Department of Agriculture, Victoria, Australia

SOIL AND LAND USE

IN THE

DEAKIN IRRIGATION AREA, VICTORIA

By

J. K. M. Skene

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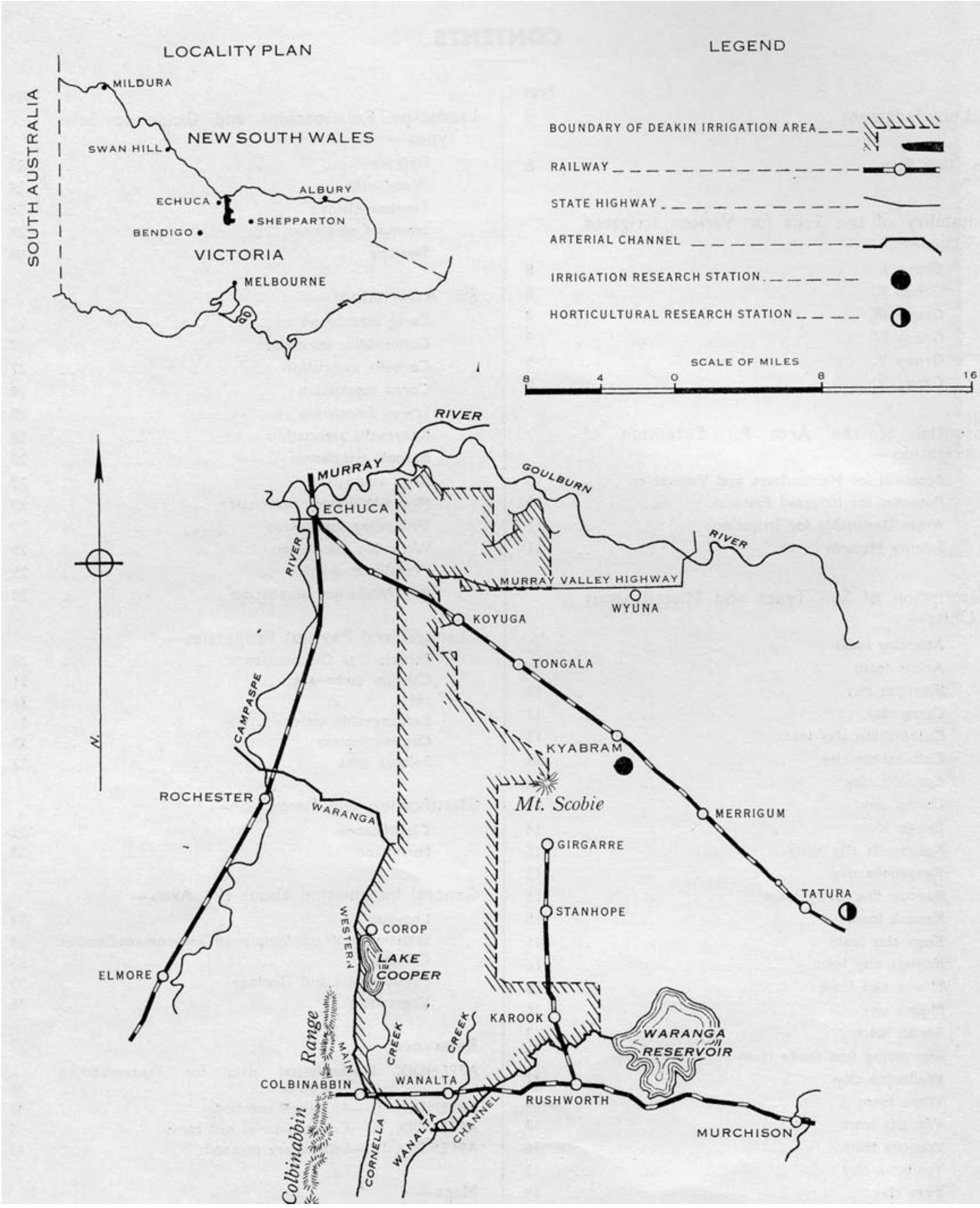

Fig 1 – Locality Plan, Deakin Irrigation Area, County Rodney

Soils and Land use in the Deakin Irrigation Area, Victoria

By J. K. M. Skene*
Soils Surveyed by J. D. Anderson, G. R. Bryant and V. O Grasmanis.

A detailed soil survey has been made of about 150,000 acres comprising most of the Deakin Irrigation Area and a small amount of adjoining land. The location of the surveyed area which is in the country of Rodney is shown in Figure 1.

Only a little more than 8 % of the land in the Deakin Irrigation Area is irrigated at present, but expansion is imminent in view of increases in the water storages serving the Area. This report, “Soils and Land Use in the Deakin Irrigation Area, Victoria”, presents a background of information against which the potential of the soils for extension of irrigation by may assessed.

The grazing of sheep for wool production on native and volunteer pastures is the main agricultural pursuit on non-irrigated land. Wheat is grown in the southern part of the Area, but there are also large tracts of low-lying country unsuitable for cropping and these have always been used exclusively for sheep raining. Dairying and fat lamb production are established on annual and perennial pastures on the irrigated lands. Fruit and vegetable growing are insignificant activities. Further information concerning the location, settlement and water supply is given in the section, “General Information about the Area”.

SUITABILITY OF THE SOILS FOR VARIOUS IRRIGATED CROPS

The soil shave been classified into soil types of other units and given names. Full descriptions of these can be found in a following section, “Description of Soil Types and Miscellaneous Units”.

In the present section, all the soil types with similar capabilities in regard to irrigated crops are grouped together. These are six different groups. The common crops that normally could be grown satisfactorily at present are listed at the head of each group, followed by the summarised features of the main soil types and the names of all the soil types in the group. In the case of Groups IV and V, the soil types within each group are divided further into sub-groups on the basis of soil differences.

Table 1 is provided to enable the crop suitability grouping of any soil type or other mapping unit to be found readily. All the soil types are listed alphabetically in the table.

Table 1 - Crop Suitability Grouping of the Soil Types and other Units

Soil Types and Units	Crop Suitability Group
Alta clay loam	Vb
Arkoo loam	IVb
Binabbin clay	IVa
Carag clay	VI
Colbinabbin clay loam	IVa
Colbinabbin clay	IVa
Cornella clay	Va
Corop clay	VI
Erwin loam, normal phase	III
Erwin clay, shallow phase	IVb
Kanyapella clay loam	Va
Kanyapella clay	Va
Karook fine sandy loam	III
Karook loam	III
Koga clay loam	IVc
Koyuga clay loam	IVc
Moora clay loam	Vb
Moora clay	Vb

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Soil Types and Units	Crop Suitability Group
Rooka loam	Va
Timmering fine sandy loam	II
Wallenjoe clay	Vi
Wana loam	IVb
Wanalta loam, light surface	III
Wanalta loam	IVb
Wanalta loam, light phase	IVb
Wenora loam	IVb
Yambuna clay	Va
Yuga clay	Vb
Type A	IVb
Type B	Va
Type C	IVb
Type D	Va
Type G	Vb
Type H	III
Type J	IVb
Soils of Prior Stream Beds – Type 2	VI
Unclassified Soils – Cemented Sandy Soils	IVb
Lunette Soils	IVb
Sand Rises	I

Crops that would be grown under dry land farming have not been included in the crops listed. All the soil types can be cultivated except some of those in Group VI.

Readers are asked to be cautions about accepting the crop suitability grouping as a rating of the soil types in order of merit, although it does suggest a general order, since high return crops can be grown less successfully in descending order from Group I to Group VI. However, if the factors restricting certain soil types to a limited range of irrigated crops are removed or ameliorated, such soil types may prove equal to or better than others with natural superiority. For example, the recommended use of the soil types in Group V is limited to the irrigation of annual pastures because of their poor surface drainage. But, if drainage can be more adequate, some of these soil types such as Cornella clay and Kanyapella clay loam should be capable of supporting very satisfactory perennial pastures.

Group I

Very good soil if given careful irrigation, for all horticultural crops, most vegetables, and tomatoes. Summer fodder crops, cereals, lucerne, and perennial and annual pastured can be grown successfully.

