Soil and Land Survey

As a basis for the comprehension of this report certain concepts and terms are defined.

Soil is the natural medium for the growth of plants, and in this sense covers land as a continuum. Soil exists in many forms and its characteristics in any one place have been defined as being the result of the combined influence of climate and living matter, acting upon the parent rock material, as conditioned relief, over periods of time, including the effects of the cultural environment and man's use. Because of the complex nature of soil, some classification, determined from a survey, must be used to define the different kinds of soils.

The study of land must include the examination of relief, soils, hydrology and vegetation. Variation in soil, or in soil and landform, is often the main cause of differences in productivity between mapped areas of land. It is for this reason that soil surveys are sometimes the basis for definition for land mapping units. However, the suitability of soils for land use cannot be assessed in isolation from other aspects of the environment, and hence, in this report topographic elements as well as soil are employed as the basis for a provisional evaluation of land capability.

Figure 1: Locality Plan



2.2 Agricultural History of the Werribee Farm

The State Research Farm, Werribee, was established in 1912 to investigate ways of improving Agricultural production in Victoria.

The early development was devoted to research into crop improvement with emphasis on rotations, fertiliser practice and plant breeding. The dry farmed areas have been utilised for the production and testing of improved cereal varieties and the multiplication of seed of outstanding varieties for general distribution to farmers.

The alluvial is devoted to irrigated permanent pastures. The first research activity in Victoria into watering and fertiliser requirements of irrigated pastures was conducted in Werribee in the mid-1920 period.

The program of livestock research had been expanded greatly in recent years since the building of the S.S. Cameron Laboratory in 1960 as the headquarters for the animal husbandry research.

The School of Dairy Technology was established on the farm in 1939, and is now incorporated in the Gilbert Chandler Institute of Dairy Technology which was opened in 1968.

2.3 Early Soil Surveys

The first soil project was a chemical survey carried out during the mid 1915-18 period. Site locations were marked accurately on a surface colour map of the farm on the western side of the outfall sewer. Analyses carried out during the chemical survey were for nitrogen, phosphoric acid (P_2O_5), potash (K_2O), lime (CaO), magnesia (MgO), chloride and pH.

F. Penman was concerned with soil changes under irrigated pasture and published his work under that title in the Journal of Agriculture, Victoria in 1940.

In 1953, V. Grasmanis carried out a soil survey and produced a map compiled from a field study of soil profiles. Profiles were recorded at about 160 metre intervals or closer where the soil pattern appeared to make this necessary. He proposed 9 soil units disturbed between two major groups themselves separated on the basis of a presumed difference in parent material.

J.K.M. Skene's review of earlier work was prepared in the light of supplementary observations and the results of laboratory analyses. The review was made in connection with his contributions to the School of Irrigated Pastures and Fodder Crops (1954), the 1956-57 Guide Book to the S.R.F. and the Study Tours handbook for the Second Australian conference in Soil Science, 1957.

Since that time, the Northcote system of soil classification has been generally adopted in Australia, and is used almost universally by agricultural research workers. Any report of soil survey of a research station should provide this classification for the soils of the area. The Northcote system had been used in the survey reported here.

2.4 Geological and Climatological Setting

2.4.1 Geology (8. 10, 34, 35)

The State Research Farm Werribee is situated partly on the Werribee River delta deposits and partly on the Newer Volcanics of the Werribee Plains. These areas form part of the catchment known as the Werribee River Basin.

In Lower Ordovician times the Werribee river Basin was covered by a sea which gradually receded to the east during the Upper Ordovician period. Following general uplift and folding, the area entered a phase of relative tectonic inactivity during which the region was subjected to sever erosion.

In Devonian times marine sediments were intruded by granitic magma. Erosion continued and much granitic material was exposed.

During Permian times the temperature became much colder and glaciers continued the general erosion of the land surface. At the end of this period temperatures began to rise and glaciers retreated leaving great masses of debris which had been carried down and deposited in the old valleys. Fluvio-glacial conglomerates and sandstones were also deposited in glacial rivers and lakes. Triassic sandstones were later deposited in a comfortable series over the beds of glacial material.

Erosion continued throughout the Triassic and Jurassic periods and by Early Tertiary times the area had been reduced to a peneplain. It is possible that some early movements along the Greendale and Spring Creek faults occurred during this time. As a result, the Ballan Sunkland was lowered and the glacial beds were protected from complete removal by erosion. During this time basalts of the Older Volcanics were extruded over the peneplain and thick piles formed in the downfaulted basin of the Ballan Sunkland. Only eroded remnants are left of the Older Volcanics.

Differential uplift along the Greendale, Spring Creek and Coimadai faults produced the raised blocks of the Lerderderg, Brisbane and Gisborne Ranges, as well as the sunklands of Ballan and the Werribee Plains. The Ballan sunklands and Werribee Plains are within a major region known as the Port Phillip Sunklands, a broad downfaulted area between the Rowsley and Selwyn Faults. From the Yarra Valley at Melbourne, west to the Rowsley Fault, the Werribee Plains are part of the volcanic plains of Western Victoria. Basaltic lava, tuffs and scoria that cover the volcanic plains are not all of the same age, but range from Pliocene to Recent. Scoria and tuffs are rare on the Werribee Plains where the points of eruption are mostly very low and broad lava domes or small lava cones of no great height. Mt. Cottrell is the most prominent dome. The basalt which formed the very extensive sheets of the Werribee Plains is Pleistocene in age.

The extensive Newer Basalt eruptions which occurred in Early Quaternary time infilled the Tertiary river system and disrupted drainage by filling valleys in the uplifted blocks and covering most of the sunklands. Among the young faults is the Rowsley Fault which affected Newer Volcanic basalt and cause extensive dissection of the upthrown block in which the Werribee and Lerderderg Gorges and the Parwan Valley have been cut. On the downthrown block, erosion of basalts of the plains has produced the Bacchus Marsh basin in which the township is situated some 60 metres below plains level. The Werribee river downstream from the basin, has cut a valley in basalt flows from Mt. Cottrell.

Alluvium, eroded by rejuvenated streams, was deposited along the base of the Rowsley escarpment and along sections of the Parwan Creek and Werribee River. The alluvium, gravels and sands, which forms the Bacchus Marsh flats and the Werribee River Delta, was deposited in Late Quaternary times.

2.4.2 Climate

Climate in this area is temperate with warm dry summers and maximum rainfall occurring during spring. Drier summer conditions and lower winter temperatures inhibit plant growth.

(a) Rainfall

The rainfall is affected by topography and the general westerly origin of rain-bearing winds. The farm lies in a region of low precipitation (Table 1) due to its low elevation (Werribee 23m A.S.L.) and its position in the lee of a mountain range tending north-south across the direction of the moisture-bearing winds. The rain shadow, on the relatively flat plains, extends from Lara to Melton.

Table 1 - Monthly and Annual Rainfall of the S.R.F. Werribee (average 63 years)

Month	Average Rainfall (mm)
January	36
February	43
March	40
April	47
May	45
June	41
July	42
August	44
September	49
October	56
November	49
December	48
Total	541

(i) Rainfall Probability:

Monthly: The monthly rainfall records which have been operating at the farm for relatively long periods have been analysed by means of cumulative frequency curves; percentage chances of receiving specified monthly totals have been calculated (1). This data can be useful in agricultural investigations. If the moisture requirements of a particular crop are known, the general suitability of the locality, with regard to rainfall alone, can be assessed. To determine the moisture requirements, Table 2 is examined to see if the crop's approximate minimum moisture requirements are likely to occur during its main growth period.

Table 2 - Monthly Rainfall Probability at Werribee

Probability (% over 63 years) of receiving at least The specified amounts						
	13mm	**35mm**	**38mm**	**51mm**	**76mm**	**102mm**
January	73	52	32	22	6	2
February	78	62	42	30	14	8
March	67	54	40	29	22	11
April	87	65	48	32	13	5
May	92	71	51	37	13	1
June	99	75	44	27	2	0
July	97	83	43	19	6	3
August	94	75	56	32	44	1
September	95	84	63	40	13	2
October	97	81	68	51	24	6
November	87	68	52	38	17	5
December	84	65	49	37	17	1

Seasonal: Total rainfall for each season has also been analysed for all years of record, and the chances of receiving specified amounts in each season determined (1). The results (Table 3) show that spring is the wettest season.

Table 3 - Seasonal Rainfall Probability at Werribee

Probability (% over 63 years) of receiving at least the specified amounts							
	51mm	**76mm**	**102mm**	**127mm**	**152mm**	**203mm**	**254mm**
Summer	89	76	56	40	24	3	
Autumn		87	65	44	31	8	2
Winter		91	76	38	14	5	0
Spring		93	79	59	42	17	3

(ii) Effective Rainfall:

The two major climatic factors limiting plant growth in the area are inadequate soil moisture in summer and excessive cold in winter. Apart from rainfall, other factors which determine the amount of soil moisture available to plants are evaporation, slope of ground and soils.

Effective rainfall is defined as the amount of rain, after the dry period, necessary to start germination and to maintain growth above the wilting point. The relationship between effective rainfall and evaporation can be expressed by the formula $P = 0.54E^{0.7}$, where P is the effective rainfall (mm/month). Using this relationship, the rainfall records were examined, and the chances of receiving rainfall equal to or exceeding the effective amounts for each month were determined(1). The results are expressed as percentage frequencies of occurrence in Table 4.

Table 4 - Chances of Receiving Monthly Rainfall Equal to or Greater than the Effective Amount at S.R.F. Werribee

Month	**Chance (%)**
January	21
February	35
March	42
April	63
May	82
June	97
July	95
August	83
September	89
October	72
November	51
December	41

(iii) Temperature:

Average monthly temperatures at Werribee are shown in Table 5. January and February are the warmest months of the year with an average daily maximum temperature of approximately 25°C. Average minimum daily temperatures are lowset during June, July and August when they are approximately 5°C.

Table 5 -Average Monthly Temperatures at S.R.F. Werribee

Month	Average Maximum Temperature (°C)	Average Minimum Temperature (°C)	Average Mean Temperature (°C)
January	25.7	12.3	19.0
February	25.3	13.3	19.3
March	23.4	11.9	17.7
April	19.8	9.4	14.7
May	16.3	7.1	11.7
June	13.7	5.2	9.5
July	13.2	4.4	8.8
August	14.5	5.8	10.2
September	16.7	5.9	11.3
October	19.3	7.7	13.5
November	21.7	9.4	15.5
December	24.2	11.5	17.9

(iv) Wind:

The predominant winds in the Werribee area come from the west and north-west and sweep across the plains towards Port Phillip Bay. Autumn winds, generally being lighter, have only slight seasonal variation. Surface winds in the area are affected to a great extent by topography.

(v) Growing Season:

The growing season can be defined as the number of months in which the probability of receiving effective rainfall exceeds 50%, plus one month. The additional month allotted makes allowance for moisture stored in the soil. Low temperatures can restrict or completely stop plant growth and must be combined with the above definition of a growing season. The commonly accepted temperature limit for active growth is 10° mean monthly temperature. No significant growth occurs below 5.5°C.

Four growth categories have been defined and three of which apply to the S.R.F Werribee. The categories are normal growth, growth restricted by cold, no growth due to cold, and no growth due to drought. These comprise a useful indicator of climatic suitability for plant growth. However, the actual length of the growing season would also depend on the availability of irrigation water, the characteristics of the plant (e.g. its tolerance to low temperatures; the depth to which its roots can penetrate) and the characteristics of the soils topography.

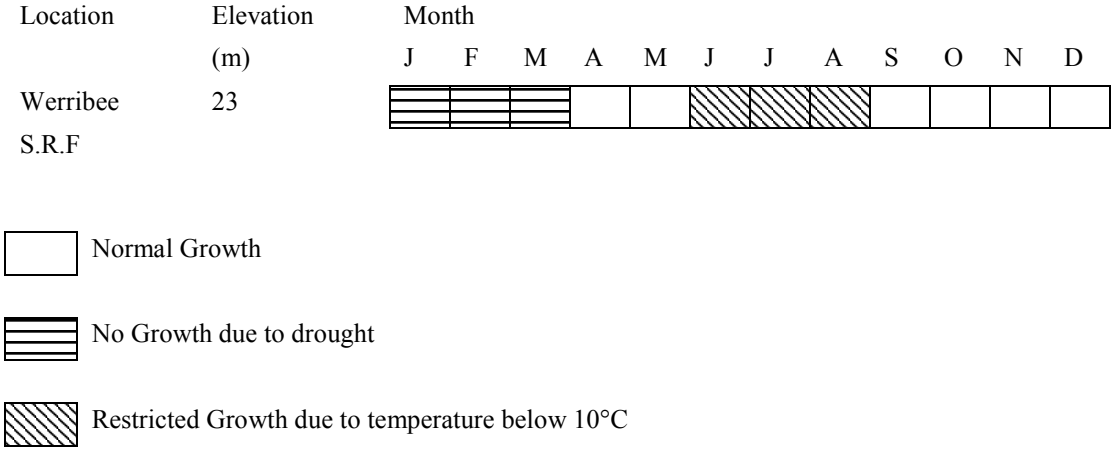


Figure 2 - Diagrammatic representation of the estimated growing Season at the S.R.F Werribee (35) derived From effective rainfall probability and Mean monthly temperatures.

