SOILS AND LAND USE IN THE TORRUNBARRY IRRIGATION DISTRICT, VICTORIA

BY

I.J. SARGEANT, J.W. NEWELL AND W.I. WALBRAN

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To all of these people the authors extend their sincere thanks.

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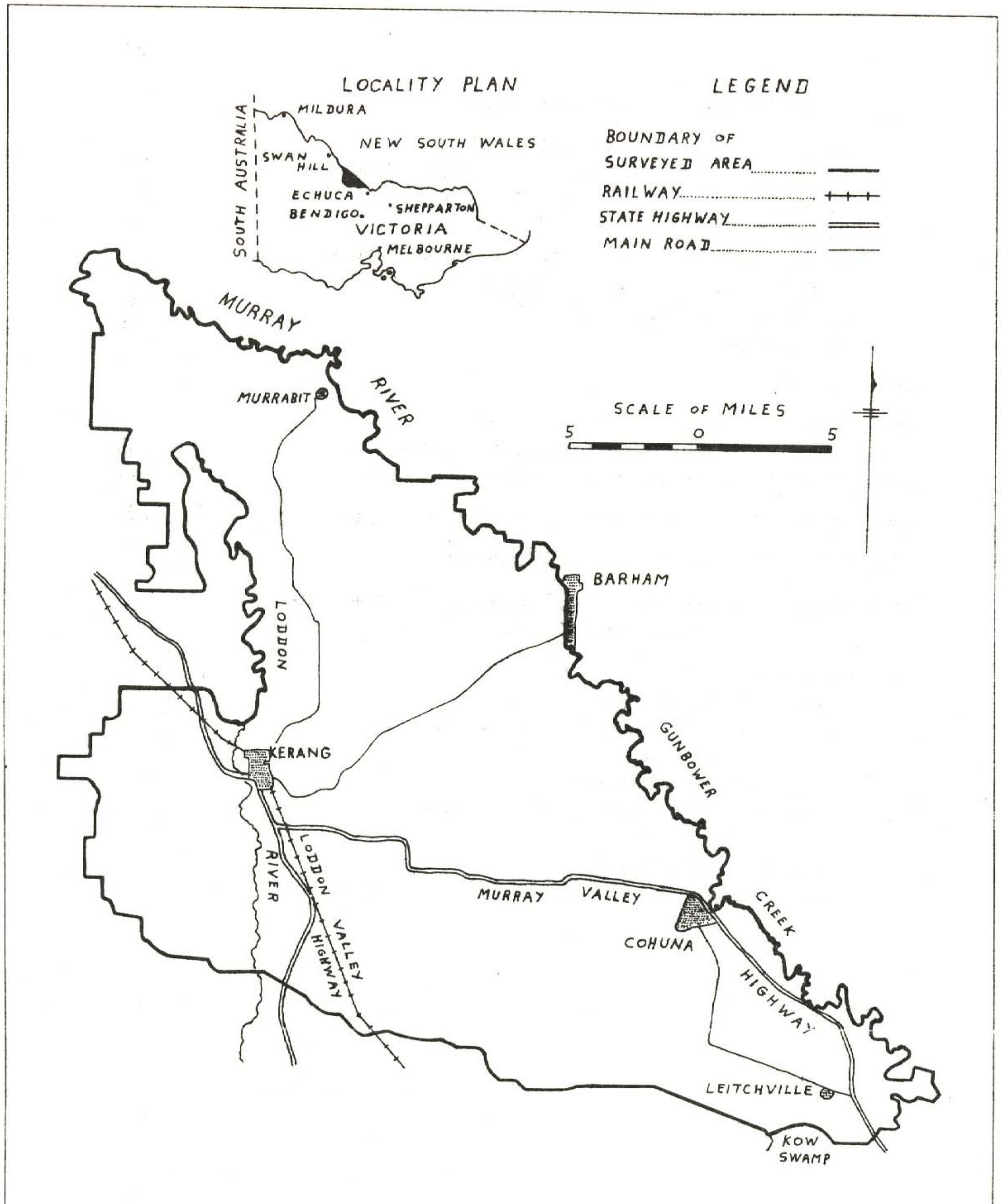

Fig. 1. Locality plan, Torrumbarry Irrigation District.

A° A' REQUIRE REDUCTION SUCH THAT LINE A°B BECOMES A'B. B

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Soils Surveyed by J. Goble, T.P. Lee, P.G. Macumber, E.H. Mikhail, J.W.Newell, J.C. Nieuwenhis, G. Pope, I.J. Sargeant, R. Thorne and W.I. Walbran.

This is a detailed soil survey of about 313,000 acres of farm land in parts of the counties of Gunbower and Tatchera. The main town of Kerang (35 deg. 44 min. S. and 143 deg. 54 min E., elevation 255 feet) is near the mid- western edge of the area. It includes, with some modifications, the survey of 54,000 acres of the Kerang Irrigation District mapped by Baldwin, Burvill and Freedman and published in 1939. Almost all of this land is in the constituted Irrigation Areas of Cohuna, Koondrook, Third Lake and Kerang, with approximately 223,600 acres irrigated, mostly under pasture. All of these areas are under gravity supply with water diverted from the Murray River by the Torrumbarry Weir.

Over one half of the irrigated area is under annual pasture, while about 66,000 acres is under perennial pasture. Most of the irrigation land carries fat lambs, sheep for wool production, and beef and dairy cattle. Land not irrigated generally supports sheep for wool production but small quantities of wheat are sown. The land use and area under irrigated agriculture in the various Irrigation Areas are given in Table 1.

Table 1 - Areas of Land Under Irrigated Agriculture in the Torrumbarry Irrigation District, 1970- 71

Land Use	Irrigation Areas				
	Cohuna	Koondrook	Third Lake	Kerang	Total
	ac	ac	ac	ac	ac
Area of Irrigation	109,908	89,292	17,779	89,800	306,779
Area Irrigated	99,602	54,843	9,341	59,845	223,631
Pastures: Annual	45,235	39,557	7,474	39,564	131,830
Perennial	43,975	10,433	441	11,211	66,060
Native	6,985	979	80	3,175	11,219
Lucerne	1,859	374	772	692	3,697
Cereals	311	298	136	1,186	1,931
Summer fodder crops	734	526	58	311	1,629
Orchards	35	534	-	-	569
Market Gardens	54	10	-	-	64
Fallow and Miscellaneous	414	2,132	380	3,706	6,632

General information about the area includes a brief outline of settlement and irrigation, and the subsequent development of salinity problems. Geomorphology, climate and native vegetation are outlined in some detail.

The main disability over much of the Torrumbarry Irrigation District is the presence of highly saline and shallow watertables. The presence of salt in the root zone is the main limitation to plant growth in this district, and over much of the area pastures are visibly affected by salt. Often ground cover is absent or comprises only salt tolerant species. Special attention has been given to the causes of salinity in the area and a salt map is included.

Another problem is that a large proportion of the surface soils is clay, many of which disperse when irrigated, and become hard and cloddy on drying out. Much field and laboratory research by the Department of Agriculture has been concerned with developing methods of improving such soils. These methods are discussed in this report.

Physical and chemical data are provided for most of the 80 soil types, units and phases described in the report. Field mapping was at a scale of 20 chains to one inch, or approximately 1:16,000, reproduced here at 40 chains to one inch. All maps accord with the standard mapping areas of the Australian One Inch Series, the grid lines being shown on the “Index to Maps”. Six colours representing different land use classes are used on the maps.

PURPOSE AND USE

This report is intended primarily for the use of farmers, farm advisers and research workers in agriculture, irrigation and hydrology, although much of the data will be of interest to teachers and regional geographers.

The report is the result of a soil survey requested by the State Rivers and Water Supply Commission of Victoria. Fieldwork was commenced in 1964 and completed in 1970. The soil survey is intended to be a broad guide to land suitability and management for different crops, using as a basis the irrigation and drainage characteristics of the soil types and their liability to salinity problems.

Maps and map legends enable the soil types to be identified at any point without reference to the text. The text gives fuller details of the soils, and discusses their limitations under irrigation and their liability to salting. Detailed technical data are given in the appendices.

USE OF THE MAPS

To Find a Particular Locality- in the supplement accompanying this report is the "Index to Maps". This is a plan of the surveyed area and shows the boundaries and serial numbers of the Soil Maps. From the key features of this plan the soil map covering a particular area can usually be found. The number of the adjoining soil maps is shown on the margins of each soil map.

Although the roads, channels and drains shown on the soil maps should usually enable a particular property to be located, the Crown Allotment and Lot numbers provide an additional check.

Map Details and the Use of Colour and Symbols- 80 different soil types, units and phases were recorded in the area, and these are delineated and marked by symbols on the coloured maps. The soils have been assign to six "Crop Suitability Groups" distinguished on the "Soil Maps" by six colours, as detailed on the fold- out, "Key to Crop Suitability Groups and Soil Type Maps" on the reverse side of this key.

The basis of the "Crop Suitability Groupings" is discussed in the sections "Suitability of the Soils for Various Irrigated Crops" and "Soil Features and Irrigation".

Reference Sites- places where soil profiles have been sampled and analysed are marked by numbered triangles on the detailed soil maps.

Soil Association and Salinity Maps- These maps are in the supplement accompanying the report. On the Soil Association Map the soil types have been combined into larger units called Soil Associations. This map enables the overall soil pattern of the area to be seen readily, and also indicates in a broad way the relationship between soils and potential land use in different parts of the district.

The salt status of the subsoils has been investigated by analysing a large number of samples taken during the course of the soil survey. The Salt Map, compiled using these analytical results, is not detailed enough to show the salt status of individual holdings, but gives a picture of the overall pattern of salt distribution in the area.

ADVISORY SERVICES

The full usefulness of the maps is explained in the section "Suitability of the Soils for Various Irrigated Crops", and farmers are strongly advised to compare their land very critically with the soil map of their area and the "Key to Crop Suitability Groups" and "Soil Type Maps".

Questions regarding irrigation and drainage layout, irrigation techniques, pasture management and soil salinity should be discussed with District Department of Agriculture advisers, contacted through the District Agricultural Centre, Kerang.

SUITABILITY OF THE SOILS FOR VARIOUS IRRIGATED CROPS

All of the soil types, units and phases are fully described in the section "Description of Soil Types and Miscellaneous Units". Their suitability for irrigated pastures and some irrigated crops is discussed below and summarised in the "Key to Crop Suitability Groups and Soil Type Maps", and in Table 2 which also includes two of the numerous variants where the deviation from normal is sufficient to affect land use.

Table 2 - Crop Suitability Croupings

Soil Types, Units, Phases and Variants	Crop Suitability Group
Benjeroop Clay	2B
Box clay	5A
Cohuna fine sandy loam	2A
Cohuna fine sandy loam, deep phase	1B
Coombatook sandy loam	2C
Coombatook sandy clay loam	2C
Cullen loam	2A
Cullen loam, eroded variant	4A
Della clay	2C
Della sandy clay loam	2C
Fairley clay	4B
Gonn clay	5B
Kerang clay, grey- brown phase	4B
Kerang clay, grey phase	4B
Koroop clay	4A
Koroop clay, saline variant	4B
Laton clay, south of Forest Reserve	4A
Laton clay, northern occurrences	4B
Leitchville sand	1B
Leitchville sand, shallow phase	2A
Macorna clay, red- brown phase	4B
Macorna clay, brown phase	4B
Meran sandy loam	4B
Meran sandy clay loam	4B
Meran clay	4B
Murrabit clay	2B
Myall clay	4A
Reedy creek clay loam	4A
Sandmount sand	1A
Sandmount sand, shallow phase	1A
Towangurr clay	6B
Tragowel clay	5A
Una loam	2A
Wandella clay	5B
Warra clay	4B
Unit I	4A
Unit II	2A
Type A	2B
Type B	5A
Type 1	2A
Type 2	2B
Type 3	1C
Type 4	4B
Type 5	4B
Soil of the Gunbower Suite	
Type G1	2A
Type G2	2A
Type G3	4A
Swamp Soils	
Type S1	5B
Type S2	5B
Type S3	5B
Type S4	6B

Soil Types, Units, Phases and Variants	Crop Suitability Group
Depression Soils	
Type d1	5B
Type d2	6A
Type d3	6B
Type d4	6A
Type dV	6B
Dune and Ridges Soils	
Type M1 sand	3B
Type M2 sandy clay loam	3A
Type M2 clay loam	3C
Type M2 clay	3C
Type M3 sandy loam	3A
Type M3 sandy clay loam	3A
Type M3 sandy clay loam, dense deep subsoil phase	3A
Type M3 clay	3C
Type M4 sandy loam	3A
Type M4 sandy clay loam	3A
Type M4 clay loam	3A
Type M4 clay	3C
Type M5 sandy loam	3B
Type M5 sandy clay loam	3B
Type M5 clay	3C
Type M6 sandy loam	3B
Type M6 clay loam	3B
Type M7 clay loam	3C
Type M7 clay	3C
Type M8 sandy loam	3A

The six groups are further sub-divided into a total of 15 sub-groups. At the head of each group is a list of common irrigated crops which can be grown, together with a brief statement of the major soil disabilities whin the group. The sub-groups which follow group the soils on the basis of various profile characteristics and, in most of the sub-groups, particularly soil disabilities are summarised.

The crop suitability grouping is not a rating of the soils in order of merit, although it does not suggest a general order, in that the high-value crops are likely to be grown less successfully in descending order from Group I to Group VI. This classification is based on the present drainage status of the area, and should factors limiting the irrigation of certain soil types be removed or ameliorated, some soil types may prove equal or superior to other with fewer natural disabilities. For example, future drainage in the area would alter the position of the soils in some of the groups and sub-groups.

As soil salinity is a hazard over much of the surveyed area, consideration should be given to salinity aspects when planning irrigation layout and land use, particularly if salt- sensitive crops are to be grown. Such aspects of irrigation are discussed in more detail in the section "Soil Features and Irrigation".

GROUP 1

Soils with no serious disabilities for irrigation. Suitable for horticultural crops, vegetables and lucerne; soybeans, sunflowers and summer fodder crops; except for 1A, for pastures and cereals.

(a) Elevated soils with more than 36 inches of very permeable surface; difficult soils for pastures and cereals.

SANDMOUNT SAND
SANDMOUNT SAND, SHALLOW PHASE

Inaccessibility to the gravitational water- supply, excessive slopes and high permeability generally necessitate spray irrigation. The high cost of spray irrigation tends to limit the use of Sandmount sand to high return crops such as citrus, vegetables and lucerne. Although water-tables from in these soils, they are usually deep except on the lower slopes and in the shallow phase.

(b) Brown fine sandy surface soils 7 to 18 inches deep, with permeable clay subsoils, sandy at depth.

COHUNA FINE SANDY LOAM, DEEP PHASE
LEITCHVILLE SAND

These soils can be watered by flood and furrow irrigation, but care is necessary to prevent over watering and subsequent salting downslope. Although there is little vegetable growing on these soils, they are generally quite suitable. However, the surface crusting of Cohuna find sandy loam may result in germination problems for small seeded vegetable crops such as carrots and lettuce.

(c) Dark grey friable clay surface; permeable profile.

TYPE 3.

Type 3, although high in clay, has an extremely well-structured surface soil and is highly permeable. It can be irrigated using spray or furrow irrigation. Oranges are successfully grown on this type, and to date no water table or salinity problems are apparent.

GROUP 2

Moderately permeable soils of low to moderate salinity and few other disabilities. Suitable for perennial and annual pastures, summer fodder crops and cereals, and in some cases also for horticultural crops, vegetables, lucerne, soybeans and sunflowers

(a) Soils with 4 to 12 inches of surface over moderately permeable subsoils, low to moderate salinity in the deep subsoils; prone to perched water tables and possible development of salinity especially in Una Loam and lower areas of Unit II. Unit II has a wide range of profiles and short uneven slopes.

COHUNA FINE SANDY LOAM
CULLEN LOAM
UNA LOAM
TYPE G1
TYPE G2
TYPE I
UNIT II

These soils generally occupy well drained positions in the landscape and are quite well suited to irrigation. The soil profiles are similar to the number of soil types successfully supporting irrigated pastures and crops over much of the northern plains of Victoria. The depth of surface soil is satisfactory for pastures and cultivated crops, and although the subsoils are fairly heavy- textures, they are moderately permeable. Salt levels are generally untried for vegetable growing, there seems to be no reason why such crops should not do well in area of low salinity.

(d) Moderately permeable clay or clay loam surfaces and medium to heavy-textured profiles. Salinity usually low: shallow water-tables unlikely.

BENJEROOP CLAY
MURRABIT CLAY
TYPE A
TYPE 2

The soils of sub- group 2(b) have a high reputation for their productive capacity in regard to pastures and lucerne, and, in the Murrabit area, oranges. Unlike similar soils in the Swan Hill Irrigation Area, salinity is generally low and shallow water- tables seldom occur.

(c) Soils with permeable profiles and low to moderate salinity. Some risk of salinity from the Gredgwin Ridge. Areas of Della clay are strongly gilgaied, and, in low areas, may be highly saline.

DELLA SANDY LOAM
DELLA CLAY
COOMBATOOK SANDY LOAM
COOMBATOOK SANDY CLAY LOAM

Although the physical properties of these soils are reasonably good in regard to irrigation, the risk of salinity is greater than in the preceding sub- groups. Della clay is the most susceptible soil to salinity with the risk increasing towards the northern part of the surveyed area.

GROUP 3

Moderately permeable soils of the dunes and ridges. Good external drainage with the exceptions noted below. Generally above gravity supply level and therefore not mapped in full detail.

(a) Brown sandy duplex soils with appreciable salinity. Water tables developing in these soils will result in salt damage in M8 sandy loam and other soils downslope.

M2 SANDY CLAY LOAM
M3 SANDY LOAM
M3 SANDY CLAY LOAM
M3 SANDY CLAY LOAM, DENSE DEEP SUBSOIL PHASE
M4 SANDY LOAM
M4 SANDY CLAY LOAM
M4 CLAY LOAM
M8 SANDY LOAM

The soils in this group have in common a reasonable depth of surface soil and moderately permeable upper B horizons. Where salinity is low and the soils have provision for reasonable surface and subsurface drainage, growth of horticultural crops should be possible. Although such crops are largely untried on these soils, similar soils near Kangaroo Lake are used for this purpose. These soils are generally inaccessible to the gravitational water- supply and irrigation usually necessitates pumping. Consequently, irrigated crops are limited to those giving reasonable economic returns, such as lucerne and horticultural crops.

(b) Mainly brown duplex soils, some suitable for irrigation but all with special disabilities, thus: M1 sand, poor water retention; M5 soils, variability; M6 soils, seepage problems.

M1 SAND
M5 SANDY LOAM
M5 SANDY CLAY LOAM
M6 SANDY LOAM
M6 CLAY LOAM

Some areas containing the following soils are comparable with subgroup 3(a), but other areas are more variable or dominated by soils of, subgroup 3(c).

SERIES M2 TO M5
COMPLEX OF M2 SANDY CLAY LOAM AND M3 CLAY
VARIOUS SOILS OF SERIES M3 AND M4

As with subgroup 3(a) these soils are generally above gravity water- supply level and irrigation usually necessitates pumping. Horticultural crops are not recommended.

(c) Wind- scalded soils not favoured for irrigation because of surface crusting, or slope, or impermeability, or variable highly calcareous surfaces. M2 soils are moderately saline.

M2 CLAY LOAM
M2 CLAY
M3 CLAY

M4 CLAY
M5 CLAY
M7 CLAY LOAM
M7 CLAY

GROUP 4

Soils generally of low saturated permeability and various salinity hazard. With effective control of salinity the soils are suitable for perennial and annual pastures, summer fodder crops and cereals; and, where drainage is good, soybeans and sunflowers.

(a) Grey cracking clays and crusting grey and brown soils. Low salinity hazard except for some areas of Reedy Creek clay loam. When allowed to dry out the clay soils crack deeply and require a very heavy first watering, especially in the autumn.

CULLEN LOAM (ERODED)
KOROOP CLAY
LATON CLAY (SOUTH OF FOREST RESERVE)
MYALL CLAY
REEDY CREEK CLAY LOAM
TYPE G3
UNIT I

Cullen loam (eroded) and Reedy Creek clay loam have a common limitation in having a shallow surface soil overlying a slowly permeable subsoil. The resulting slow water intake often leads to moisture stress in pastures during the summer period. A serious problem of the clay soil is that they crack deeply when dry, and during the first watering much of the water passes to the subsoil, adding to the water table. Water tables in these soils disperse very slowly since subsequent swelling of the clay restricts water movement. When the salt content of the soil is high, salinity becomes a problem.

(b) Inherently saline grey and brown cracking clays and associated duplex soils that require careful management to minimise actual salt damage. Control of water- tables on a district scale is necessary for complete reclamation. Heavy grading of gilgais and drainage lines is often necessary prior to pasture establishment on Kerang clay and Laton clay.

FAIRLY CLAY
KERANG CLAY, GREY PHASE
KERANG CLAY, GREY- BROWN PHASE
KOROOP CLAY, SALINE VARIANT
LATON CLAY (NORTH OF FOREST RESERVE)
MACORNA CLAY, BROWN PHASE
MACRONA CLAY, RED- BROWN PHASE
MERAN SANDY LOAM
MERAN SANDY CLAY LOAM
MERAN CALY
WARRA CLAY
TYPE 4
TYPE 5

The soils predominate in the surveyed area south of Pyramid Creek and west of the Loddon River, and soil salinity has been made the main limitation to productivity over this area. The establishment and maintenance of pastures on Macorna, Meran and Kerang clays under saline conditions have been subject to much study throughout the Kerang district. The presence of high water tables does not allow easy downward leaching of salt and the control of water-tables on a district scale is necessary. Other than by minimising additions to ground water, water tables can be reduced by ground water pumping or subsurface pipe drainage systems. Ground water pumping is only successful where there are suitable sand layers and both methods require provision for saline wastewater disposal. Discharge of saline water into the district drainage scheme is at present prohibited.

GROUP 5

Low- lying soils subject to occasional inundation and presenting drainage difficulties. Variably saline. Gilgais and drainage lines increase the cost of lay- out. Potential land use as for Group 5 soils excluding the oil seed crops, but the management difficulties are greater.

(a) Inherently saline soils of moderate permeability. All are dependent on district drainage for salinity control.

BOX CLAY
TRAGOWEL CLAY
TYPE B

Box clay and Type B are the main soil types overlying the sand beds described by Garland and Jones (1963), and if ground water pumping was permitted reclamation of some areas of these soils would be more easily achieved. However, much Box clay and most Tragowel clay have no shallow underlying sand layers, and the lowering of watertables is only possible by careful irrigation practices on a district scale, or should they be permitted, subsurface pipe systems.

(b) Generally non- saline soils, which, except for Type d1, are less permeable than subgroup 5(a).

GONN CLAY
WANDELLA CLAY
TYPE d1
TYPE s1
TYPE s2
TYPE s3

When the drainage difficulties associated with these soils are overcome, satisfactory perennial and annual pastures can be grown.

GROUP 6

Soil generally not recommended for irrigation because of extreme salinity and drainage difficulties, or because they form part of the local drainage system. Where these difficulties are alleviated the soils may support perennial or annual pastures.

(a) Medium textured soils in drainage lines or local depressions.

TYPE d2
TYPE d4

(b) Dense, grey, heavy soils in drainage lines and drainage basins.

TOWANGURR CLAY
TYPE d3
TYPE dV
TYPE s4

SOIL FEATURES AND IRRIGATION

Soil features which are important in irrigation are landscape position, physical and hydrological characteristics, and chemical properties.

Landscape features affecting irrigation in this district include excessive slopes, depressions, gilgaied areas and areas with many depression line. Physical features of importance are soil texture, structure and cracking pattern, while hydrological features considered to be important are infiltration, permeability and depth to watertable. Excessive salt is frequently the most obvious chemical property retarding plant growth. Many of these profile features are interrelated. For example, the presence of high amounts of salt in a soil, although disadvantageous to the plant, increases the permeability of the soil and gives the surface soil a very powdery structure when dry.

SOIL PERMEABILITY

Most of the soils above gravity supply level belong to Group 3, the moderately permeable soils of the dunes and ridges, with small areas of Group 1A soils which are very permeable soils adjoining the prior stream beds (see "Physiography and Geology"). It is difficult to achieve uniform water penetration through these soils using flood irrigation and as spray irrigation allows better control of water this latter method should be used whenever practicable. Generally the soils of Group 3 are appreciably saline and there is risk of salting downslope and seepage should water- table be allowed to rise.

Spray irrigation is the only effective way of controlling water entry in the Group 1A soils, Sandmount sand and its shallow phase, and, even though these soils are generally low in salt, high watertables will still result in salinity problems downslope.

Of the Group 1B and 2A soils, Leitchville sand, Leitchville sand shallow phase, Cohuna fine sandy loam and Cohuna fine sandy loam deep phase, have satisfactory surface and subsoil permeability, whilst poor surface permeability may be a problem on Cullen loam, Una Loam, Type 1, Type G1, Type G2, Unit II, and in Group A4, Reedy Creek clay loam. Shallow perched watertables easily develop in all these soils and, since they are underlain by very slowly permeable layers with the possible exceptions of Types G1 and G2, the watertables fall slowly after irrigation. The slowly permeably layers generally occur before 6 feet, but over the prior stream beds the depth is much deeper, in some cases deeper than 14 feet. Sands generally occur in the prior stream beds, and it would be possible to drain many such areas using groundwater pumping.

The dominant soils in the Torrumbarry Irrigation District are the grey and brown cracking clays on almost level plains. These soils belong to Groups 2B, 3 and 5, and are mainly used for annual pasture. By autumn these soils are deeply cracked and it is not possible to avoid initial rapid water entry. Generally the clays swell on wetting and, when saturated, may become very slowly permeable. Watertables once formed in these soils disperse only very slowly permeable. Watertables once formed in these soils disperse only very slowly and when the salt content of the profile is high surface salinity becomes a problem. Two methods of lowering the watertable, using tile drainage and pumping from shallow aquifers will be discussed later. It is possible that as the salinity of the ground water and soil is reduced, the clays may disperse lowering the permeability of the soil profiles even further.

The low- lying soils of this district vary widely in salt content, those in subgroup 5A being inherently saline whilst subgroup 5B soils are generally free of salinity problems. The soils of both subgroups have low permeability when saturated. The non- saline low- lying soils generally show deep cracking on drying out, but when salinity is high the surface of the dry soils tend to be powdery.

SURFACE STRUCTURE AND CONSISTENCE

Poor surface structure can be a problem on both light- and heavy- textured soils. Cohuna fine sandy loam and its deep phase, Una Loam, Cullen Loam and Reedy Creek clay loam have light- textured surface soils with finely-graded particle sizes. Repeated cultivation may destroy their weak structure resulting in surface sealing after wetting. This may cause gemination difficulties with small- seeded species and may also lead to water entry problems.

Many of the grey and brown clayey surface soils have a powdery or very friable consistence due to high amounts of soluble salts. As these salts are leached out, the clays disperse, lose their structure and become cloddy on drying out. The browner clays become more poorly structured than the grey clays. Although pasture seedling emergence is generally adequate on the poorly structured clay soils of the district, emergence problems on similar soils in the Riverina do occur. There, surface applications of gypsum or gypsum in the irrigation water have improved the soil structure and moisture relationships of the immediate top soil, greatly improving seedling emergence.

At the Kerang Agricultural Research Farm various rates of gypsum have been applied to the surface soil prior to establishing irrigated perennial pastures. Results to date indicate that for moderately sodic soils up to 3 tons per acre applied to the surface soil is effective. For strongly sodic soils four or more tons per acre should be spread over the surface and cultivated into the first four inches. Further work is in progress to evaluate the economies of applying gypsum to established pastures.

Poor soil structure can also be disadvantageous to the rooting pattern of the pasture species. Their roots tend to follow the cracks in the soil and few enter the large peds. This is due to both poor aeration and mechanical hindrance. Thus the plant cannot fully exploit the soil for nutrients and water. Even though, theoretically, clayey soils hold more available water than sandy soils when wet to field capacity, the effective available water holding capacity of such poorly structured clay soil is considerably less than soils of similar clay content but having better structure.

SOIL SALINITY

Most of the irrigated land in the Torrumbarry Irrigation District supports either annual (winter) pastures, or perennial (summer) pastures (Table 1).

Generally the yearly water application for annual pastures is about 12 to 15 inches, added to the rainfall which averages 14 inches. Water is applied on three occasions, usually two in autumn and one in spring. Perennial pastures require much more, about 30 to 36 inches spread over 12 to 15 applications in addition to the natural rainfall.

Efficient water usage should be the aim of all irrigators. In general this means wetting the soil only to the lower limit of the root zone, thus avoiding excessive and wasteful applications which add unduly to the watertable. However, some annual leaching is needed because salt accumulates in the soil by evaporation from both the irrigation water and the watertable. The closer the watertable is to the surface the greater will be the groundwater evaporation, and as a result, the greater the concentration of soluble salts.

When the salt accumulation is due solely to evapotranspiration from the irrigation water, the extra water required to leach the salts downward is called the leaching fraction. Under normal irrigation practices in this district, the leaching fraction is easily exceeded and controlled use of water is necessary to keep the rise of the watertable to a minimum.

To reclaim saline land the leaching fraction need to be increased by an amount depending on the salinity of the soil, the quality of the irrigation water, type of crop, length of proposed reclamation time and other factors. Whether the leaching fraction is for maintenance of existing salinity levels or for reclamation, a nett downward movement of water through the soil is necessary and will inevitably tend to raise the watertable.

Prior to irrigation the slow dissipation of groundwater was sufficient to keep watertables low but this dissipation cannot cope with the quantities of water applied at the present time. However, every effort should be made to minimise the rise in watertables by ensuring adequate surface drainage. The surplus water should be re-used if possible, or passed into the district drainage scheme. Watertables can be lowered by installing tile drains in the subsoil (Webster, 1968), but their installation under pasture is regarded as being uneconomic at present.

Another method of lowering watertables is to remove the groundwater directly from shallow aquifers, or from water-saturated sand layers. The mapping of these aquifers is being undertaken by the State Rivers and Water Supply Commission and the Mines Department following earlier work by the Department of Agriculture. Because of present restrictions on the salinity of drainage water, groundwater pumping is limited to experimental areas. If both Lake Tutchewop and Lake Tyrrell are used as evaporating basins, increased groundwater pumping will be permitted.

An investigation into groundwater pumping for the reclamation of saline land was begun at the Kerang Agricultural Research Farm in 1964 and is still continuing. Requirements for success are:-

1. The sands underlying the salt- affected areas must be sufficiently coarse- textured to yield a reasonable flow on continuous pumping.

2. The hydraulic conductivity of the overlying layer must be sufficiently high to allow downward drainage.

3. Drainage facilities must be available for disposal of the pumped saline water without detriment to the irrigation supply system or the Murray River.

The problem of salinity in the Torrumbarry Irrigation District is made more difficult by the very saline nature of the watertable, and its shallow depth from the surface. The salinity of the groundwater existed naturally prior to irrigation, but irrigation has brought increased soluble salts to the surface by forcing watertables upwards through the sediments and by washing surface salt into local evaporating basins.

Most of the sediments in this district south of Pyramid Creek are the far flood plain and terminal deposits from streams prior to the present day Loddon River. Regular flooding and evaporation from these streams has resulted in a considerable thickness of alluvium including soluble salts. These salts are from two sources, the parent rock from which the alluvium originated, and cyclic salt which falls with the rain. Cyclic salt falling in the catchment is carried with the alluvium onto the plain, where, together with cyclic salt falling directly on the plain, it accumulates after the evaporation of the floodwaters. The amounts of cyclic salt were probably greater in the past when the coastline of the Murravian Gulf was closer to Kerang and the Loddon Catchment. Even now an estimated 10 lb. per acre annually falls with the rain (Hutton and Leslie, 1958).

Towards the end of this deposition, streams from the south-east incised themselves into the old landscape north and east of Kerang. Later, these incisions were infilled. These deposits are less saline than those to the south. In the section, "Physiography and Geology", the depositional pattern is discussed in more detail.

The first effect of irrigation was to wash the salt in the surface soil downward, adding both to the watertable and its salt content. As watertables came within 6 feet of the surface it was possible for salinisation to occur, the salt rising to the surface under the influence of evaporation. The degree of salinisation depends mostly on the depth to the watertable and its salinity.

The salt content of the soils in the district has been investigated in some detail by analysing a large number of samples for chloride. About 9,600 samples from 259,000 acres were analysed, mostly from the 2 to 3 foot zone below the surface. About 600 samples were taken from the area of the old Kerang Survey of 54,000 acres south of Pyramid Creek. The salt content of this 2 to 3 foot zone provides a suitable guide to the risk of salt damage under present drainage conditions. The danger to plants lies in the redistribution of salt from the lower depths into the root zone by capillary rise or by rising watertables.