> Highly permeable, deep, sandy, brown soils:
> SAND RISES (unclassified soil).

The occurrences involved are few, small in areas and are probably above gravity irrigation supply level. Spray irrigation is recommend for any area sufficiently large to warrant consideration for irrigation. If these soils are not irrigated carefully there is the likelihood of causing waterlogging or salting on the lower land.

Group II

Good soils for all horticultural crops (except citrus), pumpkins, peas, beans, tomatoes, summer fodder crops, cereals, lucerne, and perennial and annual pastures

Brown soils 6 to 10 inches thick, overlying moderately permeable red-brown clay subsoils with lighter texture and more permeable layers below 2 feet:

> Timmering fine sandy loam

There are no problems for irrigated pastures on Timmering fine sandy loam. Adequate penetration of irrigation water is readily achieved and, although excessive irrigation may build up a watertable in the deep subsoil, there is little danger from soil salinity in this soil type.

Soils similar to Timmering fine sandy.

There are no problems for irrigated pastures on Timmering fine sandy loam. Adequate penetration of irrigation water is readily achieved and, although excessive irrigation may build up a watertable in the deep subsoil, there is little from soil salinity in this soil type.

Soils similar to Timmering fine sandy loam are highly regarded for horticulture in the adjoining Goulburn Valley. Nevertheless it is advisable wherever fruit trees or vegetables are contemplated to have the proposed site checked for suitability before planting.

Group III

Good soils for apricots, apples, pears, plums, summer fodder crops, cereals and perennial and annual pastures; fair soils for peached, tomatoes, pumpkins, peas, beans and lucerne.

Brown soils mostly 4 to 8 inches thick, overlying moderately permeable red-brown clay with variable clay layers below 2 feet:

Erwen loam, normal phase
Karook fine sandy loam
Karook loam
Wanalta loam, light surface inscription
Type H

Very little Erwen loam has been used for irrigation as it occurs on high ground mostly above present water supply level. Its similarity to Lemnos loam, a very widespread Group III soil type used extensively for horticulture and irrigated pastures in the Goulburn Valley, suggests that is could be put to the same use should it become commandable.

Wanalta loam is another soil type related to Lemnos loam, but only a few areas with a deeper and lighter textured surface than usual can be considered to have an equivalent potential under irrigation. These areas which can be used for Group III crops are indicated by the inscription "light surface" on the soil maps – all other situations of Wanalta loam are recommended only for Group IV crops.

Irrigates pastures are grown successfully on Karook fine sandy loam and Karook loam, but there is no experience with fruit trees or vegetables. However, these soil types appear to be good soils for irrigation since they have satisfactory drainage and their subsoils have good physical characteristics.

Type H which has a lighter textured profile than the other soil types is of negligible extent.

Group IV

Good soils for summer fodder crops, cereals, and perennial and annual pastures, except that sub-group (c) soils may be only fair for perennial pasture; fair soils for pears and plums.

(a) Well structured, brown clay soils on Cambrian hill slopes:
Binabbin clay
Colbinabbin clay loam
Colbinabbin clay

These soils occur on the hill slopes below the Waranga Western Main Channel and some situations are subject to high watertables. The soils possess good physical characteristics for irrigated crops, but salting has occurred in places and this remains a hazard to their utilisation for irrigation.

(b) Mainly brown and grey-brown loams 3 to 6 inches thick, overlying moderately permeable, red-brown or dull coloured clay subsoils:
Arkoo loam
Erwen loam, shallow phase

Wana loam
Wanalta loam
Wanalta loam, light phase
Wenora loam
Type A
Type C
Type J
Cemented sandy soils (unclassified)
Lunette soils (unclassified)

Wanalta loam and Wana loam are the principal soil types under irrigation in the Deakin Irrigation Area and have proved satisfactory for perennial and annual pastures. Arkoo loam has been irrigated to some extent and appears to be equally satisfactory.

The Lunette Soils and Erwen loam, shallow phase which is a shallow, stony soil are mainly above gravity irrigation level and are unlikely to be considered for irrigation, while the remaining soil types are unimportant because of their small extent.

(c) Shallow, brown and grey-brown clay loams over dense, dull, red-brown and yellowish
Brown clay subsoils:
Koga clay loam
Koyuga clay loam

These soil types which occupy large reacts of level, almost treeless plain appear best suited under irrigation for annual pastures. Disadvantages to perennial pasture lie in their shallow surface, assumed low subsoil permeability, and slow surface drainage. These influences are slightly less pronounced in Koyuga clay loam than in Koga clay loam. However, as both soil types have been irrigated only to insignificant extents their full potential for perennial pastures is unknown at present.

Many situations contain moderate amounts of salt at about 3 feet depth; this serves to emphasise the need for efficient use of water in the irrigation of these soils.

Group V

Summer fodder crops, cereal and annual pastures can be grown; if adequately drained, subgroup (a) soils are satisfactory for perennial pastures.

(a) Mainly well structured, moderately permeable, heavy-textured grey soils:
Cornella clay
Kanyapella clay loam
Kanyapella clay
Kooka loam
Yambuna loam
Type B
Type D

These are soils with good physical characteristics. But they suffer from restricted surface drainage. However, if this limitation can be removed, the soils should be capable for growing good irrigated perennial pastures.

(b) Shallow, grey soils overlying dense, poorly permeable, clay subsoils:
Alta clay loam
Moora clay loam
Moora clay
Yuga clay
Type G

The improvement of surface drainage governs the use of these soils for irrigation. Some situations of Alta clay loam are drained and irrigated, and apparently support reasonable annual pastures. However, Moora clay loam, Moora clay and Yuga clay have inferior physical properties to those of Alta clay loam and, in consequence, are likely to be less satisfactory for irrigation. Type G is unimportant.

Group VI

Soils not recommended for irrigation because of swampiness, liability to intermittent flooding, and salinity.

Low-lying, heavy textured, grey soils:
Carag clay
Corop clay
Wallenjoe clay
Soils of prior stream beds – type 2

Whilst the soil types in this group, are in general, not recommend for irrigation, individual situation might support irrigated pastures where the disabilities mentioned above are not pronounced. However, landholders should seek advice from a district agricultural adviser before attempting to irrigate soil types in this group.

POTENTIAL OF THE AREA FOR EXTENSION OF IRRIGATION

The suitability of the individual soil types for particular irrigated crops has been set out in the previous section specifically for the information of landholders. Also, reference is made in some of the later sections to various features about the soil types which are likely to have agricultural significance. In this section, the potential of the Deakin Irrigation Area generally for increased irrigation is discusses. Readers will be helped by referring where necessary to the Soil Association Map in the envelope at the back of this bulletin.

Potential for Horticulture and Vegetables

There is very little land suitable for the majority of horticultural crops and for vegetable growing. Of the soils which are classified as suitable for these purposes (Groups I, II and III), Erwen loam and the Sand Rises are mainly above gravity water supply level. Erwen loam is also inclined to be moderately saline in the subsoil, Type H is a very insignificant soil type, and Karook fine sandy loam and Karook loam are intermingled with lowland and swamps which made the landscape uninviting for intensive agriculture. Timmering fine sandy loam and those areas of Wanalta loam inscribed “light surface” on the soil maps could be considered, since these occurrences are similar, respectively, to Shepparton fine sandy loam and Lemnos loam which are both used extensively for fruit and vegetable growing in the Goulburn Valley. However, they amount to a relatively small area.

The less demanding fruit trees such as pears and plums might be grown satisfactorily on the soil types listed in Group IV, but only the Wanalta loam and Wana loam soil types warrant consideration. These two types which are fairly widespread have an advantage in that they occurring proximity to the more attractive horticultural soil type, Timmering fine sandy loam, whereas the other main soil types in Group IV, Koyunga clay loam, Koga clay loam and Arkoo loam are frequently associated with lowland quite unsuitable for horticulture. A rather large area of unclassified Lunette Soils is above water supply level, while the remaining soil types in Group IV are all of small extent.

Potential for Irrigated Pastures

Only about 11,500 acres are under irrigated pastures at present and there is room for considerable expansion in this direction. The approximate locations of areas where extension could most easily take place are defined by the Timmering, Wanalta and Karook soil associations. Reference should be made to the section “Soil Associations” for the soil types occurring in each of these associations.