On irrigated pastures at the S.R.F the growing season is lengthened, because of irrigation, to include January, February and March. The growing season would then be nine months.

SECTION 3 - METHODS

3.1 General Survey Method

Three main groups of soil survey procedures can be distinguished, grid survey, free survey and physiographic survey (3).

Grid survey involves making observations of the visible properties apparent in an auger sample. The samples are taken along regularly spaced traverse lines. Commonly, the spacing of observations is varied according to visible changes in the soil surface.

In a free survey the surveyor locates and follows soil boundaries on their association with external properties such as land form, vegetation, land use, etc., as observed on the ground or on aerial photographs.

In physiographic survey mapping, boundaries are drawn according to the external properties of soil or landscape as seen on aerial photographs with little or no ground check. Field observations are intended primarily not to locate boundaries, but to identify the soils of the areas within the boundaries.

Because of the importance of the research station, a grid survey was chosen because it is the only one of the three procedures in which all the parts of every map unit have an approximately equal chance of being recognised. In addition, free and physiographic surveys require some external expression in the landscape for differentiation of soils; however, at the scale used, some of the map units that were subdivided had no external expression.

The density of the grid was approximately one site per two hectares, i.e. a site for every 150 metres. The scale of mapping used in the field was 1:10,00 and at this relatively large scale, the grid spacing given above proved satisfactory in delineating soil units which lacked external expression. Phototone and photopattern discrimination on aerial photos at this scale were minimal; thus cadastral features were distinguishable and easily located. This facilitated the precision of soil boundaries marked on the final map.

3.2 Soil Classification System

The Principal Profile Form (P.P.F) of the Factual Key (17) was the basic system used to classify the soils of the State Research Farm. This is one of the two classification systems currently readily available and widely used in Australia. The other system, the Great Soil Group (G.S.G) is outlined in detail in the Handbook of Australian Soils (29). Both systems use the morphology of the soils as the main basis for classification.

The P.P.F. system of Northcote was chosen because it allows for greater discrimination, based on field observable features, the G.S.G. The advantages of the Northcote system can be supported by the fact that only 43 G.S.G.'s have been recorded for 855 P.P.F.'s. In Australia, soils have only been recorded in 565 P.P.F.'s and of these 240 account for the most commonly occurring soils, while the remaining 325 are restricted to only limited occurrences.

Whereas the morphology of the soil is used to describe the G.S.G.'s in a general way, the Factual Keys use morphological properties to define the P.P.F.'s. These P.P.F.'s arose as the morphological properties were listed in relation to profile form. Hence Northcote's P.P.F.'s provide precision and accuracy whereas the G.S.G's give only a broad characterisation. For example, under the G.S.G of "Red-brown earths", eight P.P.F.'s have been defined.

3.3 Morphological Features Observed

In describing the morphology of a soil profile, the features recorded at each site were as follows: Depth; textures; grits, gravels and stones; colour using the Munsell soil colour charts as a standard; condition of the surface soil (including seasonal behaviour); pedality; structure; fabric; consistence; pans; cracks; field pH; carbonates; gypsum; water regime; horizons and the nature of the boundaries between them. An explanation of terms is given in Appendix III.

3.4 Routine Sampling and Analyses

During the course of the survey, samples were collected from each site, at the three standard depths, for routine analyses. The standard depths for collection were 0-10 cm, the top 15 cm of the B horizon, and 60-90 cm, i.e. the surface soil, top of the subsoil and the deep subsoil.

The analyses carried out were – electrical conductivity, pH, and chloride. Mechanical analysis was carried out on every second surface sample.

3.5 Description and Analyses Of Typical Soils

Comprehensive laboratory analyses were carried out on soils sampled from a selected number of sites. The soil samples, selected from an array of soils described during the survey, were representative of the typical soils of the farm. Morphology was described according to the features listed in 3.3. A brief description of all analytical methods carried out is given in Appendix II.

3.6 Soil, Salinity, Slope and Capability Maps

In compiling the soil map, each site was initially classified from the profile features previously described. After classification, the soils were grouped into a number of units according to their Northcote Key notation, and the boundaries of these units were drawn on the aerial photographs. Interpretation of photopattern and the knowledge of the topography were also utilised in drawing the soil boundaries.

Soil salinity maps, based on analytical values of chloride (Cl^-) and electrical conductivity (E.C.) at each site, were compiled. The E.C. map was used when compiling the land capability map, whereas the Cl^- map was included for comparative purposes.

As no standard procedure exists in selecting depths to obtain soil samples for appraising salinity, the details of procedure therefore depend upon the purpose for which the sample was taken. Historically, the Cl^- classes of non-horticultural areas have been based on figures obtained from two standard depths, 0 to 30 cm and 60 to 90 cm. In order to relate E.C. to pedology, the E.C. values for the top of the B horizon were mapped as a guide to salinity over the farm. The depth corresponding to the top of the B horizon was chosen for a number of reasons. It is normally the region of maximum clay percentage within the solum and could represent zones of maximum reduction in permeability and of accumulation of leached salts. Also, it is a most significant horizon used in the pedological classification, e.g. its colour can indicate characteristics of aeration and drainage and may separate sola at the subdivision level. Fluctuations regime, and environmental factors, such as seasonal precipitation. However, the graph (Figure 3) of E.C. values for the representative soil sites shows that the E.C. increases with depth down the profile.

The percentage slope map was constructed from a contour map of the farm. The contour interval was 60 cm. The choice of slope classes for this topographic element map was based on the absolute slope on the farm, and on criteria used in land capability classification by the USDA, Soil Conservation Service (25).

In constructing a provisional land capability map, the soils are classified according to their potentialities and limitations for sustained production of the commonly cultivated crops and pasture plants without deterioration over a long period of time. The interpretative grouping is determined by using a numerical rating, for soil factors (Section 4.3.1), which was developed by Storie (32). The Storie index rating is based on soil characteristics only and is obtained by multiplying the selected number of factors together, thus any one factor may dominate or control the final rating. For example, a soil may have an excellent profile justifying a rating of 100% for a factor of A, but a very poor 10% rating for a factor of B.

Therefore the index rating would be 10% (i.e. 1.0 0.1 = 0.1 or 10%). In assigning soils to the various groupings the following assumptions are made.

(1) Soils within a capability grouping are similar with respect to degree of limitation for agricultural use. These soils can than be subdivided according to the kind of limitation.

(2) Capability groupings are subject to changes when new information about the behaviour and responses of the soils become available.

(3) A moderately high level of farm management is assumed, i.e. one which is practical and within the ability of a majority of farmers.

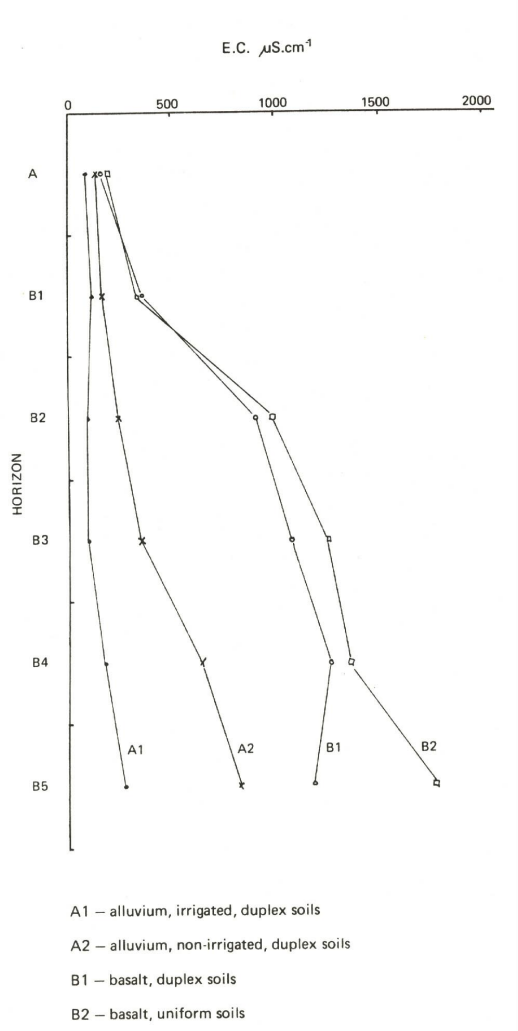


Figure 3. Soil Electrical Conductivity for the Basal and Alluvial Geological Units.

3.7 Soil Colour Descriptions

A formal description of soil colour usually includes a name and coding. In view of the nature of the colour itself, the subjective nature of its assessment and normal language limitations, it is not surprising that there is commonly less dissension concerning coding than there is in the matter of naming.

While the colour may be perceived as a continuum, for practical purposes soils are matched or compared with a number, commonly between 175 and 240, of coloured papers or chips. Since the colour matching is done on reflected light the method is valid at different intensities of incident light. The chips are systematically arranged in a book (Munsell) format so that the 3 colour components, hue, value and chroma, are easily identified. Even using the Munsell charts the probability of having a perfect matching of the same colour is less than one in one hundred (27). "Hue" is the dominant spectral colour. "Value" refers to the relative lightness of the colour and is a function (approximately the square root) of the total amount of light. "Chroma" is the relative purity or strength of the spectral colour and increases with decreasing greyness. The alphanumeric reference to hue, value and chroma is the Munsell Notation.

The historic tendency in the survey unit of not using the Munsell "names" corresponding to the chips is based on a number of factors including the American tendency to use "red" for chips for which Australians would include "brown" or "brownish", and the development of a naming system which allows greater colour discrimination according to the range of Munsell Chips. Although the survey unit has never published any detail material relevant to this subject, a basic system with some general principals appears to have been developed over many years of survey experience, particularly at detailed scales. This basic system has been accepted by former senior staff. An example of such a system, which was also used in this survey, is shown in Appendix IV.

In this particular system the core words for the 8 hues are as follows: 7.5Y – red, 10R – brownish red, 2.5YR – red-brown, 5YR – reddish brown, 7.5YR – brown, 10YR – yellowish brown, 2.5Y – yellow-brown, and 5Y – yellow. An increase in value component from 2 to 9 is indicated by the appropriate application of terms such as very dark, dark, slightly dark,

light, very light and white. With regard to the chroma component, the term dull is applied to certain chips within the middle chroma range (levels 3 to 6), and the term bright is used for certain ships within chroma 8. The final matrix uses 15 words and provides 223 word combinations (ie. colour names) for 240 Munsell chips. There are 13 situations in which one word combination refers to 2 colour chips, and 2 situations where a word combination refers to 3 chips. In terms of discrimination between colours, using

words, the system outlined here compares more than favourably with the American System which provides a total of only 51 word combinations for the same set of chips. The comparison is well illustrated with reference to the 6 Munsell Notations 5YR 5/3, 5/4, 4/3, 4/4 and 2.5YR 5/4 and 4/4. All these notations are referred to by name as "reddish Brown" in Munsell terminology. The system used in this survey provides a different word combination (name) for each of these chips.

Whatever the relative merits of the above two colouring naming systems, the unimportance of a "name" relative to its Munsell code is strongly emphasised. The Munsell notation is especially useful for international correlation, since no translation of colour name is needed (26).

Although the Munsell soil colour charts are necessary for the factual key classification of soils, no reference need be made to actual colour names (17).

SECTION 4 - RESULTS

4.1 Soils

4.1.1 Description of Soils

Modal profile descriptions are given to allow for the variability that may occur within a mapping unit. Depths stated are the average depths at which the profile changes occur.

The soils are considered in series, and in the order of their predominance which is based on their areal occurrence.

Series 1:
These soils are alkaline and have distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is whole-coloured and red.

Mapping unit: la

Northcote Classification and Surface Texture: Dr 2.13/FSCL (10)[+]

Great Soil Group Classification: Red-brown earths.

Surface soil
A 0-10 cm greyish brown (7.5YR4/4m) or lightly dull reddish grey-brown (5YR4/4m) fine sandy clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately plastic and friable moist; trace to light amounts of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm lightly dull reddish grey-brown (5YR4/4 m) or reddish brown (5YR4/6m) heavy clay, sometimes grey-brown (7.5YR4/2m) medium or heavy clay occurs from 25 to 35 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to firm moist; field pH 7.0 to 8.0; clear or gradual to:

34-45 cm dull greyish brown (7.5YR5/6m) or greyish brown (7.5YR5/4m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 8.5; clear or gradual to:

45-55 cm light dull yellowish brown (10YR6/4m), dull yellowish brown (10YR5/4m) or light yellowish grey-brown (10YR6/3m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and very firm moist; field pH 9.0; gradual or clear to;

55-70 cm yellowish brownish grey (2.5YR5/2m) or light yellowish grey-brown (10YR6/3m), sometimes light yellowish brownish grey (2.5YR6/2m), medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; trace to moderate amounts of hard and soft

[+] records the depths of the A horizon in cm for duplex soils.

calcium carbonate can occur below 55 cm, and sometimes trace to moderate amounts of rock fragments occur below 55 cm; field pH 9.0; gradual or clear to:

70-90 cm light yellowish brownish grey (2.5YR6/2m), sometimes very light yellowish brownish grey (2.5YR7/2m), medium or heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slight to moderately sticky, very plastic, firm to very firm moist; field pH 9.0.