The Salt Map in the supplement accompanying the report shows the salt content (chloride calculated as sodium chloride) of the 2 to 3 foot zone of the soils of the district in terms of four arbitrarily defined salinity classes, indicated by the four colours used on the map. Within each coloured area on the salt map most of the site will be within the range of salinity indicated by the colour, but some sites will be outside this range. The relevant percentages have been calculated for the 2,294 samples, sites located on Maps 3, 7, 8, 11 16, and the results of these calculations are given in Table 3.

Table 3 - Reliablity Of Salt Map

(Based on Salinity Calculated as Sodium Chloride for 2,294 sample Sites Located on Maps 3, 7, 8, 11 and 16).

Colour	**Range of Sodium Chloride Contents, %**	**Percentage of Samples Within Range**			
		Less than 0.12	**0.15 to 0.30**	**0.30 to 0.50**	**More than 0.50**
Yellow	Less than 0.15	90	10	-	-
Green	0.15 to 0.30	23	67	8	2
Purple	0.30 to 0.50	3	15	72	10
Red	More than 0.50	-	2	12	86

DESCRIPTION OF SOIL TYPES AND MISCELLANEOUS UNITS

In this section, all of the soil types and other mapping units shown on the 23 Soil Map Sheets in the supplement accompanying this report are described in regard to their profiles, occurrence and land use.

The profile features given in each case are the average for the particular soil type. The profiles of individual situations will frequently depart in some respects from these averages.

Six landscape patterns, each with its own distinctive topography and vegetation, can be recognised in the area. These have been designated landscape units and are indicated by Italics in ensuing parts of this section. Each soil type occupies a definite place in the landscape pattern, consequently, positional relationships occur between the soil types in each landscape unit. These aspects are dealt with in the section, "Landscape Units and Guide to Soil Types" which is also a guide to the identification of the soil types in the field.

Twenty-seven named soil types have been recorded in the surveyed area, together with 38 unnamed soil types and two soil units. The unnamed soil types include the 3 types of the Gunbower suite, 19 dune and ridge soil types, 7 minor soil types, 4 swamp soil types, 2 soil types of the prior stream beds and 3 depression soil types.

Several of the soil types have one or more phases, and an overall total of 80 soil types and phases has been described and mapped during the course of the survey. All of the soil types and all except 7 of the phases are listed in Table 2, "Crop Suitability Groupings". Of the 46 variants described in the text and indicated by appropriate inscriptions on the Soil Map, only two have been included in Table 2.

The phases and variants not included in Table 2 have been omitted from the table, because the deviations from the normal soil type do not affect the crop suitability groupings of the soils.

Benjeroop Clay

Surface soil

0 to 8 inches dark grey medium or heavy clay; dense and cracking; moderate medium or coarse subangular blocky structure; hard, dry, plastic moist; gradual transition to:

Subsoil

8 to 18 inches dark grey medium or heavy clay; dense; weak medium or coarse subangular blocky structure; hard dry, plastic moist; gradual transition to:

18 to 24 inches moderately mottled grey and yellowish grey with yellowish brown medium or heavy clay; often with traces of hard calcium carbonate; clear transition to:

24 to 48 inches moderately mottled light grey and yellow- brown medium or light clay, becoming clay loam or lighter in texture before 48 inches.

Occurrence Benjeroop clay is a minor soil type which, occurs on very slightly higher positions within the red gum landscape unit. It is found near the Murray River from Koondrook to Benjeroop, and is distinguishable from the more extensive Murrabit clay by the shallower depth (less than 48 inches) to the clay loam or lighter textures.

Land Use Benjeroop clay supports good irrigated perennial and annual pastures where salinity is not a problem.

Box Clay

Surface soil

0-8/14 inches yellowish or brownish grey (10YR 6/2 or 2.5Y 6/2)* medium or heavy clay; moderate medium subangular blocky structure; friable moist, moderately hard and brittle dry; clear transition at 8 to 14 inches to:

Subsoil

8-14/20 inches yellowish or brownish grey (5Y 5/2 or 10YR 5/3) * heavy clay; very weak medium subangular blocky structure; tough to plastic moist, very hard dry; generally with traces of fine calcium carbonate concretions; gradual transition to:

20-30 inches yellowish brownish grey or yellowish grey- brown, often mottled with dull shades of brown, heavy clay; with or without traces of calcium carbonate; gradual transition to:

* Munsell colour notation of moist soil. Also see Appendix III

30-48 inches light yellowish grey to light yellowish grey- brown, often mottled with yellow- brown, heavy clay; trace gypsum irregularly present:

48-84 inches mottled dominantly light grey and yellowish brown medium to heavy clay; trace of gypsum irregularly present.

Variants Browner subsoils are denoted bright subsoil on the soil map. The inscription light deep subsoil defines occurrence with micaceous light or medium clay before 4 feet. Lighter surface textures and overlays are noted on the soil maps with appropriate inscriptions.

Occurrence Box clay is a major component of the black box landscape unit and extensive areas occur adjoining the Loddon River north of Kerang, and the Barr and Pyramid Creeks south- east of Kerang. Where unimproved, dillon bush and lignum occur, with barely grass, wallaby grass and trefoil as ground cover. Samphire, seablite and pigface occur in more saline areas.

Land Use In spite of the adverse characteristics of Box clay, such as high subsoil salinity and heavy texture, this soil type is used successfully for irrigation of annual and perennial pastures. The good structural properties and friability of the surface soil offset the high clay content when moist. However, the saturated permeability of the subsoil is low and the leaching of salt from saline area is difficult. The utilisation of such soils and their reclamation are discussed under "Soil Features and Irrigation".

Gypseous Phase

In the gypseous phase of Box clay, light amount of gypsum occur in the deep subsoil, generally between 30 and 40 inches.

Land Use The land use for Box clay, gypseous phase, is similar to that of Box clay.

Cohuna Fine Sandy Loam

Surface soil

0-5/7 inches grey- brown or dull brown (7.5YR 4/4) fine sandy loam or loam; structureless; hard and brittle dry, friable moist; sharp transition at between 5 and 7 inches to:

Subsoil

5-7/15 inches dark greyish brown (5YR 3/4) to reddish brown (5YR 4/6) light or medium clay; weak small to medium subangular blocky structure; hard dry, very firm moist; gradual transition to:

15-30 inches yellowish brown, often diffusely mottled with light grey-brown, fine sandy clay loam or fine sandy clay; trace to light soft and hard calcium carbonate; gradual transition to:

30-40/48 inches mottled yellow- brown and light brownish grey fine sandy clay loam or fine sandy loam; clear boundary to:

40-48/84 inches mottled grey- brown and yellow- brown light pr medium clay.

Variants The inscription shallow surface on the soil map denotes areas which have less than 5 inches of surface soil. The deep surface variant has more than 7 inches and up to 12 inches depth of surface soil. A clay loam surface variant also occurs, the surface depth being about 5 inches.

Occurrence Cohuna fine sandy loam occupies the levee position of the prior stream landscape unit which occurs extensively throughout the eastern and south- eastern parts of the area. The timber, where it remains, is predominantly black box, with some occurrences of paper bark and mallee.

Land Use Irrigation of annual and perennial pastures and summer fodder crops for dairying and fat lamb raising is practised fairly extensively and successfully.

Cohuna fine sandy loam is one of the most attractive soil types in the area because of its reasonable surface depth, generally low salinity and moderate permeability. On the other hand, light textures in the subsoil are conductive to the formation of perched water tables on the underlying clay.

Apart from irrigated pastures the soil should also be suitable for growing lucerne and vegetables. Seedling emergence is occasionally a problem, as the soil sets hard when dry, because of its high content of fine sand and silt.

Deep phase In the deep phase of Cohuna fine sandy loam the light or medium clays, which appear before 48 inches in the normal phase, appear after 48 inches.

Small areas of the deep phase may occur within the areas mapped as the normal phase of Cohuna fine sandy loam.

Occurrence and Land Use The deep phase mostly occurs within the south- eastern part of the prior stream landscape unit. The land use is the same as the normal phase but the risk of high watertables developing is less.

Coombatook Sandy Loam

Surface soil

0-3/9 inches	grey (10YR 3/1) or brownish grey (10YR 3/2) sandy loam; weak large subangular blocky structure; friable dry and moist; sharp transition to:

Subsoil

3/9-18 inches	grey (10YR 3/1) to yellowish grey (10YR 4/2) sandy clay; weak large prismatic structure; hard and brittle dry, moderately sticky moist; gradual transition to:
18-48 inches	light yellowish grey passing to light yellowish grey- brown sandy medium clay; light soft and concretionary lime generally decreasing with depth.

Coombatook Sandy Clay Loam

Coombatook sandy clay loam is similar to Coombatook sandy loam except that the surface texture is slightly heavier and the subsoil which occurs at about 6 inches is often a medium clay.

Occurrence Both Coombatook sandy loam and Coombatook sandy clay loam occur within an irregular zone at the base of the Gredgwin Ridge.

Land Use these are moderately permeable soils of low salinity, with little risk of water tables developing unless soils upslope on the Gredgwin Ridge are irrigated. They grow good irrigated annual and perennial pastures as well as cereal crops.

Cullen Loam

Surface soil

0-3/7 inches	grey-brown to greyish brown (7.5YR 4/2 to 4/5) loam or fine sandy loam; structureless; slightly hard and brittle when dry, friable moist; sharp transition at 3 to 7 inches to:

Subsoil

3/7-16 inches	greyish to reddish brown (7.5YR 4/4) medium clay; weak to moderate medium angular blocky structure; hard dry, firm moist; gradual transition to:
16-28 inches	yellowish greyish brown mottled with light brownish grey light or medium clay, occasionally fine sandy clay; slight amounts of hard and soft calcium carbonate; gradual transition to:
28/40 inches	greyish yellow- brown mottled with light brownish grey fine sandy clay to medium clay; grades into:
40-84 inches	mottled yellow- brown and grey- brown light or medium clay.

Variants the inscription eroded is used when much or all of the surface has been stripped off as a result of contemporary wind or water erosion. Areas with clay loam and grey clay loam surfaces are indicated on the soil maps by appropriate inscriptions.

Occurrence Cullen loam is a minor soil type occurring in the eastern part of the area. It occurs on the near floor plain positions of the prior stream landscape unit. The original vegetation was principally black box.

Land Use The irrigation potential of Cullen loam is somewhat variable, and depends largely on the depth of surface soil and the degree of subsoil salinity. It is generally suitable for summer fodder crops, and irrigated annual and perennial pastures.

Della Clay

Surface Soil

0-4/8 inches dark grey to slightly yellowish dark grey (5Y 3/1 to 4/1) medium or light clay, generally sandy; weak fine subangular blocky structure; hard dry, very crumbly moist; sometimes with trace of hard lime; clear transition to:

Subsoil

4/8-20 inches mottled yellow-grey and yellowish brown heavy clay; weak medium subangular blocky structure; hard dry, friable moist; trace to slight soft and concretionary calcium carbonate; gradual transition to:

20-48 inches mottled yellow- grey and yellowish brown heavy clay; slight to light soft and hard calcium carbonate.

48-84 inches similar to above, with or without calcium carbonate.

Variant In occasional profiles visible lime may not occur before 18 inches, while in gilgaied areas, soils of the puff may have dominantly brown colours commencing as shallow as 12 inches.

Occurrence Della clay occurs in the south- western part of the surveyed area and originally carried black box woodland. Skene and Sargeant also recorded this soil type near Mystic Park (1966), where it is highly saline and has a very uneven surface unlike occurrences in the present survey.

Land Use Della clay is quite a favourable soil for annual and perennial pastures, except where the soil is strongly gilgaied or where salinity is a problem.

Della Sandy Loam

Della sandy loam is similar to Della clay except that its surface is a sandy loam of variable depth of from 3 to 10 inches.

Occurrence Only one area of Della sandy loam is recorded. This area is strongly gilgaied, with Della sandy loam occurring on the puffs and shelves. In the depressions the surface soil is generally of sandy clay texture.

Land Use The uneven surface texture makes Della sandy loam unattractive for irrigation, but given careful grading it should support good annual or perennial pastures.

Fairly Clay

Surface soil

0-4 inches	grey (5Y 5/1) or dark brownish grey (10YR 3/2) medium or heavy clay; weak to moderate medium subangular blocky structure; hard dry, friable moist, gradual transition to:

Subsoil

4-15 inches	brownish yellowish grey (10YR 4/1) heavy clay; weak to moderate medium subangular blocky structure; hard dry, slightly friable moist; gradual transition to:
15-28 inches	greyish brown (7.5YR 4/4) to dull reddish brown (5YR 5/4), frequently with brownish grey mottling, heavy clay; slight amounts of soft or hard calcium carbonate; gradual transition to:
28-48 inches	brownish yellow- grey to greyish yellow- brown, usually mottled with grey, heavy clay; trace to slight soft and concretionary calcium carbonate; gradual transition to:
48-84 inches	yellow- grey to yellow- brown with grey mottling, heavy clay with a trace of soft and concretionary calcium carbonate.

Variant In the dark grey surface variant the surface soil is a dark grey medium or heavy clay about 10 inches deep. In addition, the dominantly brown subsoil may occur deeper than normal.

The sandy loam surface variant has up to 6 inches of grey- brown to grey sandy loam surface.

Occurrence Fairly clay occupies the intermediate landscape position in the treeless plain landscape unit and, with the exception of two northern occurrences, is found only to the west of the Loddon River.

Although mapped as part of the Treeless Plain because of its association with Meran clay, Fairley clay probably carried open black box woodland. This, as well as its higher lime and coarse sand contents distinguishes it from the grey- brown phase of Kerang clay.

Land Use The salinity hazard of Fairley clay generally ranges from moderate to high; consequently successful utilisation depends on careful irrigation management. Where drainage is adequate and the surface salinity is sufficiently low, Fairley clay can support good irrigated annual and perennial pastures.

Gypseous phase The gypseous phase is distinguished from the normal phase by the appearance of slight to light gypsum from about 24 inches. The gypsum then decreases in amount with depth.

Occurrence and Land Use These are the same as for Fairley clay.

Gonn Clay

Surface soil

0-7 inches	grey (2.5Y 5/1) or dark grey (2.5Y 4/1) with rusty brown mottling heavy clay; weak moderate to coarse angular blocky structure; very hard dry, sticky moist; gradual transition to:

Subsoil

7-36 inches	grey (2.5Y 5/1) or dark grey (2.5Y 4/1) heavy clay, often diffusely mottled with grey- brown or yellow- grey from about 24 inches; gradual transition to:
36-60 inches	grey or steely grey, often diffusely mottled as above, heavy clay; gradual transition to:
60-84 inches	light brownish grey (2.5Y 6/1) moderately mottled with yellow- brown (7.5YR 6/6) light to heavy clay.

Variant Up to 4 inches of clay loam or light clay may occur on top of this profile as a contemporary deposition of alluvium from the Murray River (see also Type 2).

Where this deposition, of between 4 and 12 inches of recent alluvium, overlies Goon clay the inscription 2 overlays is used.

Occurrence Gonn clay occupies the lower areas and depressions on the red gum landscape unit and occurs adjacent to the Murray River from Koondrook to Benjeroop. Prior to the construction of levees the Murray River intermittently flooded such areas.

Land Use Where there is effective surface drainage these soils support good annual and perennial pastures. Salinity is rarely a problem.

Kerang Clay

Two phases based on subsoil colour have been mapped in this survey.

Grey- brown phase

Surface soil

0-4 inches brownish grey (10YR 4/1) heavy clay; moderate medium angular blocky structure; hard dry, friable moist; clear transition to:

Subsoil

4-18 inches grey- brown (10YR 4/3) or yellowish grey- brown (10YR 5/4) heavy clay; moderate to weak angular blocky structure; very hard dry, slightly friable to plastic moist; gradual transition to:

18-30 inches yellowish greyish brown or yellowish grey- brown heavy clay; frequently with slight gypsum in the lower part of the horizon; gradual transition to:

30-48 inches yellowish grey- brown to greyish yellow- brown, often diffusely mottled with brown, heavy clay; slight gypsum; slight calcium carbonate irregularly present; gradual transition to:

48-84 inches diffusely and variably mottled yellow- grey, yellow and brown heavy clay; slight soft and concretionary calcium carbonate and gypsum variably present.

Variant The clay loam surface variant has about 4 inches of grey or brownish grey clay loam surface soil.

Grey phase

Surface soil

0-6 inches brownish grey (10YR 4/1) heavy clay; moderate medium to coarse angular blocky structure; hard dry, friable moist; clear transition to:

Subsoil

6-18 inches yellowish grey (2.5Y 5/2) to yellowish brownish grey (2.5Y 4/3) heavy clay; weak to moderate angular blocky structure; very hard dry, moderately plastic moist; gradual transition to:

18-28 inches yellowish brownish grey to brownish yellow-grey heavy clay; occasionally with trace to slight calcium carbonate in the lower part of the horizon; gradual transition to:

28-48 inches brownish yellow- grey diffusely mottled with yellowish brown heavy clay; generally with slight gypsum; gradual transition to:

48-84 inches yellow-grey diffusely mottled with yellowish brown heavy clay; slight soft and concretionary calcium carbonate and slight gypsum variably present.

Variant The inscription dark grey surface denotes areas where the surface soil is dark grey or dark brownish grey to about 10inches. Darker than normal colours continues to about 20 inches.

Occurrence Baldwin et. Al. (1939) recorded Kerang clay in the Kerang Irrigation Area, and Skene (1971) in the Mid- Loddon District. Both authors recognised the grey- brown and grey phases of Kerang clay, however in the published soil maps of the mid- Loddon District the two phases are not separated. Both phases of Kerang clay occur extensively in the treeless plain landscape unit mostly to the south of Kerang, with the grey phase occupying the fractionally lower areas of the landscape.

In the virgin state both phases have a gilgaied micro relief, although the puffs are not strongly developed. The shelves generally had a shallow clay loam surface of about 2 inches. Both the uneven micro relief and clay loam surfaces have been almost completely obliterated by cultivation.

Land Use In spite of the adverse soil characteristics of inherently high subsoil salinity and heavy texture, the soils are used more or less successfully for irrigation of annual pastures and sometimes-perennial pastures for dairying and fat lamb raising. The high clay content of the soil profile is offset by its good structural qualities, which allow reasonable infiltration of irrigation water. The structure of the surface soil of the grey- brown phase is slightly better than that of the grey phase. As well, its external drainage is slightly better.

Leaching the salt from Kerang clay is difficult, as the saturated permeability is low. Successful utilisation of Kerang clay depends on careful irrigation management, including attention to drainage, as well as on as assured water supply for the type of pasture grown.

Koroop Clay

Surface soil

0-6 inches brownish grey (10YR 4/2) or dark grey (10YR 4/1) medium or heavy clay; moderate or weak subangular blocky structure; hard dry, slightly friable to plastic moist; gradual transition to:

Subsoil

6-18 inches dominantly grey medium or heavy clay; becoming yellowier and browner with depth; moderate or weak subangular blocky structure; hard dry, slightly friable to plastic moist; gradual transition to:

18-30 inches diffusely mottled yellowish grey- brown with yellowish brown medium clay; often with traces of concretionary calcium carbonate; gradual transition to:

30-48 inches moderately mottled yellowish brown and light brownish grey medium to fine sandy clay; visibly micaceous; often with traces of calcium carbonate; gradual transition to:

48-84 inches moderately mottled light to heavy clay with yellowish brown and light grey being the usual colours.

Variants Clay loam or sandy surfaces are shown on the soil map using suitable inscriptions. A heavy profile variant has heavy clay textures throughout the profile. Occasionally Koroop clay has a shallow light grey or grey light clay surface soil but such occurrences are not shown on the soil map. Areas of Koroop clay near Cohuna, which are saline and support mainly halophytic species, are denoted saline on the soil map. The variable deep subsoil variant is similar to the normal type to 30 inches, but thereafter colours are much more variable and can include red- brown mottling. It occurs only in the extreme south- eastern part of the surveyed area.

Occurrence Although Koroop clay occurs as the far flood plain deposits of the prior streams, it is included in the black box landscape unit. Some occurrences near Koondrook carry red gum.

Land Use Koroop clay is suitable for the irrigation of cereals, summer fodder crops, and annual and perennial pastures. However the success of these crops depends on the effectiveness of salinity control, as areas of Koroop clay are liable to salinity.

Laton Clay

Surface soil

0-6/12 inches yellowish grey (10YR 4/2) or dark yellowish grey (2.5Y 4/2) medium or heavy clay; moderate coarse subangular blocky structure; hard dry, friable moist; trace fine concretionary calcium carbonate; clear transition to:

Subsoil

6/12-18 inches yellowish brownish grey (2.5Y 6/2) or brownish yellow- grey (2.5Y 6/4) heavy clay; weak coarse subangular or angular blocky to prismatic structure; hard dry, friable moist; trace to slight fine concretionary calcium carbonate; clear transition to:

18-27inches brownish yellow-grey (2.5Y 6/4) heavy clay; weak medium angular blocky to prismatic structure; slight fine concretionary calcium carbonate; clear transition to:

27-36 inches light brownish yellow- grey yellowish brownish grey heavy clay; moderate small angular blocky structure; scattered fine concretionary calcium carbonate.

36-54 inches yellow-brown and light yellowish grey heavy clay; with or without scattered fine concretionary calcium carbonate.

54-72 inches light yellowish grey with grey- brown and yellow- brown heavy clay.

Variant Areas where the soil profile contains visible gypsum are indicated by the inscription gypseous on the soil maps.

In gilgaied areas the depth of surface soil may vary from as little as one inch to as much as 17 inches.

Occurrence Laton clay occurs only west of the Loddon River within the black box landscape unit. South of the Forest Reserve it is not appreciably saline; but north of the Forest Reserve most occurrences are inherently strongly saline.

Land Use Laton clay is quite a good soil for annual and perennial pastures, except where the soil is strongly gilgaied or where salinity is a problem.

Leitchville Sand

Surface soil

0-18 inches grey-brown (10YR 4/3) or greyish brown (5YR 4/5) loamy fine sand, occasionally fine sandy loam; structureless to weak crumb structure; slight brittle dry, friable moist. The depth of surface soil can vary from 12 to 24 inches. Sharp transition to:

Subsoil

18-24 inches reddish brown (5YR 4/6) to dull brown (7.5YR 5/4) light clay or fine sandy clay, occasionally fine sandy clay loam; very weak medium angular blocky structure; moderately hard dry, firm moist; gradual transition to:

24-30 inches yellowish greyish brown fine sandy clay loam or fine sandy loam; slight soft and concretionary calcium carbonate; gradual transition to:

30-52 inches variably mottled grey- brown and yellow- brown with light grey fine sandy clay loam or fine sandy loam; grades into:

52-84 inches yellowish grey mottled with dull brown light clay to fine sandy clay loam.

Variants Inscriptions on the soil map of shallow surface and deep surface denotes soils which have between 6 and 12 inches, and more than 24 inches, of surface soil, respectively. The grey profile variant comprises soils which have a grey or brownish grey surface, and a greyer than normal subsoil horizon.

Occurrence Leitchville sand is a soil type of the prior stream landscape unit. It is situated on the levees of the stronger prior streams in the south- eastern and eastern part of the area, as well as on low rises adjoining the prior streambeds.

Land Use Although Leitchville sand is suitable for horticultural crops where salinity and watertables pose no problems, most areas under irrigation are used for lucerne or perennial pastures. Care is necessary when irrigating, as these soils are quite permeable. Over watering can lead to watertables and the risk of salinity further down slope.

Macorna Clay

Two phases based on subsoil colour have been mapped in this survey.

Red- brown phase

Surface soil

0-10 inches dark greyish red- brown (2.5YR 3/4to 4/2), frequently with grey ped surfaces for the first four inches, heavy clay; moderate medium angular blocky structure; very hard dry, friable or moderately plastic moist; gradual transition to:

Subsoil

10-20 inches reddish brown to brown (2.5YR to 5YR 5/5) heavy clay; weak to moderate medium subangular blocky structure; very hard dry, friable moist; trace soft calcium carbonate in lower part; gradual transition to:

20-40 inches greyish yellowish brown, sometimes diffusely mottled with yellow- grey, medium clay; slight or light gypsum decreasing with depth; gradual transition to:

40-84 inches yellowish brown, diffusely and variably mottled with yellow and grey, medium clay; slight gypsum and small pellets or concretionary calcium carbonate variably present.

Brown Phase

Surface soil

0-10 inches dark brown to grey-brown (7.5YR 4.2 to 10YR 5/4), frequently with grey ped surfaces for the first four inches, heavy clay; moderately medium angular blocky structure; very hard dry, friable or moderately plastic moist; gradual transition to:

Subsoil

10-20 inches brown to greyish brown (7.5YR 4/4 to 10YR 5/6) heavy clay; weak to moderate subangular blocky structure; very hard dry, friable moist; trace of soft calcium carbonate in lower part; gradual transition to:

20-84 inches as for Macorna clay, red- brown phase.

Variants In the light profile variant light clay textures occurs before 48 inches. The inscriptions clay loam surface, shallow fine sandy clay loam surface and shallow sandy clay loam surface on the soil maps indicate that a surface layer tow to four inches thick of the named texture is present.

Occurrence Baldwin et al. (1939) have recorded Macorna clay in the Kerang Irrigation Area, and Skene (1971), in the Mid- Loddon District. Both authors recognised the red- brown and brown phases of Macorna clay, however in the published maps of the Mid- Loddon District the two are not separated.

Both phases of Macorna clay occur mostly south of Kerang, where they occupy the higher parts of the treeless plain landscape unit. The red- brown phase is fractionally higher than the brown phase. Both phases are gilgaied in the virgin state, with the shelf profiles frequently having shallow loam or clay loam surfaces.

Land Use Both phases of Macorna clay are used for the irrigation of annual pastures and frequently for perennial pastures. The surface drainage of Macorna clay is better than that of Kerang clay, but this is frequently offset by low infiltration into the surface soil. Reclamation of saline areas of Macorna clay is not generally a problem provided water tables are not high and careful irrigation practices are followed.

Meran Sandy Clay Loam

Surface soil

0-3 inches brown (5YR 4/4) to dark greyish brown (10YR 3/4) sandy clay loam; structureless; brittle dry, slightly friable moist; surface often badly eroded; at variable depths sharp transition to:

Subsoil

3-14 inches dark greyish brown (5YR 3/4) to reddish brown (5 YR4/8) medium clay, becoming paler and brighter in colour with depth; weak coarse prismatic to moderate medium subangular blocky structure; very hard dry, tough moist; gradual transition to:

14-24 inches reddish brown to yellowish brown medium clay; slight soft calcium carbonate and fine concretions; gradual transition to:

24-48 inches yellowish greyish brown to brownish yellow- grey, mottled with brown, medium clay; slight soft calcium carbonate and fine concretions; sometimes with slight gypsum in the lower part of the horizon.

48-84 inches similar to above.

Occurrence This type occupies the slightly higher, better drained position in the treeless plains landscape unit in the western parts of the surveyed area. Skene and Sargeant (1966) recorded Meran sandy clay loam in the Mystic Park area.

Land Use Meran sandy clay loam supports annual and perennial pastures where salinity is not a problem.

Gypseous Phase

The gypseous phase is distinguished from the normal phase by the appearance of slight to light gypsum from about 24 inches.

Land Use As for the normal phase of Meran sandy clay loam.

Meran Sandy Loam

Meran sandy loam differs from Meran sandy clay loam only in the lighter texture of the surface. It has not been separated on the soil maps, and has been recorded only as very small areas within mapped areas of Meran clay and Meran sandy clay loam.

Meran Clay

Surface soil

0-4 inches dull reddish brown (5YR 6/6) to grey- brown medium to heavy clay; weak coarse prismatic to moderate medium angular blocky structure; hard dry, slightly plastic moist; clear transition to:

Subsoil

4-12 inches dark greyish or reddish brown (5YR 4/8) medium or heavy clay; weak medium angular blocky or prismatic structure; hard dry, slightly plastic moist; grades into:

12-26 inches reddish brown medium clay with a trace of soft and hard concretionary calcium carbonate; gradual transition to:

26-48 inches yellowish brown, often mottled with yellow- grey, medium clay with a trace to slight calcium carbonate.

48-84 inches mottled yellow- brown and yellow- grey medium clay; slight soft and concretionary calcium carbonate.

Occurrence This soil type occupies the slightly higher, better-drained position in the treeless plain landscape unit in the western parts of the surveyed area.

Land Use Meran clay can support good annual and perennial pastures where salinity is not a problem. Frequently, the surface soil has a coarse angular blocky or prismatic structure, which imposes limitations on pasture growth.

Gypseous phase

The gypseous phase is distinguished from the normal phase by the appearance of slight to light gypsum from about 20 inches, which then decreases in amount with depth.

Land Use As for the normal phase of Meran Clay.

Murrabit Clay

Surface soil

0-8 inches dark grey (10YR 3/1) medium or heavy clay; dense and cracking ; moderate medium or coarse subangular blocky structure; hard dry, plastic moist; gradual transition to:

Subsoil

8-18 inches dark grey (10YR 3/1) medium or heavy clay; dense; weak medium or coarse subangular blocky structure; hard dry, plastic moist; gradual transition to:

18-30 inches moderately mottled grey and yellowish grey with yellowish grey with yellowish brown medium or heavy clay; often with traces of hard calcium carbonate; gradual transition to:

30-48 inches as above, grading before 42 inches into moderately mottled light grey and yellowish- brown medium or light clay; visibly micaceous.

48-84 inches moderately mottled light grey and yellow- brown medium or light clay; micaceous; frequently becoming lighter in texture with depth.

Variants The inscription bright subsoil denotes soil possessing dominantly brown clay subsoil occurring at 12 to 24 inches. When perceptible amounts of sand occur in the Murrabit clay profile the notation sandy profile is used. The inscription 2 overlay is applied when a veneer of Type 2 surface soil, between 4 and 12 inches thick, overlies Murrabit clay.

Occurrence Murrabit clay occurs on almost level parts of the red gum landscape unit. It is found near the Murray River from Koondrook to Benjeroop.

Land Use Murrabit clay supports good irrigation perennial pastures generally used for dairying. Oranges are grown successfully taking advantage of the later maturity of the crop when compared to the more extensive groves on the lighter soil further along the Murray River. Salinity is rarely a problem on Murrabit clay.

Myall Clay

Surface soil

0-5 inches dark grey (10YR 4/1) cracking heavy clay; moderate to weak coarse subangular blocky structure; hard dry, tough and plastic moist; gradual transition to:

Subsoil

5-24/36 inches dark grey (10YR 4/1) heavy clay; weak coarse angular blocky structure; hard dry, tough and plastic moist; gradual transition at between 24 and 36 inches to:

24/36-48 inches dominantly yellowish grey or light grey diffusely mottled with brown heavy clay; with or without calcium carbonate and traces of gypsum; gradual transition to:

48-84 inches moderately mottled light yellowish grey with brown medium or heavy clay.

Variant Areas of Myall clay, which have a clay loam, surface are delineated on the soil map, and marked accordingly.

Occurrence Myall clay occurs in the treeless plain landscape unit in the north and north- western parts of the surveyed area, with some occurrences in the red gum landscape unit between Koondrook and Benjeroop.

Land Use Myall clay is suitable for the irrigation of summer fodder crops, and annual and perennial pastures. It cracks deeply when dry, allowing initial rapid infiltration of water. When fully wetted Myall clay is only slowly permeably, making reclamation of saline areas difficult. Fortunately Myall clay rarely contains more than moderate amounts of salt in the profile. A disadvantage of this soil type is the generally poor structure of the surface soil. The dense, large soil aggregates greatly reduce the volume of soil, which the roots can exploit.

Reedy Creek Clay Loam

Surface soil

0-5 inches brownish grey or grey (10YR 4/3) clay loam; structureless; hard and brittle when dry, friable moist; sharp transition at 5 inches to:

Subsoil

5-16 inches dark brownish grey (10YR 3/3) to yellowish grey- brown (10YR 5/4) medium or heavy clay; weak subangular blocky structure; hard dry, firm moist; gradual transition to:

16-36 inches greyish yellowish brown mottled with light grey light clay or fine sandy clay; generally with light amounts of hard and soft calcium carbonate; gradual transition to:

36-84 inches mottled yellow-brown and grey- brown fine sandy clay to medium clay.

Variant The heavy profile variant delineated on the maps has medium or heavy clay from 16 to 48 inches.