Not all the soil types found in the above soil associations are regarded favourably for irrigation; those which are good soils for both annual and perennial pastures are Timmering fine sandy loam, Wanalta loam, Wana loam, Karook fine sandy loam, Karook loam and Arkoo loam. These soil types, in fact, are those on which irrigation has developed at present, but further extension of irrigation onto them is possible. This applies particularly to Wanalta loam and Wana loam as these is a fairly large unirrigated area of these two soil types. Another soil type, Alta clay loam which occurs on low land adjoining either Wanalta loam or Wana loam could also be used where drainage is made satisfactory. It is irrigated to only a small extent at present.

There is less scope for extending irrigation onto the Karook and Arkoo soils, since these are intermingles with considerable areas of lowland and swamp which are sometimes inundated for long periods. Rooka loam is the best of these inundated soils and could prove useful for irrigated pastures if adequately drained; but the associate low-lying soils, Moora clay loam and Wallenjoe clay, have, respectively, a low and a negligible potential for irrigation.

Intermediate and low plain represented by the Koga association is widespread and offers some prospect for extended irrigation, particularly of annual pastures. The soil types are Koyuga clay loam and Koga clay loam on the slightly higher situations, and Yuga clay on low plain and in depressions. These soil types do not appeal so much as the Timmering, Wanalta, Wana and Karook and Arkoo soil types discussed above. They are rather shallow surface soils with slowly permeable, heavy-textured subsoils which make them more suited to annual than to perennial irrigated pastures. Yuga clay, because of its situation, would require greater attention to drainage and some areas probably would not warrant developing.

The slopes below the Waranga Western Main Channel consist of Colbinabbin clay loam, Colbinabbin clay and Binabbin clay. Some of these occurrences are irrigated successfully, but the soils are liable to seepage and salting has been induced in places. Further irrigation should be approached with caution, but the scope for extension is small in any case as the soils occupy only a small area.

A considerable part of the Deakin Irrigation Area is subject to intermittent flooding, since drainage from the hills fringing the south and west finds its way through the Area to the Murray River via a network of swamps, drainage ways and generally low sand. Periodically, the drainage waters assume flood proportions. This imposes a serious limitation on the usefulness of the lowland soils for irrigation.

Two large areas of low land which warrant special consideration are represented by the Kanyapella association north of the Murray Valley Highway and the Cornella association in the vicinity of Lake Cooper. The principal soil types, Kanyapella clay loam, Kanyapella clay, Yambuna clay and Cornella clay, although heavy-textured soils, have good physical characteristics and low to moderate salt contents, and appear to be worthy of thought for irrigation, even though special measure foe their drainage may be necessary. Actually, some development has taken place on the Kanyapella and Yambuna soils, while extensive irrigated perennial pastures are established successfully on those soil types in the adjoining Echuca Village settlement. Cornella clay has been irrigated only to a very small extent.

Areas Unsuitable for Irrigation

The overall picture in regard to the distribution of swamps and lowland can be gauged from the Soil Association Map. The Wallenjoe and Carag associations, comprising Wallenjoe clay and Carag clay, respectively, are swamps, virtually devoid of any irrigation potential whatever. The Moora-Wallenjoe and Yuga-Wallenjoe associations represent swamps of Wallenjoe clay in lowland, either of Moora clay loam and Moora clay, or of Yuga clay. These lowland soil types are heavy intractable clays, tending to be moderately to highly saline in their deep subsoils and so not appeal for irrigation under circumstances such as these where extensive drainage measures would be necessary for their development.

North-east of Lake Cooper is a large area consisting of intermingled low and high land comprising the Corop association. The low land consists of Wallenjoe clay and Corop clay. The latter is a heavy-textured, saline soil types considered to be unsuitable for irrigation. The high land is suitable, but is above gravity water supply level.

Salinity Hazards

The risk of salt troubles arising from irrigation has been assessed from the salt contents of the deep subsoils. Salt is present to a variable extent in all the subsoils and, where the amounts are naturally high[*] and such areas are irrigated, there is risk of salinity developing in the overlying surface soils. Even where levels are low in the irrigated soils, there is risk of salinity developing in adjacent unirrigated soils if their subsoils contain significant amounts of salt. Movement of salt under the latter circumstances is minimised when the soil profile and the underlying strata are heavy-textured and unfavourable for the formation of watertables. Whilst this is the situation over most of the Deakin Irrigation Area, the salinity pattern[1] of the soils should be considered before extending irrigation onto any of the soil types suggested as suitable. Only areas with low or moderate salt levels are likely to be useful for irrigation.

In the present section, the level and distribution of soil salinity is described broadly in relation to the soil associations. Reference should be made to Table 4 in the section "Chemical and Physical Properties" for information on the relative salinity of the individual soil types.

Salt levels are low in the subsoils over most of the area defined by the Timmering, Wanalta and Kanyapella soil associations, although there are some situations with moderate salt contents which probably should be irrigated without risk of salinity developing.

In the case of the Karook, Koga and Cornella soil associations, moderate salt contents are frequent, particularly in the lower lying elements of these associations. One large occurrence of the Koga association in the west of the parishes of Timmering and Koyuga has subsoils with low salt contents while there are several such occurrences in the Karook association.

The heavy-textured, low-lying soils defined by the Moora-Wallenjoe, Yuga-Wallenjoe, Carag and Wallenjoe soil associations almost all have moderate or high levels of subsoil salt. This adds further to the unattractiveness for irrigation of the soil types in these lowland areas.

High salinity is fairly extensive near Lake Copper, particularly in the lowland components of the Corop association. One small situation near Corop township has very highly saline subsoils, the only other situation with similar levels being a small areas of the Koga association near the centre of the parish Burrumboot East. Otherwise salt contents of more than 0.5 per cent are virtually absent.

Irrigation of the Colbinabbin association from the Waranga Western Main Channel presents a risk of salting adjoining unirrigated lower slopes and lowland, since these lower situations already have appreciable salt in their subsoils.

Rather surprisingly the subsoils of the highly situated Erwen association have not low, but moderate salt contents. This could make Erwen loam unsuitable for horticulture in the remote event of the soils being brought within irrigation supply level.

DESCRIPTION OF SOIL TYPES AND MISCELLANEOUS UNITS

In this section all of the soil types and other units shown on the twelve soil maps with this bulletin are described in regard to their soil 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 usually depart in some respects from these averages.

Each soil type occupies a definite place in the landscape or topography. For example, some occur in depression, others on rises. Thus positional relationships comprising toposequences occur between the soil types. These sequences are shown in Italics under each soil type; they are dealt with fully in the section "Landscape Relationships".

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[*] In this report, the salt (sodium chloride) status of the soil is described arbitrarily as follows: Low-under 0.15%: moderate-between 0.15 and 0.3%: high-between 0.3 and 0.5%: very high-over 0.5%.

[1] A map showing the areas of low, moderate, high and very high salinity in the subsoil has been compiled, but is not included in this bulletin.

In the first section, the soil types are grouped in regard to suitability for particular irrigated crops. In this section, the information is elaborated for the soil types individually. In addition, reference is made to present as well as potential land use.

The 24 named soil types found in surveyed area (Table 1) are dealt with in alphabetical order. These are followed by seven unnamed soil types, one type of prior stream bed and three kinds of unclassified soils.

Some of the soil types are very simular to soil types described in the Goulburn Valley (Skene and Poutsma 1962). These relationships are indicated in the information given under each soil type description.

The overall pattern and approximate extent of the main soils series can be pictured from the Soil Association Map (see folder map); this is discussed in the section "Soil Associations".

Alta Clay Loam

Surface Soil

A	0 to 4 inches	brownish grey to grey-brown (10YR 5/2) clay loam with rusty colours along root channels; sometimes bleached in the lower part; variable buckshot; sharply separated from:

Subsoil

B_1	5 to 15 inches	brownish yellow-grey to yellowish grey-brown (2.5YR to 10YR 5/4) heavy clay; coarse angular blocky structure; hard dry; very plastic and moderately sticky wet; grades into:
B_2	15 to 33 inches	similar to above with medium structure, and slight calcium carbonate as concretions and in small pockets; grades into:
C	33 to 60 inches	yellow-grey (2.5YR 6/3) becoming brownish mottled, heavy clay; slight black concretions and soft inclusions, decreasing calcium carbonate.