Mapping Unit 1b

***Northcote Classification and Surface Texture*:** Dr 2.13/cl (10)

***Great soil Group Classification*:** Red-brown earths.

Surface Soil
A 0-10 cm greyish brown (7.5YR4/4m) or yellowish grey-brown (10YR4/4m) clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, slightly sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs); field pH 5.5 to 6.5; sharp to:

Subsoil
B 0-35 cm slightly dull reddish grey-brown (5YR4/4m) or reddish brown (5YR4/6m) sometimes with dull red-brown (2.5YR4/6m) medium or heavy clay, sometimes grey-brown (7.5YR4/2m) medium or heavy clay occurs from 25 to 35 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic, firm to very firm moist; field pH 7.0 to 8.0; clear or gradual to;

35-45 cm dull greyish brown (7.5YR5/6m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic, firm to very firm moist; field pH 8.5; clear or gradual to:

45-55 cm light yellowish grey-brown (10YR6/3m) or dull yellowish brown (10YR5/4m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace to moderate amounts of hard and soft calcium carbonate can occur below 45 cm; and sometimes trace to light amounts of rock fragments occur below 45 cm; field pH 8.5 to 9.0; clear or gradual to:

55-75 cm yellowish brownish grey (2.5YR5/2m) medium or heavy clay, or light yellowish brownish grey (2.5YR6/2m) medium or heavy clay continues to 90 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very moderately sticky, very plastic and firm to very firm moist; field pH 9.0; clear or gradual to:

75-90 cm light yellowish brownish grey (2.5YR 6/2m) medium or heavy clay; moderate to fine coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist field pH 9.0.

Series 2:
These soils are alkaline and have distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is mottled and dominantly brown.

Mapping Unit: 2a

Northcote Classification and Surface Texture: Db 2.13/fscl(10)

Great Soil Group Classification: No Suitable group.

Surface Soil
A 0-10 cm yellowish grey-brown (10YR4/3m) fine sandy clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately plastic and friable moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm yellowish grey-brown (10YR4/3m), sometimes greyish brown (7.5YR4/4m), with dull red-brown (2.5YR4/6m) mottled medium to heavy clay, sometimes grey-brown (7.5YR4/2m) medium clay occurs from 25 to 35 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, lightly sticky, very plastic and firm to very firm moist; field pH 7.0 to 8.0; clear to:

35-45 cm dull greyish brown (7.5YR5/6m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 8.0 to 8.5; gradual to:

45-55 cm light dull yellowish brown (10YR6/4m), light yellowish grey-brown (10YR6/3m) or dull yellowish brown (10YR5/4m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; field pH 8.5 to 9.0; gradual to;

55-70cm yellowish brownish grey (2.5YR5/2m), sometimes light yellowish brownish grey (2.5YR6/2m), medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic to very firm moist,; trace to moderate amounts of hard and soft calcium carbonate can occur below 55 cm; field pH 9.0; clear or gradual to:

70-90 cm light yellowish brownish grey (2.5YR6/2m), sometimes very light yellowish brownish grey (2.5YR7/2m), medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; field pH 9.0.

Mapping Unit 2b

Northcote Classification and Surface Texture: Db 2.13/CL(10)

Great Soil Group Classification: No Suitable group

Surface Soil
A 0-10 cm yellowish grey-brown (10YR4/3m) or greyish brown (7.5YR4/4m) clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately plastic and friable to firm moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm Yellowish grey-brown (10YR4/3m) or greyish brown (7.5YR4/4m) with dull-red brown (2.5YR4/6m) or reddish brown (5YR5/6m) mottled medium or heavy clay, sometimes grey-brown (7.5YR4/2m) or yellowish grey-brown (10YR4/2m) medium or heavy clay occurs from 25 to 35 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 7.0 to 8.0; clear to;

35-45 cm dull greyish brown (7.5YR5/6m) or dull yellowish brown (10YR5/4m) medium or heavy clay; moderately coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and firm to very firm moist; field pH 8.5 to 9.0; gradual to;

45-60 cm light yellowish grey-brown (10YR6/3m) medium or heavy clay, sometimes yellowish brownish grey (2.5YR5/2m) medium or heavy clay occurs from 55 to 70 cm; moderately coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; trace to slight amounts of rock fragments can occur, and trace to moderate amounts of hard and soft calcium carbonate can occur below 45 cm; field pH 8.5 to 9.0; gradual or clear to;

60-90 cm light yellowish brownish grey (2.5YR6/2m) medium or heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; trace to moderate amounts of rock fragments can occur; field pH 9.0.

Series 3:
These soils are alkaline and have distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is mottled and dominantly yellow or yellow-grey.

Mapping Unit: 3

Northcote Classification and Surface Texture: Dy 3.13/CL(10)

Great Soil Group Classification: No Suitable group

Surface Soil
A 0-10 cm greyish brown (7.5YR4/4m) fine sandy clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately plastic and friable moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm grey-brown (7.5YR4/2m) with dull red-brown (2.5YR4/6m) or reddish brown (5YR4/6m), sometimes greyish brown (7.5YR5/4m) with dull red-brown (2.5YR4/6m) or yellowish grey-brown (10YR5/2m) with bright yellowish brown (10YR5/8m) or light yellowish brown (10YR6/6m), mottled medium or heavy clay, moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 7.0 to 8.0; clear to;

35-45 cm light yellowish grey-brown (10YR6/3m) medium or heavy clay; moderately coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and firm to very firm moist; trace to moderate amounts of rock fragments can occur below 35 cm field pH 8.5; gradual to;

45-55cm light yellowish grey-brown (10YR6/3m) or dull yellowish brown (10YR5/3m) medium or heavy clay; moderately coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and firm to very firm moist; trace to moderate amounts of rock fragments can occur below 35 cm field pH 8.5; gradual to;

55-90 cm light yellowish brownish grey (2.5YR6/2m) medium or heavy clay, yellowish grey (2.5YR5/2m) medium or heavy clay can occur from 55 to 75; moderate medium to coarse blocky structure; smooth-ped fabric, hard-dry, lightly to moderately sticky, very plastic and firm to very firm moist; field pH 9.0.

Series 4:
These soils are alkaline and have s distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, this is at least 15 cm thick, is whole-coloured and yellow or yellow-grey.

Mapping Unit: 4a

Northcote Classification and Surface Texture: Dy 2.13/FSCL(10)

Great Soil Group Classification: No Suitable group.

Surface Soil
A 0-10 cm greyish brown (7.5YR4/4m) fine sandy clay loam; unaggregated massive to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately plastic and friable moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm grey brown (7.5YR4/2m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic to firm to very firm moist; field pH 8.5; gradual to:

35-45 cm greyish brown (7.5YR5/4m), sometimes dull yellowish brown (10YR5/4m), heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and very firm moist; field pH 8.5; gradual to:

45-60 cm light yellowish grey-brown (10YR6/3m) heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace to heavy amounts of calcium carbonate can occur below 55 cm; field pH 9.0; gradual or clear to:

60-90 cm light yellowish brownish grey (2.5YR6/2m) heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace to light amounts of rock fragments can occur; field pH 9.0.

Mapping Unit: 4b

Northcote Classification and Surface Texture: Dy 2.13/CL(10)

Great soil Group Classification: No suitable group.

Surface Soil
A 0-10 cm yellowish grey-brown (10YR4/3m), greyish brown (7.5YR4/4m) or slightly dull reddish grey-brown (5YR4/4m) clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; hard-dry, moderately to very plastic and friable to firm moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to;

Subsoil
B 10-35 cm grey-brown (7.5YR4/2m), occasionally yellowish grey-brown (10YR5/2m), medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; field pH 7.0 to 8.0; clear to;

35-50 cm dull yellowish brown (10YR5/4m) or dull greyish brown (7.5YR5/6m) heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; trace to heavy amounts of hard and soft calcium carbonate can occur below 35cm; field pH 8.5 to 9.0; gradual to;

50-65 cm light yellowish grey brown (10YR6/3m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric, hard-dry, slightly sticky, very plastic and very firm moist; trace to heavy amounts of rock fragments can occur; field pH 9.0; gradual or clear to:

65-90 cm light yellowish brownish grey (2.5YR6/2m) medium or heavy clay, sometimes yellowish brownish grey (2.5YR5/2m) medium or heavy clay occurs from 65 to 80 cm; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm moist, field pH 9.0.

Series 5:
These soils are alkaline and have a distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is whole-coloured and brown.

Mapping Unit: 5

Northcote Classification and Surface Texture: Db 1.13/CL(10)

Great Soil Group Classification: Red-brown earths.

Surface Soil
A 0-10cm yellowish grey-brown (10YR4/3m) or dull yellowish brown , slightly dark (10YR4/4m), occasionally greyish brown (7.5YR4/4m) or slightly dull reddish grey-brown (5YR4/4m), clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric, hard-dry, moderately to very plastic and dry, moderately to very plastic and friable to firm moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 10-35 cm greyish brown (7.5YR4/4m), dark yellowish brown (10YR3/4m) or yellowish grey-brown (10YR4/2m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 8.0; clear to:

35-45 cm dull greyish brown (7.5YR5/6m) or dull yellowish brown (10YR5/4m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; field pH 8.5; clear or gradual to:

45-65 cm yellowish brownish grey (2.5YR6/2m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace to moderate amounts of calcium carbonate can occur below 50 cm; field pH 9.0; clear or gradual to:

65-90 cm light yellowish brownish grey (2.5YR6/2m) medium or heavy clay, sometimes yellowish brownish grey (2.5YR5/2m) medium or heavy clay occurs from 65 to 75 cm; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; trace to light amounts of rock fragments sometimes occur; field pH 9.0.

Series 6:
These soils are neutral to alkaline and have a distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is mottled and dominantly yellow or yellow-grey.

Mapping Unit: 6

Northcote Classification and Surface Texture: Dy 3.13/CL(15) LC_{SS}*[*]

Great Soil Group Classification: No Suitable group.

Surface Soil
A 0-15 cm yellowish grey-brown (10YR5/3m), occasionally (10YR4/3m), sometimes with isolated mottles of greyish brown (7.5YR4/4m), clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; friable to hard dry, moderately plastic and friable moist; trace to light amount of organic matter (root hairs); field pH 6.0 to 7.0; sharp to:

[*] LC_{ss} (Light clay subsoil) referring to the light clay texture of the upper segment of the B horizon.

Subsoil
B 15-40 cm yellowish brown (10YR5/6m) with dull red-brown (2.5YR4/6m) or light bright yellowish brown (10YR6/8m) mottled light clay; moderate medium blocky structure; rough-ped fabric; friable to hard dry, slightly sticky, very plastic and friable to firm moist; field pH 6.0 to 7.0; gradual or clear to:

40-60 cm yellowish grey-brown (2.5YR5/4m) with light yellowish brown (10YR6/6m) or dull red-brown (2.5YR4/6m) mottled light to heavy clay; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; trace amount of dark inclusions can occur; field pH 7.0 to 8.0; gradual or clear to:

60-90 cm yellowish grey-brown (2.5YR5/4m) heavy clay, sometimes light yellowish grey-brown (2.5YR6/4m) heavy clay occurs from 60 to 80 cm; moderates coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace amount of dark inclusions can occur; filed pH 7.5 to 9.0

Series 7:
These soils are alkaline and have uniform fine-textured profiles that crack significantly when dry. The cracks are not always apparent at the surface. The soils are strongly structures clays with dominantly smooth-faced peds throughout the profile. The horizon immediately below the surface horizon is a grey clay horizon (G.C.H.) that continues to depths greater than 1.5 m. The depth, and its colour value and/or chroma may increase with depth. Gilgai are common.

Mapping Unit: 7

Northcote Classification and Surface Texture: Ug 5.24/C

Great Soil Group Classification: Grey clay os the grey,
Brown and red clays.

Surface Soil
A 0-15 cm yellowish brownish grey, slightly dark (2.5Y4/2m), yellowish grey-brown (10YR4/2m), 10YR5/2m) or dark yellowish grey-brown (10YR3/2m) medium clay, sometimes with rusty flecking or rusty root channel mottling; moderate medium to coarse blocky structure; rough or smooth-ped fabric; hard dry, slightly sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs); field pH 6.0 to 7.0; sharp or clear to:

Subsoil
B 15-45cm yellowish grey-brown (40YR5/2m) or slight yellowish brownish grey (10YR5/1m), sometimes with yellowish brown (10YR5/6m) mottled medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric ;hard-dry, slightly sticky, very plastic and firm to very firm moist, occasionally trace amount of dark inclusions; field pH 6.0 to 7.0; clear or gradual to:

45-65 cm light yellowish grey-brown (10YR6/3m), yellowish brownish grey (2.5Y5/2m) or yellowish grey-brown (2.5Y5/4m), sometimes with yellowish brown (10YR5/6m) mottled medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist, occasionally trace amounts of rock fragments, trace amount of calcium carbonate concretions was occasionally encountered at depths before 45 cm, more frequently trace to moderate amounts of hard and soft calcium carbonate were found at depths below 45 cm; field pH 8.0 to 9.0; gradual to:

65-85 cm yellowish brownish grey (2.5Y5/2m) or light yellowish brownish grey (2.5Y6/2m) heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky to moderately sticky to moderately sticky, very plastic and very firm moist; field pH 8.5 to 9.0; gradual to:

85-90 cm light yellowish brownish grey (2.5Y6/2m) medium or heavy clay; moderate to strong coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and very firm moist; field pH 8.5 to 9.0.