Occurrence Reedy creek clay loam occurs throughout the prior stream landscape unit, and occupies the near flood plain position. Where timber occurs it is generally black box.

Land Use Reedy creek clay loam is only a fair soil for irrigation as it has a shallow, hard- setting surface soil and a subsoil of low permeability. It can be used for the irrigation of summer fodder crops, and irrigated annual and perennial pastures. The salinity hazard is generally low to moderate.

Sandmount Sand

Surface soil

0-8 inches grey-brown (10YR 4/3) or greyish brown (7.5YR 4/4) loamy fine sand or loamy sand; structureless to weak crumb structure; loose dry, very friable moist; clear transition to:

8-24 inches greyish brown (7.5YR 4/4) or dull reddish brown (5YR 4/4) loamy fine sand or loamy sand; structureless; slightly hard dry, friable moist; gradual transition to:

Subsoil

24-60 inches yellowish to greyish brown loamy fine sand or sand; gradual transition to:

60-84 inches as above, occasionally passing to dominantly brown fine sandy loam to sandy clay.

Occurrence Sandmount sand is a minor soil type and occurs on dunes adjoining the prior stream beds and old river systems. These dunes arise from the reworking of riverine deposits by wind action.

Land Use Sandmount sand is almost always above gravity supply level. This, and the fact that the soils are extremely permeable, means that spray irrigation is the most suitable type of water distribution for crops grown on Sandmount sand. Watertables develop, but are too deep to be harmful, except perhaps on some occurrences of the shallow phase. However, there is a risk of salting on the lower slopes of occurrences of Sandmount sand.

A disability of Sandmount sand is its low water- holding capacity. This makes the soils unsuitable for shallow-rooting crops unless they can be watered very frequently in summer. Deep- rooted vegetable crops, citrus and lucerne should do reasonably well on this soil type.

Shallow Phase

In the shallow phase of Sandmount sand, fine sand loam or heavier textures appear between 36 and 48 inches.

Occurrence and Land Use The shallow phase occurs on the lower slopes of dunes and low dunes, adjoining the prior stream beds and old river systems. It is regarded as fair to marginal for vegetable crops and lucerne, because of the risk of salting and high watertables from irrigation further up- slope.

Towangurr Clay

Surface soil

0-4 inches grey (2.5Y 4/2) with rusty brown steaks medium to heavy clay; strong to medium crumb structure; friable dry, sticky moist; sharp transition to:

Subsoil

4-12 inches grey (2.5Y 4/2) and yellowish grey (2.5Y 5/2) heavy clay; moderate medium to coarse angular blocky to prismatic structure with pronounced vertical cracking; hard dry, sticky moist; traces of soft and hard calcium carbonate; gradual transition to:

12-24 inches yellowish grey heavy clay; moderate medium to coarse angular blocky to prismatic structure; slight hard and soft calcium carbonate; gradual transition to:

24-48 inches yellow- grey slightly mottled with yellowish brown heavy clay; slight hard and soft calcium carbonate; gradual transition to:

48-84 inches yellow-grey diffusely mottled with yellowish brown heavy clay; slight hard and soft calcium carbonate.

Occurrence Towangurr clay is the main soil of the shallow, intermittent waterways that comprise the drainage network of the treeless plains landscape unit. It is also recorded on the same landscape unit by Skene (1971) in the Mid- Loddon area.

Land Use Generally the soils are not irrigated, except where the type is extensive. The soils are not attractive for irrigation because of the risk of prolonged inundation, low profile permeability and general gilgai micro- relief. Most situations are more suited to use for drainage than for irrigation.

Tragowel Clay

Surface soil

0-8 inches	yellowish grey (2.5Y 4/2 to 5Y 5/2) heavy clay; strong or moderate fine angular blocky structure; friable dry, moderately plastic moist; traces of fine concretions of calcium carbonate; gradual transition to:

Subsoil

8-24 inches	yellowish grey (2.5Y to 5 Y 4/3) heavy clay; moderate medium to coarse angular blocky structure; hard dry, plastic moist; slight soft and fine concretionary calcium carbonate; gradual transition to:
24-48 inches	yellowish grey or yellow- grey, generally finely mottled with yellow- brown, heavy clay; slight soft and fine concretionary calcium carbonate; gradual transition to:
48-84 inches	diffusely mottled yellow- grey with yellow- brown heavy clay; trace to slight soft and fine concretionary calcium carbonate.

Occurrence Baldwin et al. (1939) first recorded Tragowel clay in the Kerang Irrigation Area. There three phases were described, the self- mulching, flooded and woodland phases. Skene (1971) redefined Tragowel clay to correspond with the self- mulching phase, and in this bulletin the description of Tragowel clay is essentially the same as for that phase. In this survey most of the flooded and woodland phases have been remapped as Box clay.

Tragowel clay occupies the lowest parts of the treeless plain landscape unit, although black box may occur along depression lines. It is very subject to flooding from the Loddon River or the distributaries, which finger out on both sides of the river. The surface is rather strongly gilgaied, but there is little differences between the profiles on different parts of the gilgai complex.

Land Use- Most occurrences of Tragowel clay in this area are used for cereal growing or grazing of native and volunteer pastures, but depending on external drainage and salinity, the soil can support irrigated annual and perennial pastures.

Because Tragowel clay occurs in the lower parts of the landscape and has a gilgai relief, irrigation layout is difficult. In addition, Tragowel clay in this area is inherently saline, whereas in the Mid- Loddon Area salinity is generally not a problem with this soil type.

Una Loam

Surface soil

0-4/8 inches	grey to grey- brown (10YR 5/2) loam or fine sandy loam; hard and brittle dry, friable moist; sharp transition between 4 and 8 inches to:

Subsoil

4/8-15 inches	brownish grey to greyish brown (10YR 5/2) light or medium clay; weak small to medium angular blocky structure; hard dry, very firm moist; gradual transition to:
15-30 inches	yellowish brown, often diffusely mottled with light grey- brown, fine sandy loam or fine sandy clay; trace to light soft and hard calcium carbonate; gradual transition to:
30-40 inches	mottled yellow- brown and light brownish grey fine sandy clay loam or fine sandy loam; clear transition to:

40-84 inches mottled grey- brown to yellow- brown medium or light clay.

Variant The dark grey clay loam surface variant has a dark grey or dark brownish grey clay loam surface. Most occurrences of this variant adjoin the Reedy Creek. The occurrence of clay textures at the surface is indicated by the inscription clay surface. Occurrence- Una loam occurs within the prior stream landscape unit on the lower parts of the levees and the near flood plain. The original vegetation was black box with some occurrences of melaleuca.

Land Use Since Una loam generally occupies situations of restricted surface drainage, and is moderately permeable in the subsoil, it develops watertables comparatively easily. It is suitable for growing summer fodder crops, cereals, and perennial and annual pastures, but is doubtful for lucerne. Surface crusting may adversely affect seedling emergence.

Wandella Clay

Surface soil

0-4 inches grey (5Y 5/1) to dark grey (5Y 3/1) heavy clay; moderate to strong medium subangular blocky structure; more or less friable dry, very plastic moist; trace of fine concretionary calcium carbonate; gradual transition to:

Subsoil

4-24 inches yellowish grey (2.5Y to 5 Y 5/2) heavy clay; moderate to weak medium subangular blocky structure; hard dry, tough moist; slight soft and concretionary calcium carbonate; gradual transition to:

24-48 inches yellowish grey to brownish yellow- grey, often diffusely mottled with yellow- brown, heavy clay; slight soft and concretionary calcium carbonate.

48-72 inches as above.

Wandella clay is a gilgaied soil type, and the profile on puff situations has smaller structural peds and is more friable than described above.

Occurrence Wandella clay has been described by Skene (1971). The soil occurs on the lower parts of the black box landscape unit west of the Loddon River, and is subject to intermittent inundation from this river and its distributaries. In the past this flooding was probably more frequent. Besides occurring in drainage ways and on extensive areas of low- lying black box woodland, Wandella clay also occurs in some terminal drainage basins.

Land Use Much of Wandella clay is not irrigated, but is utilised for the grazing of sheep and cattle on improved native pastures. Largely the irrigation layout and drainability determine the suitability of Wandella clay for irrigation, as many occurrences are subject to inundation. Soil salinity is generally not a problem. A large part of the area of Wandella clay has been retained as State Forest and is timbered with black box.

Warra Clay

Surface soil

0-8 inches grey- brown (7.5YR 4/2) to brownish grey (2.5Y 4/2) heavy clay; moderate small to medium angular blocky structure; hard dry, plastic moist; clear boundary to:

Subsoil

8-17 inches brown (5YR 5/6) or greyish brown (7.5YR 5/4) heavy clay; moderate small to medium angular blocky structure; hard dry, plastic moist; grades into:

17-38 inches brown (7.5YR 5/5) medium or heavy clay; slight soft and hard calcium carbonate; grades into:

38-48 inches moderately mottled yellowish grey- brown and brown medium or light clay, visibly micaceous; grades into:

48-84 inches similar to above or reverting to dominantly yellow- grey medium or heavy clay.

Variant Dark grey clay, and loam, clay loam, sandy clay and sandy surfaces are recorded on the soil maps using appropriate inscriptions. The heavy profile variant has heavy clay textures throughout the profile and occurs together with the normal type.

Occurrence Warra clay is a minor soil type of the treeless plain landscape unit and occurs within a broad strip of country extending north- west from Kow Swamp to Capels Crossing.

Land Use Superficially, Warra clay resembles the grey- brown phase of Kerang clay. The land use of Warra clay is similar to Kerang clay, but as a consequence of lower salinity, except where unirrigated, it tends to be a more productive soil.

SOILS OF THE GUNBOWER SUITE

The Gunbower Suite comprises a group of three unnamed soil types found adjoining the Gunbower Creek from Gunbower to Koondrook. These soils occur within the red gum landscape unit.

Type G1.

Surface soil

0-12 inches light brownish grey or grey- brown, lighter in colour when dry, fine sandy loam or loamy fine sand; structureless with porous peds; clear transition to:

Subsoil

12-18 inches grey and grey- brown, mottled with shades of brown, fine sandy clay or fine sandy clay loam; very weak subangular blocky structure with porous peds; gradual transition to:

18-48 inches moderately mottled yellow- brown and light yellowish grey fine sandy loam, occasionally fine sandy loam; generally lightening in texture to a loamy fine sand before 48 inches.

Occurrence and Land Use This is the lightest soil of the Gunbower Suite and occurs on the higher parts of the landscape. Type G1 is suitable for the irrigation of most crops and pastures, including vegetables, lucerne and fruit trees. The soil is generally low in salt and watertables are not a problem.

Type G2.

Surface soil

0-8 inches brownish grey moist (10YR 5/2), light grey dry (10YR 7/1) with rusty brown mottling fine sandy clay loam or fine sandy loam; structureless; brittle dry, crumbly moist; clear transition to:

Subsoil

8-18 inches brownish grey (10YR 5/2) and yellowish grey- brown (10YR 5/4), mottled with shades of brown, light clay which may increase in texture to medium clay; weak subangular blocky structure; gradual transition to:

18-30 inches diffusely mottled yellow- brown and yellowish grey fine sandy clay or fine sandy clay loam; weak subangular blocky structure; gradual transition to:

30-48 inches moderately mottled yellow- brown and light yellowish grey fine sandy clay loam or lighter textures.

Occurrence and Land Use Type G2 occupies the intermediate landscape position. The soil is suitable for the irrigation of most crops and pastures including lucerne. The soil is generally low in salt and watertables are rarely a problem.

Shallow Phase

The shallow phase of Type G2 has clay textures reappearing before 48 inches. It is a moderately saline soil, which is liable to shallow, perched watertables.

Type G3.

Surface soil

0-6 inches	brownish grey moist (10YR 4/3), light grey dry (10YR 6/1), with rusty mottles, clay loam; structureless; brittle dry, slightly friable moist; clear transition to:

Subsoil

6-18 inches	grey (10YR 6/1) diffusely mottled with greyish brown (10YR 5/6) light or medium clay; grades into:
18-48 inches	dominantly grey and dull brown mottled medium clay.

Occurrence and Land Use This soil occurs on the nearly level land- scape adjoin the Gunbower Creek. It is suitable for irrigated cereals, summer fodder crops, and annual and perennial pastures.

SOIL UNITS

Because of the complexity of the soil pattern in parts of the surveyed area, two soil units have been mapped.

Unit 1.

The soils, which occur on the nearly level plains in the Koroop area, vary greatly in surface depth and have been mapped as Unit I. The soil profiles resemble Koroop clay but the surface soil is generally deeper. The microrelief was originally characteristically uneven, the level surface being interrupted by numerous, irregular- shaped, shallow depressions amounting to about one third of the area. Extensive grading has obliterated most of this uneven microrelief. A representative profile for the level surface is:

Surface soil

0-6 inches	brownish grey (10YR 4/2) or dark brownish grey (10YR 3/2) medium or heavy clay; weak medium subangular blocky structure; hard dry, friable moist; gradual transition to:

Subsoil

6-14 inches	brownish grey (10YR 4/2) or dark brownish grey (10YR 3/2) medium or heavy clay; weak medium subangular blocky structure; very hard dry, plastic moist; gradual transition to:
14-24 inches	yellowish brownish grey medium clay; gradual transition to:
24-40 inches	yellowish grey- brown medium clay becoming browner with depth; gradual transition to:
40-48 inches	dull brown light clay, visibly micaceous.
48-72 inches	mottled light or medium clay with brown and light grey being the main colours.

Many of the soils on level situations within this Unit resemble Koroop clay. A greater depth of dark grey clay surface is found in the shallow depressions.

Land Use Unit I is suitable for the irrigation of cereals, summer fodder crops, and annual and perennial pastures. As areas of Unit I are liable to salinity, the success of these crops depends on the effectiveness of salinity control.

Unit II

Occurrence This Unit occurs on the pronounced but narrow levees associated with a weak prior stream called the Piccaninny-Barr Creek, which originates near the Gunbower Creek north of Cohuna and terminates in a red gum swamp near Teal Point.

Component Soils The soils include Cohuna fine sandy loam and Una loam, with some Leitchville sand, the surface soil of which is generally duller in colour than elsewhere. Soil development is not as marked on these levees as elsewhere in the survey, and it is possible that there is more than one phase of deposition from this prior stream. As extensive grading has occurred, many profiles do not fit the above types.

MINOR SOIL TYPES

The following soil types are all of small extent and, in some cases, the profile descriptions given below are based only on a few observations. They do not correspond in any way to minor soil types with the same distinguishing letters or numbers in other soil survey publications.

Type A

Surface soil

0-10 inches grey or dark grey light or medium clay; clear transition to:

Subsoil

10-18 inches moderately mottled grey- brown and yellow- brown medium clay to fine sandy clay; gradual transition to:

18-48 inches moderately mottled yellow- brown and light grey fine sandy clay or lighter textures before 48 inches.

Variant The clay loam surface variant has about four inches of grey clay loam surface.

Occurrence and Land Use Type A is a minor soil type of the red gum landscape unit and occurs mainly in the vicinity of Koondrook. It is permeable, low in subsoil salinity, and is a good soil for irrigated perennial pastures, lucerne and oranges.

Type B.

Surface soil

0-8/14 inches grey light or medium clay; clear transition to:

Subsoil

8/14-20 inches mottled yellow- brown and light grey clay loam or lighter textures.

Variants Clay loams and loam surface textures are recorded on the soil map using appropriate inscriptions.

Occurrence Type B is a minor component of the black box landscape unit and occurs adjoining the Pyramid Creek and the Loddon River.

Land Use Depending on the degree of salting, the soils are used for irrigated annual and perennial pastures. The permeability of the soil is moderate, and perched watertables form easily leading to subsequent salting.

Shallow Phase

In the shallow phase of Type B, clay textures reappear before 48 inches. Watertables and salinity problems develop easily in the shallow phase, but when these disadvantages are overcome, the land use of the soils is the same as for the normal phase.

Type 1.

Surface soil

0-6 inches brownish grey with rusty mottling fine sandy clay loam; clear transition to:

Subsoil

6-24 inches moderately mottled light brownish grey and yellowish brown fine sandy clay loam; sharp transition to:

24-48 inches grey or dark grey medium or heavy clay.

Occurrence Type 1, a minor component of the red gum landscape unit, occurs on low levees adjacent to the Murray River.

Land Use It is used successfully for irrigated annual and perennial pastures.

Deep Phase

In the deep phase of Type 1 fine sandy clay loam textures continue to deeper than 36 inches.

Land Use As well as annual and perennial pastures, the deep phase should be a suitable soil for lucerne, but there is a possibility of watertables developing on the clay layer.

Type 2.

Surface Soil

0-6 inches brownish grey with rusty mottling clay loam or light clay; clear transition to:

Subsoil

6-18 inches moderately mottled light brownish grey and yellowish brown clay loam or light clay; sharp transition to:

18-48 inches grey or dark grey medium or heavy clay which may become mottled with rusty brown with depth.

Occurrence Type 2 is a minor component of the red gum landscape unit and occurs adjacent to the Murray River.

Land Use Type 2 is a suitable soil for irrigated annual and perennial pastures.

Type 3

Surface soil

0-8 inches very dark grey (2.5YR 3/1) sandy clay or clay with sand; strong fine crumb structure; grades into:

Subsoil

8-24 inches dark grey mottled with yellow- brown sandy clay or clay with sand; grades into:

24-48 inches moderately light grey, yellow- brown and brown fine sandy clay to fine sandy clay loam; slight soft and hard lime.

Occurrence Type 3 occurs on a few low rises in the red gum landscape unit.

Land Use This soil has proved to be a good soil for oranges and lucerne, and to date there have been no watertable or salinity problems.

Type 4

Surface soil

0-10 inches brownish grey medium clay; clear transition to:

Subsoil

10-20 inches brown medium to heavy clay; gradual transition to:

20-48 inches brown to red- brown medium or heavy clay; light amounts of hard and soft calcium carbonate; with or without light amounts of gypsum.

Occurrence Type 4 is restricted to a single occurrence on the flooded lower slopes of a lunette north- east of Benjeroop.

Land Use This soil is suitable for irrigated annual and perennial pastures, but there is a risk of salting following irrigation of soils upslope from Type 4.

Type 5

Surface soil

0-4 inches greyish brown to grey- brown medium or heavy clay; clearly separated from:

Subsoil

4-16 inches greyish brown to reddish brown heavy clay; becoming yellower and lighter in colour with depth; grades into:

16-30 inches yellowish greyish brown heavy clay; slight amounts of calcium carbonate; very occasionally with gypsum; grades into:

30-48 inches mottled yellowish brown and yellow- grey medium or heavy clay, occasionally light clay; with slight amounts of calcium carbonate and very occasionally gypsum.

Occurrence Type 5 is a minor soil type found south- east of Hird's Swamp within the treeless plain landscape unit.

Land Use Type 5 is a similar soil to Macorna clay but contains less gypsum and more lime. The land use for Type 5 is the same as that for Macorna clay.

SOILS OF THE PRIOR STREAM BEDS

The soils in this group are found in the beds of the continuous depressions and chains of discontinuous depressions which run through the higher parts of the prior stream landscape unit. These represent the courses of the old non- functional streams, which are shown on the Soil Association Map in the supplement accompanying the report.

The soils of the prior streambeds are quite variable, consequently they are separated only into two broad types based mainly on differences in permeability. Soil surveys elsewhere in the northern plains make a similar separation.

Type d1.

These soils occur in the high- level, well drained prior streambeds. The profiles are light- textured, and are frequently similar to Cohuna fine sandy loam or Una loam, although texturally lighter profiles may occur.

Watertables are present in the highly- permeable deep subsoils where irrigation occurs on adjoining areas.

Type d2.

These are the soils of the lower- lying, poorly- drained, prior streambeds. Although a wide range of soils is mapped within this soil type, they generally have light to medium clay textures and are grey to grey- brown in colour.

Since Type d2 depressions are liable to hold water for prolonged periods they are not recommended for irrigation. Frequently drains are sited in these depressions.

DEPRESSION SOILS

Type d3.

Type d3 is a grey, heavy- textured soil found in poorly- drained depressions within the prior stream landscape unit. It is not recommended for irrigation, because of a generally moderate to high salinity hazard, and drainage difficulties.

Type d4.

This soil occurs only in a discontinuous chain of depressions within the treeless plain landscape unit north of Macorna. The profile is varied, approximating to 10 inches of brownish grey clay loam or light clay surface soil, slightly separated from a grey- brown medium clay subsoil, grading at about 20 inches into a strongly mottled light clay or fine sandy clay continuing to 48 inches.

Generally, these depressions have high subsoil salinity and are not suited to irrigation.

Type dv.

Type dv groups together with those depression soils, which cannot be classified, into the previously described depression soil types. It occurs in drainage ways which vary from narrow, well- defined and continuous depressions, to broad, shallow and discontinuous depressions.

Some of the less- pronounced depressions can be irrigated if drainage is adequate, but generally these soils are not suited to irrigation.

SWAMP SOILS

The swamps and larger depressions throughout the area, which do not conform to the above- mentioned depression soil types, have been designated S1, S2, S3, and S4. Prior to irrigation, these low areas were intermittently inundated with drainage from the surrounding country, or with floodwaters from rivers and creeks. Many of the swamps are now drained and often support good irrigated pastures.

Type S1.

This type occurs only west of the Loddon River and originally carried black box. It has a dark grey heavy clay surface soil, grading into dominantly grey heavy clay subsoil, which continues to at least 48 inches. Scattered small hard pellets of calcium carbonate frequently occur throughout the profile. The soil is low in salinity and is well suited to irrigated pastures where it has been drained.

Type S2.

Although most occurrence of Type S2 carries red gum, there are some treeless swamps included in this type. The Murray River fills these swamps in times of high flood. The soil has a dark grey, heavy clay surface soil, and a grey or dark grey, heavy clay subsoil. When drained, Type S2 carries good irrigated pastures, although occasionally high salinity is a problem.

Type S3.

This soil occurs in red gum swamps and depressions, infilled with comparatively recent sediments by the Murray River or the Gunbower Creek. The surface soil is a mottled grey and rusty brown light clay, which overlies, at about 4 inches depth, a mottled grey and dull yellow- brown medium or heavy clay continuing to 48 inches depth.

Although the soils are rarely saline, most areas remain unirrigated because of surface drainage problems.

Type 4.

Type S4 is a heavy- textured grey or yellowish grey soil throughout the profile, and occurs in low- lying areas and dry lakebeds formerly timbered with black box. Most of the soils are invariably highly saline and are unsuitable for irrigation.

MISCELLANEOUS UNITS

Watercourses.

Watercourses usually occur in the vicinity of the creeks and rivers. They are deep and steep- sided, and are not suited to irrigation.

River Frontage.

This unit comprises the low recent river terraces of the Gunbower Creek and the Murray River which are subject to seasonal flooding and mostly carry red gum. The soils are generally weakly organised with mainly silty and fine sandy clay loam and clay textures throughout the profile. They are not suited to irrigated agriculture.

DUNE AND RIDGE SOILS

The wide range of soils occurring on the lunettes, dunes and minor ridges have been grouped into eight unnamed series, M1 to M8.

The pattern of variation is sometimes complex within each mapping unit, but can be understood if one remembers that the soils have formed from successive, with repeated phases of deposition, leaching, soil formation and erosion. The aboriginals as evidenced by the presence of kitchen middens, but more extensively by soil drift and sheet erosion following pastoral use or cultivation have modified some areas.
The eight series relate to one another follows:

M1. The soils appear to be freshly wind- deposited materials.

M2. Rather uniform porous yellowish profiles with well developed structure and some segregation of lime and gypsum.

M3. Definite brown clay subsoils with visible soft lime throughout.

M4. As for M3 but with visible lime at least 2 inches and usually about 12 inches below the top of the subsoil.

M5. Highly calcareous profiles with bright clay subsoils much hard limestone rubble and visible depths of surface soil due to erosion.

M6. Subsoils resemble M5 but are duller in colour, and the surfaces are less variable.

M7. Grey- brown to brown dense heavy clay subsoils as compared with the less dense brown to red- brown subsoils of M4.

M8. Soils of the inter- dune swales, which resemble M3 on the slopes but have darker, duller colours and more limestone rubble.

M1 Sand

Surface soil

0-14 inches grey- brown (10YR 4/2) loamy sand; loose single grain structure; gradual transition to:

Subsoil

14-48 inches dull yellowish brown (10YR 5/5) sand or loamy sand; loose, single grain structure.

Occurrence Only two small areas of this type have been recorded, near Lake Kelly on Map 2 and near The Glut on Map 3.

Land Use The areas are too small to be considered for separate agricultural use, but most of the area near The Glut is irrigated along with the surrounding country.

M2 Clay Loam

Surface soil

0-30 inches yellowish grey- brown (10YR 4/3) sticky clay loam to sandy clay; moderate medium blocky structure; often with a surface crust; variable fine hard and soft lime, and sometimes gypsum; gradual transition to:

Subsoil

30-60 inches colours as above, gradually becoming paler and yellower. Textures range from sandy clay to medium clay and these become well structured with depth.

Occurrence M2 clay loam is restricted to a few lunettes in the district.

Land Use M2 clay loam supports poor dry pastures and grows fair barley crops in favourable years, but the surface are prone to scalding and seal after initial wetting, thus restricting further water entry. The soils are not recommended for irrigation for these reasons and because of subsoil salinity.

M2 Clay, M2 Sandy Clay Loam

These profiles resemble M2 clay loam, but have surface textures of light to medium or heavy clay, and sandy loam to sandy clay loam, respectively.

Occurrence and Land Use These are the same as for M2 clay loam.

M3 Sandy Loam

Surface soil

0-4/12 inches grey-brown or reddish grey- brown (7.5 or 5YR 4/3) sandy loam; almost structureless; slightly hard dry, friable moist; generally with some soft lime; gradual transition to:

Subsoil

4/12-30 inches reddish brown or brown (5 or 7.5YR 5/6) sandy clay or light clay with light to moderate soft calcium carbonate; gradual transition to:

30-48 inches red-brown light or medium clay; with light to heavy soft and hard lime.

Dense deep subsoil phase

This phase has dense and impermeable heavy clay occurring from 20 to 30 inches, with light lime in pockets gradually decreasing to nil before about 40 inches.

Variant The deep surface variant has surface of 12 to 30 inches depth, often visibly layered.

Occurrence M3 sandy loam occurs on the lunettes and ridges from Benjeroop to Lake Elizabeth, with the dense deep subsoil phase occurring mainly on the Gredgwin Ridge.

Land Use The soils are used successfully for cereal cropping and dry pastures, and when irrigated for lucerne.

M3 Sandy Clay Loam

Apart from the surface soil, which is a grey- brown to reddish grey- brown sandy clay loam, M2 sandy clay loam is similar to M2 sandy loam.

Dense deep subsoil phase

As in M3 sandy loam, dense heavy clays occur from about 24 to 30 inches.

Occurrence and Land Use As for M3 sandy loam.

M3 Clay

The profile is essentially that of M3 sandy loam with the surface soil removed by wind erosion.

Occurrence and Land Use M3 clay occurs in similar situations to M3 sandy loam and M3 sandy clay loam. Because of the lack of surface soil M3 clay is less suited to cereal cropping or pasture and is not recommended for irrigation.

M4 Sandy Loam

Surface soil

0-4/12 inches grey- brown (7.5YR 4/3) to reddish grey- brown (5YR 4/2) sandy loam; structureless to weak subangular blocky structure; slightly hard dry; friable moist; sharp transition to:

Subsoil

4/12-16 inches brown (7.5YR 4/6) to red- brown (2.5YR 5/6) light or medium clay; moderate medium subangular or angular blocky structure; hard dry, tough moist, gradual transition to:

16-48 inches brown, often diffusely mottled with duller colours, light or medium clay; light to heavy concretionary hard and soft lime decreasing with depth; occasionally with slight gypsum.

Variant The grey surface variant has a grey to brownish grey surface soil.

Occurrence M4 sandy loam occurs on the lunettes in the north- western part of the surveyed area.

Land Use The soils are generally used for cereal growing and dry pastures. Although lucerne is sometimes grown under irrigation, the dense subsoil does restrict water and root penetration.

M4 Sandy Clay Loam

This soil type is identical to M4 sandy loam, except that it has a sandy clay loam rather than a sandy loam surface.

Occurrence and Land Use As for M4 sandy clay loam.

M4 Clay Loam

Surface soil

0-2/6 inches dark reddish grey- brown to dull brown (5YR 3/4) to 7.5YR 5/5) clay loam; gradual transition:

Subsoil

2/6-16 inches brown (7.5YR 4/6) to red- brown (2.5YR 5/6) light or medium clay; moderate medium subangular or angular blocky structure; hard dry, tough moist; gradual transition to:

16-48 inches brown, often diffusely mottled with duller colours, light or medium clay; light to heavy concretionary hard and soft lime decreasing with depth; occasionally with slight gypsum.

M4 Clay

As for M4 clay loam except that the surface soil has been removed by erosion.

The clay loam and clay surface merge imperceptibly into one another, and have not been separated on the soil maps. Surface colour and structure may also vary greatly.

M4 Sandy Loam M4 Clay Complex

This mapping unit delineates areas where these two soil types are present in almost equal proportions, and so intermingled that their separation on the soil map is not practicable.

Occurrence As for M4 sandy loam. M4 clay loam and M4 clay occur on post settlement erosion surfaces, and mainly on the western slopes and windswept crest of the older lunettes and lunette remnants. Aboriginal middens were also found on these lunettes, but these have been mostly removed for farm tracks, roads and stockyards.

Land Use M4 clay loam and M4 clay are only fair for pastures and cereal creping. The surfaces are generally windswept and tend to seal after initial wetting, thus restricting additional water entry.

This soil features together with excessive slopes makes irrigation of these soils difficult.

M5 Sandy Loam

Surface soil

0-3/12 inches brownish grey to dull reddish brown (7.5YR 4/2 to 5YR 5/5) sandy loam; structureless; slight to light soft lime; sharp transition to:

Subsoil

3/12-30 inches dull brown to red- brown (7.5YR 5/5 to 2.5YR 4/6) light clay or sandy clay; with light to heavy amounts of soft lime and rubble; gradual transition to:

30-48 inches brown medium clay; with heavy limestone rubble.

Variant The deep surface variant includes surfaces from 12 to 30 inches deep, often visibly stratified, with layers ranging from calcareous sand to sandy clay loam.

Occurrence M5 sandy loam is a minor soil type occurring on eroded dunes and dune remnants, mainly between Winlaton Creek and Third Lake.

Land Use This soil type occurs on areas too small for individual land use separation. Fair cereal crops can be grown as well as irrigated annual pastures. Wind erosion of bare surface can be very severe.

M5 Sandy Clay Loam

Apart from its sandy clay loam surface this type is identical with M5 sandy loam.

Occurrence and Land Use As for M5 sandy loam.

M5 CLAY

The profile of M5 clay is essentially that of M5 sandy loam, with the surface soil removed by erosion.

Occurrence and Land Use As for M5 sandy loam and M5 sandy clay loam. Increased erosion hazard, surface sealing, and sometimes heavy amounts of limestone rubble on the surface, and added disadvantages.

M6 Sandy Loam

Surface soil

0-6 inches greyish brown (7.5 to 10YR 4/1) sandy loam; weak subangular blocky structure, almost structureless; slightly hard dry, friable moist; clear transition to:

Subsoil

6-20 inches grey- brown (7.5YR 4/2) to brown (7.5YR 4/6) light clay or sandy clay; moderate medium subangular or angular blocky structure; moderate hard and soft lime; gradual transition to:

20-48 inches grey- brown to dull brown light clay or sandy clay with moderate hard and soft lime.

Occurrence This is a minor soil type situated on the lower western slopes of the dunes and lunettes.

Land Use Because of their small extent and position, these soils are used similarly to the adjoining soils. M6 sandy loam is well suited to irrigated annual pasture and would be suitable for vegetable growing.

M6 Clay Loam

The profile is identical to M6 sandy loam, except that the surface soil is a sandy clay loam or clay loam.

Occurrence and Land Use As for M6 sandy loam.

M7 Clay Loam

Surface soil

0-12/22 inches grey-brown to dark reddish grey- brown (7.5YR 4/3 to 4YR 3/4) clay loam; trace of soft lime; gradual transition to:

Subsoil

12/22-30 inches grey-brown to brown heavy clay; moderate large angular blocky structure; trace, increasing to light, hard and soft lime; sometimes with a trace of gypsum; gradual transition to:

30-48 inches dull brown to grey-brown heavy clay; light hard and soft lime; gypsum irregularly present.

Occurrence M7 clay loam occurs on the mid and lower northern and eastern slopes of the lunettes.