Variants – The inscriptions on the soil maps of light surface and heavy surface denote soils with loam and light clay surface textured, respectively; deep surface refers to depth of 6 or 7 inches.

Occurrence – Alta clay loam occupies low plain and the less well0defined depressions and drainage ways in the prior stream sequence. The timber, where remaining, is grey box. Some situations are slightly gilgaied.

Similar Soil Types – The greyer occurrences of Alta clay loam resemble Congupna clay loam, but some situations tend towards grey-brown and these resemble Goulburn clay loam. Both the last two soil types are extensive in the Goulburn Valley (Skene and Freedman 1944, Skene and Poutsma 1962) and, like Alta clay loam, are low-lying components of prior stream sequences. The boundary between the Deakin Irrigation Area and the Tongala-Stanhope Irrigation Area has been used arbitrarily as a point of change over from the Congupna clay loam and Goulburn clay loam to the Alta clay loam.

Land Use – Most of the Alta clay loam has been under cereal cropping at some time or other. Other pursuits are the grazing of sheep on native pastures. A little Alta clay loam supports irrigated annual pasture, but there is scope for further irrigation provided the surface drainage can be improved. A shallow surface and rather dense, slowly permeable, clay subsoil make the type unattractive for other than irrigated cereals, summer fodder crops and annual pastures.

Arkoo Loam

Surface Soil

A_1	0 to 5 inches	light yellowish grey-brown (10YR 6/4) loam; trace of fine buckshot; grades into:
A_2B_1	5 to 15 inches	diffusely mottled yellowish brown (7.5YR 6/5) and yellow-grey light clay; strong medium granular structure; slightly friable dry, very friable moist, plastic wet; sharply separated from:

Subsoil

B_1	15 to 37 inches	mottled yellowish grey-brown (10YR 5/4), and yellow-grey heavy clay; strong angular blocky structure; tough and intractable; incipient soft black concretions; grades into:
B_2C	27 to 48 inches	mottled yellow-grey medium or heavy clay; more crumbly than above; trace soft calcium carbonate and concretions; grades into:
	48 to 84 inches	mottled brownish yellow-grey medium or light clay; light soft calcium carbonate and concretions in the upper part.

Variants **–** A light surface variant with a fine sandy loam surface and a grey surface variant have been recorded.

Occurrence – Arkoo loam occurs as the intermediate member of the Karook sequence. The landscape is one of numerous, almost treeless swamps with intervening plain and low rises which carry grey box, yellow box and buloke.

A little Arkoo loam occurs in the adjoining Tongala-Stanhope Irrigation Area and has been described by Skene and Poutsma (1962); the above description amplifies the earlier one.

Land Use – Cereals have been grown successfully on Arkoo loam, while sheep are grazed on native and irrigated annual pastures.

A deep, friable surface makes Arkoo loam attractive for most irrigated crops. The subsoil is well structured and should allow water to penetrate easily. However, the dense deep subsoil below 27 inches may hinder penetration of water and render the soil liable to surface waterlogging. Provided removal of surplus irrigation water is satisfactory, perennial pastures could be grown.

Binabbin Clay

Surface Soil

A	0 to 3 inches	dark grey-brown (7.5YR to 10YR 3/3) clay; crumbles to fine subangular blocky peds; friable moist; plastic and slightly sticky wet; slight calcium carbonate may be present; grades into:

Subsoil

B	3 to 16 inches	dark greyish brown (7.5YR 3/3) heavy clay; moderate medium subangular blocky structure; friable moist; plastic wet; slight calcium carbonate usually present; grades into:
C	16 to 30 inches	dark brown (5YR 3/4) heavy clay; light calcium carbonate; gypsum irregularly present; grades into:
	30 to 72 inches	brown, passing to reddish brown 2.5YR 4/5), heavy clay; light calcium carbonate; at variable depths below 6 feet grades into clay containing fragments of weathered rock.

Occurrence – Binabbin clay occurs with Colbinabbin clay loam and Colbinabbin clay on the Cambrian hills which flank the south-western part of the surveyed area. It occupies the relatively lower situations on the hill slopes. It is of small extent in the Deakin Irrigation Area.

Land Use – Binabbin clay is used mainly for wheat growing and good yields are obtained. A little irrigation is practiced where the soils adjoin the Waranga Western Main Channel. The soil profile appears to have good properties for water penetration and should support perennial pastured well. However, there is risk of seepage downhill and salinity developing on adjoining lower land.

Carag Clay

Surface Soil

A	0 to 3 inches	grey (2.5YR 6/1) to brownish grey (10YR 5/2) clay, with rusty mottling along root channels; fine subangular to medium angular blocky structure; hard dry, plastic and slightly sticky wet; at 1 to 5 inches sharply separated from:

Subsoil

B_1	3 to 20 inches	yellow-grey (2.5YR 5/3) heavy clay with black staining on ped faces in top few inches; moderate, passing to weak, angular blocky structure; hard dry, tough and intractable moist; grades into:
B_2C	20 to 36 inches	similar to above with slight soft calcium carbonate and concretions; gypsum infrequently present; grades into:
	36 to 72 inches	brownish or mottled yellow-grey medium clay; slight calcium carbonate.

Occurrence and Land Use – Carag clay occupies poorly drained depression and some swamps. It is frequently inundated for long periods and in consequence has a low agricultural value and is not recommended for irrigation. Its main use is for grazing sheep and cattle.

Colbinabbin Clay Loam

Surface Soil

A	0 to 6 inches	dark reddish brown (2.5YR 3/4) clay loam; crumbles readily to fine subangular blocky peds; very friable moist; sharply separated from:

Subsoil

B_1	6 to 21 inches	dark reddish brown (2.5YR 3/4) heavy clay; moderate to strong medium subangular blocky structure; hard dry, friable moist; grades into:
B_1C	21 to 33 inches	reddish brown (2.5YR 3/6) heavy clay; structure as above; slight to light calcium carbonate; grades into:
	33 to 48 inches	red-brown heavy clay; decreasing calcium carbonate; gypsum sometimes present; grades into:
	48 to 84 inches	as above or with inclusions of weathered rock.

Occurrence – This soil type extends as a fringe below the Waranga Western Main Channel where if flanks the Cambrian hills which lie to the west of the area. Associated soil types on the lower slopes are Colbinabbin clay and Binabbin clay. Although there is only a relatively small area of Colbinabbin clay loam within the Deakin Irrigation Area, it is probably extensive on the nearby hills above the Waranga Channel.

Land Use – Colbinabbin clay loam is farmed extensively for wheat and yields well. Under irrigation, good perennial pastures are grown in places, but salting has occurred in other. Watertables are liable to develop and there are risks of further with extension of irrigation into some situations of this soil type.

Colbinabbin Clay

Surface Soil

A 0 to 3 inches dark brown 5 to 7.5YR 3/4) light clay; crumbles readily to fine subangular blocky peds; very friable moist; sharply separated from:

Subsoil

B 3 to 15 inches dark brown (5YR 3/4) or dark reddish brown (2.5YR 3/4) heavy clay; moderate subangular blocky structure, hard dry, friable moist; grades into:

15 + inches; similar to Colbinabbin clay loam.

Occurrence and Land Use – The remarks about Colbinabbin clay loam apply also to Colbinabbin clay.

Cornella Clay

Surface Soil

A 0 to 5 inches dark grey (10YR to 2.5YR 3/1) medium clay; strong medium or fine subangularblocky structure; "self mulching" when slightly moist; often with slight fine calcium carbonate concretions; at 3 to 6 inches grades into:

Subsoil

B 5 to 20 inches dark grey (10YR to 2.5YR 3/1) heavy clay; strong coarse prismatic structure showing deep vertical cracking; very friable moist; light soft calcium carbonate and a few concretions; grades into:

20 to 36 inches dark grey heavy clay with pockets of yellowish brown (10YR 5/4) clay increasing with depth; light soft calcium carbonate and concretions; grades into:

36 to 84 inches weakly mottled yellowish brown (10YR 5/4) clay with yellow-grey colours increasing and calcium carbonate decreasing gradually with depth; black inclusions often prominent with depth.