Series 8:
The soils are alkaline and have uniform fine-textured profiles that crack significantly when dry. The cracks are not always apparent at the surface. They are strongly structured clays with dominantly smooth-faced peds throughput the profile. The horizon immediately below the surface horizon is a grey clay horizon (G.C.H.) that continues to depths greater than 1.5 m. The G.C.H., which has a hue as yellow or yellower then 2.5Y, may become mottled with depth, and its colour value and/or chroma may increase with depth. Gilgai are common.

Mapping Unit: 8

Northcote Classification and Surface Texture: Ug 5.28/C

Great Soil Group Classification: Grey clay of the grey,
Brown and red clays.

Surface Soil
A 0-15 cm yellowish brownish grey, slightly dark (2.5Y4/2m) or yellowish grey-brown (10YR5/2m) medium clay, occasionally with rusty flecking or rusty root channel mottling; moderate medium to coarse blocky structure; rough or smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 15-40 cm yellowish grey-brown (2.5Y5/4m) or yellowish brownish grey (2.5Y5/2m), sometimes with light yellowish brown (10YR6/6m) mottled medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; occasionally with trace amount of dark inclusions, and occasional to moderate amounts of hard and soft calcium carbonate can occur below 35cm; field pH 7.0 to 8.5; clear or gradual to:

40-75 cm yellowish grey-brown (2.5Y5/4m) heavy clay, sometimes continues to 90cm; moderate coarse blocky structure; smooth-ped fabric; hard to very hard-dry, slightly sticky, very plastic and very firm moist, field pH 8.5 to 9.0; gradual change to:
75-90 cm yellowish brownish grey (2.5Y5/2m) heavy clay; moderate to strong coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and very moist; field pH 9.0.

Series 9:
These soils are alkaline and have a distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is mottled and dominantly yellow.

Mapping Unit: 9

Northcote Classification and Surface Texture: Dy 3.13/FSCL (20)

Great soil Group Classification: No Suitable Group.

Surface Soil
A 0-20 cm yellowish grey-brown (10YR4/3 m) or greyish brown (7.5YR4/4m), sometimes isolated mottles of reddish brown (5YR4/6m), fine sandy clay loam; unaggregated massive breaking down to moderate fine to medium blocky structure; rough-ped fabric, friable dry, moderately to very plastic and very friable moist; trace to light amount of organic matter (root hairs); field pH 6.0 to 6.5; sharp or clear to;

Subsoil
B 20-45 cm greyish brown (7.5YR 5/4m), dull yellowish brown (10YR5/4m) or yellowish brown (10YR5/6m) with a dull red-brown (2.5YR4/6m) or reddish brown (5YR4/6m) mottled medium clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm moist; trace amount of dark inclusions sometimes occurs; field pH 73.0 to 8.0; clear to:

45-65 cm dull yellowish brown (10YR5/4m), sometimes with reddish brown (5YR5/6m) mottled medium clay (or light clay); moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm moist; trace to slight amounts of hard and soft calcium carbonate and rock fragments can occur below 45 cm, and trace amount of dark inclusions sometimes occurs; field pH 7.0 to 8.5; gradual or clear to:

65-90 cm yellowish grey-brown (2.5Y5/4m), light yellowish grey-brown (10YR6/3m) or light dull yellowish brown (10YR6/4m) medium or heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 8.5.

Series 10:
These soils are alkaline and have a distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is whole-coloured and red.

Mapping Unit: 10a

Northcote Classification and Surface Texture: Dr 2.13/FSL(30)

Great Soil Group Classification: Red-brown earths.

Surface Soil
A 0-30 cm greyish brown (7.5YR4/4m) or slightly dull reddish grey brown (5YR4/4m) fine sandy loam; unaggregated massive breaking down to weak fine blocky structure; friable dry, non plastic to slightly plastic and very friable moist; trace to light amount of organic matter (root hairs); field pH 6.0 to 6.5 sharp to:

Subsoil
B 30-55 cm bright reddish brown (5YR4/8m) medium clay; moderate medium blocky to platy structure; smooth-ped to moderately to moderately to moderately sticky, very plastic and firm moist; trace amounts of dark inclusions can occur, and trace amounts of hard and soft calcium carbonate can occur below 50 cm; field pH 6.0 to 7.0; clear to:

55-90 cm greyish brown (7.5YR5/4m) light clay, sometimes with fine sand; moderate coarse blocky structure; rough-ped fabric; friable to hard dry, slightly sticky, very plastic and firm moist; field pH 8.0 to 9.0.

Mapping Unit: 10b

Northcote Classification and Surface Texture: Dr 2.13/FSCL (25)

Great Soil Classification: Red-brown earths.

Surface Soil
A 0-25 cm slightly dull reddish grey-brown (5YR4/4m) or greyish brown (7.5YR4/4) fine sandy clay loam, occasionally yellowish grey-brown (10YR4/3m) with reddish brown (5YR4/6m) mottled fine sandy clay loam; unaggregated massive breaking down to weak to moderate fine blocky structure; rough-ped fabric; very friable dry, slightly sticky, slightly plastic and friable moist; trace to light amount of organic matter (root hairs) occasionally with rusty root channel mottling; field pH 6.0; sharp or clear to:

Subsoil
B 25-50 cm reddish brown (5YR4/6m) or bright reddish brown (5YR4/8m) medium clay; moderate medium blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm moist; field pH 6.5 to 7.5; clear to:

50-90 cm greyish brown (7.5YR5/4m) light clay, sometimes with fine sand; unaggregated massive breaking down to weak coarse blocky structure; hard-dry, slightly sticky, very plastic and firm moist; trace amounts of hard and soft calcium carbonate can occur below 50 cm; field pH 7.5 to 8.5.

Series 11:
These soils are alkaline and have uniform fine-textured profiles that crack significantly when dry. The cracks are not always apparent at the surface. The soils are strongly structured clays with dominantly smooth-peds throughout the profile and include a sporadic bleached A2 horizon. The horizon below the sporadic bleached A2 horizon has a value/chroma rating of 2 or 3 and is referred to as the grey clay horizon.

Mapping Unit: 11

Northcote Classification and Surface Texture: UG 3.2/C

Great Soil Group Classification: Grey clay of the grey,
Brown and red clays.

Surface Soil
A_1 0-15 cm yellowish grey-brown (10YR5/2m) or yellowish brownish grey, slightly dark (2.5Y4/2m) medium clay, sometimes with rusty flecking; moderate medium blocky structure; rough or smooth-ped fabric; hard-dry, slightly or moderately sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs); field pH about 6.0 to 7.0; sharp to:

A_2 15-40 cm sporadic bleached yellowish brownish grey (2.5Y5/2m, 2.5Y7/2d) or light brownish grey (10YR6/1m, 10YR8/2d) with yellowish brown (10YR5/6m) or light bright yellowish brown (10YR6/8m)) mottled light or medium clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and friable to firm moist; field pH 6.0 to 7.0; gradual to:

Subsoil
B 40-65 cm yellowish grey-brown (2.5Y5/4m) or yellowish brownish grey (2.5Y5/2m) with light yellowish brown (10YR6/6m) or bright yellowish brown (10YR5/8m) mottled medium clay; moderate coarse blocky structure; smooth-ped fabric; hard to extremely hard dry, slightly to moderately sticky, very plastic and firm moist; trace to light amounts of hard and soft calcium carbonate can occur below 55 cm; field pH 7.0 to 8.5; gradual to:

65-80 cm yellowish grey-brown (2.5Y5/4m) medium or heavy clay, sometimes continues to 90 cm, or yellowish grey-brown (2.5Y5/4m) with light bright yellowish brown (10YR6/8m) mottle medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard to extremely hard dry, slightly to moderately sticky, very plastic and firm moist; field pH 7.0 to 9.0; gradual to:

80-90 cm yellowish grey-brown (2.5Y5/4m) or yellowish brownish grey (2.5Y5/2m) heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard to extremely hard dry, moderately sticky, very plastic and firm; field pH 8.5 to 9.0.

Series 12:
These soils are alkaline and have uniform fine-textured profiles that crack significantly when dry. The cracks are not always apparent at the surface. They are strongly structured clay with dominantly smooth-faced peds throughout the profile. The horizon immediately below the surface has a hue yellower than 5YR and is referred to as the brown clay horizon (B.C.H.). The B.C.H. is underlain by grey or mottled grey clay and unweathered or weathered country rock is not encountered by a depth of 1.5m.

Mapping Unit: 12

Northcote Classification and Surface Texture: Ug 5.35/C

***Great Soil Group Classification*:** Brown clay of the grey,
Brown and red clays.

Surface Soil
A 0-15 cm yellowish grey-brown (10YR4/2m) medium clay, sometimes with rusty root channel mottling; moderate medium to fine blocky structure; rough-ped fabric; hard dry, slightly sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs); field pH 6.0 to 6.5; sharp to:

Subsoil
B 15-45 cm dark yellowish brown (10YR3/4m) or yellowish grey brown (10YR4/2m), sometimes mottled with dull red-brown (2.5YR4/6m), medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; field pH 7.0 to 8.5; clear to:

45-55 cm dull greyish brown (7.5YR5/6m) or yellowish grey-brown (10YR5/33m) medium or heavy clay, or light yellowish brownish grey (2.5Y6/2m) medium or heavy clay continues to 90 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; field pH 8.0 to 9.0; gradual to:

55-65 cm light yellowish grey-brown (10YR6/3m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard dry, slightly sticky, very plastic and very firm moist; trace to moderate amounts of hard and soft calcium carbonate can occur below 60 cm; field pH 8.5 to 9.0; clear to:

65-80 cm light yellowish brownish grey (2.5Y6/2m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm moist; field pH 9.0; clear to:

80-90 cm very light yellowish brownish grey (2.5Y7/2m) medium or heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, moderately sticky, very plastic and very firm moist; field pH 9.0.

Series 13:
These soils are alkaline and have a distinct texture contrast between a hard-setting A horizon and a moderately to strongly pedal B horizon. In these profiles the upper most segment of the clayey B horizon, that is at least 15 cm thick, is mottled and dominantly brown.

Mapping Unit: 13

Northcote Classification and Surface Texture: Db 2.13/FSCL (20)

Great Soil Group Classification: No Suitable group.

Surface Soil
A 0-20 cm greyish brown (7.5YR5/4m) or yellowish grey-brown (10YR4/3m) fine sandy clay loam; unaggregated massive breaking down to moderate medium blocky structure; rough-ped fabric; friable dry, moderately to very plastic and firm to very firm moist; trace to light amount of organic matter (root hairs); field pH 6.0; sharp to:

Subsoil
B 20-50 cm yellowish grey-brown (10YR4/3m) or greyish brown (7.5YR4/4m) with red-brown (2.5YR4/8m) mottled medium clay, sometimes dull greyish brown (7.5YR5/6m) medium clay occurs from 40 to 50 cm; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; field pH 8.0; clear to:

50-70 cm yellowish grey-brown (2.5Y5/4m) or dull yellowish brown (10YR5/4m) medium or heavy clay; moderate to strong coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm to very firm moist; trace amount of hard and soft calcium carbonate can occur below 50 cm; field pH 8.0 to 9.0; clear to:

70-90 cm light yellowish grey-brown (10YR6/3m), occasionally light yellowish brownish grey (2.5Y6/2m), light to heavy clay; moderate medium to coarse blocky structure; smooth-ped fabric; hard-dry, slightly to moderately sticky, very plastic and firm to very firm moist; trace amounts of dark inclusions or rock fragments can occur; field pH 8.5 to 9.0.

Series 14:
These soils are alkaline and have uniform fine-textured profiles that crack significantly when dry. The cracks are not always apparent at the surface. They are strongly structured clays with dominantly smooth-faced peds throughout the profile and immediately below the surface horizon have a dark clay horizon (D.C.H.) with a value/chroma rating of 1. Gilgai are common.

Mapping Unit: 14

Northcote Classification and Surface Texture: Ug 5.1/C

Great Soil Group Classification: Black earths.

Surface Soil
A 0-15 cm slight yellowish brownish grey (10YR4/1m) medium clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and firm moist; trace to light amount of organic matter (root hairs) sometimes with rusty root channel mottling; field pH 6.5 to 7.0; sharp to:

Subsoil
B 15-40 cm dark brownish grey (10YR3/1m) or dark grey (7.5YR3/0m) medium clay; moderate coarse blocky structure; smooth-ped fabric, hard-dry, slightly sticky, very plastic and firm moist; field pH 7.5 to 8.5; clear to:

40-60 cm yellowish brownish grey (2.5Y5/2m) heavy clay, sometimes continues to 90 cm; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; trace amount of hard and soft calcium carbonate can occur below 45 cm; field pH 8.5 to 9.0; gradual to:

60-90cm light yellowish brownish grey (2.5Y6/2m) heavy clay; moderate coarse blocky structure; smooth-ped fabric; hard-dry, slightly sticky, very plastic and very firm moist; field pH 9.0.

4.1.2 Formal Classification

(a) Relation of Earlier Surveys

All previous published surveys of this area have been conducted at reconnaissance level and this did not permit mapping of individual soils. However, it is generally agreed that the dominant soils of the area are red-brown earths. Table 6 gives a summary of the terms used in the legends of earlier surveys to describe the soils of the area in which the research station is located.