Land Use This soil type is used for dry pastures and sometimes fro cereal cropping.

M7 Clay

M7 clay has a grey- brown to dark reddish grey- brown medium to heavy clay surface soil, overlying subsoil identical to M7 clay loam.

Occurrence and Land Use As for M7 clay loam.

M8 Sandy Loam

Surface soil

0-5/10 inches brownish grey (6YR 4/2) sandy loam; occasionally sandy clay loam; weak subangular, blocky structure; clear transition to:

Subsoil

5/10-12/24 inches brown (7.5YR 4/6) to dark reddish brown (4 YR 3/6) sandy clay or medium clay; trace of hard lime; gradual transition to:

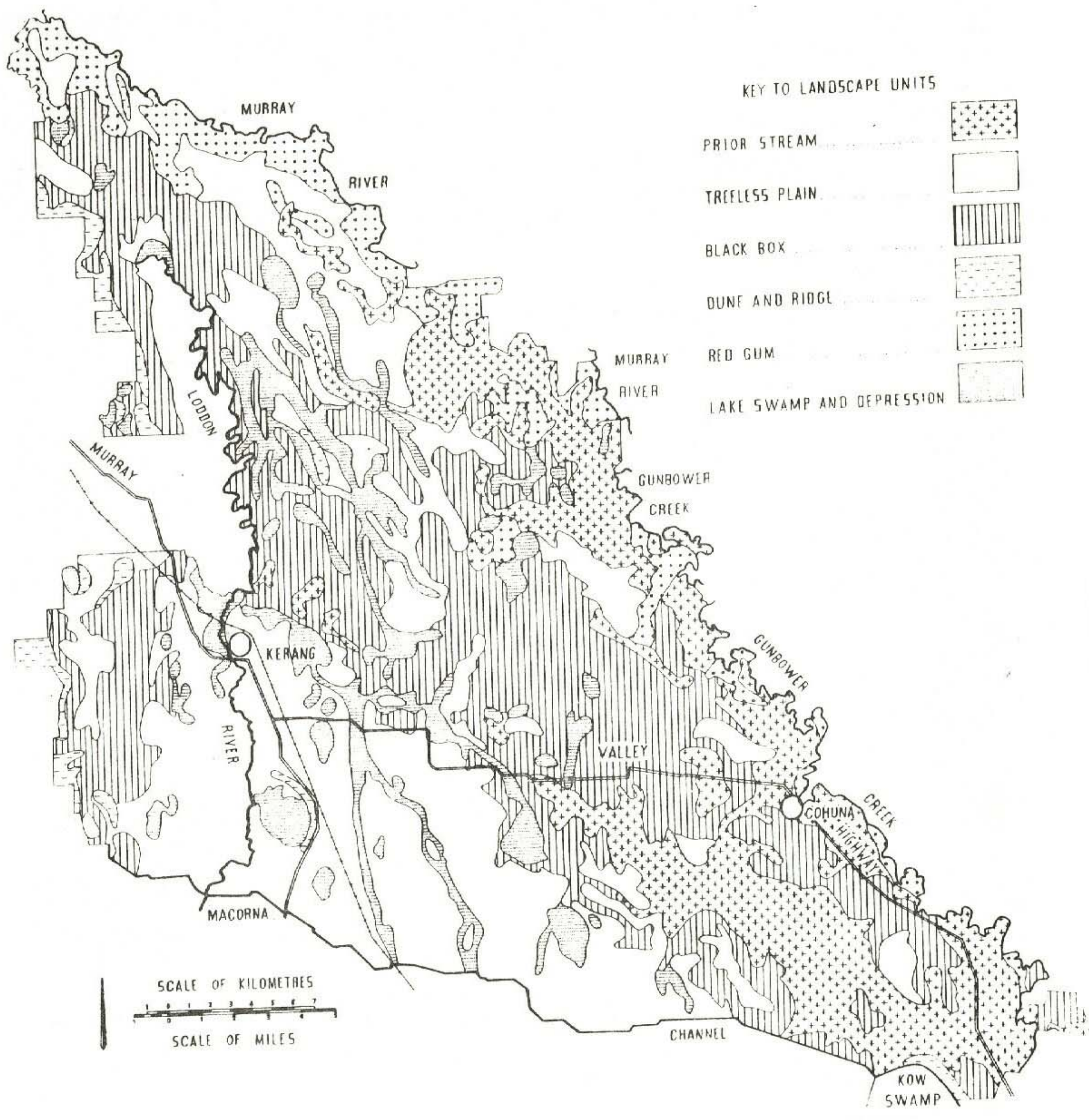
12/24-48 inches dull brown to reddish brown light or medium clay; with slight to moderate hard and soft lime. Gypsum may occur in some profiles adjacent to the salt lakes.

Variant The variable surface variant has a surface soil which may range in texture from sandy loam to clay loam.

Occurrence These soils occur in the interdune swales associated with the lunettes.

Land Use These soils are generally used for dryland pastures and cereal growing. Because of their landscape position salinity problems would be likely to develop under irrigation.

Fig 2 – Landscape Units in the Torrumbarry Irrigation District



LANDSCAPE UNITS AND GUIDE TO SOIL TYPS.

In this section the soil types are discussed in relation to major features of the landscape. Six landscape units have been recognised, and their distribution is shown on Fig. 2. These landscape units are as follows: treeless plain; prior stream; black box; red gum; dune and ridge; and lake, swamp and depression.

Each of the landscape units has its own array of soil types. In some of the landscape units certain soil types are related to each other through their positions in slope sequences or toposequences. However, each member of the slope sequence sequences is not necessarily present, and a soil type in the field may not occur next to the soil type adjoining it in the idealised toposequence.

Within each landscape unit there are one or more soil associations. These are described in the following section and shown on the Soil Association Map in the supplement accompanying this report. The landscape units and component soil association, together with their areas are given in Table 4.

Table 4 - Areas of Landscape Units and their Component Soil Associations

Landscape Unit	Area, acres	Soil Association	Area, acres
Treeless Plain	101,330	Macorna	68,600
		Myall	14,070
		Meran	9,710
		Tragowel	8,950
Black Box	92,005	Koroop	42,445
		Box	36,175
		Laton	8,490
		Wandella	4,895
Prior Stream	54,070	Cohuna	
Lake, Swamp and Depression	30,555	Swamp	
Red Gum	19,350	Murrabit	14,910
		Gunbower	4,440
Dune and Ridge	9,030	Dune	7,040
		Gredgwin	1,990
Not Surveyed	6,660 acres		

In the description of each landscape unit, the component soil types and the associations to which they belong are shown in italics, and the main profile features distinguishing the soil types are given.

Treeless Plain

A great part of the Riverine Plain which extends over northern Victoria and southern New South Wales is almost flat and devoid of trees, except for black box and red gum in some of the shallow drainage ways. These treeless areas constitute a landscape unit commonly referred to as treeless plain. In Victoria, occurrences extending from Koyuga, near Tongala to near Boort have been described by Baldwin *et al.* (1939), Skene and Sargeant (1966) and Skene (1971). The treeless plain landscape unit is the most extensive unit of this survey.

The toposequences which occur here are the Macorna clay- Kerang clay Tragowel clay catena which predominates in the southern and south- eastern parts, and the Meran clay- Fiarley clay catena which occurs in the western part. Myall clay, which occurs in the northern part of the survey, is not related to the soil types of the Macoran or Meran catenas. The soil types of the Macorna catena have been recorded previously by Baldwin *et al*. (1939) and Skene (1971).

Macorna clay occupies the highest landscape positions within the Macoran association. Two phases of Macorna clay are recognised, a red- brown phase where the subsoil colour immediately below the surface is dark red- brown or dark reddish brown, and a brown phase where the subsoil colour is dark brown dark greyish brown. Downslope from the two phases of Macorna clay are the tow phases of Kerang clay, the fractionally higher grey- brown clay are the two phases of Kerang clay, the fractionally higher grey- brown phase, where the subsoil colour is grey- brown, and the lower grey phase where the subsoil colour is grey. Gypsum becomes deeper on moving down the sequence; in the red- brown phase of the Macorna clay it occurs at about 20 inches, whereas in the grey phase of Kerang clay it is generally deeper than 30 inches.

Tragowel clay occurs on extensive areas of low- lying land situated slightly below Kerang clay in the treeless plain landscape unit. In its virgin state, it has distinctive features such as a conspicuous gilgai surface, and strong structure and friability in the upper part of the profile. These characteristics may be obscured where Tragowel clay is laid out to irrigation, in which case its profile is superficially like that of the greyer occurrences of Kerang clay. However, the types may be distinguished by the presence of occasional fine concretions of calcium carbonate in the surface foot of Tragowel clay, and the absence of gypsum in the 2 to 4 foot zone.

Warra clay and Type 5 are minor soil types in this survey and are included in the Macorna association. Type 5 occurs only in the south- eastern part of the area and occupies similar landscape positions to Macorna clay. It differs from Macorna clay in that it has less gypsum and more lime profile. The surface of Warra clay resembles Kerang clay. It differs in that the subsoil is browner, and the deep subsoil is a light or medium clay, visibly micaceous.

The Meran association is largely confined to the generally treeless plain west of the Loddon River. The soils are derived mainly from sediments from the Loddon River, but a variable aeolian component is incorporated. Meran clay occupies the highest landscape position and has a dark reddish brown light or medium clay surface overlying a brown to reddish brown clay subsoil. The deep subsoil contains lime and occasionally gypsum. Meran sandy loam and Meran sandy clay loam have a sandy loam and sandy clay loam surface respectively overlying, at about 4 inches depth, a profile similar to that of Meran clay. Fairley clay occupies the lower landscape position. It has a grey- brown to grey clay surface overlying a brown heavy clay subsoil containing light amounts of calcium carbonate concretions.

Myall clay is the only soil type of the Myall association and occurs on the level plains in the northern part of the area. Its surface soil is dark grey, blocky clay. Medium or heavy clays continue to 48 inches.

The soils of practically all depressions within this landscape unit have been classified into Towangurr clay, a grey and heavy- textured, poorly- drained soil. Although Towangurr clay occurs within the treeless plains landscape unit it may carry timber. Type d4 occurs only in a discontinuous chain of depressions west of Hirds Swamp. Of minor occurrence are depressions classified as Type dV.

Prior Stream Landscape

This landscape unit occurs mostly in the south-eastern portion of the surveyed area, extending in irregular fingers along the Gunbower Creek north-west of Koondrook, and along Leitch's Creek. The landscape is gently undulating, with the lighter soils originally carrying Murray Pine, tea-tree, Mallee and a few black box, although adjoining the Gunbower Creek red gum may occur. The heavier soils carried predominately black box.

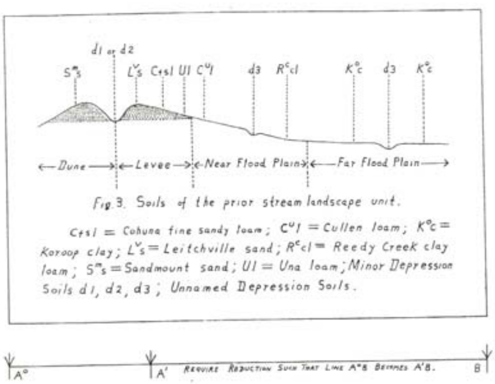


Fig 3 – Soils of the prior stream landscape unit

Prior streams, and the soils associated with them, occur extensively on the Riverine Plain of South-eastern Australia. In Victoria, these soils have been mapped and described in the Murray Valley (Butler *et al* 1942, Johnstone 1952), the Goulburn Valley (Skene and Poutsma 1962), the Deakin Irrigation Area (Skene 1963), the Rochester-Echuca District (Skene and Harford 1964), and the Mid-Loddon Valley (Skene 1971). The broad pattern of prior streams of the Riverine Plain has been presented by Butler *et al* (1973).

In the area covered by this survey the following soil types occur in the prior stream landscape unit. All of the soils are included in the Cohuna association.

Sandmount sand occurs on dunes and low rises adjoining the prior stream beds (Fig 3). The surface soil is a dull brown loamy fine sand or loamy sand, and similar textured material continues to at least 4 feet.

Leitchville sand is situated on the levees of the stronger prior streams in the south-eastern and eastern parts of the area. The normal type has 12 to 24 inches of loamy fine sand overlying a dominately brown light clay or fine sandy clay, which reverts to lighter textures in the deep sub-soil.

Cohuna fine sandy loam and Una loam are soil types occurring on the levees of the prior streams with Una loam occupying the fractionally lower landscape positions. Cohuna fine sandy loam has a grey-brown to brown surface soil overlying a dominantly brown clay subsoil, with fine sandy clay textures occurring from about 18 inches. Mottled clays appear abruptly before 48 inches. In Cohuna fine sandy loam, deep phase, the mottled deep subsoil clays are deeper than 48 inches. Una loam is similar to Cohuna fine sandy loam in texture but is duller in surface and immediate subsoil colours.

Cullen loam and Reedy Creek clay loam occur on the near flood plains of the prior streams. Cullen loam has a brownish grey to greyish brown surface soil and a dominantly brown clay subsoil, whereas Reedy Creek clay loam has a grey surface over a brownish grey or grey-brown clay subsoil. Both soil types have a mottled clay or fine sandy clay subsoil to at least 4 feet. Small amounts of the far flood plain soil type, Koroop clay, occur within the prior stream landscape unit.

Unit II is a minor unit and comprises a number of light-textured soil types which occur on the pronounced but narrow levees of a weak prior stream called the Piccaniny-Barr Creek. These soils are similar to the other levee soils except that the surface soils are generally duller in colour.

The soils in the beds of the prior stream channels range from high-level, well-drained prior stream bed soils (Type d1) to soils of the lower-lying poorly-drained prior stream beds, and poorly-drained depressions (Type d2). Type d1 has a light-textured profile and is generally similar to Cohuna fine sandy loam or Una loam, although texturally lighter profiles may occur. Although a wide range of soil profiles are mapped within Type d2, the soils are generally light-to medium-textured grey to grey-brown clays.

Type d3 is a grey heavy-textured soil found in poorly drained depressions within the prior stream landscape unit.

Black Box Landscape

This landscape unit is scattered throughout the surveyed area, except in the north-eastern and central southern portions. The overall topography is almost flat, and originally supported on open woodland. When uncleared, the surface is characteristically uneven, with a network of interconnected shallow drainage lines, one to two feet deep.

Four soil associations occur within this unit, the Box, Koroop, Laton and Wandella associations. They occur in different parts of the surveyed area in landscape positions subject to occasional inundation.

The Box association occurs adjoining the Loddon River, the Barr and Pyramid Creeks, and in the slightly lower areas in the central to south-eastern part of the surveyed area. Box clay and minor Type B, are the only soil types occurring within this association. Box clay has a grey clay surface soil and a yellowish brownish grey heavy clay subsoil. Heavy clays continue to at least 4 feet. Type B also has a similar surface but overlies a mottled yellow-brown and light grey fine sandy loam at about 2 feet.

The soils of the Koroop association are predominantly flood plain deposits of the prior streams, and therefore occur mainly in the south-eastern and eastern parts of the area. Koroop clay has a grey medium or heavy clay surface and becomes yellower and browner with depth. Mottled yellowish brown and light brownish grey medium clay or fine sandy visibly micaceious, occurs from about 30 inches. Unit I is fairly extensive but is broadly restricted to areas near Piccaninny-Barr Creek. The original surface had a fairly uneven micro-relief.

The surface soil is a dark grey or grey medium or heavy clay, which at a variable depth of 5 to 14 inches passes to a yellowish brownish grey heavy clay. The deep subsoil is mottled greyish yellowish brown light or medium clay, visibly micaceous, and often containing slight amounts of gypsum.

The Laton association occurs in the western part of the area and most occurrences of the Wandella association are west of the Loddon River. Although these soils are predominantly riverine in origin, the relatively large amounts of calcium carbonate and the appreciable coarse sand present suggest that there is a high aeolian component in Laton clay and Della clay. Laton clay occurs in slightly higher landscape positions and has a grey friable clay surface soil, frequently with a high coarse sand component. This overlies a brown clay containing slight amounts of lime. Della clay has a similar surface soil to Laton clay, or darker, but has a yellowish grey calcareous clay subsoil becoming yellowish grey-brown with depth. Wandella clay occurs in lower situations than either Della clay or Laton clay and is more subject to inundation. The surface is a grey friable heavy clay with traces of hard lime. With depth the soils become slightly yellowish grey heavy clay with slight hard lime. In the virgin state both Wandella clay and Della clay were gilgaied.

The shallow ramifying depressions within this landscape unit are classified into the Type dv. The symbol WC refers to well incised depression lines or water-courses.

Red Gum Landscape

This landscape unit includes the Gunbower and Murrabit soil associations. Although much of the timber has been cleared, it is thought that an open grassy red gum woodland adjoined the Gunbower Creek, the Murray River, the Little Murray River and the northernmost part of the Loddon River.

The Gunbower association, which occurs discontinuously along the Gunbower Creek to just north of Koondrook, is comprised of three minor unnamed soil types separated on a textural basis. All of the soils have dominantly grey surfaces and mottled subsoils. Type G1 is the lightest soil and occurs on the slightly higher parts of the landscape. Apart from a fine sandy clay B horizon at about 12 to 24 inches, the heaviest texture to 48 inches is a sandy clay loam. Type G2 occupies the intermediate landscape position and is slightly heavier textured. The B horizon is a light or medium clay and fine sandy clay loam or lighter textures occur from about 30 inches. In the shallow phase clay textures are re-encountered before 4 feet. Type G3 occurs on level areas and has a clay loam or loam surface overlying mottled clays which continue to at least 48 inches.

Murrabit clay occurs on almost level situations and is the most extensive type of the Murrabit association. This is a grey or dark grey cracking clay which passes, at about 30 inches, to a moderately mottled, light grey and yellow-brown light or medium clay which is visibly almost flat and slightly higher landscape. It is similar to Murrabit clay, but differs in that the mottled clays appear at about 24 inches depth and pass to a clay loam before 4 feet. Myall clay, described under the Myall association of the treeless plain landscape unit, also occurs in the Murrabit association as relatively small areas between shallow depression lines. Type A and Type 3 resemble Benjeroop clay. However, Type A is more variable in surface texture, and the light-textured subsoil appears at the shallower depth of 12 to 24 inches. Type 3 has a very dark grey and strongly fine-structured sandy clay or clay with sand surface soil, quickly passing, at from 12 to 24 inches, to a mottled light grey, yellow-brown and brown sandy clay to sandy clay loam with slight concretionary calcium carbonate. Types 1 and 2 are soils on more recent alluvium from the Murray River. Type 1 is a mottled brownish grey and dull brown fine sandy clay loam abut 2 feet deep, and occurs superimposed on a grey medium to heavy clay. Where the clay is deeper than 2 feet the deep phase of Type 1 is mapped. Type 2 is similar to Type 1 but surface textures are clay loam or light clay.

Dune and Ridge Landscape

This landscape dominates the western edge of the surveyed area, and forms a link with the soils of the Mallee Region. The landscape has two distinct features – the Gredgwin Ridge, whose surface has been modified by gullying and the action of the wind, and the chain of lunettes which continues the line of the Ridge from Lake Elizabeth to Benjeroop. Further east, these lunettes become less frequent and smaller, Westby Hill north-east of Kerang being the biggest, and the Kow Swamp lunette being the farthest east in the surveyed area.

The soils of the Gredgwin association are fairly uniform in nature, apart from depth of surface where modified drift, and the soils of the ridge and upper slopes are classified as M3 and sandy clay loam dense deep subsoil.

This soil has from 4 to 14 inches of greyish to reddish brown sandy loam or sandy clay loam surface soil, with slight fine lime, over a red-brown or brown light clay or sandy clay subsoil, with variable amounts of lime, passing between 24 and 48 inches to a dense well-structured red-brown medium, or occasionally light clay, with visible lime decreasing to none with depth. Coombatook sandy loam and sandy clay loam occur at the base of the ridge slopes just prior to passing to flood plain sediments. Typical profiles have been from 3 to 9 inches of grey sandy loam or sandy clay loam overlying a grey, passing to light yellowish grey, sandy clay with light soft lime continuing with little change to 48 inches. Frequently 4 to 8 inches of grey-brown sandy loam overlay is present.

Many widely-differing soils occur on the dunes and lunettes of the Dune association, and include the unnamed series M1 to M8. Most of these series are variable over short distances, in the depth and texture of the surface soil, and in the amount of lime in the subsoil. For this reason, on each lunette or smaller ridge, only the most characteristic soil types or soil series are shown on the maps.

M1 sand is a very minor soil type restricted to sandy dune near the lower Loddon River, and is a young soil formed on non-calcareous material. It has about 40 to 60 inches of brownish grey to light brown sand over a grey-brown sandy loam or sandy clay loam. The M2 series occurs on younger lunettes and shows only weak profile development with surface textures ranging from sandy loam to medium clay. The subsoil are sandy clay to heavy clay in texture, and contain much lime, gypsum and other salts.

The M3, M4 and M5 series occur on the crests and slopes of older lunettes and dunes, and are named in order of increasing profile development. The surface textures range from sandy loam to medium clay. The M3 series is characterised by a brown to reddish brown sandy clay loam to light clay subsoil containing light amounts of soft lime. Soils of the M4 series have visibly lime-free brown to red-brown light or medium clays in the upper B horizon. Lime concretions occur deeper. The M5 series is formed on highly calcareous and eroded dunes. The surface soils are extremely variable in texture and almost always visibly calcareous. Subsoils are highly calcareous dull brown to red-brown light clays or sandy clays with hard rubble and the texture increasing with depth. The M6 series occurs on the lower western slopes of eroded dunes and can be regarded as hydromorphic variant of the M5 series with a more uniform and leached surface. Subsoils are grey-brown to brown light clays or sandy clays containing moderate amounts of lime.

The M7 series is of very minor extent. Soils of this series differ from those of the M4 series in having brown to grey-brown medium or heavy clay subsoils instead of the brown to red-brown light to medium clay subsoils of the latter. In addition, less lime is present.

The M8 series occurs in the interdune swales. The surface soils are dominantly grey sandy loam to clay loam, and the subsoils brown to dark reddish brown sandy clay to medium clay. Deeper, reddish brown to dull brown light or medium clays occur, with variable amounts of concretionary lime, and occasionally gypsum.

Lake, Swamp and Depression Landscape

There are a number of lakes, swamps and major depression lines throughout the surveyed area. Those containing permanent water are generally named, whilst those not named are classified into Types S1, S2, S3 and S4 and Towangurr clay, or have been left unclassified.

Types S1 and S4 formerly carried black box. Type S1 occurs only west of the Loddon River and is a dark grey, non-saline swamp soil. This highly saline low-lying areas and dry drainage basins are classified into Type S4.

Swamp soils which supported red gum have been classified into Types S2 and S3. Type S2 is a grey or dark grey heavy-textured soil occurring in swamps which are filled by the Murray River in times of high flood, prior tot he building of levees. Type S3 is a mottled grey an dull yellow-brown, heavy-textured soil.

Drainage lines on the treeless plain are classified as Towangurr clay. The soil types of this landscape unit are included within the Swamp association.

SOIL ASSOCIATIONS

The soil types have been combined into larger units called Soil Associations; these are shown the Soil Association Map contained in the supplement accompanying this report. The map enables the overall soil pattern of the area to be seen readily, and indicates in a broad way the potential land use of the soils.

The relationship of the soil associations to landscape features is given in the section "Landscape Units and Guide to Soil Types". The landscape unit in which the association occurs and the areas of the individual associations are given in Table 4.

Each soil association has been given the name of the major soil type, or has been named after a characteristic of the landscape it occupies. They are described below in terms of their major and minor soil types. Any one soil type may occur in two or more different soil associations, assuming a different degree of importance in each. As well, the present and potential agricultural use of each association is stated in general terms.

Fourteen soil associations have been recognised in the present area. Of these, the Macorna and Tragowel associations have been recorded previously by Skene (1971) in the Mid-Loddon Valley to the south, and the Meran association by Skene and Sargeant (1966) in the Swan Hill area to the north.

Box Association

The Box association is a widespread one, and occurs adjoining the Loddon River and the Barr and Pyramid Creeks, and in the slightly lower situations in the central and south-eastern part of the area. It is one of three soil associations within the black box landscape unit.

Major soil type

Box clay

Minor soil types

Type S4
Type B
Type d2

Most of the Box association is subject to a high salinity hazard and irrigation measures to control salinity are necessary. Present land use is the grazing of sheep and cattle on both irrigated annual and perennial pastures. Irrigated summer fodder crops are sometimes grown.

Cohuna Association

The Cohuna association includes all of the soil types of the prior stream landscape unit. The prior stream courses themselves are shown on the Soil Association Map.

Major soil types

Cohuna fine sandy loam
Reedy Creek clay loam
Una loam

Minor soil types

Cullen loam
Leitchville sand
Sandmount sand
Kooroop clay
Unit II
Type d1
Type d2
Type d3
Type dV

The soils are generally irrigated, mainly for dairying and fat lamb production, and are the most attractive soils for irrigated pastures in the area. Many of the soils are suitable for lucerne, most horticultural crops and vegetables. Soil salinity is variable, but in the lighter-textured soils salt can be easily leached from the surface soil. However as most such areas are underlain by dense clays, perched watertables develop easily.

Gredgwin Association

This is a minor soil association located on the Mallee fringe in the south-west part of the surveyed area. Together with the Dune association it occurs in the dune and ridge landscape unit.

Major soil types

M3 sandy clay loam, dense deep subsoil phase
Coombatook sandy loam
Coombatook sandy clay loam

Minor soil types

M3 sandy loam
M3 sandy loam, dense deep subsoil phase

Type M3 sandy clay loam, dense deep subsoil phase is above gravity irrigation supply level and present land use is confined to cereal growing and dryland grazing of sheep. The remaining two soil types are irrigated and carry satisfactory irrigated annual and perennial pastures. Salinity hazards are generally low.

Gunbower Association

This is a minor association which adjoins the Gunbower Creek from Gunbower to just north of Koondrook. It is one of the two associations which occur in the red gum landscape unit.

Major soil types

Type G2
Type G3

Minor soil types

Type G1
Type S2
Type S3

Most of this association is under irrigation farming, and both annual and perennial pastures are grown. Timber remains on a few low areas adjoining the Gunbower Creek. In general salinity hazard is low, but there are areas of moderate salinity and even one area of high salinity hazard.

Koroop Association

The soils of the Koroop association are predominantly flood plain deposits of the prior streams. All occurrences are to the north and east of the Pyramid Creek, and to the east of the Loddon River north of Kerang. This association is part of the black box landscape unit.

Major soil types

Koroop clay
Unit I

Minor soil types

Type d2
Type d3
Type dV

Most of the Koroop association supports good annual and perennial pastures. Some areas of irrigated summer fodder crops have also been grown successfully. Salinity is generally low or moderate, but areas of high and very high salinity also occur. Where large areas of Koroop clay are either bare or support only halophytic species, the areas is shown on the map as saline.

Laton Association

The Laton association is a component of the black box landscape unit in the western part of the surveyed area. The soils are grey clays and, north of the Forest Reserve, are generally saline.

Major soil type

Laton clay

Minor soil types

Della clay
Fairley clay

Most of this association is under annual irrigated pasture. Throughout most of the association soil salinity is the principal hazard to the establishment of irrigated crops.

Macorna Association

The Macorna association is a widespread soil association which occurs in the treeless plain landscape unit.

Major soil types

Kerang clay, grey-brown phase
Kerang clay, grey phase
Macorna clay, red-brown phase
Macorna clay, brown phase

Minor soil types

Towangurr clay
Warra clay
Type 5
Type d4

This association is mainly under irrigation farming, with most areas under annual pasture. Summer fodder crops and irrigated cereal crops have also been grown successfully. Non-irrigated areas are generally saline, with clovers and medics growing around the lignum and dillon bushes, and patches of barley grass elsewhere. Such areas serve a purpose in spelling sheep and cattle from irrigated pastures. The salinity hazard for soils within this association is moderate to very high.

Meran Association

This association forms part of the treeless plain landscape unit, and is confined tot he plains west of the Loddon River. The soils are derived mainly from sediments from the Loddon River, but a variable aeolian component is incorporated.

Major soil types

Meran clay
Meran sandy clay loam
Fairly clay

Minor soil types

Meran sany loam

The Meran association is mainly used for the grazing of sheep and cattle on irrigated pastures, but it can also support irrigated cereals and summer fodder crops. The subsoils vary from low to very high in salinity, and measures to control salinity are necessary.

Murrabit Association

The Murrabit association adjoins the Murray River downstream from Koondrook, the Little Murray River, and to a lesser extent, the northernmost part of the Loddon River. This association occurs as part of the red gum landscape unit.

Major soil types

Murrabit clay
Gonn clay

Minor soil types

Benjeroop clay
Myall clay
Type 1
Type 2
Type 3
Type 4
Type A
Type d2
Type S3

The soil association includes areas generally suitable for irrigated annual and perennial pastures. On the better drained soils such as Murrabit clay and Type 3 citrus is also grown successfully. The salinity hazard within this association is generally low but occasionally moderate.

Myall Association

The association comprises part of the treeless plain landscape unit. It occurs between the Murray River and the Barr Creek from south of Koondrook to north of Benjeroop.

Major soil type

Myall clay

Minor soil types

Gonn clay
Towangurr clay
Type dV

The soils of the Myrall association generally carry satisfactory irrigated annual and perennial pastures. The soils should also be suitable for summer fodder crops. Soil salinity hazards are generally low to moderate, but there are areas of high hazard.

Tragowel Association

Although the Tragowel association represents the low elements of the treeless plain landscape unit it may carry black box in the drainage lines.

It occurs mainly adjoining the Loddon River south of Kerang.

Major soil type

Tragowel clay

Minor soil types

Kerang clay, grey-brown phase
Kerang clay, grey phase

Wandella clay
Type dV

Much of the Tragowel association is given to grazing pursuits and some to cereal growing. Although irrigated pastures are grown, there are difficulties with grading, drainage and general high salinity. Where these difficulties are overcome, the soils of the Tragowel association are suitable for irrigated pastures and summer fodder crops.

Wandella Association

This soil association only occurs west of the Loddon River in the southern part of the surveyed area. It belongs to the black box landscape unit.

Major soil types

Wandella clay
Della clay

Minor soil types

Laton clay
Della sandy loam
Type dV
Type S1

In the southern part Della clay is the dominant soil type whilst further north Laton clay is dominant.

The Wandella association is mainly given to grazing pursuits on dryland and irrigated annual pastures. Much of this association is gilgaied, which adds to the problem of surface drainage and grading. The salinity hazard is low to moderate with some areas being high.

Swamp Association

All major depression lines and most swamps occur within the lake, swamp and depression landscape unit and have classified into the Swamp association. However, several permanent or semi permanent swamps have not been included in any soil association and are left uncoloured on the soil maps. Most of these swamps are also named.

Major soil types

Towangurr clay
Type S3
Type S4

Minor soil types

Box clay
Type S1
Type S2
Type dV
Type d3

CHEMICAL AND PHYSICAL PROPERTIES

72 profiles taken from the principal soil types have been examine in the laboratory. The locations of these sampling sites are shown by the numbers and symbols on the soil maps, while their analyses are presented in Appendix I. This Appendix provides a reference to the more important measurable features of the principal soil types. The analytical methods employed are given in Appendix II. Detailed comparisons should not be made between the physical and chemical properties of the soil types on the basis of one or two profiles. A single profile by itself can only indicate broadly the physical and chemical properties of a particular soil type, since it represents only part of the range of any of the characteristics that constitutes the type.

Particle Size Distribution

The analyses in Appendix I can be used to relate particle size distribution to assessments of field texture. However, it must be remembered that the analysis in some cases represent only single profiles, whereas the field textures of the soil types cover a range of mechanical analyses. Some idea of the range in mechanical composition of the more common soil types can be gained since in some cases several profiles of the one soil type have been analysed.

The particle size data shows that soils with textures described as light clay have, in general, lower clay contents than those described as medium or heavy clays. However the field assessment of clay content is often difficult, since the texture is modified by the presence of high amounts of soluble salts, soft lime or exchangeable sodium.

Fine sand is the dominant constituent of the non-clay fraction of all profiles. However, there are differences in the magnitude of the coarse sand and silt fractions which are related to the parent materials. The following generalisations are made from consideration of the subsurface horizons. In the profiles of soil types derived entirely from riverine materials the coarse sand content, with one exception, is always below 5%. In profile derived mainly from aeolian materials, or those profiles containing an aeolian component, (Table 5), the coarse sand content is generally greater than 5%. However some of the soils on the more clayey lunettes have a low coarse sand component.