Variants – This type is very variable. Surface colours range from grey-brown to grey, while the yellowish brown, calcareous, deep subsoil, may occur within 12 inches from the surface. Not all occurrences are self-mulching.

Occurrence – Cornella clay is found on low-lying and poorly drained gilgai plains south of Lake Cooper. In places it occurs intermingled with the treeless plain soil types, Koga clay loam and Yuga clay.

Land Use – Defective surface drainage limits the use of Cornella clay. Where drainage is reasonably good, satisfactory cereal crops are grown. Elsewhere, the type is used for the grazing of sheep on native pastures. Little or none of the type os irrigated, but, given adequate drainage, it could grow irrigated perennial pastures well, since the soil profile has a favourable structure for root and water penetration.

Corop Clay

Surface Soil

A 0 to 3 inches grey (5Y 4/1) medium clay; weak angular blocky structure; hard dry; sticky wet; sharply separated from:

Subsoil

B_1 3 to 18 inches grey (5Y 4/1) heavy clay; moderate medium subangular blocky structure; very friable moist, sticky wet; grades into:

B_2C 18 to 42 inches yellowish grey (5Y 5/2) heavy clay; structure is above; very friable moist; slight soft calcium carbonate and concretions; slight gypsum; grades into:

42 to 72 inches weakly mottled yellowish grey heavy clay; slight calcium carbonate.

Variant – The inscription light surface means that the texture of the surface soil is clay loam instead of the usual clay.

Occurrence – Corop clay is widespread on the lowland associate with the conspicuous lake-lunette landscape in the vicinity of the Corop township. It sometimes occupies the lower concave slopes of the lunettes.

Land Use – Sheep are grazed on the rather sparse native pastures found on this soil type. It is unattractive for heavy irrigation because of its liability to inundation, heavy-textured and shallow surface soils, and saline deep subsoils.

Erwen Loam

Surface Soil

A	0 to 5 inches	greyish brown (7.5YR 5/4 to 4/3) loam, irregularly and weakly bleached in the lower part; more or less buckshot and iron-impregnated chips; at 3 to 8 inches sharply separated from:

Subsoil

B_1	5 to 18 inches	red-brown (2.5YR 3/6) heavy clay; moderate coarse prismatic structure; very hard dry; plastic and sticky wet; grades into:
B_2	18 to 27 inches	reddish brown (2.5YR 4/6), sometimes mottled, heavy clay; weak coarse angular blocky structure; light calcium carbonate; at 24 to 30 inches grades into:
C	27 to 48 inches	variously mottled brown, red, yellow-grey, heavy clay; light calcium carbonate; at 36 to 48 inches grades into more strongly mottled clay containing sandstone fragments with calcium carbonate concentrated around them; merges into weathered Silurian rock.

Occurrence – Erwen loam has been recorded by Skene and Poutsma (1962) in the Goulburn Valley. It also occurs in the Silurian hills which flank the south and south-eastern part of the Deakin Irrigation Area, and also in several places where they rise above the depositional plain. Associated soil types are Wenora loam and Type G. The shallow phase occurs on the crests of the hills.

Land Use – Where the original grey box and buloke have been removed, the soils are used successfully for cereal cropping. Volunteer and native pastures are used for grazing sheep.

Much of the Erwen loam is above the present gravitational water supply system and it is unlikely that it will be considered for irrigation. However, some adjoins the Waranga-Echuca Trust Channel and a little irrigation is practiced there. It should be possible where water is available to grow perennial and annual pastures satisfactorily, and irrigated, cultivated crops on occurrences with 6 inches or more of surface soil.

Shallow Phase – The profile is less than 36 inches deep, weathered Silurian rock occurring before then. The red-brown clay subsoil is reduced, while the deeper mottled clay is absent or very restricted. Iron-impregnated sandstone chips are numerous on and in the surface soil.

Kanyapella Clay Loam

Surface Soil

A	0 to 4 inches	grey (2.5YR 5/1) or brownish clay loam; moderate medium subangular blocky structure, vesicular peds; slight buckshot; at 3 to 7 inches grades into:

Subsoil

B_1	4 to 18 inches	yellowish grey (2.5YR 5/2) with slight rusty mottling light or medium clay; moderate angular blocky structure, vesicular peds; sometimes slight ferruginous concretions; grades into:
B_2	18 to 33 inches	weakly mottled yellow-grey and yellow-brown medium clay; slight soft black inclusions; slight soft calcium carbonate and concretions.
C	33 to 48 inches	mottled yellow-brown and grey light clay; soft black inclusions; calcium carbonate irregularly present; grades into:
	48 to 72 inches	variable; as above, or silty clay, or micaceous fine sandy clay passing to fine sandy clay loam; calcium carbonate concretions sometimes present.

Variants – Sometimes micaceous fine sandy clay occurs before 48 inches; such occurrences are inscribed light deep subsoil on the soil map. The inscription light surface denotes a loam instead of a clay loam surface texture.

Occurrence – Kanyapella clay loam occupies a distinctive low-lying areas of riverine black box woodland to the north of the Murray Valley Highway. Kanyapella clay and Yambuna clay are associated soil types found at slightly lower levels, while Wallenjoe clay occurs in a central depressed area carrying red gum.

Land Use – The soils are well structured and experience in the adjoining Echuca Village settlement, where Kanyapella clay loam is irrigated successfully for dairying, shows that good perennial pastures can be grown on this soil type when it is adequately drained. In the Deakin Irrigation Area, irrigated annual pastures are established in a few places, but generally the soils support only native pastures used for grazing sheep and cattle.

Kanyapella Clay

This soil type commonly has a grey light clay surface 2 to 4 inches deep, otherwise it is identical with Kanyapella clay loam.

Occurrence and Land Use – The remarks about Kanyapella clay loam apply to Kanyapella clay.

Karook Fine Sandy Loam

Surface Soil

A_1	0 to 9 inches	yellowish brown (7.5YR 6/5) fine sandy loam; very friable dry; grades into:
A_2B_1	9 to 18 inches	weakly mottled dull reddish brown (5YR 5/4) clay loam passing to light clay; strong medium granular structure; very friable dry, plastic wet; sharply separated from:
	18 + inches	similar to Karook loam.

Occurrence and Land Use – Karook fine sandy loam, like Karook loam, occurs on low rises in the south-eastern part of the area, but is much less extensive. It has the same land use as Karook loam and can also be considered with that soil type in regard to irrigation potential.

Karook Loam

Surface Soil

A_1 0 to 8 inches		yellowish brown (7.5YR 6/5) loam; moderately friable; slight fine buckshot occasionally present; grades into:
A_2B_1 8 to 15 inches		diffusely mottled dull reddish brown (5YR 5/4) light clay; strong medium granular structure; very friable dry, plastic wet; sharply separated from:

Subsoil

B_1	15 to 21 inches	mottled red-brown (2.5YR 4/6) and brownish yellow heavy clay; strong large angular blocky structure; tough and intractable; grades into:
B_2C	21 to 39 inches	mottled brown (7.5YR 5/4) passing to yellowish grey-brown (10YR 5/3) heavy clay; more crumbly than above; slight to light soft calcium carbonate and concretions; grades into:
	39 to 84 inches	mottled yellow-grey and brown heavy clay passing to medium clay; slight calcium carbonate.

Occurrence **–** Karook loam is the upper well-drained member of the Karook sequence and is found on low rises and brown plains originally carrying grey box, yellow box and buloke. It occurs to a very small extent in the adjoining Tongala-Stanhope Irrigation Area where it has been described by Skene and Poutsma (1962).

Land Use – Dry farming pursuits on Karook loam are cereal growing and the grazing of native and volunteer pastures by sheep. Irrigated pastures are established on some occurrences and it appears to be a good soil type for both perennial and annual pastures. The surface soil is reasonably deep, while the good physical condition of the upper part of the soil profile allows adequate penetration of irrigation for deep rooting crops.