Table 6 - Early surveys and descriptions a mapping units including the Werribee areas

Survey/map	Description of mapping units
Prescott (1931)	Podsolised soils
Prescott (1944)	Red-brown earths and Terra rossas
Skene (1956)	Red-brown – slightly acid, brown loams Over alkaline, clay subsoils containing calcium Carbonate. Includes grey soils of heavy texture.
Northcote (1960a2)	Hard alkaline red soils (Dr 2.13) often gilgai Micro-association with dark cracking clays (Ug 5.1), and grey and brown cracking clays (Ug 5.2 and Ug 5.3).
Northcote (1960b3)	Hard alkaline red soils (Dr 2.23, Dr 2.33 and Dr 2.43) with hard alkaline yellow mottled soils (Dy 3.43).
Stephens (1961)	Red-brown earths with Black earths.
Stace et. al (1968)	Red-brown earths – Dr 2.13, Db 1.13: Hard Alkaline red and brown duplex soils
Northcote et. al (1975)	Alkaline, hard, pedal, red duplex soils on underlaying country (Dr 2.13).

(b) Soil Classification

The soil of the area, as described using the Factual Key notation of Northcote (1972), are duplex (D) on the alluvium and basalt with uniform (U) soils occurring in gilgais, local depressions and the depression bordering the basalt flow.

Twenty-four P.P.F.'s were identified in the survey area, and of these, only 10 occurred in large enough areas to enable them to be mapped at least to the level of sub-dominance, in any mapping unit. Using the Great Soil Group system of classification of Stace et. al (1968), these 10 dominant P.P.F.'s are classified as follows: red-brown earths (Dr 2.13; Db 1.13), grey members (Ug 5.24; .28; Ug 3.2) and a black earth (Ug 5.1). Three P.P.F.'s (Db 2.13; Dy 2.13; Dy 3.13) have no equivalent Great soil Group.

Soils of only minor occurrence include the following: non-calcic brown soils (Dr 2.12. .22), solodized solonetz and a solodic soils (Dr 3.33; Db 1.33; Db 2.33, .43; Dy 3.33, .43; Dd 1.13), a soloth (Dy 3.32), a red member of the grey, brown and red clays (Ug 5.39) and a number that have no equivalent groups (Dy 3.12; Dd 2.13; Ug 3.3).

Table 7 shows the relationship of the described modal profiles which have been derived from the P.P.F.'s, surface texture and depth, and the names given to corresponding soils in the 1954 survey.

Table 7 - Relationship of described modal profiles to earlier described soils

Described Modal Profiles (1977)	Earlier Described Soils (1954)
Ug 3.2/C	-
Ug 5.1/C	Type A
Ug 5.24/C	Scl
Ug 5.28/C	Scl
Ug 5.35/C	-
Dr 2.13/FSL (30)	Wfsl
Dr 2.13/FSCL (25)	Wl
Dr 2.13/FSCL (10)	Bcl
Dr 2.13/CL (10)	"
Db 1.13/CL (10)	-
Db 2.13/FSCL (20)	-
Db 2.13/FSCL (10)	Rcl
Db 2.13/CL (10)	"
Dy 2.13/FSCL (10)	-
Dy 2.13/CL (10)	-
Dy 3.13/FSCL (20)	Dfscl
Dy 3.13/CL (15) LC_{SS}	Hcl
Dy 3.13/CL (10)	Rcl

4.1.3 Key to Recognition

The following key is provided as a guide to the recognition of the soils in the field and does not replace the descriptions used for classification purposes.

Mapping Unit

A. Surface Texture:

i) fine sandy loam — 10a
ii) fine sandy clay loam — B
iii) clay loam — C
iv) medium clay — D

B. Colour of top 15 cm of clay subsoil:

i) reddish brown, bright reddish brown, or slightly dull reddish grey brown — (a)
ii) yellowish grey-brown or greyish brown slightly dark with red-brown or dull red-brown mottle — (b)
iii) grey-brown — 4a
vi) light greyish brown, dull yellowish brown or yellowish brown with reddish brown or dull red-brown mottle — 9

a) surface depth:
   1) about 10 cm. — 1a
   2) about 25 cm. — 10b

b) surface depth:
   1) about 10 cm. — 2a
   2) about 20 cm. — 13

c) Colour of top 15 cm of clay subsoil:

i) slightly dull reddish grey-brown or reddish brown — 1b

ii) greyish brown slightly dark, dark yellowish brown or yellowish grey-brown 5

iii) yellowish grey-brown or greyish brown slightly dark with dull red-brown or reddish brown mottle 2b

iv) grey-brown 4b

v) grey-brown with dull red-brown or reddish brown mottle, or light greyish brown with dull red-brown with bright yellow-wish brown or light yellowish brown mottle 3

vi) yellowish brown with dull red-brown or light bright yellowish brown mottle 6

D. (a) Sporadic bleached A2 horizon 11

(b) Colour of soil below the immediate surface horizon

i) dark brownish grey or dark grey 14

dark yellowish brown or dark yellowish grey-brown, sometimes with dull red-brown mottle 12

ii) light yellowish grey-brown or slight

iii) yellowish brownish grey, sometimes with yellowish brown mottle 7

vi) yellowish grey-brown or yellowish brownish grey, sometimes with light yellowish brown mottle 8

4.1.4 Physical and Chemical Properties of Representative Soils

(a) Particle Size Distribution

As a check on field texture, percentages of coarse and fine sand, silt and clay were determined for every second surface sampled. These percentages, together with mechanical analyses carried out on representative profiles, show a fairly close correlation with field texture (Table 8). It is expected that the texture grade determined in the laboratory will differ from the field texture. This is because although strongly influenced by clay content, field texture is also affected by other soil properties such as, the type of clay mineral, the amount of silt, organic matter, oxides, and aggregation. A feature of the surface of the duplex soils is the high fine and silt content which contributes to their hard-setting character (Appendix I).

Table 8 - Relationship between Field Texture and Mechanical analysis for the Soils Sampled at the S.R.F Werribee.

	Field Texture				
	FSL	**FSCL**	**CL**	**MC**	**HC**
Clay % range and average determined by mechanical analysis for this survey	15-17 (16)	18-36 (27)	25-41 (31)	36-60 (47)	48-59 (53)
Clay % range for given field textures, Northcote (1974)	10-20	30-35	30-35	45-55	>50

(b) Organic Matter

The general level or organic matter in the soils is illustrated by the values of total nitrogen and organic carbon reported in Appendix I. Because these values normally decrease with depth, only those horizons in the top 40 to 50 cm were analysed. The contents of organic matter in many of the soils of the farm, at the selected sites, were moderate. However, it is difficult to relate this status to particular kinds (areas) of the soil because of the low number of site tested. Furthermore the actual soil management practiced in different area, even on the same soil will have a marked influence on the organic matter content. With the above observations in mind it is suggested that the lighter textured soils, with surfaces of fine

sandy loam and fine sandy clay loam, contain lower organic carbon and total nitrogen levels than the heavier soils. This is probably because of the lower moisture content and the more ready oxidation occurring in the lighter soils (5).

Northcote and de Mooy (1957) separated soils into the following three general classes on the basis of organic matter content.

Class (a) - High organic matter content (>0.25 percent N).

Class (b) – Moderate organic matter content (0.25 to 0.1 percent N).

Class (c) – Low organic matter content (<0.1 percent N).

The surface soil of only one representative profile (site 6) belongs to Class (a). Sites 1 and 4 were in Class (c), whereas the remainder were in Class (b).

(c) Exchangeable Cations

For the fifteen representative profiles, the exchangeable calcium, magnesium, potassium, sodium and "acidity" (at pH values less than 8) and the sum of these cations, representing the exchange capacity, are given in Appendix I.

The main agricultural interest is in the exchangeable sodium percentage (ESP). Values less than 6 are associated with normal soils, bur values of 6 or more are taken to indicate the presence of sodium salts as an important factor in adversely affecting the physical properties of the soils (18). Sodic soils have an ESP of 6 or more and those with an ESP of 15 or greater are considered to be strongly sodic.

The soil at site 2 is non-sodic and that at site 5 is sodic. These soils have excellent and good capability ratings respectively. The remainder of the farm soils representing approximately 85% of the total area, are strongly sodic with only fair to very poor capability ratings.

The high relative content of exchangeable sodium, at ESP 6 or above, causes dispersion of clay and hence poor soil structure, represented by either coarsely or massively structure material. The sharp rise in ESP from surface to subsoil in the strongly sodic soils is particularly evident from Table 9. The high subsoil values will result in low subsoil permeability and will also cause some restriction to root development.

Studies have shown that magnesium, as opposed to calcium, has a similar, though less marked, effect to sodium on the dispersion of clay (2,7). Although the effect of a high ratio of exchangeable magnesium to exchangeable calcium at different ESP values is still uncertain, the high exchangeable magnesium compared to exchangeable calcium, particularly in the subsoil, appears to be important with regards to the physical properties of the farm soil. The exchangeable (magnesium/calcium) for the representative profiles are given in Table 9.

Table 9 - Morphology, Classification, ESP and Exchangeable (magnesium/calcium) For Representative Profiles

Texture	ESP	Exch. (Mg/Ca)	Texture	ESP	Exch. (Mg/Ca)	Texture	ESP	Exch. (Mg/Ca)
Site 1.			**Site 6.**			**Site 11.**		
Db 2.13/FSCL (20)			Dy 3.13/CL (15) LC_{SS}			Ug 5.35/C		
FSCL	1	0.2	CL	8	0.9	MC	12	1.1
MC	11	0.8	LC	27	1.0	MC	32	2.0
MC	31	2.9	LC	25	2.4	MC	38	2.9
MC	34	4.0	HC	29	2.7	MC	38	3.1
MC	41	4.2				HC	38	3.1
MC	40	4.5				MC	39	3.6
Site 2.			**Site 7.**			**Site 12**		
Dr 2.13/FSCL (25)			Ug 5.28/C			Ug 5.24/C		
FSCL	1	0.7	MC	5	1.1	MC	14	2.1
HC	4	1.2	MC	13	1.7	MC	21	2.3
LC_C	3	1.7	HC	26	2.1	HC	33	3.2

Texture	ESP	Exch. (Mg/Ca)	Texture	ESP	Exch. (Mg/Ca)	Texture	ESP	Exch. (Mg/Ca)
Fs			HC	27	2.3	MC	37	3.4
LC_C	3	1.2				MC	38	3.8
Fs								
Site 3.			**Site 9.**			**Site 14.**		
Dy 3.13/Cl (10)			Db 2.13/CL (10)			Db 1.13/CL (10)		
CL	8	1.6	CL	7	1.6	CL	10	1.6
MC	17	2.5	MC	18	2.2	MC	22	2.7
MC	35	4.1	MC	32	2.8	MC	36	4.2
HC	35	4.5	HC	34	3.2	HC	38	5.5
HC	36	4.6	HC	35	3.8	HC	40	4.0
MC	38	4.1	HC	36	3.8			
			HC	37	3.8			
Site 5.			**Site 10.**			**Site 15.**		
Dy 3.13/FSCL (20)			Dr 2.13/CL (10)			Dy 2.13/CL (10)		
FSCL	2	0.8	CL	10	1.4	CL	13	1.6
MC	4	1.4	MC	27	2.6	HC	24	2.0
MC	8	1.8	MC	35	5.1	HC	36	2.9
MC_C	7	2.5	HC	35	4.9	MC	36	3.0
FS			HC	36	4.4	MC	36	2.8
HC	10	4.0	HC	36	3.5			
MC	7	1.5						

With the exception of site 6, the ESP values and the exchangeable (magnesium/calcium) are higher in the surfaces of the basalt soils than in the surfaces of the alluvial soils. This indicates that problems with water infiltration, soil aeration and root penetration are more likely to occur on the basalt soils. Addition of gypsum could therefore be required if any cropping was to be carried out on these soils.

Although exchangeable calcium is low in all surface soils, no deficiency should occur if superphosphate is used.

The figures of exchangeable potassium show that the fine textured subsoils contain considerably more potassium than the coarser textured surface soils. Although root systems penetrating the subsoil could make use of the reserve there, assuming 0.2 milliequivalent/100 gm soil as a minimum value for sufficient supply of K to pasture plants (6), it is likely that the surface soils of sites 4 and 5 would have only a marginal potassium supply.

4.5.1 Soil Map

Each mapping unit consists of the following:

(i) a central core or nucleus – a single modal profile representing the most usual condition of each property of all soils in the class, and

(ii) many other closely related profiles that vary from this central nucleus within precisely defined units.

Any area shown as having a single mapping unit symbol may have small area of one or more soils but not to a greater extent than about 1/6 (16-17%) of the occurrence. Where the other soil (or soils) covers more than 1/6, but not more than 1/3 (33-34%) its presence has been denoted by fraction, where the dominant soil is the numerator and the sub-dominant soil is the denominator, e.g. $\frac{1a}{1b}$ Should the second soil exceed 1/3, the occurrence had been mapped as a complex of both soils, e.g. 8-7. A description of the soil map units is given in Table 10.

Therefore, occurrence of sites for dominant soils is greater then 33-34%, greater than 16-17% but less than 33-34% for sub-dominant soils and less than 16-17% for minor soils.