Table 5 – Clay and Silt contents of the Principal Soil Types

Landscape Unit and Soil /type	Profile No.	Surface			Subsoil			Deep Subsoil		
		Depth	Silt	Clay	Depth	Silt	Clay	Depth	Silt	Clay
		in.	%	%	in.	%	%	in.	%	%
Prior Stream										
Sandmount sand	39	0-5	5	7	8-22	4	9	60-84	4	10
Leitchville sand	64	0-9	21	14	9-16	25	23	43-70	25	16
Cohuna fine sandy loam	61	0-8	34	29	8-15	37	42	46-64	28	24
Una loam	23	0-3	20	22	3-10	17	45	36-52	19	46
Cullen loam	60	0-	46	33	5-10	35	53	48-63	44	36
Reedy Creek clay loam	63	0-5	46	33	5-10	35	53	48-63	44	36
Red Gum										
Type G2	40	0-7	36	25	7-13	33	31	54-75	25	58
Type G3	41	0-5	31	29	5-12	27	37	42-58	26	31
Murrabit clay	7	0-8	17	47	8-17	15	51	43-60	10	37
Gonn clay	3	0-7	22	58	7-24	24	59	50-60	26	62
Black Box										
(a) Riverine sediments										
Koroop clay	5	0-4	16	50	4-13	15	63	46-64	32	52
Unit I	37	0-6	20	44	6-16	19	46	40-56	26	45
Box clay	62	0-3	19	59	3-10	27	46	54-72	24	58
Wandella clay	52	0-5	12	70	5-30	13	67	30-56	21	60
(b) Largely aeolian sediments										
Laton clay	12	1-13	4	53	13-17	4	62	46-60	6	58
Della clay	49	0-4	7	42	14-18	6	47	48-64	4	50
Treeless Plain										
(a) Riverine sediments										
Myall clay	15	0-7	21	55	7-12	21	57	46-72	27	55
Macorna clay	36	0-3	5	64	3-10	9	65	54-60	10	60
Kerang clay	66	0-8	18	64	8-17	16	68	48-60	18	68
Tragowel clay	56	0-8	11	74	8-20	13	71	40-58	12	70
(b) Largely aeolian sediments										
Meran clay	2	0-4	9	35	4-10	5	62	48-54	6	50
Fairley clay	1	0-4	8	45	4-9	6	67	42-62	8	59
Dune and Ridge										
Coombatook sandy loam	44	0-3½	8	21	8-18	4	30	48-63	9	31
Type Me sandy clay loam	30	0-8	5	24	8-14	6	25	48-72	4	48

Landscape Unit and Soil /type	Profile No.	Surface			Subsoil			Deep Subsoil		
		Depth	Silt	Clay	Depth	Silt	Clay	Depth	Silt	Clay
		in.	%	%	in.	%	%	in.	%	%
Type M5 sandy clay loam	14	0-6	7	36	6-27	4	28	57-72	5	46
Type M4 clay	10	0-3	6	53	3-14	4	64	48-68	5	50

The silt fraction is low in all horizons of the profiles of soils dominantly aeolian origin, with amounts always less than 10% and commonly less than 5%. Three exceptions are one profile on Laton clay and two profiles on Meran clay. The analyses suggest that these profiles are largely riverine soils with only a small aeolian component. The silt contents of the profiles derived from riverine materials are always greater than 10% and generally greater than 20%. The highest silt to clay ratios are found in those profiles on the levees and near flood plains of the prior streams. This ratio is highest in the surface soils with the silt contents approximately equal to the clay contents. In the subsoils of these profiles the silt content is about half that of the clay. Further down the profile the silt to clay ratio again increases, the silt content being generally nearly equal to or greater than the clay. In the deeper subsoils the ratio is much more variable, because of the variable depth of the prior stream sediments.

Calcium Carbonate

Although calcium carbonate was not directly determined, an indication of the amount in the soil profile is given by the value given for loss on acid treatment. Values above 2% generally indicate the presence of calcium carbonate, exceptions being soils high in soluble salts. The soil types of the dunes and ridges, as well as those of the treeless plain and black box landscape units with a high aeolian component, all contain calcium carbonate, and both fine and concretionary forms usually occur by about 18 inches from the surface. The dune and ridge soils generally contain over 20% calcium carbonate in the horizon of maximum accumulation. However, the deep subsoils of the soils of the Gredgwin ridge are lime-free.

The profiles of the soils of the riverine plains vary from being slightly or lightly calcareous to lime free. Where calcium carbonate does appear it is generally in the subsoil from about 18 inches. Comparatively lime-free soils occur within the red gum landscape unit.

pH

The surface pH values of the riverine soils are mainly within the limits of pH 6.4 to pH 7.8. although occasionally the values are as high as pH 8.5. The trend in practically all the profiles is for the pH to increase with depth, with values between pH 8.0 and pH 9.0 being common in the subsoils. However, some profiles on the treeless plain are moderately acid in the deep subsoil.

The soils of the dunes and ridges, as well as those soils with a high aeolian component, have a surface pH range of between 7.2 and 9.9. The subsoils of these soils are always more alkaline than their surface soils and are usually very strongly alkaline. Most of the profiles samples have subsoil pH values in the range 9.0 to 10.0, and this high alkalinity generally continues to at least 6 feet. However, the deep subsoil of the profile sampled on the Gredgwin Ridge is slightly acidic.

The pH data indicates that liming is unnecessary on the soils of the Torrumbarry Irrigation area, unless acidifying fertilisers such as sulphate of ammonia have been used liberally on light-textured soils.

Exchangeable Cations

Exchangeable calcium, magnesium, potassium, sodium and hydrogen, and the sum of these cations representing the total exchange capacity are given in Appendix I. These values have been determined for a large number of horizons in nearly all of the soil profiles.

Exchangeable calcium and magnesium in the surface soils generally comprise 80 to 90% of the total exchangeable metal cations, except in very saline situations. These cations are present in approximately equal amounts in most cases, although in three profiles magnesium values were about two to three times that of calcium. Generally, calcium decreases and magnesium increases with depth, and in the deeper subsoil the magnesium values are usually two to three times greater than those for calcium. Notable exceptions are some well-drained profiles on the prior stream levees, where the deep subsoil values are approximately equal.

The main agricultural interest is in the exchangeable sodium percentage (ESP) since this has a marked influence on the physical properties of the soil. It is generally recognised that significant dispersion of the clay occurs in non-saline, irrigated soils if the ESP exceeds 15%. Clay dispersion lowers the permeability of the soils. Most of the profiles have ESP values below 8 n the surface horizons. Almost all ESP values increase in the subsoil with values generally over 20. Values of this order are indicative of probable poor permeability and in fact, low subsoil permeability is a problem experienced with many irrigated soil types in the Torrumbarry Irrigation District. However the data indicates that low ESP values in the deep subsoil do occur in the soils of the red gum landscape unit.

Exchangeable potassium contents are high in the surface and subsoils in all but some of the most light textured soils, and responses to potassium fertiliser by pastures are not likely. The clay fractions of these soils contain much illite, a clay mineral rich in potassium, and as the exchangeable potassium is taken up by the plant more is released from the illite fraction of the clay.

Organic Matter

The general level of organic matter in the soils can be seen from the total nitrogen and organic carbon values reported in Appendix I.

Total nitrogen in the surface soil ranges from 0.1 to 0.3% with only six values falling outside this range. The average value is 0.17%. Corresponding organic carbon ranges are from 0.9 to 3.67% with only three values falling below this range. The average value for organic carbon is 1.74.

In terms of organic matter these figures in the surface soil represent an average amount of 3%. The range of organic matter contents in the surface soils is wide since the soils analysed were drawn from irrigated as well as from dryland areas. Most values for the carbon to nitrogen ratio of the surface soil range between 8 and 14 with an average value of 10.6.

The organic matter in the subsoils varies from about one-third to two-thirds of the amount in the surface. Here the average carbont o nitroen ratio is 8.3 with most values between 6 and 12.

Soil Salinity

For a discussion of soil salinity in the Torrumbarry Irrigation District see the section "Soil Features and Irrigation".

Clay Mineralogy

The cation exchange capacity of the clay fraction is a broad guide to its mineralogy. This may be calculated for the subsoil horizons, which do not contain organic matter, using the clay percentages and cation exchange capacities for the oven-dry soil as given in Appendix I. In making this calculation it is assumed that the silt fraction does not contribute to the cation exchange capacity. In face, the silt fraction can make a significant contribution, but generally it is low.

The cation exchange capacities of the clay so calculated fall into two groups, those of the riverine plain, and those of the aeolian landscape which includes the dunes and ridges, together with the soils of the Meran association. The clays from the subsoils of the riverine plain are generally lower in exchange capacity than those from the aeolian landscape with a mean value for cation exchange capacity per 100 gm of clay of 45 (s.d. = 5, n = 48) and 58 (s.d. = 7, n = 16) respectively. Although these results are consistent with those given in other soil survey publications relating to soils in northern Victoria, this difference between the clays from the alluvial and aeolian deposits has not previously been pointed out.

In addition, X-ray diffractograms, cation exchange capacity and percentage potassium were determined on the clay fraction from a range of soils. The riverine soils are generally lower in cation exchange capacity and higher in total potassium when compared to the soils of the aeolian landscape.

All the X-ray diffractograms of the clay fraction, when saturated with magnesium followed by glcerol solvation, show strong kaolin and illite peaks, and some show well-defined montmorillonite peaks. However, it is not possible to separate the riverine and aeolian soils on this basis, because both the highly calcareous subsoils of the ridge and dune soils and the subsoils of some riverine soils show similar diffractograms. Where montmorillonite peaks are now shown, differences between the above X-ray diffractograms and X-ray diffractograms of the potassium-saturated clays indicate that randomly interstratified montomorillonite-illite is present.

SOIL RELATIONSHIPS – RELATIONSHIP TO EARLIER SURVEYS

Baldwin et al (1939) published the results of a soil survey of 54,000 acres of land in the Kerang Irrigation District which are situated within the area of the present survey. This area was inspected during the course of the soil survey published in this report, but the soil map of Baldwin et al (1939) has been reproduced with little modification.

Minor changes have been made to the boundaries between the brown phase of Macorna clay and the grey-brown phase of Kerang clay, and in the naming of the minor soil types near the Pyramid Creek. The only substantial change is concerned with the re-naming of the three phases of Tragowel clay as mapped by Baldwin et al. Resulting from the inspection of much larger survey, Tragowel clay has been defined as being identical with Tragowel clay, self-mulching phase as mapped by Baldwin et al. Most of the flooded phase of Baldwin et al has been reclassified as Box clay or Towangurr clay; and the woodland phase has been reclassified as Box Clay or type S4.

Skene (1971) has published the results of a soil survey of about 620, 500 acres of farmland and forest reserve situated in the Mid-Loddon Valley to the south of the present survey area. Soil types common to the two surveys are Coombatook sandy loam and sandy clay loam, Kerang clay, Macorna clay, Towangurr clay and Wandella clay. In this survey, the phases of Kerang clay and Macorna clay were not separated. Also, the salinity of Tragowel clay differs considerably from the present survey.

CLASSIFICATION

As originally defined by Prescott (1944) and later modified by Stephens (1961), the Torrumbarry Irrigation District lies mainly within the zone of Grey and Brown soils of Heavy Texture, but Solonized Brown Soils and Red-Brown Earths also occur. Recently, the group of Grey and Brown Soils of Heavy Texture have been re-designed as Grey, Brown and Red Clays (Stace et al 1968).

Using the criteria of Stace et al (1968) the Great Soil Group classifications of the main soil types are considered to be as follows:-

Grey clays –
Benjeroop, Box, Della, Gonn, Koroop, Kerang, Laton, Murrabit, Myall, Towangurr and Tragowell clays.

Brown and Red Clays –
Fairley, Macorna, Meran and Warra clays.

Red-Brown Earths –
Conhuna fine sandy loam, Cullen loam, Leitchville sand, and the hydromorphic variants Reedy Creek clay loam and Una loam.

Solonized Brown soils –

Soils of the M1 to M8 series, as well as Coombatook sandy loam and Coombatook sandy clay loam.

Solonchaks –

Some occurrences of Della, Fairley and Laton clays.

Sheets 1 and 2 of the Atlas of Australian Soils (Northcote 1960, 1962), using different concepts of soil classification and mapping, show the surveyed area as overlapping three landscape map units within which the soils are dominantly brown calcareous earths (GcJ), cracking clay soils (Ug5) and hard-setting loamy soils with red clayey subsoils (Dr 2). A complex soil pattern is recorded within each of these landscape units.

GENERAL INFORMATION ABOUT THE AREA – LOCATION AND GOVERNMENT CENTRES

The location and outline of the surveyed area is shown on the "Locality Plan" (Fig 1), and the "Index to soil Maps", which is in the supplement accompanying the report.

The main centre for the area is the town of Kerang (4103*) which is 176 miles by road from Melbourne. Other towns in this are Cohuna (2136*), 20 miles south-east of Kerang, and Barham – Koondrook 16 miles north-east of Kerang. Murrabit and Leitchville and hamlets, whilst Benjeroop, Gonn Crossing, Lake Charm and other localities are identified by post offices or schools.

The parishes covered by the soil maps, either wholly or in part are Benjeroop, Cohuna, Gannawarra, Gunbower, Gunbower West, Kerang, Macorna, Murrabit West and Tragowel in the Country of Gunbower, and Benjeroop, Dartagook, Koorangie, Meering and Meran in the country of Tatchera.

The five Irrigation Areas of Cohuna, Kerang, Kerang North West Lakes, Koondrook and Third Lake are the administrative divisions set by the State Rivers and Water Supply commission for the control and distribution of water in the Torrumbarry Irrigation District. They comprise part of the River Murray System. The Kerang, Kerang North West Lakes, Third Lake and Koondrook Irrigation districts are administered from Kerang, and the Cohuna Irrigation District from Cohuna.

The Department of Agriculture maintains District Offices at Kerang and Swam Hill, and carries out research on the privately-owned Kerang Agricultural Research Farm and the Swam Hill Irrigator's Research Farm, as well as on farmers' properties throughout the area.

HISTORY OF SETTLEMENT AND IRRIGATION

On June 23rd, 1836[1], when returning to Sydney from a search for the Darling River mouth, Major Thomas Mitchell camped on the bank of the Loddon river near to where Kerang is now situated. He found both Wandella and Pelican Lakes dry, and the Loddon river nearly dry. Next day, he crossed the dry Pyramid Creek and at night found an ideal park-like camping site on the Barr Creek (Mitchell though this was the Murray), he then rode to Mount Hope and decided that the party should travel further south.

The grassy, treeless plains and open woodlands soon attracted settlers, and although settlement began in 1842[1], the first lease was granted in 1845[1] to Curlewis and Campell. The boundary of their run, the Reddy Lake – Bael Bael run, included most of the country west of the Loddon River to a line running from Swam Hill to Dumosa, and from Dumosa to Boort. By 1851[1], such large runs had been subdivided into a number of smaller ones, but from 1877 onwards all leases were progressively cancelled, and the land subdivided into allotments of about 320 acres.

The first attempt at irrigation in Northern Victoria began at Kerang in the late 1870's[3], in answer to the devastating drought from 1877 - 81[3], and used water from the Loddon River. In 1884[2] a Trust Scheme, using water from the Nine Mile creek and the Loddon River, was implemented under the Water Conservation Act 1883[3], but water supplies using this scheme were unreliable. Following the Irrigation Act of 1886[3], which vested the Crown with the right to use water in any stream, lake or swamp, National State Works were authorized, and Trusts were able to carry out their schemes with money advance by the Government. The survey for the Kow Swamp National Works was begun in 1888[3], and by 1890 a design was prepared and work began.

The works comprised an intake regulator at the head of the Gunbower Creek with a direct cut into Kow Swamp, Taylors Creek and Gunbower Creek being used as far as practicable. Kow Swamp was converted into a storage basin of 33, 287 acre feet capacity, and a contour channel was built around the north-eastern perimeter of the storage basin. An earthern channel of 200 cusecs capacity, the Macorna Main, was constructed from Kow Swamp to a point on the Loddon River 12 miles south of Kerang. It was the intention to draw water from the contour channel into the Macorna channel in the winter, and in the summer to draw storage water directly from Kow Swamp. These works were completed in 1896[4] and in 1900[4] the storage capacity of Kow Swamp was increased to 40, 863 acre feet. This increase the commanded area and improved the district reticulation services of the Trusts concerned.

* Population 1971 Census.

However, because water was still limited be seasonal conditions, the Cohuna and Gannawarra Irrigation Trusts installed steam pumps on the Murray River near Gunbower. Another tow pumps were installed just north of Koondrook.

The State Rivers and Water Supply commission was constituted in 1905, and all Irrigation Trusts except Mildura were abolished. By 1910[4], new pumping units were installed but no major changes were made until 1923[4] when the Torrumbarry Weir was completed, and water disturbed utilizing the Pyramid Creek and a chain of lakes north-west of Kerang. These lakes were also used in the early Trust days when water was diverted from the Loddon River using a weir just downstream fro Kerang.

No further major changes were made to the Torrumbarry system until the 1960's when the Kerang remodelling works were undertaken in 1963. These works involved improving the carrying capacity of the channel into Reedy Lake and Middle Lake, and bypassing Third Lake with a contour channel directly into Lake Charm, and Racecourse and Kangaroo Lakes. Additional works were also carried out in the Mystic Park Irrigation Area which is administered from Swan Hill.

In 1967 work began on dredging a deeper channel in the Pyramid Creek. This work, completed in 1971, was undertaken to reduce water loss through evaporation and seepage.

HISTORY OF DRAINAGE AND SALINITY

There has been a loss of productivity in the area caused by soil salinity which is linked with the general rise of the saline watertables. When irrigation began the watertables were 20 to 30 feet below the surface, but by 1900 salty water was only 10 feet below the surface at Tragowel. Today, most of the area surveyed has water tables within 6 feet of the surface.

Signs of salinity were found in the Cohuna area at the beginning of this century. This area had received more water than any other area, and since 1908 much of this had been concentrated in a area of almost 12, 000 acres acquired by the State Rivers and Water Supply Commission and divided into blocks of about 80 acres for closer settlement. The salt-affected area increased from 200 acres in 1911 to nearly 1, 00 acres in 1914. Rudimentary surface drainage involving about 9 miles of drains was installed, and although farmers were cautioned about using excessive water, this advice was of no help to farmers whose land was already salted.

First indications of salinity in the Kerang Irrigation Area appeared along the Macorna channel soon after its opening in 1896, and the trouble spread rapidly northwards. In the Lower Loddon area, north of Kerang, crops failed due to salinity in 1908. After the completion of the Torrumbarry weir in 1923 water was cheap, unmeasured and unrestricted. As this water use continued unchecked until a system of surface drains was excavated over the period 1934 – 36. Large open lines of the Nine Mile, Calivil and Piccaninny Creeks south of the Pyramid Creek, and a number of large open drains north of the Pyramid Creek and east of the Loddon River were also excavated. This system of drains functions reasonably well, and outfalls into the Barr Creek which is the main collector drain.

The Barr Creek receives drainage water from most of the Mid-Loddon Valley east of the Loddon River, and almost all of the drainage water from the area covered by this survey. The drainage water consists of irrigation surpluses, rainwater, irrigation run off, ground water seepage, and some effluent from dewatering pumps and sub-artesion discharges.

The effect of the Barr Creek on the salinity of the River Murray has long concerned the towns and irrigators further downstream, and especially the City of Adelaide. In 1967 the State Rivers and Water Supply commission allowed extra water to be released at the Kerang Weir on the Loddon River. Although this diluted the salt concentration in the Murray River, the need to prevent such waters from entering the river was recognized.

In 1967[5], an investigation into the salinity of the River Murray was commissioned by the River Murray Commission. Within the terms of reference the consultants, Gutheridge, Haskins and Davey, in association with Hunting Technical Services Limited, were required to recommend the tolerable levels of salinity and to recommend action needed for its control.

It was found that the Barr Creek made a considerable addition to the salt load in the Murray River, estimated at about 180, 00 tons per year. In a normal year typified by July 1966 to June 1967 about a third of the salt load passing Mildura originates from the Barr Creek, and a third from the Loddon River. The remainder enters the Murray downstream from the Loddon-Murray junction. In a drought period, typified by October 1967 to April

1968, about 25 percent originates from the Barr Creek. About two thirds of this salt load is derived from groundwater flow together with sudden peaks of salinity in flows following rain. These peaks are largely due to the flushing of shallow water courses which, being lower in the landscape, accumulate salt between rains.

During 1967 – 71 further drainage works were undertake, so that water above a certain level in salt content could be pumped from Barr Creek into Lake Tutchewop, and ephemeral lake of 2, 000 acres area. Ultimately, drainage surpluses from Lake Tutchewop may be pumped to Lake Tyrell, some 60 miles tot he west.

The references used in compiling this section are as follows and are indicated by the specified numbers in the text.

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CLIMATE

The Torrumbarry Irrigation District is almost uniform climatically, and the data for Kerang (Table 6) are typical of the area. At Kerang the average annual rainfall is 14.2 inches, compared with 14.4 inches at Cohuna to the south east, and 14.0 inches at Benjeroop to the north. Considerable variations in monthly and yearly rainfall occur over the district, and are due mainly to summer storms.

The rainfall data are given as percentile figures as well as averages. These percentile figures give a somewhat better idea of rainfall expectancy than the average figures, which may be unduly influenced by occasional very high low figures. The 50 percentile figure means that the chance of the rainfall being less than this figure is 10 per cent with a 90 per cent chance of it being more. The yearly percentile figure refers to the chance that a year will have a total rainfall less than the given figure, and is not the sum of the monthly percentile figures.

A comparison between the 50 percentile figures and the average monthly figures shows that the summer and autumn rainfall is more erratic than the rainfall in winter and spring. The average annual monthly values for Kerang show that the winter rainfall is only slightly higher than the summer rainfall, 7.85 inches falling on the average in the months April to September, and 6.37 inches in October to March.

Monthly mean temperatures range form 8.8º C in July and 23.0º C in February. Severe frosts (screen temperatures below 0º C) may be expected about 8 times annually, and light frosts (Screen temperatures between 0º C and 2.2 º C) and about 21 times a year. Frosts occur mainly in the period May to October, earlier and later occurrences being rare.

At temperatures below 10º C plant growth is severely retarded. In the Kerang district such low temperature conditions occur in June and July, which coincides with the most favourable rainfall conditions.

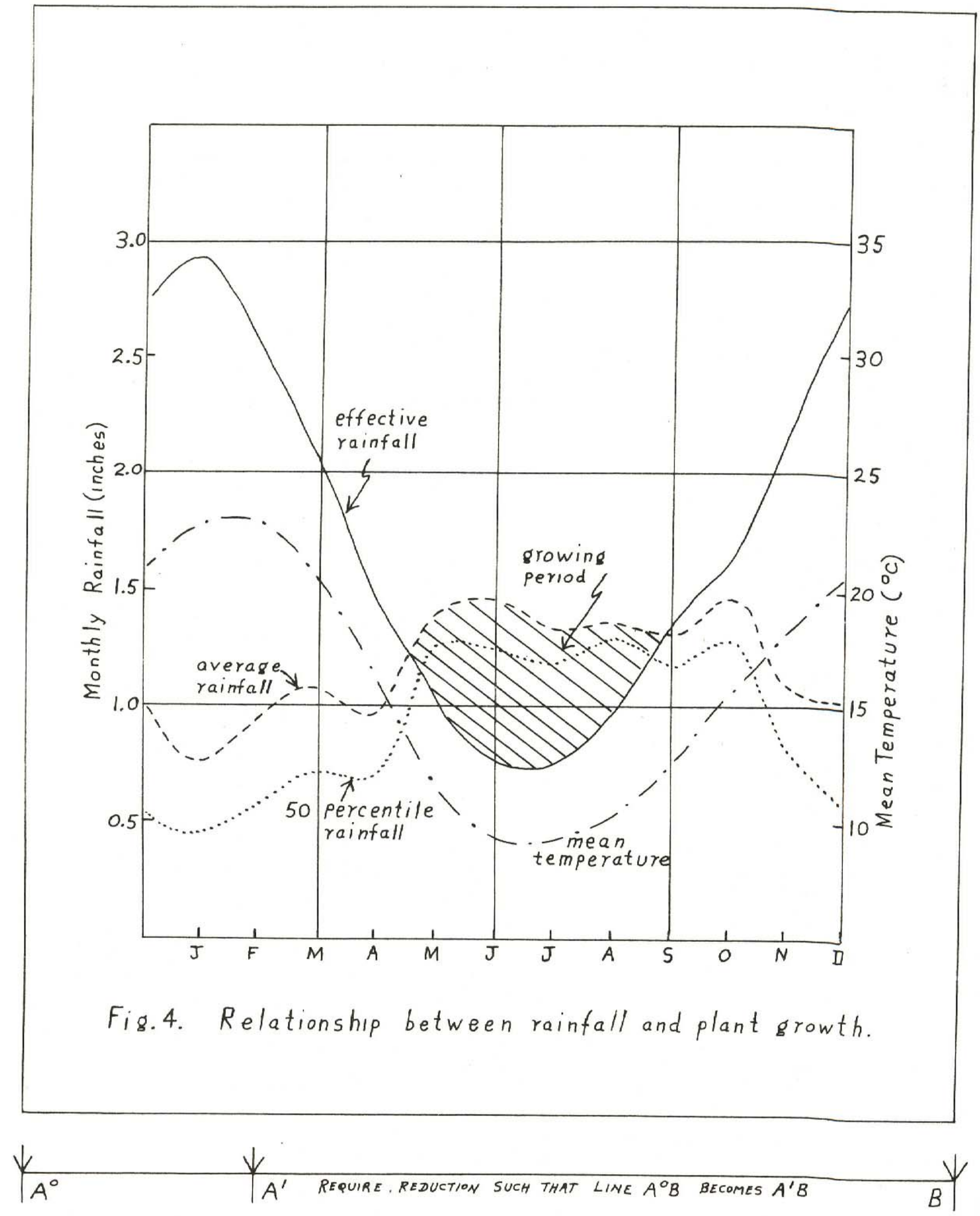

Fig 4 – Relationship between rainfall and plant growth

*Table 6 – Climatic Data For Kerang. **

Month	Rainfall (88 years)				Tank Evaporation	Change of Effective Rainfall	Average Daily Temperature (9 years)			Total Incident Radiation
	Average	Percentiles								
		10	50	90			Max.	Min.	Mean	
	inches	inches	inches	inches	inches	%	° C	° C	° C	Cal. cm^{-2} day^{-1}
January	0.77	0.00	0.45	1.98	9.6	less than 10	31.3	14.5	22.9	665
February	0.95	0.00	0.56	2.52	7.9	10 – 20	30.9	15.2	23.0	590
March	1.09	0.02	0.72	2.78	6.0	10 – 20	27.9	13.2	20.5	480
April	0.98	0.07	0.68	2.16	3.7	20 – 30	23.0	9.5	16.3	350
May	1.42	0.25	1.29	2.87	2.3	60 – 70	17.2	6.9	12.0	240
June	1.46	0.45	1.25	2.48	1.6	70 – 80	14.6	4.6	9.6	200
July	1.32	0.42	1.17	2.49	1.5	70 – 80	13.6	3.9	8.8	225
August	1.36	0.53	1.32	2.57	2.2	60 – 70	15.5	5.0	10.3	290
September	1.31	0.34	1.18	2.53	3.4	40 – 50	18.3	6.5	12.4	405
October	1.48	0.31	1.29	3.01	4.3	30 – 40	22.7	8.9	15.8	510
November	1.05	0.11	0.81	3.23	6.4	10 – 20	25.9	10.6	18.3	620
December	1.03	0.08	0.56	2.38	8.6	less than 10	28.8	13.2	21.0	665
Year	14.22	9.29	14.32	18.69	57.5		22.5	9.4	15.9	435

* Commonwealth Bureau of Meteorology; Evaporation from Maps, Review of Australia's Water Resources, 1966.

From monthly figures (Table 6), the so-called effective rainfall can be obtained approximately using a formula developed by Prescott (1949). According to this formula the effective rainfall is the amount of rain which must fall in any month before plant growth can persist, and the formula relates the effective rainfall to the nett evaporation occurring from a free water surface during the month concerned. The formula is as follows:

$P = K \times E^{0.75}$

where P is the monthly rainfall required,
E is the monthly evaporation from a free water surface,
and K is a constant depending on the nature of the soil and the plant species concerned.

For shallow-rooted pasture species the value for K is usually taken as 0.54. The chance of receiving the effective rainfall is given in Table 6.

Figure 4 shows that the average rainfall exceeds the effective rainfall from mid-May to the end of August. Thus, the natural rainfall provides, on the average, enough moisture to give pasture plants between four and five months growth each year. These figures assume optimum distribution of rain, and are the minimum moisture requirements for shallow rooting pasture plants. However, the use of average figures can be misleading, because surplus rain in wet months may be of benefit in subsequent months, but cannot be beneficial in the following year. Also, during the winter months, when moisture supplies are generally adequate, low solar radiation and low temperatures place major restrictions on plant growth.

Irrigation is the usual method in this district of extending the growing period. In irrigated pasture the water requirement is ultimately dependent on solar radiation. This radiation has a direct influence on temperature, plant growth and evapo-transpiration from the plant leaves. The evapo-transpiration rate is also affected by wind velocity and humidity.

Using estimates of the evapo-transpiration rate and the leaching requirement, the irrigation requirement and frequency can be calculated from month to month. In the Kerang District the total annual irrigation requirement (not including rainfall) for permanent pastures is estimated at 36.0 inches, and for annual pastures at 11.5 inches.

GEOLOGY AND GEOMORPHOLOGY

The Torrumbarry Irrigation district lies within the vast Murray Basin, a large shallow basin of tectonic origin. The basin is filled with Tertiary and Quaternary sediments resting unconformably on a basement of highly deformed sedimentary and crystalline rocks, mainly of Paleozoic age.

The stratigraphy of these sediments has been studied extensively, and an exhaustive review of the literature is given by Gutteridge et al (1970). Bores sunk by the Mines Department show a considerable thickness of sediments over the Torrumbarry Irrigation District, and below the Kerang Agricultural Research Farm the basement rocks are encountered at about 600 feet. Basement rocks outcrop about 30 to 40 miles beyond the southern limits of the area and rise gradually to form the Central Highlands. However, the northern parts of the Terrick Terrick Range, a granite monadnock, occur less than 10 miles to the south. At Pyramid hill the granite is 340 feet above the plain level.

The oldest Tertiary sediments are the Eocene to Oligocene sediments of the Knight Group. These are described as carbonaceous clays, silts and sands and extend over almost all of the Murray Basin (Lawrence, 1966). In at least as fas as Swam Hill. Towards the end of the Tertiary the sea began to retreat. Following retreat of the sea, extensive littoral sediments were exposed, and under prevailing westerly winds and alternating wetter and drier cycles, the sediments were rearranged as relatively high stranded beach ridges and as east-west aligned seif dunes. This broadly is the aeolian running approximately north-west, marks the western limits of the Riverine block (Macumber, 1969). There is therefore a distinct physiographic separation between the Riverine Plain to the east and the Mallee in the west. The Riverine Plain of south-eastern Australia is described in detail by Butler *et al* (1973) and a geomorphic map of the area is presented.

The aeolian landform is comprised of a succession of depositional layers marking cycles of stable and unstable periods in the history of the landscape (Churchward, 1961; 1963a, 1963b; Skene and Sargent, 1966). The resulting soil profiles are variable and broadly related to landscape position.

Other important physiographic features are lake-lunette systems, mainly found in the north-western part of the surveyed area. The crescentic ridges (or lunettes) are formed from material blown from the dry lake beds, and vary from a few feet to over 100 feet in height. The lakes are considered to have developed as terminal basins during the final stages of prior stream activity. Macumber (1970) has proposed that some lake-lunette systems were created by deflation of salt-affected areas, and Lawrence (1971) has suggested the origin of lakes with saline water as points of ground water discharge.

Alluvial sediments fill the Murray Basin eastwards of the limits of the Murravian Gulf. These comprise sands, silts and clays laid down during a long period, from the Oligocene to the Recent. Geological evidence suggests that in the Late Tertiary rivers were flowing from the central and eastern highlands and had high discharges and considerable be loads, with sizeable sand and gravel fractions. In this way the deep lead systems were formed as described by Macumber (1968), who has traced the Loddoon deep lead as far north as the Kerang Research Farm.