Although untried for horticulture, it probably could grow stone fruits successfully. However, its situation in a landscape of plains intermingled with swamplands makes its utilisation for horticulture unlikely.

Koga Clay Loam

Surface Soil

A	0 to 4 inches	diffusely mottled grey-brown (10YR 5/3) clay loam; hard dry, plastic and slightly separated from:

Subsoil

B_1	4 to 21 inches	dull brown (7.5YR 4/3) to yellowish grey-brown (10YR 4/3) heavy clay, often darker with diffuse rusty mottling in the upper part; moderate angular blocky structure, peds 3 to 6 inches; hard dry, tough and intractable moist; grades into:
B_2C	21 to 30 inches	dull yellowish brown (10YR 5/4) heavy clay; moderate medium subangular blocky structure; hard dry, friable moist; slight soft calcium carbonate and fine concretions; grades into:
	30 to 48 inches	dull yellowish brown or diffusely mottled yellowish grey-brown medium clay; friable moist; variable calcium carbonate; gypsum irregularly present; grades into:
	48 to 84 inches	moderately mottled brownish yellow-grey and brown medium clay, black flecks on ped faces; slight calcium carbonate irregularly present.

Variants – Light (loam), heavy (light clay), and grey surface variants are indicated by inscriptions on the soil maps. Gypsum does not occur in the deep subsoils of occurrences further south than Lake Cooper, but is generally present elsewhere.

Occurrence – Koga clay loam is the intermediate member of the treeless plain sequence. It has been recorded previously by Skene and Poutsma (1962) in the Goulburn Valley where it occurs to a small extent. Koga clay loam is one of the widespread soil types in the Deakin Irrigation Area while it is known to occur extensively further north-west in the Rochester-Echuca district.

Land Use – Koga clay loam has been used for cereal cropping, but is now given mainly to the grazing of sheep on native and volunteer pastures. Irrigation of Koga clay loam in the present area is almost negligible. As the soils are both shallow and slowly permeable, and surface drainage is only fair or indifferent, irrigated annual pastures are likely to be more successful than perennial pastures. The soils are unattractive for horticulture and at the most could be used for pears and plums.

Koyuga Clay Loam

Surface Soil

A	0 to 5 inches	dull brown (7.5YR 5/4) clay loam, occasionally loam; structureless or weak angular blocky structure; hard dry; at 3 to 7 inches sharply separated from:

Subsoil

B_1	5 to 21 inches	dark reddish brown (2.5YR ¾) passing to brown heavy clay; moderate angular blocky structure; hard dry, tough and intractable moist; grades into:
B_2C	21 to 30 inches	yellowish brown, sometimes diffusely mottled, heavy clay; friable moist; slight to light soft calcium carbonate and concretions; grades into:
	30 to 48 inches	diffusely mottled, yellowish brown medium clay; friable moist; slight to light soft calcium carbonate and concretions; grades into:
	48 to 72 inches	moderately mottled brownish yellow-grey and brown medium clay; black flecks on ped faces; slight calcium carbonate irregularly present.

Variant – The inscription light deep subsoil on the soil map defines occurrences with light clay textures below 4 feet.

Occurrence – Koyuga clay loam occupies the slightly higher, better drained positions in the treeless plain sequence. It is not very extensive in the Deakin Irrigation Area, but has been found to be widespread in the Rochester-Echuca district. Skene and Poutsma (1962) have recorded small areas in the Goulburn Valley.

Land Use – Koyuga clay loam has been used similarly to Koga clay loam and, except that it has slightly better surface drainage, it has the same potential for irrigation.

Moora Clay Loam

Surface Soil

A	0 to 2 inches	grey (2.5YR 6/2) with rusty mottling clay loam; platy passing to weak small angular blocky structure; hard dry, plastic and sticky wet; sharply separated from:

Subsoil

B_1	2 to 15 inches	dark yellowish grey (2.5YR 4/2) with rusty mottling heavy clay; moderate passing to weak prismatic structure; very hard dry, plastic and sticky wet; a few black inclusions; grades into:
B_2C	15 to 36 inches	yellow-grey (2.5YR 6/3) heavy clay; light soft calcium carbonate and concretions; grades into:
	36 to 72 inches	mottled yellow-grey and light grey heavy or medium clay; slight calcium carbonate concretions.

Variant – Some occurrences which have a loam surface 3 to 4 inches deep are inscribed light surface on the soil map.

Occurrence – Moora clay loam occupies treeless, poorly drained, low plain and broad, shallow depressions, and is particularly extensive on the lowland east of Lake Cooper where it intermingles with swamps of Wallenjoe clay.

Land Use – Very little cropping is carried out on Moora clay loam and the main pursuit is the grazing of sheep on native pastures. Moora clay loam is unattractive, because of its shallow surface, heavy intractable subsoil, and poor surface drainage, and only irrigated annual pastures, cereals and summer fodder crops should be considered.

Moora Clay

Apart from having a clay surface, the profile of Moora clay is he same as that of Moora clay loam. Its occurrence and present land use are the same, and it is even less attractive than Moora clay loam for irrigated pastures and crops.

Rooka Loam

Surface Soil

A_1	0 to 5 inches	brownish grey (10YR 6/2) loam or clay loam; moderately friable; slight fine buckshot; grades into:
A_2B_1	5 to 10 inches	diffusely mottled light grey (10YR 7/2), yellowish brown and yellow-grey clay loam or light clay; strong fine subangular blocky structure; slightly friable dry, very friable moist, plastic wet; sharply separated from:

Subsoil

B_1	10 to 15 inches	yellow-grey (2.5YR 5/4) mottled with brown and yellow shades, heavy clay; moderate large prismatic structure; tough and intractable; grades into:
B_2C	15 to 36 inches	brownish yellow-grey heavy clay, slight calcium carbonate; grades into:
	36 to 84 inches	mottled yellow-grey and grey-brown heavy passing to medium clay, more friable than above; slight calcium carbonate.

Variants – Several areas with clay loam textures are denoted on the soil maps, but such textured are more common than indicated by the inscriptions.

Occurrence – Rooka loam is the lowest member of the Karook sequence, occupying low plains and well defined depressions. Rooka clay loam, identical with Rooka loam, has been described by Skene and Poutsma (1062) in the Goulburn Valley, but it is of insignificant extent.

Land Use – The better drained situations of Rooka loam have been cultivated for cereals, but mostly it is used for grazing sheep on native pastures. The value of Rooka loam for irrigation depends on whether surface inundation can be restricted. Where drainage measures are made adequate, it should be possible to grow perennial pastures, since the topsoil has good permeability characteristics. In areas of indifferent drainage Rook loam, if irrigated, should be restricted to annual pastures, summer fodder crops and cereals.

Timmering Fine Sandy Loam

Surface Soil

A_1	0 to 5 inches	dull brown (7.5YR 5/4) fine sandy loam, occasionally loam; slightly friable dry, friable moist; grades into:
A_2	5 to 8 inches	brown (7.5YR 6/4) fine sandy clay loam; slightly hard dry, friable moist; sharply separated from:

Subsoil

B_1	8 to 20 inches	red-brown (2.5YR 4/5) medium clay; moderate medium subangular blocky structure; hard dry, plastic wet; grades into:
B_2C	20 to 30 inches	brown (5YR 4/6), sometimes diffusely mottled with yellowish brown, light clay; strong medium subangular blocky structure; slightly friable dry, very friable moist; variable soft calcium carbonate concretions; grades into:
	30 to 48 inches	mottled yellowish grey-brown (10YR 6/4), colours yellower and greyer with depth, light clay passing to clay loam, micaceous fine sandy clay, or fine sandy loam; calcium carbonate decreasing; grades into:
	48 to 84 inches	textured as above or lighter continuing below 7 feet or resting on clay.

Variant – Deep surface denotes areas with more than 12 inches of surface depth.

Occurrence – Timmering fine sandy loam occupies the levee positions of a prior stream sequence which enters the Deakin Irrigation Area from the east. The series is also found further to the north west in the Nanneella, Rochester and Lockington districts. In these districts, Timmering loam largely replaces Timmering fine sandy loam.