Table 10 - Description of Soil Map units

Mapping Unit Symbol	Area ha.	Dominant Soil	Sub-Dominant Soil	Minor soil
1a 1b	53.0	Dr 2.13/FSCL	Dr 2.13/CL	Db 2.13/FSCL
1a-1b	71.6	Dr 2.13/FSCL Dr 2.13/CL	-	Dy 2.13/FSCL
1b	22.6	Dr 2.13/CL	-	Dy 3.13/CL; Dr 2.22/CL
1b 1a	17.2	Dr 2.13/CL	Dr 2.13/FSCL	Db 1.13/CL
1b 3	5.8	Dr 2.13/CL	DY 3.13/CL	-
2a	20.9	Db 2.13/FSCL	-	Dr 2.13/CL; Db 1.13/CL
2b	87.5	Db 2.13/CL	-	Dr 2.13/CL; Db 1.13CL; Db 2.13/FSCL; .43/FSCL; Dy 3.13/CL
2b 4b	53.3	Db 2.13/CL	Dy 2.13/CL	Dr 2.13/CL; Db 2.13/FSCL; .43/CL; Dy 3.13/CL; .13/CL. LC_{SS}
3	84.8	Dy 3.13/CL	-	Db 2.13/CL; Dy 2.13/CL; Dy 3.13/FSCL, .43/CL; Dd 1.13/CL; Dd 2.13/CL.
3 4b	20.8	Dy 3.13/CL	Dy 2.13/CL	-
4a	8.1	Dy 2.13/FSCL	-	Dy 3.33/CL
4a 2b	10.7	Dy 2.13/FSCL	Db 2.13/CL	-
4b	16.4	Dy 2.13/CL	-	-
5	29.3	Db 1.13/CL	-	Db 2.13/CL
5 4b	23.0	Db 1.13/CL	Dy 2.13/CL	Db 2.13/CL; Dy 3.13/CL; .43/ CL; Dd 1.13/CL
6	81.1	Dy 3.13/CL. LC_{SS}	-	Dy 2.13/CL. $LC_{SS;}$ Dy 3.32/CL. LC_{SS}
7	12.1	Ug 5.24/C	-	-
8	9.4	Ug 5.28/C	-	-
8 7	58.7	Ug 5.28/C	Ug 5.24/C	Ug 3.3/C; Ug 5.35/C
8-7	12.3	Ug 5.28/C Ug 5.24/C	-	Ug 3.2/C
9	72.3	Dy 3.13/FSCL	-	Dr 2.13/FSCL; Db 1.33/FSCL ; Db 2.13/FSCL; Dy 3.12 /FSCL, .13/CL. .13/CL. LC_{SS} 43/FSCL
10a	5.3	Dr 2.13/FSL	-	-
10b	33.7	Dr 2.13/FSCL	-	-
10b-7	3.2	Dr 2.13/FSCL Dy 3.13/FSCL	- -	- -
11	13.1	Ug 3.2/C	-	-
11-7	16.3	Ug 3.2/C Ug 5.24/C	-	-
12	11.3	Ug 5.35/C	-	Ug 5.39/C
12 7	3.2	Ug 5.35/C	Ug 5.24/C	-
13	13.8	Db 2.13/FSCL	-	Dr 3.33/FSCL; Db 2.33/FSCL
14	3.2	Ug 5.1/C	-	-

4.1.6 Map and Legend Relationships

A clear knowledge of the relationship between map and legend is considered essential for the use of soil maps because of the existence of the "soil continuum". With the exception of water and bare rock bodies, it is necessary to draw map boundaries over areas representing soil which has many properties varying continuously and independently across the landscape. It is therefore clear that the factors relevant to an appreciation of the soil map include:

i) the classification used;

ii) the relationship between the formulation of the classification in terms of property arrangement and the degree of covariance of these properties;

iii) the classification level used in the legend; and

iv) the actual construction of the legend.

Other more obvious features which are important to soil map quality include complexity of the soil material over the area, observation and sampling site density and scale.

Several authors have constructed systems to deal with the above mentioned complexities. One system in which the values of general purpose classification are compared (36), involves the use of a computer. A second system includes the concept of a :legend score" (3). The construction and possible mis-interpretation of the :legend score" in relation to map quality is discussed with reference to the soil map of the research farm.

The scoring procedure assumes that he entire area of every mapped soil unit exactly matches its description in the map legend. On this basis the system estimates the average probability that the soil profile class at any randomly located site within a survey area is correctly predicted: each class is weighted according to the proportion of the total area which it occupies. The score obtained was 70% for the soil subdivision map and 59% for the soil map, i.e for the soil map a prediction with 59% certainty can be made over 100% of the survey area at the P.P.F. level. This does not mean that the soil subdivision map is more useful than the soil map, but it is simply a reflection on the level of classification and the complexity of the soil pattern. The soil map at the P.P.F. level gives more precise information on the soil conditions and thus attempts to account for all possible variations in soil profiles over the area. Hence the score may be misinterpreted because the map with the lower score is more useful in predicting soil conditions. Because it is not practical to map each individual occurrence, any map unit will contain a certain level of impurities. In this survey these levels have been stated in the previous section of the text.

4.17. Regional Representation of Soils

A simplified soil map was constructed to enable the farm soils to be related to areas of similar soils in the region. This region covers an area of approximately 7,00 km² contained within the boundaries of the Melbourne and Queenscliff standard map sheets. The soils were compared using the Factual Key notation at only the "higher" level of classification, i.e. the soil "subdivision". It was found that the state research Farm soils are representative of about 60% of the soils found in the surrounding region (Table 11)

Table 11 - The proportional Representation in the Region of the Soil Identified on the S.R.F. Werribee

Soil subdivision	Region	Werribee S.R.F. (%)
Ug	38.2	16.0
Dr	2.3	24.3
Db	4.8	26.0
Dy	16.2	33.7

4.18. Soil Per Cent Chloride Map

In the classical soil salinity reports by the Department of Agriculture, Victoria, the "salt" status of the soils was estimated from chloride figures which were reported as per cent sodium chloride. Levels of sodium chloride were found to vary in proportion to the total salt values, and because in general sodium chloride wad the dominant salt, the potential salinity hazards could be evaluated (24).

The salinity hazard of the soil was determined arbitrarily as follows: low – under 0.06 per cent. chloride; slight – 0.06 to 0.09 per cent; moderate – 0.10 to 0.18 per cent; high – 0.19 to 0.30 per cent; very high – over 0.30 per cent. The extent to which plant growth is retarded at any one of these salt levels varies with the soil type and with the salt tolerance of the crop grown. The topsoil and subsoil are examined in any salt survey (Table 12), because the salt content of the topsoil is an indication of the immediate risk to crops, whereas salt level in the subsoil indicates a potential hazard to crops, both in dry-land soils should they be irrigated, and in irrigated soils should water tables develop.

Table 12 - Salinity Hazard and Salt Content (%Cl) of Soils at Given Depths

Salinity Hazard		Salt Content (%Cl)	
Status	Map Unit	0-30 cm depth	60-90 cm depth
Low	Class I	0-0.06%	0.06%
Slight	Class II	0-0.09%	0.06-0.18%
Moderate	Class III	0.09-0.18%	0.09-0.18%
High	Class IV	0.18-0.30%	0.18-0.30%
Very High	Class V	more than 0.30%	more than 0.30%

In the soil chloride maps of the farm the salt status corresponds to Classes I, II and IV.

4.1.9 Soil Electrical Conductivity Map

The measurement of electrical conductivity (E.C.) is used universally as a means of appraising soil salinity. The electrical conductance of a soil increases with soluble salt content and thus allows simple interpretation of the readings. The limits of the salinity classes used in this survey are those of the American system 926) and are given in Table 13.

Table 13 - Salinity Hazard, Salt content (T.S.S.%) and Equivalent E.C.

Salinity Hazard	Equivalent Relationships	
	Total Soluble Salts (%)	E.C. of 1:5 soil-water suspension in micro Siemens cm^{-1} at 20°C
Class 1: Free	0-0.15	0-460
Class 2: Slightly affected	0.15-0.35	460-1080
Class 3: Moderately affected	0.35-0.65	1080-2015
Class 4: Strongly affected	>0.65	>2015

Only Class 1 and Class 2 have been encountered on the farm at the depth examined.

For more rapid determinations, the E.C. of a 1:5 soil-water suspension is measured in preference to the total soluble salts (T.S.S.). However, the T.S.S. can be estimated from the E.C. figures by the following equation:

T.S.S. = percentage salt on dry weight basis (grams of salt per 100 grams of dry soil)
= concentrations of salt © x moisture content of the soil (A) x 100%

where,

C is determined by a rule-of –thumb method and

$$= \left(\frac{\text{E.C. (micro Siemens cm}^{-1})}{1000} \text{ x } 0.64) \right) \text{ grams/1}$$

and

$$\text{A} = \left(\frac{500 \text{ ml water}}{100 \text{ gm soil}} \text{ x } \frac{1}{1000} \right) \text{1./grams}$$

This estimation of salinity may be used for soils high in chloride salts.

4.2 Topography

4.2.1 Elevation Relationships

The elevation classes were determined from the contour map of the farm, where the height above sea-level ranges from 11 to 24 metres. From an overlay of the Soil Subdivision map it was then possible to obtain area of different soils within each class. Because of the nature of the landscape, i.e. very gentle undulating, it is difficult to make comparisons between soil subdivisions over the whole farm. However, from the two extremes in elevation classes (Table 14) it can be observed the

Ug soils occupy most of the area at the lowest level and Dr soils occupy most elevations of the area at the highest. The Ug soils that occur at the higher elevations comprise small gilgai areas or local depressions.

Table 14 - Soils and Elevation classes

Elevation Class	1		2		3		4		5	
Soil Subdivision	11m - 12m		12m - 15m		15m - 18m		18m - 21m		21m - 24m	
	area ha	% in class	area ha	% in class	area ha	% in class	area ha	% in class	area ha	% in class
Dr	3.1	5.9	27.6	16.3	66.1	34.3	39.1	21.2	44.3	71.3
Db	13.5	25.5	47.3	47.3	43.4	16.0	71.0	38.4	17.8	28.7
Dy	5.5	10.4	54.4	54.4	124.5	45.8	65.1	35.2	-	-
Ug	30.8	58.2	40.0	40.0	37.9	13.9	9.7	5.2	-	-

4.2.2 Slope Relationships

The maximum slope on the farm was calculated as being 6%. From the guide for placing soils in land capability classes by the U.S. Department of Agriculture, soil conservation Service (25), slopes are divided into two categories, 0-2% and 2-6%. With respect to slope, soils in the first class have limitations that reduce the choice of plants or require moderate conservation practices.

Maximum slopes occur along lines which join adjacent contours at their closest points. These slopes were measured using a template of a size determined by map scale and contour interval.

4.3. Land Capability

4.3.1 Provisional Land Capability Map

The appraisal of soil capabilities is done by assigning numerical values to major soil factors that affect productivity. For each capability class, physical specifications are set by dividing the various physical factors into equally significant categories. The rating of these factors is based on criteria used by the USDA, Soil conservation Service (25) and the N.Z. soil Bureau (9). Index values are given on the basis of a score of 100 for the ideal soil. Area of the farm were then classified using these criteria (Table 15)

Table 15 - Agricultural Capability classification of the S.R.F. Werribee

Capability Class Map unit	Relative Capability for general Intensive agriculture	Index Rating	Farm Area (ha)
I	Excellent	80 to 100	34.9
II	Good	60 to 80	87.9
III	Fair	40 to 60	470.8
IV	Poor	20 to 40	260.9
V	Very Poor	10 to 20	19.5
VI	Considered unsuitable for agriculture	Less than 10	-

The specifications (Appendix V) give the range of requirements, relevant to the farm, for each soil factor. The factors are listed below:

(1) *Slope*. Slopes are considered to be a permanent limitation and are definite obstacle to irrigation, and in non-irrigated area will affect management and land use. The degree of slope is considered in relation to erodibility (susceptibility to erosion), type of crop, infiltration rate, permeability, available moisture and overall drainage.

(2) *Drainage*. This is an indication of the rate at which water is removed from the soil and is affected by surface run-off, soil permeability, internal soil drainage, topographic situation, and slope. The drainage class is estimated from soil morphological data collected during the detailed soil survey.

(3) *Salinity*. The estimation of salinity is based on the electrical conductivity figure. The class ranges corresponds to commonly used international standards.

(4) *Effective rooting depth*. This is the soil depth which can provide a medium for root development, retain available water, and supply nutrients. In most cases this is the depth to the first layer at which restriction to root penetration is encountered. Soil texture profile is usually closely related to the depth. For the farm soils this depth for duplex soils is considered as being the A horizon and for uniform soils, the depth to the first heavy clay textured horizon.

(5) *Surface texture and structure*. These give an indication of (i) the ease with which roots penetrate the soil and (ii) the rate of moisture infiltration, i.e. the rate at which surface soil absorbs water.

(6) *Permeability*. The permeability class describes that quality of the soil which enables it to transmit water or air. Each horizon in the soil usually has a different permeability and the least permeable horizon. In the absence of measurements the relative permeability class is estimated from knowledge of the structure, texture, consistence and colour of the soil.

4.3.2 A Subjective Evaluation of the Map

Field agronomic experiments required to conclusively prove the final capability map ratings have not been carried out and would be expensive in terms of time alone (seasonal replications). However, farm management experience, consulted after completion of the map, supports the ratings allocated to the separate areas. It is also pointed out that farm management decisions must often be made on currently available, although sometimes unproven, information.