The Riverine Plain within the Torrumbarry Irrigation District is comprised of sediments from two different stream systems – the Loddon system and the Murray–Goulbourn system. South of the Pyramid Creek the Riverine Plain is formed mainly from sediments of the Loddon system, and the area constitutes a zone of terminal deposition, with practically no aquifers. This area is generally referred to as the Tragowel clay plains. North of the Pyramid Creek the sediments are predominantly those of the Murray-Goulbourn system, although the lithology of the sediments of the treeless plain north of the Pyramid Creek is very similar to that of the sediments of the Tragowel Plains.

An elaborate braided system of non-functional, or prior streams traverses the Riverine Plain in a north-westerly direction from Kow Swamp. Usually the slightly raised levees of the prior streams and their high level channels are recognisable features of the landscape, but in some cases the stream courses have been obliterated. The pyramid Creek downstream from Johnson's Swamp broadly follows the course of one of these prior streams, and north of Kerang, the Loddon follows the same course. Pels (1964) proposed the concept of ancestral rivers for non-functional stream courses with belts of sediment below the level of the plain, and the above prior stream fits this concept. The shallow sand beds delineated by Garland and Jones (1963) are generally related to this prior stream system.

Much of the black box landscape unit north of Pyramid reek comprises the far flood plain sediments of the prior streams, but these are generally covered by later sediments which become thicker towards the Pyramid reek and the Loddon River, where they also cover some levee and near-plain sediments from the prior streams.

The sediments of which the soils of the red gum landscape unit are formed are also older than the prior stream sediments. The youngest soils are also found on this landscape unit, namely the soils of the Gunbower Suite and Types 1 and 2.

The soils of the treeless plain towards the extreme west of the Torrumbarry Irrigation District have high coarse sand and low silt fractions, as well as more lime than the typical soils of the Riverine Plain. The sediments from which these soils are formed are largely aeolian.

Using data from the State Rivers and Water Supply commission , Gutteridge et al (1970) have shown that the fluctuations in water-tables are seasonal and that over the drought period 1967/68 a dramatic drop in watertables occurred over the whole district. The reverse probably occurred following excessive rains in 1956, and did occur over the 1973/74 period. Although individual farmers can assist by minimising additions to the ground water by careful irrigation practices, such as large fluctuations in the watertables and resultant salinity problems are outside the irrigators control.

An understanding of the groundwater and salinity problems of the Torrumbarry irrigation District can only be achieved by detailed investigations of the whole depositional pattern and groundwater hydrology. Currently, most investigations into the deeper depositional layers are being made by the Mines Department.

VEGETATION

The landscape units described earlier originally carried their own distinctive vegetation. However, this has been greatly modified by agricultural practices and now only remnants remain.

The treeless plain landscape was mostly grassland with some black box (*Eucalyptus largiflorens*) in the depressions, with increasing amounts – south-west of Kerang. There, the remifying depressions occupy one third of the area, and an overall impression of a woodland still remains. Dillon bush (*Njitraria schoberi*) occurred on the treeless plain, with lignum (*Muehlenbeckia cunninhamii*) in swampy depressions. The ground cover was probably of various wallaby and spear grasses (*Danthonia and Stipa spp.*), growing in widely separated tussocks, interspersed with various salt bush species and many small patches of pigface (*Mesembryanthemum aequilaterale*). The earliest sheep and cattle grazing quickly produced a closer sward, including introduced grasses and herbs, and the district pastures became famous for their productivity.

Firstly cereal cropping, and, after 1890, irrigation, caused further drastic changes, good irrigated pastures alternating with patches of bare ground, and swamp and salt-tolerant plant communities. This phase saw the dominance of barely grass (*Hordeum marinum*) with increased amounts of dillon bush on both dry and wetter areas. Saline swampy areas carried lignum and samphire (*Salicornia australis*) and sea barely grass (*Hordeum* *hystrix*). Pasture species during this phase included Wimmera ryegrass (*Lotium rigidum*), windmill grass (*Chloris truncata*), umbrella grass (*Chloris acicularis*), blowngrass (*Agrostis avenacea*) wholly clover (*Trifolium tormentosum*) and burr trefoil (*Medicago hispida*).

The shrub woodland of the prior streams had large areas dominated by black box, with some occurrences of paperbark (*Melaleuca pubescens*), locally known as tea-tree. On the drier rises, oil mallee (*Eucalyptus oleosa*), sandalwood (*Myoporum platycarpum*), Murray pine (*Callitris preissii*) and probably belar (*Casuarina lepidophloia*) occurred, with some acacias, hakeas and cassias. Little is known of the former ground cover.

The black box woodland was originally a dense woodland with lignum in the ramifying depression lines and occasional swamps.

Red gum (*Eucalyptus camaldulensis*) dominated both the red gum forest near the major rivers, and the more extensive red gum woodland on slightly higher ground. Small, seasonally-waterlogged areas near the river carried can grass (*Pragmites communis*) and nardoo (*Marsilea drummondii*). Fruiting bodies on the nardoo were ground into a flour by the aboriginals. The original boundaries separating the red gum woodland the red gum forest are difficult to draw. Irrigation is known to have extended the province of both red gum and black box where salinity is low, but where high, tree have been killed.

The non-riverine landscape comprises dunes, ridges, and both sandy and clayey lunettes. On the dunes and ridges the dominant tree cover was oil mallee species, belar, needlewood (*Hakea vittata*) and cattle bush (*Heterodendron oleifolium*), with paper bark and black box on the wetter fringes. The sandier lunettes carried similar vegetation on the ridges, whereas the lunettes with clayey or shallow surface soils were probably treeless.

The present plant cover everywhere in the surveyed area variously reflects the hand of a man. Much of the area now receives water from irrigation and carries sown pastures. These are either annual pastures of subterranean clover (*Trifolium subterranean*) and Wimmera rye grass (*Lolium rigidum*), or perennial pastures based on rye grass (*Lilium perenne*), white clover (*Trifolium repens*) and strawberry clover (*Trifolium fragiferum*), Paspalum (*Paspalum dilatum*) soon appears in most perennial pastures and often becomes the dominant species. Birdsfoot fenugreek (*Trigonella ornithopodioides*) is becoming important in situations prone to waterlogging. Black rush (*Juncus polyanthemus*) and docks *(Rumes spp.*) are weeds widespread in perennial pastures, with annual beard grass (*Polypogon monspeliensis*) of lesser importance. Weaker annual pastures may be invaded by barely grass, windmill grass, umbrella grass and various clovers and medics.

In very saline areas the common halophytic species include dillon bush, seablite (*Suaeda maritima*), samphire (*Crithumum maritimum*), various saltbushes (*Atriplex spp.*) and pig face. Sea barely grass (*Hordeum hystrix*) grows on moderately salt-affected soils.

Cumbungi (*Typha spp.*) and canegrass form tall, dense stands in irrigation channels and drains. Other water weeds which present a continual threat to efficient water distribution are water couch (*Paspalum distichum*), eel weed (*Vallisneria spiralis*) and cat tail (*Myriophylum elatinoides*). Formerly, these weeds were controlled using manual and mechanical methods, but the increasing use of chemical methods, notably preparations containing acrolein, are greatly reducing the channel cleaning costs, and are keeping the channels weed-free for linger periods.

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Appendix 1 – Analytical Data For Representative Profiles

SYMBOLS USED: S, sand; LS, loamy sand; SL, sandy loam; SCL, sandy clay loam; SC, sandy clay; FS, fine sand; LFS, loamy fine sand; FSL, fine sandy loam; FSCL, fine sandy clay loam; FSC, fine sandy clay; VFSL, very fine sandy loam; VFSCL, very fine sandy clay loam; VFSC, very fine sandy clay; L, loam; CL, clay loam; LC, light clay; MC, medium clay; HC, heavy clay; EC, electrical conductivity. A blank space indicates that the analyses has not been done; a dish indicates that only a trace or none of the constituent was present.

Analyses are based on the oven-dry weight of soil.

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
BOX CLAY: PROFILE 17 – MAP 5																									
0-5	MC	7.8	16.9	-	1	23	17	56	2.6	0.04	0.02	0.12	1.09	4.7	17	9.6	36	9.3	34	1.3	5	2.2	8	27.1	23175
5-12	HC	8.6	20.2	-	1	16	15	66	2.2	0.08	0.04	0.06	0.51	3.5	10	12.6	37	12.9	38	1.3	4	3.6	11	33.9	23176
12-17	HC	9.1		-	-	16	16	65	2.9	0.15	0.06														23177
17-30	HC	9.2		-	-	16	19	62	3.6	0.30	0.14			0.9	3	8.5	28	12.8	42	1.1	4	7.0	23	30.3	23178
30-38	HC	9.1		-	-	17	20	60	3.2	0.42	0.21														23179
38-48	HC	8.5		-	-	18	20	61	2.1	0.44	0.25			1.9	6	8.7	29	11.9	39	0.8	3	7.1	23	30.4	23180
50-70	MC	7.9				25	26	48	1.8	0.52	0.31			2.5	10	6.8	27	9.9	38	0.7	3	5.5	22	25.4	23181
70-88	LC	7.4		-	-	23	38	39	1.6	0.61	0.40														23183
BOX CLAY: PROFILE 57 – MAP 16																									
0-4	MC	8.1	18.7	-	2	25	19	48	3.4	0.84	0.62	0.17	1.83	1.0	3	9.3	32	13.8	46	1.3	4	4.4	15	29.8	5530
4-12	HC	8.6	18.0	-	1	21	18	53	6.2	0.66	0.40	0.07	0.47	2.4	8	8.9	29	12.8	42	1.1	4	5.3	17	30.5	5531
12-26	HC	8.5		-	-	21	19	55	4.4	0.69	0.40			0.8	3	5.8	24	12.6	51	0.8	3	4.6	19	24.6	5532
26-42	HC	7.9		-	-	22	19	55	3.4	1.00	0.34														5533
42-56	HC	7.3		-	-	20	17	59	2.5	0.67	0.40			4.5	15	7.0	22	12.3	39	0.7	2	6.9	22	31.4	5534
56-84	HC	5.7		-	-	18	16	64	2.3	0.66	0.51														5535
BOX CLAY: PROFILE 62 – MAP 19																									
0-3	MC	8.0	20.0	-	1	12	19	59	4.3	0.30	0.17	0.25	3.04	2.1	7	13.8	43	10.9	34	1.7	5	3.4	11	31.9	20322
3-10	HC	7.7	14.8	-	2	21	27	46	2.7	0.22	0.15	0.12	1.62	2.6	11	10.0	42	7.9	33	1.3	6	1.9	8	23.7	20323

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
PROFILE 62 – MAP 19 *continued…*																									
10-20	HC	8.5		-	-	15	21	59	6.4	0.40	0.25			-	-	11.8	45	10.4	39	0.9	3	3.4	13	26.5	20324
20-30	HC	8.5		-	-	12	21	63	4.2	0.48	0.30			-	-	7.4	29	12.3	49	0.9	4	4.6	18	25.5	20325
30-54	HC	8.4		-	-	14	24	60	2.8	0.48	0.31			0.9	4	6.3	26	11.6	47	0.6	2	5.2	21	24.6	20326
54-72	HC	6.3		-	-	17	24	58	2.0	0.48	0.34			4.7	18	4.0	15	10.3	40	0.4	2	6.6	25	26.0	20327
BOX CLAY, LIGHT DEEP SUBSOIL VARIANT: PROFILE 22 – MAP 7																									
0-2	LC	7.5	17.5	-	6	16	27	45	2.6	0.15	0.10	0.30	3.67	5.2	19	9.0	32	11.3	40	0.7	3	1.8	6	28.0	23143
2-4	LC	8.1	11.3	-	4	26	35	33	1.7	0.13	0.09	0.13	1.72	3.0	15	6.8	34	7.6	37	0.6	3	2.3	11	20.3	23144
4-10	MC	8.4		-	1	16	26	59	1.9	0.19	0.12														23145
10-15	MC	8.3		-	-	15	27	57	2.1	0.27	0.16														23146
15-22	MC	8.2		-	-	17	33	50	1.8	0.29	0.18														23147
22-36	LC	7.1		-	-	24	35	47	1.7	0.39	0.28			4.4	24	2.9	16	7.6	42	0.3	2	3.0	16	18.2	23148
36-43	MC	5.1		-	-	19	24	57	1.6	0.65	0.46														23149
43-56	MC	4.9		-	-	18	24	58	1.8	0.75	0.35														23150
56-68	MC	5.3		-	1	21	19	58	1.9	0.79	0.60														23151
68-75	MC	6.4			1	22	21	54	2.2	0.82	0.63														23152
75-84	MC	6.9			2	23	14	59	2.6	1.05	0.8														23153
COHUNA FINE SANDY LOAM: PROFILE 18 – MAP 6																									
0-1	FSL	6.5	8.6	-	11	17	29	26	2.4	0.11	0.04														23267
1-4	FSL	7.0	15.5	-	22	31	37	27	1.3	0.04	0.02	0.14	1.26	3.6	28	3.9	30	3.2	25	1.2	9	1.0	8	12.9	23268
4-14	MC	8.4		-	1	20	35	42	1.3	0.14	0.08	0.10	0.68	1.8	10	5.7	30	7.2	38	0.7	4	3.4	18	18.8	23269
14-24	FSCL	9.7		-	-	26	48	24	2.2	0.26	0.12			-	-	3.2	29	5.7	51	0.1	1	2.2	19	11.2	23270
24-38	CL	9.2		-	1	19	46	32	1.4	0.15	0.11			1.1	7	3.1	20	6.6	42	0.4	3	4.4	28	15.6	23271
38-53	FSCL	8.9		-	1	22	43	32	1.5	0.11	0.07			1.1	8	4.2	31	6.6	48	0.1	1	1.7	12	13.7	23272
53-62	LC	8.9		-	-	19	29	50	1.6	0.14	0.07														23273
62-76	LC	8.8		-	-	21	41	36	1.3	0.14	0.08														23274

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
COHUNA FINE SANDY LOAM: PROFILE 59 – MAP 19																									
0-1	VFSL	6.0		-						0.10	0.06	0.68	7.33												5495
1-7	VFSL	6.1	4.8	-	2	63	20	14	1.0	0.07	0.04	0.14	1.29	4.5	52	2.1	25	1.4	16	0.2	2	0.4	5	8.6	5496
7-14	LC	7.5	9.9	-	1	51	16	31	1.1	0.05	0.01			2.2	16	6.6	48	3.6	26	0.8	6	0.5	4	13.7	5497
14-17½	FSCL	8.5		-	1	56	18	19	4.7	0.15	0.06														5498
17½-24	FSCL	9.1		-	-	56	19	20	4.7	0.11	0.03														5499
24-37	VFSL	9.2		-	-	62	18	17	1.4	0.11	0.04			-	-	3.0	42	2.8	39	0.1	1	1.3	18	7.2	5500
37-41	LFS	9.0		-						0.11	0.04														
41-63	VFSL	8.7		-	-	50	30	19	1.2	0.07	0.03														
70-80	CL	8.7		-						0.04	0.02														
80-86	LC	8.6		-	-	12	43	42	1.8	0.04	0.02														
COHUNA FINE SANDY LOAM: PROFILE 61 – MAP 19																									
0-8	FSL	6.9	11.6	-	5	29	34	29	2.3	0.05	0.01	0.24	2.47	0.5	5	5.6	52	3.4	32	0.3	3	0.9	8	10.7	20342
8-15	LC	7.9	13.8	-	1	18	37	42	2.6	0.06	0.03	0.11	0.86	3.5	19	5.9	31	7.0	37	0.4	2	2.0	11	18.8	20343
15-24	LC	8.9		-	-	15	41	41	4.2	0.15	0.02			-	-	5.2	32	6.7	41	0.3	2	4.0	25	16.2	20344
24-31	VFSC	8.8		-	-	23	40	35	2.1	0.20	0.02			-	-	4.6	32	5.1	36	0.3	2	4.3	30	14.3	20345
31-46	FSCL	8.3		-	1	46	25	27	4.5	0.25	0.02			0.4	3	4.6	39	3.8	33	0.2	2	2.7	23	11.7	20346
46-64	FSL	8.0		-	-	48	28	24	1.1	0.05	0.01			1.4	14	5.6	56	2.1	21	0.2	2	0.7	7	10.0	20347
64-84	FSC	7.8		-	-	13	41	44	1.7	0.05	0.01			3.6	20	10.2	58	2.2	13	0.3	2	1.2	7	17.5	20348
COOMBATOOK SANDY LOAM: PROFILE 44 – MAP 13																									
0-3½	FSL	8.4	9.0	-	18	48	8	21	3.5	0.04	0.01	0.15	1.74	0.5	3	11.0	67	2.3	14	2.3	14	0.2	2	16.3	26479
3½-8	SL	8.8	4.6	-	28	53	4	13	2.4	0.03	-	0.05	0.76	0.6	6	6.4	68	1.2	13	1.0	11	0.2	2	9.4	26480
8-18	SC	9.0	15.2	-	27	37	4	30	2.4	0.05	0.01			-	-	9.4	53	6.2	35	1.3		1.0	6	17.9	26481
18-26	MC	9.5		8.8	19	30	7	35	8.1	0.11	0.02			-	-	6.6	33	10.1	51	1.0		2.1	11	19.8	26482
26-40	MC	9.7		-	17	33	6	33	10.6	0.22	0.10														26483
40-48	MC	9.7		0.9	17	32	8	31	11.6	0.29	0.15			-	-	4.4	20	9.4	44	1.1		6.7	31	21.6	26484

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
PROFILE 44 – MAP 13 *continued…*																									
48-63	MC	9.8		-	18	32	9	31	10.6	0.36	0.18														26485
63-72	MC	9.8		0.8	26	33	7	27	7.3	0.34	0.17														26486
72-84	SC	9.6		-	22	29	9	36	4.7	0.41	0.11														26487
MYALL CLAY: PROFILE 42 – MAP 12																									
0-4	MC	7.0	18.8	-	2	10	23	62	2.4	0.06	0.03	0.13	1.30	7.8	23	10.8	34	11.1	33	0.9	3	2.4	7	33.0	5540
4-12	HC	7.4	19.0	-	1	10	23	64	2.3	0.08	0.05	0.07	0.55	6.1	18	10.2	30	12.8	38	0.7	2	4.1	12	33.9	5541
12-24	HC	8.6		-	-	10	23	63	3.1	0.31	0.21			3.1	11	7.3	25	13.9	48	0.5	2	3.9	14	28.7	5542
24-46	HC	8.8		-	-	11	22	65	3.8	0.46	0.28			1.8	7	6.2	23	14.0	52	0.6	2	4.2	16	26.8	5543
46-54	MC	8.7		-	-	11	21	65	2.5	0.39	0.26			1.7	5	8.4	29	13.9	48	0.6	2	4.6	16	29.2	5544
54-64	MC	8.5		-	1	14	18	65	2.2	0.35	0.23														5545
64-72	MC	8.9		-	1	16	15	65	3.1	0.36	0.20														5546
72-84	MC	9.0		-	1	17	13	65	4.1	0.37	0.20														5547
MYALL CLAY: PROFILE 43 – MAP 12																									
0-5	MC	6.9	15.2	-	1	15	23	57	2.3	0.04	0.03	0.11	1.17	8.4	28	8.9	30	9.7	34	0.6	2	1.9	6	29.5	5536
5-12	HC	6.5	17.6	-	1	16	23	58	1.9	0.06	0.04	0.08	0.64	9.4	32	7.0	24	9.0	31	0.4	2	3.2	11	29.0	5537
12-28	HC	6.4			1	16	23	59	2.1	0.25	0.18			6.7	22	8.9	30	9.8	33	0.4	2	4.0	13	29.8	5538
28-40	HC	7.5			1	17	25	55	2.3	0.37	0.26			3.2	11	8.9	31	11.2	40	0.5	2	4.5	16	28.3	5539
REEDY CREEK CLAY LOAM: PROFILE 27 – MAP 8																									
0-3	CL	7.0	10.1	-	1	34	29	29	1.3	0.02	0.01	0.15	1.61	5.4	35	4.9	32	3.8	25	0.4	3	0.8	5	15.3	23131
3-12	HC	7.8	17.5	-	-	17	23	57	1.6	0.05	0.03	0.11	0.76	5.1	22	7.3	30	8.4	35	0.7	3	2.5	10	24.0	23132
12-18	MC	8.2		-	-	18	25	55	0.5	0.11	0.06														23133
18-24	MC	8.5		-	-	27	24	45	2.5	0.17	0.09														23134
24-33	LC	8.5		-	-	34	22	44	1.3	0.15	0.08														23135
33-43	FSCL	8.4		-	-	45	21	33	1.0	0.09	0.06														23136
43-56	FSCL	8.2		-	1	53	17	29	0.9	0.10	0.06														23137
56-62	CL	7.1		-	-	23	40	36	0.9	0.23	0.16														23138

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
PROFILE 27 – MAP 8 *continued…*																									
62-78	MC	5.9		-	-	12	24	62	1.2	0.39	0.26														23139
78-88	MC	5.6		-	-	15	22	62	1.4	0.47	0.32														23140
REEDY CREEK CLAY LOAM: PROFILE 63 – MAP 20																									
0-5	CL	7.1	10.7	-	1	16	46	33	1.7	0.22	0.13	0.14	1.29	3.7	29	3.4	27	4.4	36	0.3	2	0.8	6	12.6	5507
5-10	MC	8.2	16.9	-	-	11	35	53	2.1	0.44	0.25	0.14	0.87	3.1	16	4.4	23	7.2	38	0.4	2	4.1	21	19.2	5508
10-24	LC	8.8		-	-	10	45	43	2.4	0.56	0.34			1.4	9	3.1	20	6.5	41	0.3	2	4.6	28	16.0	5509
24-36	LC	8.0		-	-	13	46	39	1.8	0.44	0.28			1.5	10	3.1	21	6.8	44	0.2	1	3.8	24	15.4	5510
36-48	LC	7.6		-	-	15	46	36	1.9	0.42	0.28														5511
48-63	LC	7.6		-	-	19	44	36	2.0	0.45	0.29			2.0	12	3.8	22	6.6	39	0.1	1	4.6	26	17.1	5512
63-84	LC	7.5		-	-	24	36	38	1.9	0.44	0.30														5513
SANDMOUNT SAND: PROFILE 39 - MAP 12																									
0-5	LFS	6.8	2.8	-	4	83	4	7	0.6	0.02	0.01	0.05	0.45	1.4	33	1.7	41	0.6	14	0.4	10	0.1	2	4.2	5475
5-8	LFS	6.5	2.9	-	4	83	4	8	0.6	0.02	0.01	0.04	0.35	1.3	33	1.5	39	0.6	15	0.4	10	0.1	3	3.9	5476
8-22	LFS	7.0		-	2	83	4	9	0.6	0.02	0.01			0.9	21	2.4	56	0.6	14	0.3	7	0.1	2	4.3	5477
22-60	LFS	7.5		-	3	82	4	9	0.5	0.02	0.01			0.7	17	2.4	57	0.9	22	0.1	2	0.1	2	4.2	5478
60-84	FS	7.8		-	4	80	4	10	0.5	0.02	0.01			0.6	14	2.5	57	1.1	25	0.1	2	0.1	2	4.4	5479
TOWANGURR CLAY: PROFILE 70 – MAP 14																									
0-3½	HC	6.8	22.4	-	4	20	13	58	4.9	1.26	1.08	0.19	2.21	3.7	18	12.8	35	14.0	39	1.3	4	1.5	4	36.3	32281
3½-12	HC	7.5	22.3	-	2	18	10	66	4.3	1.67	1.49	0.07	0.70	3.6	9	13.1	31	19.4	46	1.4	3	4.4	11	41.9	32283
12-15	HC	8.0		-	2	17	11	65	5.0	1.77	1.53														32283
15-24	HC	8.0		-	2	18	11	65	5.1	1.83	1.46			1.5	4	12.4	31	20.3	50	1.1	3	5.0	12	40.3	32284
24-42	HC	8.0		-	2	18	12	64	4.6	1.2	1.47														32285
42-48	HC	7.8		-	2	20	14	62	4.4	1.81	1.26			2.4	6	10.2	27	18.6	50	1.0	3	5.1	14	37.3	32286
48-54	HC	7.7		-	2	21	14	62	3.4	1.59	1.04														
54-72	HC	7.6		-	2	23	13	59	2.6	1.04	0.81														

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TRAGOWEL CLAY: PROFILE 56 – MAP 17																									
0-8	HC	7.6	22.3	-	1	9	11	74	3.8	0.41	0.31	0.10	0.95	4.3	10	15.4	38	16.7	41	1.5	4	3.1	7	41.0	26547
8-20	HC	8.4	23.8	-	-	12	13	71	3.7	0.65	0.46	0.06	0.46	2.3	5	13.4	31	19.6	45	1.3	3	7.2	16	43.8	26548
20-40	HC	8.5		1.2	-	12	12	71	4.4	0.99	0.69			1.7	4	9.6	22	20.0	46	1.3	3	10.9	25	43.5	26549
40-58	HC	8.1		4.1	-	12	12	70	5.2	1.50	0.81			1.9	5	10.6	26	17.1	43	1.1	3	9.5	23	40.2	26550
58-84	HC	8.3		2.1	-	14	14	68	3.6	1.34	1.00			2.1	6	9.5	26	6.2	44	1.0	3	8.3	21	37.1	26551
UNA LOAM: PROFILE 23 – MAP 7																									
0-3	FSL	7.5	9.2	-	2	47	20	22	1.8	0.50	0.37	0.15	3.03	1.9	10	8.0	45	6.3	36	0.5	3	1.0	6	17.7	23277
3-10	LC	8.1	15.9	-	1	35	17	45	2.5	0.40	0.24	0.06	0.69	2.1	8	9.3	34	11.0	40	1.0	4	3.9	14	27.3	23278
10-17	LC	8.8		-	1	34	17	47	2.6	0.45	0.30			-	-	8.0	34	10.7	46	0.9	4	3.8	16	23.4	23279
17-30	FSCL	8.6		-	1	48	20	30	1.7	0.49	0.33			0.3	2	5.0	32	7.7	49	0.4	2	2.4	15	15.8	23280
30-36	CL	8.2		-	1	39	18	40	1.6	0.63	0.43														23281
36-52	LC	8.2		-	1	31	19	46	2.2	0.79	0.49			1.3	5	6.6	27	11.8	47	0.8	3	4.5	18	25.0	23282
52-67	MC	8.1		-	1	22	12	61	2.4	0.99	0.70														23283
67-78	MC	7.8		-	1	21	13	61	2.3	1.04	0.79														23284
UNA LOAM: PROFILE 58 – MAP 10																									
0-3	FSL	5.5	13.1	-	3	36	30	20	2.2	0.07	0.01	0.40	4.21	10.3	58	4.8	27	2.0	11	0.3	2	0.4	2	17.8	20314
3-8	L	6.5	7.7	-	1	41	33	20	1.4	0.04	0.02	0.11	1.08	4.3	36	4.3	36	1.5	13	0.1	1	1.6	14	11.8	20315
8-14	MC	8.5	17.9	-	1	30	28	39	1.7	0.09	0.03			2.6	14	7.1	39	3.1	17	0.5	3	4.8	27	18.1	20316
14-24	MC	9.4		-	1	34	25	37	2.2	0.11	0.03			-	-	4.9	34	4.3	29	0.4	3	5.0	34	14.6	20317
24-34	FSCL	8.9		-	2	54	18	24	1.1	0.04	0.02			0.3	3	4.8	50	2.9	30	0.3	3	1.3	14	9.6	20318
34-48	FSC	8.4		-	-	27	36	34	3.2	0.02	0.01			1.6	13	6.8	53	3.3	26	0.4	3	0.7	5	12.8	20319
48-74	FSC	8.2		-	-	24	42	33	1.1	0.02	0.01			1.6	14	5.7	48	3.5	30	0.4	3	0.6	5	11.8	20320
74-84	CL	8.3		-	-	38	33	27	1.0	0.02	0.01			1.4	3	4.8	43	3.6	32	0.3	3	1.0	9	11.1	20321

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
WANDELLA CLAY: PROFILE 50 – MAP 13																									
0-2	HC	8.1	20.0	0.8	6	16	16	57	3.3	0.06	0.01	0.16	1.77	4.3	15	11.3	41	9.5	35	1.6	6	0.8	3	27.5	26520
2-9	HC	8.6	20.2	0.1	3	22	14	58	3.2	0.05	0.01	0.08	0.76	2.3	9	10.5	41	10.0	39	1.2	4	1.9	7	25.9	26521
9-23	HC	9.2		1.6	1	14	14	65	5.5	0.11	0.02														26522
23-42	HC	9.5		0.9	1	13	17	63	5.9	0.26	0.09			-	-	5.3	20	12.4	46	1.0	4	8.2	30	26.9	26523
42-72	HC	8.4		1.8	1	12	20	64	4.5	0.91	0.19														26254
MERAN SANDY CLAY LOAM, GYPSEOUS PHASE: PROFILE 28 – MAP 9																									
0-3½	SCL	7.1	9.4	-	5	46	20	26	1.1	0.04	0.02	0.14	1.36	4.3	30	4.3	30	3.4	24	1.2	9	0.9	7	14.1	32248
3½-9	MC	8.3	27.2	-	2	22	10	64	2.3	0.17	0.08	0.12	0.74	3.5	12	8.2									32249
9-18	MC	8.7	26.2	-	1	21	15	61	2.9	0.57	0.29	0.06	0.31	1.2	4	7.6									32250
18-32	MC	8.7		-	1	19	17	59	5.4	1.85	0.80				-	9.3									32251
32-45	MC	8.6		-	-	20	21	56	4.0	0.89	0.51														32252
45-57	MC	8.5		-	-	33	15	50	2.5	0.80	0.57			1.1	4	4.7	19	11.4	45	1.1	4	6.9	28	25.2	32253
57-67	MC	8.3		-	7	28	17	47	2.2	0.91	0.67														32254
67-70	MC	8.4		-	12	24	5	57	3.1	1.24	0.89				-	5.7	23	11.4	45	1.1	4	6.9	28	25.1	32256
78-82	MC	8.7		-	16	25	3	45	11.3	1.07	0.79														
MERAN SANDY LOAM: PROFILE 55 – MAP 14																									
0-4	SL	7.1	5.0	-	31	46	6	14	1.1	0.03	0.01	0.08	0.92	3.6	39	2.1	23	2.2	24	0.5	5	0.8	9	9.2	26488
4-15	LC	9.7	16.9	-	20	29	10	39	2.6	0.26	0.16	0.07	0.55	1.8	8	4.0	17	9.8	42	1.3	5	6.7	28	23.6	26489
15-26	LC	9.2		1.2	13	23	12	45	6.9	0.53	0.28			-	-	3.9	16	11.5	48	1.6	7	6.9	29	23.9	26490
26-48	LC	9.0		-	14	22	10	51	3.9	0.74	0.46														26491
48-63	LC	8.9		-	13	22	4	56	5.7	0.87	0.55			0.2	1	3.9	16	12.3	47	1.2	5	8.3	32	25.9	26492
63-76	MC	9.0		8.8	11	21	4	48	16.0	0.90	0.56														26493
76-84	HC	9.0		2.6	12	21	6	45	16.7	0.85	0.55														26494