Similar Soil Types – Brown soils with red-brown clay subsoils and lighter textures beneath, such as occur in Timmering fine sandy loam, are common the well drained positions of the prior stream sequences of the Goulburn Valley. Shepparton fine sandy loam has the lighter profile and a few occurrences of Timmering fine sandy loam, such as those with a deep surface, correspond to this soil type. But, in the main, Timmering fine sandy loam has features approximating to those of Shepparton fine sandy loam, and the soils of these two types may be regarded as identical where they occur together on each side of the eastern boundary of the Deakin Irrigation Area.

Land Use – Most of the original woodland of grey box, yellow box, casuarina and Murray pine has been cleared for cereal cropping and the grazing of native and volunteer pastures by sheep. Irrigated perennial and annual pastures are grown successfully, both in the Deakin Irrigation Area, and on the comparable Shepparton fine sandy loam in the Goulburn Valley. Timmering fine sandy loam is also suitable for stone and other fruit trees and for vegetable, although these crops are not grown at present. It should be the best soil type for lucerne. Over irrigation will induce watertables in the light-textured deep subsoils and these would present some risk to stone fruits.

Wallenjoe Clay

Surface Soil

A_1	0 to 4 inches	grey (N 4/0) heavy clay, rusty mottling along root channels; moderate angular blocky structure; very hard dry, sticky wet; slight buckshot; grades into:

Subsoil

B	4 to 24 inches	steel grey (N 5/0) or dark yellowish grey (2.5YR 4/2) heavy clay; moderate large angular blocky structure; very hard dry, very sticky moist; grades into:
	24 to 48 inches	as above; slight calcium carbonate concretions occasionally present.

Occurrence – Wallenjoe clay is the soil of the red gum swamps which remain inundated for long periods, although some lesser depressions are also included in the type. It is frequently associated with other heavy-textured, lowland soils viz., Yuga clay and Moora clay. The surface is usually gilgaied.

Land Use – Apart from providing grazing during its dry periods, Wallenjoe clay has little agricultural value. Several of the more heavily timbered situations are state forest reserves.

Wana Loam

Surface Soil

A	0 to 5 inches	diffusely mottled grey-brown (7.5 to 10YR 5/4) loam; at 4 to 7 inches sharply separated from:

Subsoil

B_1	5 to 21 inches	yellowish brown (7.5 to 10YR 4/4) heavy clay; moderate prismatic passing to weak blocky structure; hard dry, plastic and sticky wet; at 18 to 24 inches grades into:
B_2C	21 to 30 inches	weakly mottled yellowish brown and yellow-grey heavy clay; moderate small subangular blocky structure; friable moist; slight or light soft calcium carbonate and concretions; grades into:
	30 to 42 inches	medium clay as above; slight calcium carbonate; gypsum occasionally present; grades into:
	42 to 84 inches	weakly mottled yellow-grey and grey medium or light clay; black flecks on ped faces; trace of calcium carbonate sometimes present.

Variants – Inscriptions used on the soil maps are light surface, heavy surface, gypseous, and grey surface denoting, respectively, fine sandy loam and clay loam textures, gypsum in the deep subsoil, a and surface colours similar to those of Alta clay loam.

Occurrence – Wana loam occurs on nearly level situations in the mid-flood plain position of the prior stream sequence. The timber is grey box where it still remains.

Similar Soil Type – Goulburn loam which occurs extensively on mid-flood plain situations of prior streams further eastward in the Goulburn Valley (Skene and Freedman 1944, Skene and Poutsma 1962) shows only minor variations from Wana loam. As the change in soil features is gradual, an arbitrary separation of the Wana loam from the Goulburn series has been made at the eastern boundary of the Deakin Irrigation Area.

Land Use – Much of the Wana loam is given to the grazing of sheep on native and volunteer pastures combined with cereal-farming. However, Wana loam is one of the main soil types used for irrigation. Irrigated annual, and to a lesser extent, perennial pastures are grown for fat lamb production.

Wana loam occupies situations of slow surface drainage while its clay subsoil is fairly dense and is not more than moderately permeable. For these reasons its soils are suitable for irrigated pastures, but not for fruit trees, other than pears and plums, or for vegetable crops.

Wanalta Loam

Surface Soil

A	0 to 5 inches	brown or greyish brown (5 to 7.5YR 5/4) loam, occasionally with weak bleaching in the lower part; at 4 to 8 inches grades into:

Subsoil

B_1	5 to 21 inches	red-brown or reddish brown (2.5 to 5YR 4/6) passing to brown heavy clay; moderate prismatic passing to weak blocky structure; hard dry; plastic and slightly sticky wet; at 18 to 24 inches grades into:
B_2C	21 to 30 inches	weakly mottled brown-yellow-grey medium clay; moderate small subangular blocky structure; friable moist; slight or light soft calcium carbonate and concretions;

30 to 48 inches	medium clay as above; calcium carbonate decreasing with depth; gypsum occasionally present;
48 to 84 inches	weakly mottled yellow-grey and grey medium or light clay; black flecks on ped faces.

Variants – Sometimes the surface is a fine sandy loam instead of loam and, in these soils, an A_2 horizon of about 2 inches thickness is usually clearly evident. There is also a tendency towards a greater than normal depth of surface and slightly lighter textures in the subsoil horizons. Such occurrences are denoted by the inscription light surface and, where the fine sandy loam is about 10 inches deep, by deep surface. The normal loam occurrences marked deep surface are only about 8 inches deep.

Other inscriptions used in the soil maps are heavy surface and gypseous to denote, respectively, clay loam surface textures and the present of gypsum in the deep subsoils.

Occurrence – Wanalta loam occurs on the near flood plain positions of the prior stream sequence. Usually the focal prior stream bed and levee soils of Timmering loam are clearly evident in the Wanalta loam landscape, and this is the case with most of the occurrences in the parishes of Carag Carag, Timmering and Kyabram. But in the case of the more southern occurrences in the parishes of Wanalta, Moora and Burrumboot East, the prior stream courses have not been identified and Wanalta loam occurs associated only with Wana loam and Alta clay loam.

Similar Soil Type **–** Lemnos loam, a very wide-spread soil type in the Goulburn Valley (Skene and Freedman 1944, Skene and Poutsma 1962), is similar to Wanalta loam. Both soil types are components of prior stream systems and occupy similar positions in their landscapes. Their profile characteristics change gradually and it has been found convenient to make an arbitrary separation of Wanalta loam from Lemnos loam at the eastern boundary of the Deakin Irrigation Area.

Land Use **–** Most of the original woodland of grey-box and casuarina has been cleared from Wanalta loam. Mixed cereal and sheep farming is practised extensively, but this soil type is one of the most favoured in the area for irrigation, and annual, and to a lesser extent, perennial pastures are grown where water is available. The raising of fat lambs is the principal activity on the irrigated soils, but a little dairy farming is practised also.

Whilst experience has shown that Wanalta loam is a satisfactory soil for irrigated pastures, there similarity with Lemnos loam, used extensively for fruit growing in the Goulburn Valley, suggests that it would be suitable for pears and plums, and perhaps for some other horticultural crops. However, compared with Lemnos loam, it tends on the average to have less surface depth and rather heavier and denser subsoils; consequently, it is not recommended for stone fruits, vegetables or lucerne, except in situations denoted by either *light surface* or *deep surface* inscriptions.

Light Phase

A light phase of Wanalta loam is shown on the soil maps. In this phase, light clay instead of medium clay should occur at depths between 30 and 48 inches; below this depth either heavier or lighter textures may occur.

Whilst the light phase sometimes indicates a more permeable situation of Wanalta loam, in other cases the distinction is not reliable, and for all practical purposes it is best to regard the light phase as not materially different from the normal Wanalta loam.

Wenora Loam.

Surface soil

A_1 0 to 4 inches; brownish grey to grey-brown (10YR 4/2-5/4) loam or clay loam; slight iron-impregnated sandstone chips; grades into:

A_2 4 to 6 inches; weakly bleached grey-brown loam or clay loam; slight to moderate buckshot and iron-impregnated sandstone chips; sharply separated from:

Subsoil

B_1 6 to 18 inches; yellowish brown (7·5YR 4/4) to grey-brown heavy clay; tough and intractable moist; hard dry; grades into:

B_2C 1 8 to 45 inches; mottled grey, yellow, brown heavy clay; isolated iron-impregnated sand-stone floaters; slight or light soft calcium carbonate and concretions; grades into:

45 to 84 inches; mottled grey and brown silty clay; sandstone fragments increasing with depth and merging with weathered sand-stone at depths varying from 48 inches to more than 84 inches.