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Appendix I - Analytical Data or Representative Profiles

Depth cm.	Texture	pH	E.C. µS.cm^{-1}	Chloride %	CS %	FS %	Si %	C %	LAT %	Organic Carbon %	Total Nitrogen %	Cation Exchange change Capacity me%	Exchangeable Cations										Sample No. 1977
													m.e.% - milliequivalents per 100 g of soil										
													% - percentage of CEC										
													Ca		Mg		K		Na		Acidity		
													me		me		me		me		me		
													%	%	%	%	%	%	%	%	%	%	
Db 2.13/FSCL (20): Site 1																							
0-20	FSCL	5.2	150	0.01	5	14	26	24	1.6	0.79	0.08	9.7	2.3	24	0.4	4	0.3	3	0.1	1	6.6	68	8775
20-40	MC	6.3	260	0.01	1	15	11	73	1.8	0.93	0.09	25.7	5.2	20	4.2	16	0.8	3	2.8	11	12.7	50	8776
40-50	MC	8.4	340	0.02	1	14	11	72	2.1			26.4	4.3	16	12.6	48	1.2	5	8.3	31	-	-	8777
50-80	MC	8.8	360	0.02	1	16	19	56	2.4			28.9	3.6	12	14.4	50	1.1	4	9.8	34	-	-	8778
80-120	MC	9.5	650	0.03	1	18	22	52	2.6			36.8	3.9	11	16.5	45	1.2	3	15.2	41	-	-	8779
120-140	MC	9.6	840	0.04	1	14	30	58	6.6			39.8	4.1	10	18.6	47	1.3	3	15.8	40	-	-	8780
Dr 2.13/FSCL (25): Site 2																							
0-30	FSCL	6.9	70	-	4	49	26	19	0.8	0.99	0.14	9.1	3.0	33	2.0	22	0.3	3	0.1	1	3.7	41	8762
30-55	HC	7.3	100	0.01	2	17	14	59	1.9	0.71	0.11	18.7	5.3	28	6.4	34	0.9	5	0.7	4	5.4	29	8763
55-90	LCcFS	7.7	90	0.01	5	47	18	27	1.0			13.1	3.5	27	5.8	44	0.3	2	0.4	3	3.1	24	8764
90-120	LCcFS	8.0	90	0.01	2	38	31	28	0.9			9.0	3.8	43	4.6	51	0.3	3	0.3	3	-	-	8765
Dy 3.13/CL: Site 3																							
0-10	CL	6.3	120	0.01	6	36	22	36	1.2	1.99	0.21	18.7	2.3	12	3.7	20	0.4	2	1.5	8	10.8	58	8828
10-40	MC	7.3	240	0.02	3	25	14	51	1.8	1.50	0.18	30.0	3.9	13	9.6	32	1.1	4	5.0	17	10.4	34	8829
40-50	MC	8.8	730	0.07	2	18	13	35	3.8	0.60	0.09	34.1	4.0	12	16.5	48	1.8	5	11.8	35	-	-	8830
50-60	HC	9.0	930	0.09	2	20	16	56	3.1			35.6	3.9	11	17.6	49	1.8	5	12.3	35	-	-	8831
60-85	HC	9.4	1120	0.12	1	22	22	50	4.0			36.4	3.9	11	17.8	49	1.7	4	13.0	36	-	-	8832
85-90	MC	9.3	1310	0.14	2	22	11	63	5.8			36.5	4.1	11	17.0	47	1.6	4	13.8	38	-	-	8833
Dr 2.13/FSL (30): Site 4																							
0-35	FSL	6.0	90	0.01	17	49	15	17	0.8	0.54	0.08	6.5	1.2	18	0.7	11	0.2	3	0.1	2	4.3	66	8772
35-55	MC	6.7	120	0.01	9	34	13	44	1.4	0.64	0.09	13.3	2.8	21	2.5	19	0.4	3	2.0	15	5.6	42	8773
55-90	LC	8.7	140	0.02	7	37	18	37	1.5			12.6	4.0	32	4.0	42	0.4	3	2.9	23	-	-	8774
Dy 3.13/FSCL (20): Site 5																							
0-20	FACL	3.8	90	0.01	4	41	27	24	1.7	1.40	0.18	10.3	3.2	31	2.7	26	0.1	1	0.1	2	4.1	40	8766
20-45	MC	7.3	130	0.01	1	17	14	70	1.3	0.72	0.12	22.5	5.0	22	6.9	31	0.4	2	1.0	4	9.2	41	8767
45-55	MC	7.7	100	0.01	2	32	25	40	1.1	0.32	0.06	8.3	2.6	31	4.7	57	0.3	4	0.7	8	-	-	8768
55-75	LCcFS	8.1	90	0.01	3	36	31	29	0.9			5.8	1.5	26	3.7	64	0.2	3	0.4	7	-	-	8769
75-100	HC	8.3	170	0.01	2	20	13	64	2.2			24.1	4.1	17	16.4	68	1.2	5	2.4	10	-	-	8770
100-120	MC	9.0	280	0.01	3	29	14	39	11.0			19.9	7.1	36	10.6	53	0.9	4	1.3	7	-	-	8771
Dy 3.13/CL (15) LC_{SS}: Site 6																							
0-25	CL	6.4	160	0.01	5	31	27	29	0.9	2.63	0.28	15.0	3.9	26	3.5	23	0.6	4	1.2	8	5.8	39	8781
25-50	LC	7.3	100	0.01	2	22	21	55	1.1	0.55	0.55	18.9	2.7	14	2.7	14	0.5	3	5.0	27	8.0	42	8782
40-75	LC	7.8	220	0.02	1	11	15	74	1.6			28.7	3.9	14	9.5	33	0.8	3	7.2	25	7.3	25	8783
75-100	HC	8.7	340	0.03	1	17	21	60	2.0			25.0	4.5	18	12.2	49	1.0	4	7.3	29	-	-	8784
Ug 5.28/C: Site 7																							
0-15	MC	6.4	170	0.01	1	23	25	45	1.7	2.03	0.22	23.4	5.7	24	6.1	26	1.6	7	1.2	5	8.8	38	8790
15-40	MC	7.3	230	0.02	1	14	18	64	1.7	0.84	0.12	35.0	7.9	23	13.6	39	1.9	5	4.6	13	7.0	20	8791
40-75	HC	8.2	920	0.11	1	12	19	68	1.5	0.47	0.08	33.2	7.2	22	15.2	46	2.0	6	8.8	25	-	-	8792
75-150	HC	9.0	1330	0.17	2	15	21	62	3.6			33.0	6.9	21	15.8	47	1.8	5	8.8	26	-	-	8793
Ug 3.2/C: Site 8																							
0-10	MC	6.3	70	0.01	3	26	23	45	2.0	1.90	0.21	25.6	5.3	21	6.6	26	1.1	4	1.0	4	11.6	45	8787
10-35	LMC	6.5	90	0.01	4	31	27	39	1.2	0.80	0.11	18.1	4.1	23	4.8	26	0.4	2	1.1	6	7.7	43	8786
35-60	MC	6.9	160	0.01	2	19	17	62	1.5	0.47	0.11	19.3	4.8	25	9.4	48	1.1	6	4.0	21	-	-	8787
60-80	MC	7.8	270	0.03	2	21	20	57	1.5			18.1	3.8	21	8.4	46	1.2	7	4.7	26	-	-	8788
80-110	MC	8.5	550	0.07	1	16	16	58	2.3			29.8	5.4	18	14.7	49	1.5	5	8.2	28	-	-	8789

Depth cm.	Texture	pH	E.C. µS.cm^{-1}	Chloride %	CS %	FS %	Si %	C %	LAT %	Organic Carbon %	Total Nitrogen %	Cation Exchange change Capacity me%	Exchangeable Cations m.e.% - milliequivalents per 100 g of soil % - percentage of CEC										Sample No. 1977
													Ca		Mg		K		Na		Acidity		
													me		me		me		me		me		
													%	%	%	%	%	%	%	%	%	%	
Db 2.13/CL (10): Site 9																							
0-10	CL	6.3	120	0.01	4	41	22	32	1.1	1.49	0.16	18.6	2.6	14	4.1	22	0.8	4	1.3	7	9.8	53	8821
10-30	MC	7.1	260	0.02	2	30	17	45	2.0	1.24	0.14	25.9	3.8	15	8.2	31	0.7	3	4.7	18	8.5	33	8822
30-45	MC	8.2	600	0.07	2	20	15	65	1.9	1.40	0.18	29.1	4.9	17	13.6	47	1.1	4	9.5	32	-	-	8823
45-55	MC	8.6	840	0.09	1	18	19	63	1.9			33.4	4.9	15	15.6	47	1.4	4	11.5	34	-	-	8824
55-65	HC	8.5	910	0.10	1	19	15	62	2.0			34.1	4.4	13	16.5	48	1.2	4	12.0	35	-	-	8825
65-85	HC	8.7	920	0.11	1	24	17	54	1.9			35.5	4.6	13	17.3	49	0.9	2	12.7	36	-	-	8226
85-120	HC	9.2	1370	0.14	1	8	19	65	3.2			44.0	5.6	13	21.3	48	0.8	2	16.3	37	-	-	8227
Dr 2.13/CL (10): Site 10																							
0-10	CL	7.0	110	0.01	4	40	19	34	1.0	1.31	0.15	17.2	3.0	17	4.1	24	0.8	5	1.8	10	7.5	44	8794
10-35	MC	8.1	350	0.04	1	18	9	72	2.3	1.93	0.24	30.2	5.5	18	14.2	47	2.4	8	8.1	27	-	-	8795
35-45	MC	8.7	1010	0.11	1	15	10	70	2.4	0.69	0.11	36.9	3.5	10	17.7	48	2.7	7	13.0	35	-	-	8796
45-55	HC	9.1	1320	0.13	2	20	12	62	2.4			36.8	3.7	10	18.2	50	1.9	5	13.0	35	-	-	8797
55-65	HC	9.3	1410	0.14	2	20	12	59	5.3			42.8	4.6	11	20.2	47	2.6	6	15.4	36	-	-	8798
65-90	HC	9.6	1310	0.13	2	16	8	44	16.3			35.1	4.6	13	16.2	46	1.8	5	12.5	36	-	-	8799
Ug 5.35/C: Site 11																							
0-15	MC	6.9	190	0.03	2	34	20	37	1.3	1.64	0.19	23.0	5.5	24	6.2	27	0.6	2	2.7	12	8.0	35	8834
15-45	MC	8.3	470	0.06	1	28	17	48	1.9	1.6	0.18	25.0	5.4	22	10.6	42	0.9	4	8.1	32	-	-	8835
45-50	MC	8.5	1040	0.12	1	20	16	55	2.1	0.62	0.09	35.5	5.3	15	15.5	43	1.3	4	13.4	38	-	-	8836
50-60	MC	8.7	1240	0.15	1	21	17	54	4.7			35.5	5.1	14	15.7	44	1.3	4	13.4	38	-	-	8837
60-80	HC	9.2	1380	0.15	1	23	18	50	5.2			35.8	5.1	14	15.7	44	1.2	4	13.8	38	-	-	8838
80-150	MC	9.1	1800	0.22	-	17	18	59	2.0			40.9	5.3	13	18.9	46	0.8	2	15.9	39	-	-	8839
Ug 5.24/C: Site 12																							
0-10	MC	7.0	170	0.02	3	31	19	46	1.4	1.45	0.17	24.9	4.1	17	8.5	34	0.3	1	3.5	14	8.5	34	8800
10-40	MC	7.9	360	0.04	2	21	15	61	1.7	1.50	0.18	33.7	5.7	17	13.2	39	1.4	4	7.0	21	6.4	19	8801
40-60	HC	8.5	1050	0.12	1	17	16	65	1.8	0.47	0.08	36.8	5.4	15	17.2	47	1.9	5	12.3	33	-	-	8802
60-75	HC	9.2	1200	0.15	1	20	18	56	3.2			35.0	4.7	13	16.2	46	1.3	4	12.8	37	-	-	8803
75-150	MC	8.8	1380	0.17	1	15	17	66	1.8			42.7	5.2	12	20.0	47	1.4	3	16.1	38	-	-	8804
Dy 2.13/FSCL (10): Site 13																							
0-10	FSCL	6.5	190	0.01	4	40	18	35	1.4	1.59	0.18	19.2	4.2	22	3.7	19	1.7	9	1.0	5	8.6	45	8805
10-35	MC	8.3	590	0.05	2	22	11	63	2.1	1.64	0.20	29.4	3.9	13	13.6	46	2.0	7	9.9	34	-	-	8806
35-45	HC	8.6	1060	0.10	1	17	11	72	2.1	0.55	0.09	36.3	4.1	11	16.9	47	2.5	7	12.8	35	-	-	8807
45-50	HC	8.8	1170	0.11	2	21	14	59	2.8			36.6	3.6	10	17.5	48	2.3	6	13.2	36	-	-	8808
50-65	HC	8.9	1310	0.14	2	19	14	59	3.4			41.4	3.9	9	19.8	48	2.3	6	15.4	37	-	-	8809
65-110	HC	9.4	1250	0.12	2	28	17	49	4.4			32.1	3.5	11	15.6	48	0.9	3	12.1	38	-	-	8810
Db 1.13/CL (10): Site 14																							
0-10	CL	6.6	150	0.02	5	42	20	35	1.5	1.50	0.16	17.7	2.7	15	4.2	24	0.6	3	1.8	10	8.4	48	8811
10-35	MC	7.7	380	0.12	2	21	14	56	1.9	1.27	0.17	32.1	4.4	14	12.0	37	1.2	4	7.2	22	7.3	23	8812
35-45	MC	9.0	1060	0.18	1	18	18	60	2.5	0.44	0.08	35.2	4.0	11	16.9	48	1.7	5	12.6	36	-	-	8813
46-65	HC	9.2	1240	0.14	1	17	18	61	3.1			37.2	3.3	9	18.1	49	1.6	4	14.2	38	-	-	8814
65-120	HC	9.5	1470	0.19	-	15	14	53	9.3			42.2	4.8	12	19.1	45	1.3	5	17.0	40	-	-	8815
Dy 2.13/CL (10): Site 15																							
0-10	CL	6.8	130	0.03	-	39	20	39	1.2	1.31	0.14	18.0	2.6	15	4.1	23	0.4	2	2.4	13	8.5	47	8816
10-40	HC	7.9	330	0.04	2	29	16	55	1.8	1.49	0.17	28.7	51.	18	10.0	35	0.9	3	6.8	24	5.9	20	8817
40-65	HC	8.4	1010	0.12	2	18	13	64	2.2	0.60	0.11	36.4	56	16	16.1	44	1.6	4	13.1	36	-	-	8818
55-65	HC	8.8	1260	0.14	1	17	16	63	2.2			38.5	5.7	15	17.3	45	1.6	4	16.9	36	-	-	8819
65-110	MC	9.2	1460	0.17	1	13	17	63	6.2			43.4	6.8	16	19.1	44	1.8	4	15.7	36	-	-	8820