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO[3])	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
MURRABIT CLAY: PROFILE 7 – MAP 3																									
0-8	MC	6.9	18.8	-	2	30	17	47	2.0	0.02	0.01	0.14	1.51	8.2	30	10.7	39	7.0	25	0.9	3	0.9	3	27.7	25352
8-17	MC	7.8	19.1	-	3	29	15	51	2.0	0.03	0.01	0.08	0.69	5.0	17	12.9	43	9.4	31	0.8	3	1.7	6	29.8	25353
17-24	MC	8.6		-	4	21	14	58	2.0	0.05	0.02			2.9	10	12.9	42	11.0	37	0.4	1	2.9	10	30.1	25354
24-30	MC	8.9		-	1	31	14	52	1.9	0.07	0.02			1.8	7	11.1	42	9.9	37	0.4	1	3.5	13	26.7	25355
30-43	LC	9.1		-	2	47	14	35	1.8	0.08	0.02			1.2	6	7.9	39	7.9	39	0.3	1	2.9	15	20.2	25356
43-60	FSCL	8.8		-	2	50	10	37	1.3	0.05	0.02			1.8	9	8.7	45	6.6	34	0.4	2	1.9	10	19.4	25357
60-80	FSCL	8.3		-	1	54	12	31	1.2	0.05	0.02														25358
80-84	FSCL	8.2		-	1	57	11	29	1.6	0.06	0.03														
MYALL CLAY: PROFILE 4 – MAP 3																									
0-5	HC	7.7	17.8	-	2	20	18	57	2.1	0.11	0.05	0.13	1.48	5.3	19	15.0	54	4.9	18	1.1	4	1.5	5	27.8	25155
5-20	HC	7.1	20.2	-	1	17	17	63	1.8	0.35	0.22	0.06	0.51	5.8	17	12.4	36	11.5	33	0.6	2	4.3	12	34.6	25156
20-34	HC	6.9		-	1	15	20	54	1.8	0.50	0.34			5.7	17	11.3	33	11.4	34	0.6	2	4.8	14	33.8	25157
34-48	HC	6.8		-	-	11	22	67	1.7	0.52	0.31			5.6	17	10.3	32	11.4	35	0.6	2	4.6	14	32.5	25158
48-66	HC	6.9		-	1	12	25	61	1.7	0.48	0.22														25159
66-84	HC	5.4		-	1	11	27	59	1.3	0.35	0.22			8.8	28	8.6	27	9.1	29	0.5	2	4.9	14	31.9	25160
MYALL CLAY: PROFILE 15 - MAP																									
0-7	HC	6.9	19.6	-	1	17	21	55	2.1	0.04	0.02	0.17	1.59	9.5	32	10.5	36	8.5	29	0.3	1	0.6	2	29.4	23260
7-12	HC	7.4	18.0	-	1	17	21	57	2.2	0.04	0.02	0.09	0.74	6.7	22	10.6	36	9.6	32	0.9	3	2.1	7	29.9	23261
12-25	HC	7.8		-	1	17	22	68	1.9	0.09	0.04			5.3	17	10.9	36	10.4	34	1.0	3	3.2	10	30.8	23262
25-33	HC	8.2		-	1	15	21	61	2.0	0.26	0.17														23263
33-46	HC	7.9		-	-	15	23	60	2.1	0.34	0.23			3.4	12	9.4	32	10.4	36	0.7	2	5.3	18	29.2	23264
46-72	MC	5.2		-	1	16	27	55	1.6	0.42	0.27														23265
72-84	MC	4.9		-	1	15	27	57	1.7	0.49	0.34														23266

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
MACORNA CLAY, BROWN PHASE: PROFILE 33 – MAP 10																									
0-4	HC	7.0	16.2	-	3	31	14	49	2.3	0.03	0.01	0.17	1.55	9.1	34	5.2	19	9.6	36	0.9	3	2.2	8	27.0	26514
4-10	HC	8.3	21.4	-	1	25	12	59	2.6	0.06	0.02	0.12	0.86	5.9	17	8.3	24	14.6	42	1.5	4	4.3	13	34.6	26515
10-20	HC	9.0		-	1	23	31	42	3.4	0.22	0.04														26516
20-34	MC	8.2		-	-	28	34	31	6.5	1.04	0.06			0.7	3	9.7	40	8.9	36	0.7	3	4.3	18	24.3	26517
34-46	LC	9.0		-	-	23	32	43	2.6	0.38	0.11			-	-	6.3	28	9.1	40	0.8	4	6.4	28	22.6	26518
46-60	LC	9.0		-	-	33	21	43	3.5	0.36	0.12														26519
MACORNA CLAY, RED-BROWN PHASE: PROFILE 36 – MAP 11																									
0-3	HC	8.0	18.9	-	8	19	5	64	3.0	0.21	0.08	0.16	1.56	4.0	10	12.3	33	15.2	41	1.7	5	4.2	11	37.4	23216
3-10	HC	8.5	18.0	-	4	20	9	65	3.3	0.38	0.17	0.07	0.70	1.7	5	10.7	29	14.8	41	1.6	4	7.7	21	36.5	23217
10-20	MC	8.6		-	3	20	23	45	9.9	0.6	0.20														23218
20-34	MC	8.2		-	2	21	12	4	12.1	1.19	0.23			-	-	16.3	50	11.2	35	1.2	4	3.5	22	32.2	23219
34-48	MC	8.5		-	2	22	11	57	9.5	1.04	0.18														23220
48-54	MC	8.7		-	2	21	11	58	9.1	0.98	0.22			-	-	7.4	21	15.0	43	1.1	3	11.4	33	34.9	23221
54-60	MC	8.9		-	2	20	10	60	9.4	0.89	0.34														23222
60-84	LC	8.9		-	1	22	9	60	7.7	0.99	0.49														23223
MACORNA CLAY, RED-BROWN PHASE: PROFILE 54 – MAP 14																									
0-3	CL	6.2	7.9	-	4	46	23	24	1.6	0.06	0.03	0.18	1.89	3.7	14	6.5	25	14.3	56	0.6	2	0.9	3	26.0	26540
3-12	HC	8.5	22.7	-	2	25	14	57	2.8	0.16	0.07	0.11	0.87	3.3	11	9.6	32	11.7	40	1.1	4	4.0	13	30.8	26541
12-18	HC	8.8		-	1	21	21	53	4.2	0.63	0.31														26542
18-36	MC	8.4		-						0.91	0.36			1.0	4	7.5	30	10.3	42	0.7	3	5.2	21	24.7	26543
36-56	LC	8.8		-	2	19	16	57	7.3	0.69	0.40			-	-	8.8	29	13.1	43	1.3	4	7.6	24	30.8	26544
56-72	MC	8.8		1.0	1	17	10	59	12.0	0.86	0.54														26545
72-84	MC	8.8		2.0	1	16	12	60	10.4	1.09	0.77														26546

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
MACORNA CLAY : PROFILE 2 - MAP 14																									
0-3½	HC	7.3	12.3	-	15	40	9	35	2.0	0.03	0.01	0.12	1.12	5.6	28	6.1	31	6.4	32	0.9	4	1.0	5	20.0	25175
3½-10	HC	8.4	22.7	-	12	20	5	62	2.0	0.05	0.01	0.11	0.75	3.2	10	9.5	29	14.8	44	1.9	6	3.7	11	33.1	25176
10-18	MC	9.1		-	9	22	7	61	2.1	0.09	0.02			2.9	9	9.5	29	15.0	45	1.6	5	3.9	12	32.9	25177
18-24	MC	8.8		-	8	20	6	62	3.8	0.16	0.01			3.4	10	14.1	40	12.3	35	1.6	5	3.6	10	35.0	25178
24-34	LC	8.0		-	11	17	8	53	11.2	0.81	0.01			0.3	1	20.8	65	7.3	23	1.2	4	2.2	7	31.8	25179
34-48	LC	8.0		-	14	19	9	50	7.0	0.69	0.01			-	-	17.5	66	7.0	26	0.8	3	1.2	5	26.5	25180
48-54	LC	8.3		-	9	30	6	50	6.0	0.26	0.01														25181
54-66	LC	8.4		-	19	20	4	50	7.7	0.21	0.01			-	-	15.7	55	9.9	34	1.3	5	1.8	6	28.7	25182
66-84	LC	8.6		-	10	26	4	53	6.2	0.17	0.02														25183
MARAN CLAY: PROFILE 31 – MAP 10																									
0-1	CL	6.4		-	22	35	12	27	3.1	0.04	0.01	0.26	2.75												32240
1-5	CL	7.5	17.1	-	21	36	13	29	1.4	0.03	0.01	0.10	0.74	4.3	20	10.8	50	4.6	21	0.6	3	1.4	6	21.7	32241
5-13	HC	8.8	19.3	-	11	20	8	59	2.4	0.14	0.06	0.08	0.66	2.1	6	14.1	40	12.6	36	1.4	4	5.1	14	35.3	32242
13-18	HC	9.2		-	10	21	7	61	2.7	0.26	0.11			0.4	1	6.3	21	13.6	45	1.6	5	8.6	28	30.8	32243
18-28	MC	9.4		-	8	23	15	51	3.9	0.25	0.09														32244
28-42	MC	9.2		-	9	26	14	50	2.3	0.20	0.08			0.5	2	4.9	20	11.1	44	1.3	5	7.2	29	25.0	32245
42-54	MC	9.4		-	10	26	7	53	5.3	0.28	0.10														32246
54-72	MC	9.4		-	10	24	3	53	11.1	0.34	0.14				-	6.3	22	11.3	40	1.4	5	9.2	33	28.2	32247
LATON CLAY: PROFILE 17 – MAP 4																									
0-1	MC	7.5	20.0	-	13	19	4	53	12.4	7.37	6.62	0.10	1.22												32274
1-13	HC	8.0	22.6	-	13	18	4	62	4.1	1.83	1.50	0.06	0.45	2.0	6	5.5	15	16.2	46	1.3	4	10.2	29	35.2	32275
13-17	HC	8.4			12	17	4	63	5.2	1.78	1.44	0.04	0.47	-	-	6.8	19	17.1	48	1.3	4	10.2	29	35.4	32276
17-27	HC	8.2			11	16	3	62	9.2	2.20	1.18			-	-	8.5	25	15.1	44	1.2	3	9.5	28	34.3	32277
27-36	HC	8.1			11	16	4	60	10.4	2.10	1.01			-	-										32278
36-46	HC	8.2			11	18	6	57	7.4	1.71	0.80			-	-	7.9	25	13.2	42	1.1	4	9.2	29	31.4	32279
46-60	HC	8.3			11	18	6	58	8.1	1.64	0.87			-	-	7.3	23	13.8	44	1.1	3	9.4	30	31.6	32280

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
LATON CLAY: PROFILE 29 – MAP 9																									
0-5	MC	8.2	26.6	-	11	23	10	53	3.1	0.07	0.01	0.21	2.00	3.8	12	15.2	50	9.0	30	1.3	4	1.2	4	30.5	32266
5-9	HC	8.8	23.1	-	8	17	10	61	5.2	0.07	0.01	0.08	0.59	1.2	4	15.3	48	12.2	38	1.2	4	1.8	6	31.7	32267
9-17	HC	9.2		-	7	15	11	62	6.1	0.09	0.02	0.05	0.33	-	-	11.2	37	14.6	48	1.3	4	3.4	11	30.5	32268
17-25	HC	9.4		-	6	14	12	62	7.1	0.15	0.04														32269
25-44	HC	9.4		-	2	9	18	65	5.5	0.33	0.16			-	-	3.0	10	15.1	51	1.3	4	10.5	35	29.9	32270
44-54	HC	9.2		-	1	6	25	66	2.7	0.38	0.21														32271
54-63	HC	8.8		-	1	6	23	68	3.2	0.55	0.35														32272
63-72	HC	8.7		-	6	13	15	65	2.2	0.36	0.21			1.8	6	3.6	12	13.1	44	1.4	5	9.8	33	29.7	32273
LEITCHVILLE SAND: PROFILE 69 – MAP 23																									
0-8	LFS	6.7	3.0	-	4	79	8	8	0.5	0.01	0.01	0.05	0.42	1.9	41	1.6	35	0.7	15	0.3	7	0.1	2	4.6	5480
8-27	LFS	7.3	3.1	-	4	79	8	9	0.3	0.01	0.01	0.03	0.20	0.9	21	2.3	50	1.1	24	0.5	4	0.1	2	4.6	5481
27-33	FSL	8.5		-	2	76	6	15	0.8	0.03	0.01			0.4	5	3.3	47	3.0	43	0.3	4	0.1	1	7.1	5482
33-47	CL	9.3		-	1	25	35	37	2.4	0.07	0.01			-	-	5.5	44	6.2	50	0.5	4	0.2	2	12.4	5483
LEITCHVILLE SAND, SHALLOW SURFACE VARIANT: PROFILE 64 – MAP 20																									
0-9	VFSL	6.4	5.2	-	2	30	21	14	1.6	0.74	0.64	0.12	1.52	2.7	22	5.5	47	1.9	16	1.2	10	0.5	4	11.8	5489
9-16	VFSCL	8.5	8.2	-	1	48	25	23	2.8	0.83	0.67	0.07	0.60		-	5.7	47	3.9	31	1.3	11	1.3	11	12.2	5490
16-24	FSL	8.8		-	1	46	23	25	5.8	0.77	0.61														5491
24-43	FSL	8.9		-	3	58	19	17	3.9	0.63	0.48				-	3.0	41	3.4	47	0.4	6	0.4	6	7.2	5492
43-70	FSL	8.3		-	1	56	25	16	1.2	0.69	0.55			0.1	1	2.4	31	3.6	46	0.2	3	1.5	19	7.8	5493
70-78	LC	8.0		-	1	40	19	38	1.7	0.56	0.42														5494
LEITCHVILLE SAND, SHALLOW SURFACE VARIANT: PROFILE 68 – MAP 23																									
0-10	FSL	7.4	3.9	-	2	73	13	10	1.0	0.02	0.01	0.08	0.83	1.8	27	3.0	45	1.3	19	0.4	6	0.2	3	6.7	5484
10-20	LFS	9.4	9.2	-	1	52	18	28	1.9	0.10	0.02	0.05	0.30		-	3.4	34	4.3	43	0.8	8	1.5	16	10.0	5485
20-30	FSC	9.8		-	-	38	31	29	3.5	0.12	0.05			-	-	2.2	21	4.0	38	0.8	8	3.4	33	10.4	5486
30-52	FSCL	9.5		-	-	56	22	21	1.3	0.20	0.08														5487
52-72	FSCL	8.6		-	-	72	13	14	0.7	0.21	0.12			0.8	12	1.2	18	2.4	38	0.2	3	1.9	26	6.5	5488

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
KOROOP CLAY: PROFILE 21 – MAP 7																									
0-3	VFSC	5.6	11.3	-	2	31	25	39	2.4	0.35	0.27	0.14	1.57	7.1	35	5.0	25	6.3	32	0.8	4	0.8	4	29.0	23205
3-12	MC	6.3	16.9	-	1	21	22	55	2.6	0.56	0.43	0.09	0.74	6.9	24	8.6	29	10.5	35	0.6	2	3.0	10	29.6	23206
12-20	MC	7.4		-	-	22	22	55	2.7	0.63	0.47			3.7	12	8.7	29	12.2	41	0.6	2	4.6	16	29.5	23207
20-24	MC	7.8		-	-	22	22	55	2.6	0.62	0.46														23208
24-38	MC	7.8		-	-	18	29	52	2.5	0.67	0.49			2.3	9	7.2	28	11.1	43	0.5	2	4.5	18	25.6	23209
38-48	LCC	7.6		-	-	18	35	46	2.3	0.57	0.44			2.7	11	6.8	28	9.6	40	0.4	2	4.5	19	24.0	23210
48-60	LC	7.1		-	-	24	28	47	2.3	0.63	0.48														23211
60-78	LC	6.4		-	-	34	24	42	0.8	0.67	0.53														23212
78-84	CL	6.1		-	-	50	17	33	1.4	0.60	0.48														23213
KOROOP CLAY: PROFILE 26 - MAP 8																									
0-7	HC	6.7	17.0	-	1	20	23	55	1.6	0.03	0.01	0.11	0.89	8.0	29	9.3	34	8.2	30	0.7	2	1.4	5	27.6	23165
7-17	HC	8.2	18.8	-	1	14	21	63	2.5	0.07	0.04	0.08	0.43	3.4	12	10.3	36	11.1	39	0.9	3	3.0	10	28.7	23166
17-21	HC	8.6		-	-	14	22	62	2.5	0.13	0.06			2.4	8	11.6	39	11.4	38	0.8	2	3.8	13	30.3	23167
21-32	MC	8.8		-	2	17	22	57	3.1	0.22	0.10			2.1	8	9.9	35	11.3	40	0.7	2	4.3	15	28.3	23168
32-40	MC	8.6		-	1	21	23	54	2.4	0.25	0.12														23169
40-50	LC	8.1		-	1	25	26	47	2.0	0.26	0.14														23170
50-58	LC	7.3		-	-	22	26	51	1.8	0.29	0.16			3.4	13	7.6	30	9.1	36	0.4	2	4.7	19	25.2	23271
58-84	HC	5.2		-	-	18	27	55	1.6	0.36	0.20														23172
KOROOP CLAY: PROFILE 38 – MAP 11																									
0-4	MC	7.4	19.6	-	3	25	18	54	2.6	0.10	0.06	0.18	1.71	2.8	21	10.7	39	8.9	32	0.7	2	1.7	6	27.8	5527
4-10	MC	8.8	18.1	-	1	22	17	59	3.7	0.15	0.06	0.07	0.48	1.3	5	11.7	42	10.9	39	0.8	3	3.0	11	27.7	5528
10-22	HC	9.0		-	1	21	18	57	3.8	0.31	0.17														5529
KOROOP CLAY: PROFILE 65 – MAP 20																									
0-5	MC	7.7	15.5	-	4	14	29	52	2.2	0.08	0.05	0.14	1.32	5.1	20	10.0	38	8.2	31	1.0	4	1.9	7	26.2	20349
5-12	HC	9.0	17.1	-	-	10	28	58	5.3	0.13	0.04	0.08	0.53	2.8	11	7.9	30	11.4	44	0.7	2	3.3	13	26.1	20350
12-22	HC	9.3		-	-	9	30	54	8.5	0.25	0.11			2.4	9	4.2	17	11.6	46	0.6	2	6.5	26	25.3	23051
21-31	MC	9.3		-	-	14	36	47	4.4	0.31	0.15			1.0	5	2.1	10	9.7	48	0.4	2	7.1	35	20.3	20352

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO³)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
PROFILE 65 – MAP 20 *continued…*																									
31-44	LC	8.8		-	-	27	34	38	1.9	0.27	0.18			0.3	2	1.6	10	7.5	48	0.3	2	5.9	38	15.6	20353
44-54	MC	8.8		-	-	25	22	52	2.1	0.29	0.17			1.0	4	2.5	10	10.9	48	0.6		7.9	35	22.9	20354
54-84	HC	3.1		-	-	15	22	61	2.1	0.47	0.30			2.2	8	2.5	9	13.2	48	0.6	2	9.3	33	27.8	20355
KOROOP CLAY: PROFILE 67 – MAP 23																									
0-3	LC	7.2	15.6	-	1	34	25	30	6.1	3.13	3.11	0.22	3.03	3.8	18	4.3	21	10.4	50	0.7	3	1.6	8	20.8	5514
3-11	MC	8.4	15.0	-	1	29	23	45	3.2	0.89	0.68	0.06	0.54	1.8	9	3.4	17	10.3	51	0.6	3	4.1	20	20.2	5515
11-22	MC	8.8		-	1	25	23	46	5.3	1.03	0.81				3	3.2	17	10.1	55	0.5	3	4.1	22	18.5	5516
22-42	LC	8.6		-	1	28	26	43	2.4	0.83	0.64			0.8	5	3.8	23	8.1	50	0.4	2	3.2	20	16.3	5517
42-67	LC	7.0		-	-	41	27	31	1.6	0.63	0.51														5518
67-76	CL	4.9		-	-	16	47	37	1.7	0.68	0.55														5519
KERANG CLAY, GREY PHASE: PROFILE 66 – MAP 22																									
0-8	MC	7.8	20.1	-	1	12	18	64	4.0	0.88	0.66	0.14	1.70	1.8	6	11.7	37	12.0	38	1.0	3	4.9	16	31.4	20328
0-17	HC	8.3	20.3	-	-	9	16	68	6.1	0.68	0.42	0.07	0.63	0.6	2	11.1	34	13.3	41	0.8	2	6.8	21	32.6	20329
17-33	HC	8.1		-	-	8	18	69	5.6	0.78	0.36			1.2	4	9.2	26	14.2	41	0.7	2	9.5	27	34.8	20330
33-48	HC	6.4		-	-	8	18	68	5.6	1.42	0.33			5.1	15	9.8	28	11.2	32	0.6	2	8.1	23	34.8	20331
48-60	HC	5.3		-	-	8	18	68	5.7	1.37	0.32			8.5	24	9.3	27	10.0	28	0.6	2	6.7	19	35.1	20332
60-66	HC	4.6		-	-	7	18	69	5.6	1.35	0.31			9.9	27	8.6	26	9.5	26	0.5	2	7.0	19	36.5	20333
66-84	HC	4.7		-	-	9	19	71	2.0	0.60	0.35														20334
KERANG CLAY, GREY-BROWN PHASE: PROFILE 32 – MAP 10																									
0-3	LC	6.3	14.4	-	1	18	26	48	2.3	0.21	0.15	0.18	1.82	7.6	22	8.3	25	6.3	19	1.2	4	10.2	30	33.6	23226
3-9	HC	6.5	17.4	-	-	13	22	64	2.2	0.48	0.36	0.09	0.69	6.5	20	12.6	38	9.8	30	0.8	2	3.2	10	32.9	23227
9-15	HC	7.7		-	-	10	20	68	2.9	0.98	0.79			3.5	10	13.8	40	12.9	38	0.8	2	3.5	10	34.5	23228
15-22	MC	7.7		-	-	10	21	67	3.0	1.29	1.07														23229
22-33	MC	7.7		-	-	12	22	60	7.2	2.16	1.17														23230
33-52	MC	7.6		-	-	14	24	55	7.6	2.14	1.19														23231
52-70	LC	7.4		-	-	16	21	61	3.3	1.62	1.23														23232
70-84	MC	7.6		-	-	20	17	61	3.4	1.72	1.54														23233

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO3)	Particle Size: Coarse sand	Fine sand	Silt	Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
KERANG CLAY, GREY-BROWN PHASE: PROFILE 51 – MAP 13																									
0-5	MC	7.8	21.9	-	7	20	10	59	3.1	0.07	0.03	0.14	1.33	5.7	17	6.4	19	13.4	38	1.9	6	6.9	20	34.3	26525
5-18	HC	8.4	28.2	-	3	12	12	70	3.5	0.20	0.11	0.07	0.50	3.7	9	6.5	16	14.3	35	1.6	4	14.7	36	40.8	26526
18-32	HC	8.4		-	2	11	16	67	3.1	0.46	0.27													33.2	26527
32-48	HC	8.1		-	3	10	13	60	9.4	1.71	0.45			1.6	5	8.3	25	11.9	36	0.8	2	10.6	32		26528
48-72	HC	8.3		-	5	13	15	58	9.9	2.02	0.86														26529
72-84	MC	8.5		-	9	20	5	56	10.1	2.14	1.00														26530
KOROOP CLAY: PROFILE 5 – MAP 3																									
0-4	MC	6.3	19.0	-	1	26	16	50	2.0	0.04	0.01	0.24	2.57	12.9	40	10.0	31	7.2	23	0.6	2	1.2	4	31.9	25168
4-13	HC	7.4	21.0	-	1	20	15	63	2.0	0.05	0.02	0.07	0.55	6.6	19	13.7	39	11.0	32	0.7	2	2.9	8	34.9	25169
13-19	HC	8.5		-	1	20	13	66	1.9	0.13	0.07			3.1	10	12.1	37	12.8	39	0.8	2	3.7	12	32.5	25170
19-26	MC	8.8		-	-	19	15	63	2.8	0.28	0.15			0.4	1	11.6	38	13.0	42	0.8	3	5.0	16	30.8	25171
26-46	MC	8.5		-	-	26	22	49	2.0	0.43	0.27			3.7	13	8.4	29	10.1	35	0.3	1	6.5	22	29.0	25172
46-64	MC	8.1		-	-	14	32	52	1.9	0.46	0.29														25173
64-84	HC	8.0		-	1	14	24	58	2.0	0.43	0.26														25174
KOROOP CLAY: PROFILE 19 – MAP 6																									
0-6	HC	6.8	16.7	-	1	16	29	50	2.0	0.04	0.01	0.18	2.11	8.7	35	7.3	29	6.6	27	0.7	3	1.6	6	24.9	23154
6-18	HC	8.0	17.3	-	1	12	29	57	2.0	0.08	0.04	0.09	0.58	4.0	15	7.7	29	8.8	34	0.9	4	4.8	18	26.2	23155
18-24	HC	9.2		-	-	10	31	58	2.2	0.23	0.10			1.6	6	8.6	33	9.7	38	0.7	3	5.1	20	25.7	23156
2-34	HC	9.3		-	-	10	31	57	2.5	0.28	0.12														23157
34-45	HC	9.1		-	1	14	30	51	5.0	0.22	0.10			1.4	6	7.6	31	9.3	37	0.6	2	6.0	24	24.9	23158
45-59	MC	8.9		-	1	16	27	53	1.6	0.19	0.09			2.1	8	6.9	27	9.7	38	0.5	2	6.6	25	25.8	23159
59-69	MC	8.6		-	2	22	24	52	1.4	0.16	0.08														23160
69-80	MC	8.5		-	4	33	20	43	1.2	0.15	0.08			2.3	10	6.2	26	9.0	38	0.4	2	5.7	24	23.6	23161
80-84	FSC	8.4		-	5	44	17	33	1.1	0.15	0.09														23162

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
FAIRLEY CLAY: PROFILE 45 – MAP 13																									
0-5	MC	7.0	18.5	-	13	27	5	51	2.4	0.10	0.10	0.20	2.10	8.5	33	8.1	32	5.1	20	1.6	6	2.6	9	25.6	26533
5-14	HC	8.4	20.9	-	10	24	6	58	2.7	0.24	0.06	0.09	0.60	3.8	13	6.7	22	13.6	46	1.2	4	4.6	15	29.9	26534
14-18	HC	8.9		-	8	22	7	59	4.8	0.46	0.18	0.07	0.54	1.1	4	6.7	23	13.6	47	1.3	4	6.5	22	29.2	26535
18-28	MC	9.0		1.3	8	24	10	2	5.8	0.49	0.21														26536
28-40	MC	9.1		0.9	11	28	13	44	3.5	0.50	0.20			0.4	2	4.6	19	10.8	45	1.2	5	7.1	29	24.1	26537
40-70	LC	9.2		1.7	11	28	6	46	8.6	0.49	0.19														26538
70-84	MC	9.2		-	10	24	6	54	6.2	0.63	0.30														26539
GONN CLAY: ROFILE 3 – MAP 3																									
0-7	HC	6.2	25.2	-	1	16	22	58	2.3	0.02	0.02	0.14	1.29	11.1	37	10.5	35	6.5	22	1.2	4	0.6	2	29.9	25161
7-24	HC	5.6	24.1	-	-	15	24	59	1.7	0.04	0.03	0.08	0.64	12.0	40	9.3	31	6.8	23	0.6	2	1.1	4	29.8	25162
24-34	HC	5.7		-	1	15	21	61	1.8	0.05	0.04			11.6	39	9.3	31	7.3	24	0.6	2	1.2	4	30.0	25162
34-50	HC	6.9		-	-	11	23	66	1.7	0.06	0.05			6.3	19	13.6	41	11.0	33	0.8	2	1.7	5	33.4	25164
50-60	HC	8.1		-	1	11	26	62	1.6	0.08	0.03														25165
60-70	MC	8.9		-	1	15	36	45	2.2	0.10	0.03			0.9	4	12.1	49	9.3	38	0.4	2	1.8	7	24.5	25166
70-84	LC	8.9		-	1	17	36	45	1.8	0.08	0.03														25167
KERANG CLAY, GREY PHASE: PROFILE 24 – MAP 8																									
0-5	MC	6.9	16.8	-	1	15	24	59	1.7	0.06	0.03	0.15	1.47	8.4	28	10.8	36	8.1	27	1.2	4	1.4	5	29.9	23242
5-8	HC	7.0	17.0	-	1	15	23	58	2.5	0.06	0.03	0.10	0.83												23243
8-21	HC	6.2		-	-	14	21	62	2.3	0.25	0.16			9.1	30	11.5	38	8.1	27	0.2	1	1.0	4	29.9	23244
21-29	HC	6.9		-	-	14	20	63	2.7	0.49	0.33														23245
29-34	MC	7.6		-	-	13	21	63	2.7	0.50	0.34														23246
35-54	MC	7.7		-	-	14	23	62	2.3	0.57	0.37			3.2	12	12.0	44	10.3	38	0.1	-	1.7	6	27.3	23247
54-58	MC	6.0		-	-	14	22	62	2.3	0.58	0.36														
58-84	HC	4.8		-	-	15	27	57	2.3	0.80	0.34														

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
KERANG CLAY, GREY PHASE: PROFILE 34 – MAP 11																									
0-1	LC	6.4	18.4	-	6	18	19	50	2.5	0.32	0.22	0.28	2.60												23234
1-12	HC	6.5	19.1	-	-	13	16	68	2.5	0.40	0.28	0.10	0.79	8.2	22	9.0	24	12.6	34	1.0	3	6.5	17	37.3	23235
12-22	HC	5.5	20.7	-	-	11	16	70	2.7	0.76	0.52			10.6	29	7.1	19	10.8	30	0.7	2	7.4	20	36.6	23236
22-28	MC	5.1		-	-	11	16	67	5.1	1.70	0.66														23237
28-41	MC	6.3		-	-	13	16	65	5.2	1.85	0.74			5.1	14	8.5	24	12.5	35	0.6	2	8.8	25	35.5	23238
41-54	MC	7.8		-	1	16	19	62	1.3	1.01	0.75														23239
54-72	MC	7.9		-	-	18	17	60	4.4	1.31	1.06			1.7	5	6.6	20	15.0	46	0.8	3	8.3	26	32.4	23240
72-84	MC	8.6		-	1	18	15	61	5.9	1.36	1.08														23241
KERANG CLAY, GREY PHASE: PROFILE 53 – MAP 13																									
0-5	HC	7.9	22.2	-	7	22	7	60	2.8	0.05	0.02	0.15	1.34	6.1	18	9.3	27	11.8	34	3.2	9	4.2	12	34.6	26503
5-18	HC	9.2	27.6	-	4	15	4	74	3.9	0.38	0.20	0.07	0.51	-	-	7.9	26	14.9	49	2.3	8	5.1	17	30.2	26504
18-30	HC	9.2		-	4	15	5	72	3.9	0.65	0.33														26505
30-54	HC	8.4		-	3	14	7	67	8.1	1.55	0.91														26506
54-84	HC	8.8		-	2	14	9	68	7.2	1.39	0.86														26507
CULLEN LOAM: PROFILE 60 – MAP 19																									
0-3	L	7.1	10.4	-	5	36	24	30	4.2	0.35	0.19	0.50	2.15	3.8	22	5.3	30	5.8	33	1.2	7	1.4	8	17.5	20335
3-15	HC	8.4	15.1	-	1	26	20	52	2.3	0.51	0.20	0.05	0.67	0.6	3	4.2	19	8.7	39	1.9	9	6.6	30	22.0	20336
15-20	MC	8.2		-	1	30	22	45	3.5	0.74	0.21			-	-	5.5	26	7.7	37	1.4	7	6.2	30	20.8	20337
20-34	LC	8.0		-	-	33	27	38	3.2	0.99	0.23			-	-	5.2	21	12.5	50	0.6	2	6.6	27	24.9	20338
34-52	MC	7.7		-	-	21	20	55	6.1	1.34	0.25			0.4	2	8.5	29	10.0	34	0.6	2	9.8	33	29.3	20339
52-66	MC	7.6		-	1	19	14	58	6.4	1.52	0.30			1.4	4	9.2	26	12.8	36	0.7	2	11.4	32	35.5	20340
66-84	MC	7.9		-	-	15	17	64	5.0	1.42	0.42			0.5	1	8.0	22	13.4	37	1.0	2	13.8	38	36.7	23041
DELLA SANDY LOAM – GILGAI DEPRESSION: PROFILE 46 – MAP 13																									
0-18	SC	8.4	15.8	-	22	36	7	32	2.2	0.06	0.01	0.14	1.87	2.6	9	15.5	53	9.0	30	1.4	5	0.9	3	29.4	26531
18-36	MC	8.9	19.7	-	21	32	3	40	4.8	0.07	0.01	0.06	0.59	0.4	1	14.5	52	10.4	37	1.5	5	1.5	5	28.3	26532

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO[3])	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
DELLA SANDY LOAM – GILGAI SHELF: PROFILE 47 – MAP 13																									
0-3	SL	8.0	7.3	-	24	50	4	18	2.0	0.03	0.01	0.16	1.85	1.3	10	7.6	59	2.5	20	1.0	8	0.4	3	12.8	26495
3-8	MC	9.2	18.8	-	18	28	6	44	3.5	0.09	0.01	0.05	0.48												26496
10-30	MC	9.9		1.6	17	28	3	42	11.6	0.24	0.08			-	-	4.5	20	7.7	34	1.9	8	8.7	38	22.8	26497
DELLA SANDY LOAM – GILGAI PUFF: PROFILE 48 – MAP 13																									
0-2½	CL	8.8	11.7	-	15	37	7	22	16.7	0.06	0.01	0.16	1.69	-	-	12.4	64	4.3	22	2.2	11	0.5	3	19.4	26500
2½-10	LC	9.8	14.4	-	13	26	6	25	29.9	0.17	0.05	0.05	0.60	-	-	6.0	34	5.0	28	2.3	13	4.5	25	17.8	26501
10-24	LC	10.2		-	13	26	5	31	25.2	0.37	0.10			-	-	1.0	5	2.8	15	2.3	12	13.1	68	19.2	26502
DELLA CLAY: PROFILE 49 – MAP 13																									
0-4	LC	8.7	17.9	-	16	26	7	42	8.8	0.06	0.01	0.16	1.79	1.5	6	12.6	53	7.4	31	1.8	8	0.4	2	23.6	26508
4-18	MC	9.2	19.4	-	16	28	6	47	3.5	0.08	0.01	0.08	0.66	1.0	4	10.6	46	8.5	37	1.3	6	1.7	7	23.1	26509
18-36	HC	9.7		-	13	23	5	48	12.4	0.17	0.05														26510
36-48	MC	9.7		-	10	23	3	50	14.3	0.26	0.10														26511
48-64	MC	9.7		-	10	22	4	50	13.3	0.38	0.18														26512
64-84	MC	9.7		-	12	22	3	50	13.2	0.43	0.21														26513
FAIRLEY CLAY: PROFILE 1 – MAP 2																									
0-4	MC	9.0	15.4	-	13	30	8	45	2.1	0.12	0.05	0.11	1.01	1.4	6	9.0	36	8.2	33	1.6	6	4.7	19	24.9	25184
4-9	HC	9.0	24.4	-	6	18	6	67	2.5	0.17	0.08	0.08	0.55	1.9	5	9.7	26	12.8	35	2.8	8	9.9	27	37.1	25185
9-15	MC	9.2		-	8	21	8	61	2.5	0.27	0.10			0.6	2	6.7	20	12.0	36	1.5	4	12.6	38	33.4	25186
15-24	MC	9.2		-	6	18	8	63	5.7	0.43	0.22			-	-	7.1	21	11.6	34	1.1	3	14.2	42	34.0	25187
24-42	MC	9.2		-	9	18	8	58	5.1	0.46	0.23			-	-	5.4	17	11.8	36	1.1	3	14.4	44	32.7	25188
42-62	MC	9.1		-	9	18	8	59	5.5	0.96	0.31														25189
62-84	MC	9.2		-	12	25	7	51	6.0	0.62	0.32														25190

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TYPE 1: PROFILE 8 - MAP 3																									
0-7	CL	6.9	9.7	-	1	51	21	25	1.7	0.05	0.03	0.15	1.56	4.0	24	7.0	41	4.7	28	0.9	5	0.3	2	16.9	25143
7-16	VFSCL	7.7	12.2	-	1	36	29	32	1.4	0.10	0.07	0.06	0.57	3.0	17	6.0	34	7.9	41	0.3	2	1.0	6	17.4	25143
16-19	CL	7.3		-	1	37	28	31	1.3	0.14	0.09			3.7	20	5.6	31	6.9	38	0.2	1	1.7	9	18.1	25144
19-26	VFSC	6.3		-	1	46	24	27	1.0	0.20	0.14			4.8	32	2.8	19	5.6	37	0.2	1	1.7	11	15.1	25145
26-34	HC	5.2		-	1	25	25	47	1.7	0.34	0.25			8.9	40	3.9	18	6.6	30	0.2	1	2.6	11	22.2	25146
34-48	HC	4.9		-	1	31	23	44	1.7	0.46	0.37			9.8	39	4.8	20	7.0	28	0.3	1	3.1	12	25.0	25147
48-72	HC	5.0		-	1	33	19	45	2.2	0.58	0.47			8.7	38	5.1	22	5.5	24	0.3	1	3.5	15	23.1	25148
72-84	CL	5.9		-	1	41	20	36	1.7	0.45	0.41														25149
TYPE 3: PROFILE 6 – MAP 3																									
0-8	MC	6.1	15.4	-	10	36	12	40	2.2	0.03	0.02	0.15	1.63	9.8	37	10.0	38	4.3	16	1.7	7	0.4	2	26.2	25150
8-26	MC	6.6	14.3	-	9	37	15	37	1.8	0.05	0.02	0.06	0.62	6.9	30	9.4	42	5.2	23	0.9	3	0.5	2	22.7	25151
26-43	MC	6.5		-	5	34	14	44	2.4	0.06	0.02			6.3	30	8.5	40	5.3	24	0.6	3	0.6	3	21.3	25152
43-56	VFDCL	6.8		-	5	42	16	31	4.0	0.04	0.02			3.9	21	9.0	47	5.0	27	0.6	3	0.3	2	18.8	25153
56-84	FSL	7.3		-	3	56	16	24	1.2	0.02	0.01			2.8	20	7.7	54	2.9	20	0.2	1	0.7	5	14.3	25154
TYPE 5: PROFILE 72 – MAP 21																									
0-3	MC	6.9	17.6	-	6	34	15	42	2.1	0.07	0.03	0.24	2.52	7.6	32	7.9	34	5.6	24	0.7	3	1.7	7	23.5	32230
3-7	HC	7.8	26.4	-	2	16	8	71	2.7	0.08	0.04	0.13	0.92	5.5	6	12.7	36	11.9	34	1.6	5	3.2	9	34.9	32231
7-12	HC	8.5	27.7	-	2	15		75	2.8	0.13	0.06														32232
12-21	HC	9.1		-	2	17	8	67	6.7	0.28	0.12			-	-	11.2	35	13.0	40	1.5	5	6.6	20	32.3	32233
21-35	HC	8.9		-	2	17	9	66	6.8	0.40	0.18														32234
35-43	HC	8.7		-	2	17	8	68	5.7	0.48	0.23			-	-	12.1	37	11.9	37	1.3	4	7.3	22	32.6	32235
43-56	HC	8.7		-	2	17	8	68	5.4	0.56	0.30														32236
56-64	HC	8.7		-	2	20	8	67	4.2	0.60	0.35			-	-	10.5	33	12.6	39	1.2	4	7.8	24	32.1	32237
64-80	HC	8.6		-	5	32	9	52	3.0	0.69	0.46														32238
80-84	HC	8.5		-	4	42	11	42	2.4	0.77	0.53														32239

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TYPE d4: PROFILE 71 – MAP 18																									
0-4	FSCL	6.3	8.2	-	2	55	18	23	0.9	0.03	0.02	0.17	1.68	7.9	63	2.0	16	1.3	10	0.3	3	1.0	8	12.5	32257
4-7	FSC	7.8	12.9	-	2	42	12	43	1.0	0.06	0.04	0.07	0.41	4.4	27	4.5	28	4.4	27	0.8	5	2.0	13	16.1	32258
7-13	MC	8.5	18.7	-	1	29	9	61	1.6	0.08	0.05	0.07	0.37	3.2	14	6.0	27	7.4	34	1.4	6	4.1	19	22.1	32259
13-22	MC	9.1		-	1	34	12	53	1.7	0.13	0.07			1.4	7	4.2	22	7.8	40	1.4	7	4.7	24	19.5	32260
22-42	FSC	9.3		-	-	42	13	43	2.4	0.23	0.13														32261
42-55	FSC	8.6		-	-	43	15	41	1.7	0.32	0.22			1.0	7	1.8	12	6.9	47	0.9	6	4.2	28	14.8	32262
55-68	FSC	8.5		-	-	41	21	38	1.4	0.38	0.25														32263
68-78	LC	8.9		-	-	23	33	39	3.6	0.54	0.39														32265
78-84	MC	8.9		-	-	7	32	56	3.3	0.54	0.39														32265
TYPE G3: PROFILE 41 – MAP 12																									
0-5	VFSCL	6.4	12.2	-	2	36	31	29	1.4	0.02	0.01	0.14	1.52	8.1	48	4.3	25	3.3	20	0.9	5	0.4	2	17.0	5553
5-12	LC	6.3	10.7	-	1	34	27	37	1.4	0.03	0.01	0.06	0.51	6.8	44	4.0	26	3.7	24	0.7	4	0.4	2	15.6	5554
12-32	LC	5.6		-	1	31	27	41	0.9	0.05	0.03														5555
32-42	FSC	5.4		-	1	27	28	43	1.1	0.08	0.06			8.3	43	1.9	10	6.7	35	0.4	2	2.0	10	19.3	5556
42-58	FSC	6.6		-	3	39	26	31	1.0	0.14	0.09			3.0	23	2.0	15	6.2	47	0.3	2	1.7	13	13.2	5557
58-74	FSC	7.7		-	1	40	23	35	1.1	0.19	0.14			1.9	15	2.1	17	6.8	54	0.2	2	1.7	12	12.7	5558
TYPE M2 CLAY LOAM OR CLAY: PROFILE 13 – MAP 4																									
0-3	HC	7.2	23.6	-	5	10	7	74	3.1	0.05	0.01	0.27	2.21	7.2	18	17.6	44	9.4	24	4.9	12	1.0	2	40.1	32212
3-9	HC	8.1	25.1	-	2	6	5	85	3.4	0.10	0.04	0.13	0.88	4.5	10	19.6	44	12.8	29	3.4	8	4.1	9	44.4	32213
9-12	HC	8.3	23.9	-	1	6	4	84	3.6	0.44	0.28														32214
12-18	HC	8.8		-	2	6	5	85	6.3	0.67	0.46				-	11.3	28	15.6	39	1.9	5	11.7	28	40.5	32215
18-31	HC	9.0		-	3	-	5	62	50.4	0.94	0.66				-	7.3	22	13.3	40	1.4	4	10.9	34	32.9	32216
31-43	HC	8.7		-	3	11	5	67	13.9	1.10	0.67														32217
43-55	HC	8.9		-	5	10	5	68	12.9	0.58	0.17				-	8.9	25	14.0	40	1.6	5	10.8	30	35.3	32218
55-68	HC	8.2		-	3	10	5	68	14.3	2.25	1.04														32219
68-84	HC	8.2		-	3	11	5	68	13.6	2.17	1.08				-	9.7	25	16.8	44	1.4	4	10.3	27	38.3	32220

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations (m.e%-milliequivalents per 100 g of soil; %-percentage of cation exchange capacity): H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TYPE M3 SANDY LOAM: PROFILE 30 – MAP 9																									
0-8	SCL	8.9	12.7	-	24	31	5	24	15.1	0.06	0.01	0.10	1.27	-	-	12.0	62	5.4	28	1.4	7	0.5	3	19.2	26472
8-14	SC	9.9	14.3	-	19	23	6	25	28.6	0.15	0.03	0.06	0.71	-	-	6.5	30	9.8	45	1.4	6	3.9	19	21.6	26473
14-22	SC	10.0		-	17	26	7	30	19.5	0.31	0.10														26474
22-36	LC	9.8		-	17	30	7	37	9.1	0.41	0.18			-	-	1.6	7	11.4	50	1.2	5	8.8	38	23.0	26475
36-48	MC	9.6		-	16	32	7	43	3.2	0.49	0.24			-	-	2.1	8	11.5	42	1.5	6	11.8	44	26.9	26476
48-72	MC	8.2		-	14	33	4	48	1.5	0.60	0.33														26477
72-84	MC	6.8		-	13	33	3	49	1.3	0.63	0.38														26478
TYPE M4 CLAY: PROFILE 10 – MAP 4																									
0-3	MC	8.2	16.4	-	8	28	6	53	3.0	0.09	0.01	0.20	1.92	2.9	11	14.4	54	5.6	21	2.9	11	0.7	3	26.5	20356
3-14	MC	8.9	20.2	-	4	25	4	64	2.4	0.07	0.01	0.10	0.75	2.8	9	7.7	26	10.9	36	2.0	7	6.5	22	29.9	20357
14-26	MC	9.6		1.2	2	18	6	66	9.1	0.21	0.04			-	-	5.9	17	16.0	45	1.9	5	11.6	33	35.4	20358
26-48	LC	9.3		10.0	2	17	5	58	18.1	0.39	0.16			-	-	6.8	19	16.5	45	1.7	5	11.7	31	36.7	20359
48-68	LC	9.1		5.4	2	17	5	50	26.4	0.46	0.17			-	-	5.0	15	15.9	46	1.6	5	11.9	34	34.4	20360
68-84	LC	9.0		-	2	18	6	54	20.9	0.56	0.23			-	-	4.8	16	12.6	41	1.8	6	11.2	37	30.4	23061
TYPE M 5 SANDY CLAY LOAM: PROFILE 14 – MAP 4																									
0-6	SCL	8.2	11.9	0.3	12	40	7	36	4.0	1.32	1.00	0.09	0.94	-	-	11.7	47	7.6	31	1.2	5	4.4	17	24.9	20362
6-27	LC	8.7	12.8	-	5	25	4	28	39.1	1.12	0.80	0.03	0.28	-	-	5.5	30	8.1	44	0.8	4	4.0	22	18.4	20363
27-44	MC	8.7		-	4	31	6	41	18.9	0.95	0.57			-	-	5.5	23	10.2	42	1.0	4	7.7	31	24.4	20364
44-54	MC	8.2		5.3	4	34	5	45	13.7	1.63	0.55			-	-	9.0	31	10.7	37	1.2	4	8.3	28	29.2	20365
54-72	MC	8.2		2.1	7	35	5	46	6.8	1.67	0.54			-	-	9.0	30	10.8	37	1.3	4	8.5	29	29.6	20366
72-84	MC	8.1		5.2	10	35	4	44	6.8	1.60	0.50			-	-	9.0	30	10.6	36	1.3	4	8.7	30	29.6	20367

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TYPE M7 CLAY: PROFILE – MAP 4																									
0-3	MC	7.7	17.7	-	9	28	6	55	2.3	0.13	0.07	0.12	0.92	4.4	15	13.3	45	7.5	25	2.1	7	2.4	8	29.7	32221
3-7	HC	8.2	21.4	-	7	20	4	66	2.6	0.55	0.14	0.10	0.70	3.2	9	14.5	42	10.2	29	2.1	6	2.9	14	34.9	32222
7-11	MC	9.0	18.4	-	7	26	5	54	8.0	0.59	0.41	0.06	0.44												32223
11-16	HC	8.9		-	7	21	4	65	3.7	0.47	0.33	0.09	0.64		-	13.1	38	11.4	33	1.7	5	8.2	24	34.4	32224
16-27	HC	8.6		-	7	22	4	61	7.0	0.84	0.58														32225
27-38	HC	8.3		-	6	20	4	51	20.1	1.24	0.56				-	13.8	42	10.4	32	1.1	3	7.6	23	32.8	32226
38-50	HC	8.2		-	5	22	4	47	21.7	1.25	0.56				-	13.0	44	9.7	33	0.9	3	6.0	20	29.6	32227
50-62	HC	8.5		-	5	21	4	54	17.7	0.69	0.33														
62-84	HC	8.0		-	2	12	4	54	28.9	1.48	0.47														
TYPE S2: PROFILE 25 – MAP 8																									
0-10	HC	6.8	16.8	-	1	15	23	58	2.4	0.02	0.01	0.15	1.66	9.4	34	8.4	31	7.1	26	1.3	5	1.1	4	27.3	23252
10-28	HC	6.3	18.1	-	-	13	22	63	1.8	0.08	0.06	0.18	0.49	9.2	32	8.7	31	7.5	27	1.0	4	1.8	6	28.2	23253
28-37	HC	6.2		-	-	13	23	61	2.1	0.23	0.18														23254
37-53	HC	7.9		-	-	13	26	59	2.1	0.23	0.17			2.5	10	10.8	41	9.8	37	0.7	3	2.3	9	26.1	23255
53-76	MC	8.7		-	-	15	24	60	2.3	0.19	0.11														23256
76-84	HC	8.4		-	-	8	23	67	2.1	0.19	0.11														23257
TYPE S3: PROFILE 35 – MAP 11																									
0-4	MC	6.4	15.1	-	-	24	26	45	2.0	0.03	0.02	0.14	1.45	8.5	39	7.3	34	4.4	20	0.9	4	0.5	3	21.6	5560
4-12	MC	6.3	15.5	-	-	23	26	50	1.6	0.02	0.01	0.07	0.54	7.9	37	7.3	34	4.9	23	0.6	3	0.6	3	21.3	5561
12-36	MC	5.8		-	-	22	26	50	1.4	0.05	0.03			8.2	45	3.7	20	5.2	28	0.6	3	0.7	4	18.4	5562
36-54	MC	6.0		-	-	22	26	51	1.3	0.04	0.02														5563
60-84	FSCL	6.5		-	-	.9	26	33	0.9	0.03	0.02			4.1	32	3.1	24	4.6	36	0.4	3	0.6	5	12.8	5564

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size: Coarse sand	Particle Size: Fine sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity: H		Ca		Mg		K		Na		Cation Exchange Capacity	Sample Number
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
TYPE S4: PROFILE 11 – MAP 4																									
0-6	MC	7.2	21.9	-	7	22	6	59	2.8	0.47	0.33	0.24	3.09	6.4	23	8.2	31	9.7	36	2.1	8	0.5	2	27.2	20368
6-18	HC	8.4	27.6	-	1	9	4	82	4.6	0.68	0.45	0.07	0.48	2.7	7	7.3	19	14.1	36	3.3	8	11.5	30	38.9	20369
18-38	HC	8.9		-	2	9	4	72	13.9	0.78	0.48			-	-	5.0	14	15.1	43	2.7	8	13.1	36	35.9	20370
38-52	MC	8.9		1.4	4	11	4	62	20.9	1.00	0.66			-	-	4.6	13	16.5	46	1.9	5	13.0	36	36.0	20371
52-62	MC	9.0		-	5	12	3	54	27.5	1.03	0.71			-	-	4.3	14	13.0	43	1.4	5	11.3	38	30.0	20372
62-84	MC	8.9		-	5	14	5	49	28.4	1.07	0.75			-	-	4.3	15	12.3	43	1.2	4	11.1	38	28.9	20373
TYPE S4: PROFILE 16 – MAP 5																									
0-2	CL	7.0	18.7	-	2	17	32	34	12.0	7.65	9.23	0.22	3.02	2.7	10	13.0	43	10.6	35	1.6	5	2.1	7	30.0	23184
2-6	LC	6.3	17.3	-	1	19	25	47	5.2	2.79	2.82	0.21	3.04	6.6	23	10.5	35	9.2	31	1.0	3	2.3	8	29.6	23185
6-12	MC	6.1		-	1	19	22	54	3.7	2.02	1.88														23186
12-32	HC	6.8		-	-	17	20	60	4.0	2.07	1.82			4.1	13	11.7	37	11.1	35	1.0	3	3.6	12	31.5	23187
32-48	HC	7.7		-	-	14	19	65	3.7	1.85	1.68														23188
48-68	HC	7.8		-	-	14	19	65	3.4	1.56	1.37			2.1	7	11.7	36	12.7	39	1.3	4	4.4	14	32.3	23189
68-80	HC	8.3		-	-	13	19	65	3.8	1.13	0.92														23190
80-84	HC	8.2		-	-	13	19	65	3.3	1.16	0.93														23191
WANDELLA CLAY: PROFILE 52 – MAP 13																									
0-5	HC	8.5	29.2	2.1	3	11	12	70	4.0	0.08	0.01	0.15	1.18	3.2	9	19.0	52	10.8	30	1.9	5	1.5	4	36.4	26552
5-30	HC	9.3	32.3	2.9	3	10	13	67	7.0	0.15	0.04	0.06	0.34	-	-	10.8	34	14.7	46	1.8	6	4.5	14	31.8	26553
30-56	HC	9.8		-	3	10	21	60	5.8	0.36	0.14			-	-	2.0	6	12.1	39	1.8	6	15.2	49	31.1	26554
56-84	HC	9.9		-	3	9	15	70	4.3	0.41	0.17			-	-	1.6	5	9.1	28	1.7	5	20.1	62	32.5	26555

Depth	Field Texture	pH	Moisture 15 Atmosphere	Gravel (Ca CO^3)	Particle Size				Loss on Acid Treatment	Soluble salts (E.C. mho/cm x 340)	Sodium Chloride (Cl x 1.65)	Nitrogen	Organic Carbon	Exchangeable Cations m.e%-milliequivalents per 100 g of soil %-percentage of cation exchange capacity										Cation Exchange Capacity	Sample Number
					Coarse sand	Fine sand	Silt	Clay						H		Ca		Mg		K		Na			
inches			%	%	%	%	%	%	%	%	%	%	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	%	m.e %	
WARRA C;AY: PROFILE 20 – MAP 7																									
0-2	CL	6.0	10.7	-	9	31	23	33	1.3	0.07	0.03	0.25	2.54	8.5	32	3.8	14	4.3	16	1.4	6	8.4	32	26.4	23194
2-5	HC	7.7	20.4	-	1	16	16	64	2.2	0.07	0.04	0.13	1.10	6.3	18	8.5	25	13.5	39	1.6	5	4.4	13	34.3	23195
5-15	HC	8.5		-	1	17	16	64	3.6	0.26	0.14			3.0	10	8.8	28	11.6	37	1.1	3	6.8	22	31.3	23196
15-17	HC	9.0		-	-	19	24	50	6.1	0.56	0.33														23197
17-38	MC	9.1		-	-	14	44	39	2.9	0.55	0.35			0.2	1	4.9	23	8.8	41	0.7	3	7.0	32	21.6	23198
38-48	MC	8.9		-	-	7	42	49	2.3	0.57	0.37														23199
48-72	LC	8.3		-	-	10	31	58	2.3	0.57	0.38			2.7	8	7.2	22	12.8	40	0.7	2	9.1	28	32.5	23200
72-84	MC	8.2		-	-	10	23	66	2.1	0.70	0.47														23201
UNIT I: PROFILE 37 – MAP 11																									
0-6	MC	7.0	14.1	-	3	30	20	44	2.0	0.04	0.02	0.14	1.39	6.2	27	8.3	36	7.0	30	0.6	2	1.2	5	23.3	5520
6-16	HC	8.1	15.7	-	2	31	19	46	1.9	0.10	0.05	0.08	0.61	4.0	21	5.5	29	8.6	46	0.5	3	0.3	1	18.9	5521
16-25	MC	8.9		-	1	26	19	53	2.3	0.23	0.13			2.4	11	4.7	21	10.5	47	0.5	2	4.1	19	22.2	5522
25-40	MC	8.9		-	1	24	20	54	2.7	0.29	0.18			2.6	11	4.2	18	10.4	46	0.6	3	5.0	22	22.8	5523
40-56	LC	8.3		-	1	26	26	45	1.7	0.43	0.28			1.7	8	4.8	24	8.8	43	0.4	2	4.8	23	20.5	5524
56-63	LC	7.7		-	1	24	24	50	1.8	0.57	0.40														5525
63-84	MC	6.9		-	1	18	20	59	2.0	0.54	0.36														5526
TYPE G2: PROFILE 40 – MAP 12																									
0-7	VFSCL	6.3	9.3	-	1	35	36	25	1.5	0.03	0.01	0.14	1.71	6.8	46	3.9	23	3.2	22	0.3	2	0.6	4	14.8	5548
7-13	LC	6.5	11.1	-	1	34	33	31	1.2	0.08	0.05	0.06	0.63	5.0	33	3.6	23	5.2	34	0.2	1	1.4	9	15.4	5549
13-30	LC	5.9		-	-	36	31	31	1.1	0.19	0.15			5.7	39	2.1	14	5.1	36	0.2	1	1.4	10	14.5	5550
30-54	FSCL	6.6		-	1	43	28	28	1.1	0.22	0.16			3.6	26	3.5	25	4.9	34	0.1	1	2.0	14	14.1	5551
54-75	MC	8.8		-	-	16	25	58	2.0	0.32	0.15														5552

Appendix II – Analytical Methods

All estimates were carried out on the air-dried fine earth, i.e., material passing a 2 mm round hole sieve. For nitrogen and organic carbon analyses, the fine earth was further reduced to pass through a 0.5 mm sieve. All results except pH and gravels are reported on an oven-dry basis. Gravel is reported as a percentage of the field sample.

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

Particle size distribution – Silt and clay were determined with a plummet balance.

Soluble Salts – A 1:5 soil-water suspension was shaken for one hour and the electrical conductivity (E.C.) determined at 20 ºC. This was converted to per cent total soluble salts (T.S.) through the relationship:

T.S. = E.C. x 340

Where E.C. is expressed in mho/cm. The factor 340 has been derived from gravimetric determinations of total soluble salts in soils from the surveyed area.

15 atmosphere percentage – This is the moisture retained, as a percentage of the oven-dry soil, after 48 hours at 15 atmosphere pressure in the pressure membrane chamber.

pH – After determination of electrical conductivity (soluble salts), the same suspension was used to determine pH by the glass electrode.

Chloride – These were determined by the electrometric titration methos of Best.

Nitrogen – The Kjeldahl method was used.

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

Exchangeable Basic 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 and magnesium were determined by atomic absorption spectrophotometry, and sodium and potassium using an EEL flame photometer. The individual cations have been expressed as milligram equivalents per 100 g of soil and as percentage of the total cation exchange capacity.

Exchangeable Hydrogen – This was determine by Mahlich's barium chloride – triethanolamine method (reference point pH 8.0), using the modification of Peech et at. (1962)

Cation Exchange Capacity – This is the sum of exchangeable calcium, magnesium, potassium, sodium and hydrogen.

Appendix III – Explanation Of Soil Terms

Bleached : Describes a horizon which has become light or pale in colour owing to leaching.

Buckshot: More or less rounded, hard, ferruginous concretions varying from shot to marble size.

Catena: As used here; a sequence of different soil types derived from similar parent material, their differences arising from drainage effects due to variation in slope.

Concretions: Local concentrations of certain chemical compounds deposited in the form of hard, more or less rounded nodules of various sizes.

Consistence: This describes the behaviour of the soil when manipulated. It indicates the resistance of the soil deformation and is a measure of the degree of cohesion of a soil or of a soil aggregate. It is affected markedly by the moisture state of the soil. The following consistence terms are used in this report: friable, plastic, hard, brittle, sticky, crumbly, loose, firm, tough, dense.

Ferruginous concretions: Concretions, mainly of iron oxide; commonly deposited in the A_2 and B_1 horizons, but sometimes occur on the surface and in other parts of the profile.

Gilgai: An uneven surface manifestation of puffs and depressions often referred to as crabholes.

Gypsum: Hydrated calcium sulphate.

Illuvial: Material in the soil profile as the result of translocation during soil weathering processes. It is customary to refer to the A horizons as eluvial horizons and the B horizons as illuvial horizons.

Lime: Calcium carbonate either finely divided or in the form of soft or hard concretions.

Morphology: The physical constitution of the various horizons and their arrangement in the soil profile.

Mottled, mottling: These terms refer to soil horizons in which two or more colours are present. The soil may differ in colour either within peds or aggregates, or between them. They do not refer to stains or coloured deposits on ped faces of the linings of cavities. Diffusely mottled implies that neighbouring colours are only slightly different; moderately mottled means that the colours are evidently different, but not strongly contrasting; while strongly mottled indicates the presence of markedly contrasting colours. The words fine, medium and coarse, when used in the description of mottling, refer to the size of the coloured aggregates or portions of aggregates.

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 in this report are for moist soils. These, in general, are about two intervals lower in value than for the soils in their dry states. The written description of the surface soils refer to the dry soils since these convey better the normal colour of the soil.

Parna: A fine-textured calcareous deposit of aeolian origin. It is postulated to be derived from older soils and transported mostly as small clay aggregates.

Ped: an individual natural soil aggregate.

Prior stream: The course of a former stream responsible for the deposition of the nearby sediments, which does not now carry water other than local drainage.

Soil association: As used here a group of soil types regularly associated geographically in a defined pattern.

Soil horizon: A layer of soil with similar characteristics throughout. The horizon may be distinguished by difference in structure, consistence, organic matter content and the presence of visual products of weathering such as calcium carbonate, gypsum, and iron oxide concretions.

Soil Profile: This is the vertical section of a soil exposing the sequence of horizon from the surface to an arbitrary depth, in this case, to at least 4 ft. The principal horizons, some of which may not be in the soils described, are:

A_1 The surface layer in which organic matter has accumulated and is partly depleted of clay and soluble material. It represents the zone of maximum biological activity and roughly corresponds to the layer affected by tillage.

A_2 A lighter coloured, sub-surface layer, poor in organic matter. This is the zone of maximum leaching.

B_1 A subsoil layer representing the zone of accumulation of some materials, chiefly clay, from the A horizon.

B_2 A zone of accumulation of other materials, usually calcium carbonate.

C A layer representing unchanged material from which the above horizons are formed.

Soil phase: A modification of a soil type in which one feature is accentuated without altering the main profile form.

Soil series: 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. The series name is taken from the locality where it was first described. A series may consist of one, two or more soil types.

Soil type: A group of soils with the same profile characteristics, including the texture of the surface soil. The unit of soil mapping used over most of this survey.

Structure: Describes the way in which the primary soil particles are arranged into soil aggregates (peds). The descriptive terms used here are: blocky, angular blocky, sub-angular blocky, prismatic, crumb, single grain. The size or grade of the aggregates may be fine, medium or coarse while the structure may be weakly, moderately or strongly developed.

Texture: This is a soil property determined by the size distribution of the primary mineral particles. It is described in terms of texture classes; some examples are sand, sandy loam, clay loam, sandy clay, light clay, heavy clay. The field texture of a soil is the texture class rating determined by kneading the wetted soi in the hand. Its assessment depends primarily upon the cohesiveness, plasticity and particle size distribution, and is influenced by the presence of organic matter, calcium carbonate and gypsum.

Toposequence: As used here, an orderly sequence of soil types passing from the highest to the lowest part of a particular landscape unit. The differences in soil types may be due to either parent material, or drainage or both. Where the parent material is uniform, “catena” is synonymous.

Variant: a minor modification of a soil type which is usually indicated by a suitable inscription on the soil map.

Appendix IV – Soil Survey Methods

In the making this soil survey, the soil surveyors listed at the front of this report walked over the land and bored holes at interval varying from 4 to 20 ch. Apart, depending on the complexity of the soil pattern. The soil profile at each spot was exposed with a 4 in. Jarrettsoi auger, usually to a depth of 4 ft., but sometimes to 7 ft., and the soil classified into its soil type. To do this the soil surveyor examined the various horizons in the soil profile and noted their texture, friability, colour, thickness, and the presence of lime, iron concretions and gypsum.

The soil type at each point examined was marked on an aerial photograph (scale 1 in. to 20 ch.) and a boundary drawn to show where one soil type changed to another. Surface features such as change of slope, depressions and rises, which often show on aerial photos were helpful in determining where the change occurred. But it should be appreciated that a soil boundary line shown on a soil map represents a zone transition. This Zone may be narrow which means that the soil change covers only a few feet or yards, or it may be gradual with the transitional zone extending over one or more chains.

Preliminary soil maps at a scale of 1 in. to 20 ch. Were constructed by transferring the soil boundaries from the aerial photographs on to suitable base plans. These are the relevant standard mapping areas of the Military Map Series with the parishes and allotments shown.

It has been necessary to reduce the particle size of the soil maps for publication, consequently, the scale of the maps in this report has been reduced to 1 in to 40 ch.

The smallest area that can be shown on the soil map at the scale used it about 1½ac., i.e., 4 ch. Across. This means that any area shown as a single soil type may have small areas of one or more soil types with it, <u>but not to a greater extent that about one sixth of the occurrence</u>. Where the other soil type (or types) covers more than one sixth, but not more than one third, its presence has been denoted by an inscription on the map. Should the second soil type exceed one third, the occurrence is mapped as a <u>complex</u> of both soil types. Where three or more soil types are intermingled in such a way that they cannot be separated at the scale of mapping used, the occurrence is mapped as a <u>soil unit</u>. In each of these cases the individual soil types may occupy areas much greater than 1½ ac.

A <u>soil association</u> may be regarded as a complex of soil types on a broad scale of mapping. The Soil Association Map shows the soils of the area grouped on this basis, but in this case the map was compiled from the detailed soil maps after they were completed, and not by mapping the soils as associations in the field.

Appendix V – Factors For Converting Imperial To Metric Units

Imperial Unit		Metric unit
	Length	
inch	= 2.540	centimetre
foot	= 30.48	centimetre
yard	= 0.914	metre
chain	= 20.12	metre
mile	= 1.609	kilometre
	Area	
acre	= 0.405	hectare
square mile	= 2.590	square kilometre
	Volume	
acre-inch	= 1.028	hectare-centimetre
	= 102.8	cubic metre
acre-foot	= 12.33	hectare-centimetre
	= 1233.6	cubic metre
gallon	= 4.546	litre
super foot	= 0.00236	cubic metre
	Mass	
ounce	= 28.5350	gram
pound	= 0.454	kilogram
hundredweight	= 0.508	quintal
ton	= 1.016	tonne
	Yield	
pound/acre	= 1.121	kilogram/hectare
hundredweight/acre	= 1.255	quintal/hectare
	Temperature	
º C (Celcius)	= 5/9 (º F – 32)	