Appendix II - Analytical Methods

All estimations were carried out on air-dried fine earth, i.e. material passing a 2 mm round hole sieve. For the total nitrogen and organic carbon analyses, the fine earth was further reduced to pass though a 0.5 mm sieve. All results except pH are reported on an oven-dry basis.

The methods used are given below, except where indicated otherwise, are essentially as described by Piper (1950)

Mechanical Analysis
This is a method for separating silt, clay fine sand and coarse sand-sized fractions after removal of organic matter and lime. The procedure also measures losses occurring in acid treatment of soils. Silt and clay percentages are determined by the Plummet Balance. Fine sand, coarse sand, and loss in acid treatment are determined by weight.

Electrical conductivity
A 1:5 soil-water suspension was shaken for one hour and the electrical conductivity (E.C.) determined at 20˚C. The E.C. is expressed in micro Siemens per centimetre, $\mu S.cm^{-1.}$

pH
After determination of electrical conductivity the same suspension was used to determine pH by the glass electrode.

Chlorides
These were determined by the electrometric titration method of Best.

Total Nitrogen
The Kjeldahl method was used.

Organic Carbon
The wet combustion method of Walkley and Black was used. Results have been multiplied by an empirical recovery factor of 1.25.

Exchangeable Cations
The extraction method of Tucker (1974) was used for the removal of soluble salts and for leaching the cations, but at least three extractions were carried out for removal of soluble salts.

In the leachate calcium, magnesium and potassium were determined by atomic absorption spectrophotometry, sodium was determined by flame emission spectrophotometry. The individual cations have been expressed as milligram equivalents per 100g. of soil and as a percentage of the total cation exchange capacity.

Exchangeable Acidity
This is Meclich's barium chloride – triethanslamine method (reference point pH 8.0), using the modification of Peech et. Al. (1962). This method is applicable only to soils below pH 8.0.

Cation Exchange Capacity
This is determined by the addition of the individual cations. No determination of exchangeable acidity was carried out for soils with pH of 8 or greater.

Appendix III - Explanation Of Terms

Bleached Horizon
This is an A_2 horizon that has become pale in colour due to leaching. A sporadic bleach is one in which the bleached portions appear irregularly through the A_2 horizon, or as blotches at the interface of the A and B horizons, or as nests of bleached grains of soil material often at the interface of the A and B horizons, when no other evidence of and A_2 horizon may occur.

Condition of Surface Soil
This refers to the natural condition of the A horizon and its reaction to the usual wetting and drying cycle, hence;

Hardsetting – A horizons are considered to be hardsetting when a compact, hard, and apparently apedal condition prevails on the drying-out of the soil periodically.

Consistence
Consistence comprises the attributes of soil material that are expressed by the degree and the kind of cohesion and adhesion or by the resistance to deformation or rupture. It is affected markedly by the moisture state of the soil.

Duplex Soils
These are soils with contrasting texture profiles. The characteristic feature is the high content of clay in the B horizon relative to the A horizon.

Fabric
Fabric describes the appearance of the soil material (under 10 x hand lens). Differences in fabric are associated with the presence of peds and the lustre, or lack thereof, of the ped surfaces, and the presence, size and arrangement of pores (voids) in the soil mass.

Gilgai
Surface microrelief associated with soils that have clay subsoils and consisting of hummocks and/or hollows, in some instances separated by subplanar or slightly undulating surfaces.

Land Capability
The inherent capacity of land to perform at a given level for general use.

Modal Profile Description
This represents the most usual condition of each property of all soils in the class. Profile characteristics have determined ranges of expression.

Mottles
Mottles are considered to be masses, blobs or blotches of subdominant colours.

Munsell Colour
This is the soil colour determined by matching against the Munsell colour chart and expressed in its notation of hue, value and chroma. The notations given are for moist (m) or dry (d) soil where indicated.

Ped
A ped is an individual, natural soil aggregate.

Primary Profile Form
Primary profile from is textural in character and is the term given to the first or primary division of all soils. So far four primary profile forms have been recognised, as follows:

1.	Organic	O	3.	Gradational	G
2.	Uniform	U	4.	Duplex	D

Primary Profile Form (P.P.F.)
Principal profile form represents the complete concept and character of profile form and is the end point of the present factual key classification. The aim is that each P.P.F. should be of such a coherent character that it will be possible to make a reasonably concise statement concerning the group soils belonging to it: and moreover, that further (more detailed) classification within each P.P.F. into more restricted groupings will be readily achieved using the P.P.F. as the starting point

Profile Form
Profile form is the term used to express the overall material impression created by the soil properties as these are considered art different stages of the key. Profile form is based on texture at the Primary Profile Form stage, but other properties are considered at each further stage in the key to the Principal Profile Form stage which represents the complete concept and character of profile form.

Seasonal Cracking
This refers to those shrinkable clay soils which develop and exhibit during a dry-season or period cracks as wide, or wider than 6mm and which penetrate at least 30 cm into the soil profile.

Soil Horizon
A soil horizon is a layer within the soil profile having morphological characteristics and properties different from those layers which occur below and/or above it.

Soil Profile
The soil profile is the face os soil exposed in a vertical section. More realistically it is a column or prism of soil of small cross-sectional area and extending from the soil surface to the parent material.

Soil Series
This is a group of soils having horizons similar in distinguishing characteristics and arrangement in the soil profile, except for the texture of the surface soil, and formed from the same parent material.

Solum
The solum consists of either the A+B horizons (the AB profile) or the A horizon alone when no B horizon is present.

Structure
This refers to the arrangement of all soil particles. Particles refer to all peds and non-peds and may be described in terms of the grade, class and form of the soil aggregates.

Texture
Soil texture, in the field, is a measure of the behaviour of a small handful of soil when moistened and kneaded into a ball and then passed out between thumb and forefinger. Although strongly influenced by clay content, texture is also affected by other soil properties such as, the type of clay mineral, silt, organic matter, oxides, calcium – magnesium carbonates, exchangeable cations, and strong, fine-structured aggregation.

Uniform Soils
These are soils with small, if any, texture differences throughout the profile.

Appendix IV - Munsell Notation and Colour Names

Symbol Used:

Main colours	R-red; B-brown; Y-Yellow; G-grey; w-white
Modifying Colours:	r-reddish; b-brownish; y-yellowish; g-greyish
Additional Terms:	L-light; (pale has been used); dk-dark; dl-dull; br-bright; sl-slightly; v-very

Value	Colour Names							Hue	Name
9	w	w sl b G R w v L r G B w v L y B w v L sl y G	w sl r G w v L g B w v L y G B w v L y b G w v L y G	w v L Y G	w sl y G B w v L g Y	w sl dl Y B w v L dl Y	w s l Y B w v L b r Y	10R 5YR 10YR 2.5Y 5Y	b R r B y B Y B Y
8	V L G w	v L sl b R G w v L b G w v L y B w v L sl y G w	v L r G w v L b R G w v L R G B w v L r G B w v L G B w v L y G B w v L y b G w v L y G w	v L dl b R w v L r G B w v L y G B w v L Y G w	v L g R w v L dl b R w v L g R B w v L r B w v L g B w v L dl y B w v L y G B w v L g Y w	v L b w v L y B w v L dl Y B w v L dl Y w	v L br y B w v L Y B w v L br Y	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
7	v L G	v L sl b R G v L b G v L y B v L sl y G	v L r G V L b R G v L R G B v L r G B v L G B v L y G B v L y b G v L y G	v L dl b R v L r G B v L y G B v L Y G	v L g R v L dl b R v L g R B v L dl r B v L g B v L dl y B v L y G B v L g Y	v L dl R v L b R v L dl R B v L r B v L B v L y B v L dl Y B v L dl Y	v L R v L R B v L br r B v L br B v L br Y B v L Y B v L Y	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
6	L G	L sl b R G L b G L y B L sl y G	L r G L b R G L R G B L r G B L G B L y G B L y b G L y G	L dl b R L r G B L y G B L Y G	L g R L dl b R L g R B L dl r B L g B L dl y B L y G B L g Y	L dl R L b R L dl R B L r B L B L y B L dl Y B L dl Y	L R L br b R L R B L br r B L br B L br y B L Y B L Y	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
5	G	sl b R G b G sl y b G sl y G	r G b R G R G B b G G B y G B y b G y G	dl b R sl r G B y G B Y G	g R dl b R g R B sl dl r G B g B dl y B y G B g Y	dl R b R dl R B r B dl g B y B Y B dl Y	br R br b R R B br r B B br y B	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
4	G sl dk	sl b R G sl dk b G sl dk sl y b G sl dk sl y G sl dk	r G sl dk b R G sl dk R G B sl dk b G sl dk G B sl dk y G B sl dk y b G sl dk y G sl dk	dl b R sl dk sl r G B sl dk y G B sl dk Y G sl dk	g R sl dk dl b R sl dk g R B sl dk sl dl r G B sl dk g B sl dk dl y B sl dk y G B sl dk g Y sl dk	dl R sl dk b R sl dk dl R B sl dk r B sl dk	R sl dk br b R sl dk R B sl dk br r B sl dk	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
3	dk G	dl sl b R G dk b G dk b G dk sl y G	dk r G Dk b R G dk R G B dk b G dk G B dk y G B dk y b G dk y G	dk dl b R dk sl r G B dk y G B	dk g R dk dl b R dk g R B dl sl r G B dk y B	dk dl R dl b R dl R B	dk R	7.5R 10R 2.5YR 5YR 7.5YR 10YR 2.5Y 5Y	R b R R B r B B Y B Y B Y
2	v dk G	v dk sl b R G v dk b G v dk b G v dk sl y G	v dk r G v dk b R G v dk R G B v dl b G v dk y G B v dk y G		v dk g R v dk g R B			7.5R 10R 2.5YR 5YR 10YR 5Y	R b R R B r B y B Y
	0	1	2	3	4	6	8		

Appendix V - Land Capability Classification Factors and Ratings

FACTOR	CATEGORY	RATING
1. Slope	0 - 2%	100
	2 - 6%	80
2. Drainage	1. Poorly drained	40
	2. Somewhat poorly drained	60
	3. Moderately well drained	80
	4. Well drained	100
	5. Somewhat excessively drained	60
	6. Excessively drained	40
3. Salinity	Class 1: 0 – 460 $\mu S.cm^{-1}$	100
	Class 2: 460 – 1080 $\mu S.cm^{-1}$	80
4. Effective	Greater than 20 cm	100
Rooting depth	20 – 10 cm	80
	10 – 5 cm	50
	5 – 00 cm	10
5. Surface	1. Medium textured soil: loam, sandy loam, sandy	
Texture and	clay loam or fine sandy clay loam.	100
Structure	2. Medium to heavy textured soil: sandy clay,	
	clay loam or silty clay loam.	
	Structure: a) Massive to prismatic	80
	b) Blocky to crumb (or massive	90
	but porous)	
	3. Heavy textured soil: clay or silty clay	
	Structure: a) Massive to prismatic	60
	b) Blocky to crumb (or massive	
	but porous)	80
	4. Light textured soil: fine sand or loamy sand	
	Structure: a) Unstable	40
	b) Stable	50
	5. Poorly structured dispersed clay, or swelling,	40
	sticky and impermeable clay.	
	6. Very coarse textured soil:	
	(a) Pure Sand	10
	(b) Soil with up to 45% coarse Sand	30
	(c) Soil with non-decomposed “raw” humus	30
6. Permeability	1. Very slow	40
	2. Slow	60
	3. Moderately slow	80
	4. Moderate	100
	5. Moderately Rapid	80
	6. Rapid	60
	7. Very Rapid	40