Occurrence.—Wenora loam occurs on the Silurian hills in situations which receive run-off from Erwen loam on higher country. It has been described in similar situations by Skene and Poutsma (1962) in the adjoining Rodney Irrigation Area.

Land Use.—Where cleared of grey box and buloke, Wenora loam has been used for cereal cropping and the grazing of sheep on native and volunteer pastures.

As Wenora loam is of small extent and is largely above gravitational water supply level, it has very little potential for development under irrigation. It would only be suitable for Group IV crops.

Yambuna Clay.

Surface soil

A 0 to 4 inches; diffusely mottled grey (2·5Y 5/1) light clay; moderate angular blocky structure; hard dry; slight buckshot; at 3 to 6 inches, grades into:

Subsoil

B_1 4 to 18 inches; dark yellowish grey (2·5Y 4/1) mottled with rusty colours, heavy clay; coarse angular blocky structure with deep vertical cracking; sometimes with slight buckshot; grades into:

B_2 18 to 33 inches; brownish yellow-grey heavy clay; slight soft black inclusions; slight calcium carbonate irregularly present; grades into:

C 33 to 48 inches; moderately mottled yellow-brown and grey medium or light clay;

48 to 72 inches; mottled light grey and yellow-brown light clay, silty clay or micaceous fine sandy clay; slight calcium carbonate concretions.

Variants.—The inscription *light surface* on the soil maps denotes areas with clay loam surface textures. Sandy clay loam and coarser materials may occur below 60 inches.

Occurrence.—Yambuna clay is found at slightly lower levels than Kanyapella clay loam in the generally low area of riverine woodland which occurs to the north of the Murray Valley Highway. It is also known to occur in the adjoining Echuca Village settlement.

Land Use.—Irrigated annual pastures have been established in a few places, but generally the soils support only native pastures and are used for grazing sheep and cattle.

Yambuna clay is almost identical with Kanyapella clay and, like that soil type, should be capable of supporting perennial pastures where drainage measures are adequate.

Yuga Clay.

Surface soil

A	0 to 3 inches; grey (2·5Y 5/2) diffusely mottled with rusty colours, light clay; hard and cloddy dry; often with soft buckshot; sharply separated from:

Subsoil

B_1	3 to 15 inches; dark brownish grey (10YR 3/2) to yellowish grey (2·5 4/2) heavy clay; moderate angular blocky structure; hard dry, tough and intractable moist; grades into:

B_2C	15 to 24 inches; yellow-grey heavy clay; weak angular blocky structure; slight soft calcium carbonate and concretions; grades into:

24 to 42 inches; brownish yellow-grey heavy clay; slight soft calcium carbonate, odd concretions; gypsum irregularly present; grades into:

42 to 72 inches; weakly mottled brownish yellow-grey and yellowish brown medium clay; black staining on ped faces and soft black inclusions; slight calcium carbonate.

Variant.—Areas with a clay loam instead of a clay surface texture are indicated on the soil maps by the inscription *light surface.*

Occurrence.—Yuga clay is the lowest member of the *treeless plain sequence.* It occurs on low plain and in shallow depressions in a generally treeless landscape, although black box is found in the more pronounced depressions and wet areas. When dry the soil cracks deeply and some situations are weakly gilgaied.

Small areas of Yuga clay have been recorded in the Goulburn Valley by Skene and Poutsma (1962) and it is also known to occur in the Rochester-Echuca district further to the north-west.

Land Use.—The intractable nature of the surface soil makes Yuga clay uninviting for dry-farming, cultivated crops, consequently the grazing of natural pastures by sheep is the main agricultural pursuit.

Poor surface drainage coupled with low permeability in the soil profile make Yuga clay a doubtful soil for irrigated perennial pastures. However, with provision for surface drainage, annual pastures, summer fodder crops and cereals could be grown under irrigation.

Unnamed Soil Types.

The following soil types are all of small extent and are agriculturally unimportant. In some cases the descriptions given below are based on only a few observations.

Type A.

A	0 to 6 inches; grey-brown clay loam, occasionally brown loam.

B	6 to 39 inches; grey-brown, or reddish brown passing to brown, heavy clay; well structured and becoming friable with depth.

39 to 60 inches; weakly mottled brown, yellowish brown and yellow-grey; friable clay.

Occurrence and Land Use.—Type A occurs on small rises adjoining watercourses and drainage ways in the treeless plain areas to the south of Lake Cooper. The soils have good physical characteristics for irrigation and would be suitable for Group IV. crops.

Type B.

A	0 to 4 inches; grey silty clay loam; slight soft buckshot.

B	4 to 33 inches; dark grey-brown passing to brown, heavy clay; well-structured and becoming friable with depth.

33 to 60 inches; weakly mottled brown, yellow-brown, and yellow-grey, friable clay.

Occurrence and Land Use.—This soil type occurs in shallow depressions adjoining watercourses and drainage ways in the treeless plain areas to the south of Lake Cooper. Although the soil profile of Type B has fairly good physical properties, its association with areas liable to inundation probably would restrict its use under irrigation to Group V. crops.

Type C.

A_1	0 to 5 inches; brown or grey-brown fine sandy loam.

A_2	5 to 7 inches; paler fine sandy clay loam.

B_1	7 to 15 inches; brown or grey-brown heavy clay.

B_2	15 to 24 inches; diffusely mottled yellowish brown medium clay; slight calcium carbonate.

24 to 48 inches; weakly mottled brown, yellowish brown, yellow-grey light clay passing to fine sandy clay or lighter textures; slight calcium carbonate.

Occurrence and Land Use.—Type C occupies faint rises which adjoin certain watercourses and drainage ways in the southern part of the area. The landscape is one of grey box woodland plain, the associated soil types being Wanalta loam, Wana loam, Alta clay loam and Type D.

The soil profile has similar textural features to that of Timmering loam, but Type C is considered to have a more restricted irrigation potential be-cause of its small extent and landscape situation. It is placed, therefore, with Wanalta loam in Group IV.

Type D.

A	0 to 6 inches; diffusely mottled grey fine sandy clay loam; sometimes with soft buckshot.

B	6 to 21 inches; brownish yellow-grey heavy clay passing to mottled yellow-grey and yellow-brown medium clay.

21 to 48 inches; mottled yellow-grey and yellow-brown clay passing to sandy clay and lighter textures.

Occurrence and Land Use.—Type D occurs in shallow watercourses and poorly drained depressions associated with grey box woodland in the southern part of the area. The soils have moderately good physical properties and provided their surface drainage is improved perennial and annual irrigated pastures could be grown.

Type G.

A	0 to 3 inches; diffusely mottled grey clay loam; slight iron-impregnated sandstone chips.

B_1	3 to 18 inches; dark brownish grey heavy clay. B_2 18 to 48 inches; brownish yellow-grey heavy clay becoming mottled with depth; slight calcium carbonate below 27 inches.

Occurrence and Land Use.—Small areas of gilgaied soils are found in low-lying positions at the base of the Silurian hills. Skene and Poutsma (1962) have described a grey (Type G) and a brown (Type H) gilgaied soil in these situations to the east of the area. The present Type G corresponds to the earlier described Type G, but the brown gilgaied soil has not been recorded in the Deakin Irrigation Area.

Provided drainage measures are adequate, irrigated annual pastures could be grown on Type G.

Type H

A 0 to 7 inches; brown fine sandy loam, bleached in the lower part.

B_1 7 to 12 inches; brown fine sandy clay; small sub-angular blocky structure, vesicular peds.

B_2C 12 to 30 inches; brownish yellow fine sandy clay passing to fine sandy clay loam; light calcium carbonate.

30 to 72 inches; brownish yellow fine sandy loam, becoming weakly mottled; calcium carbonate decreasing with depth.

Occurrence.—Type H is a very minor soil type of no agricultural importance in the area. It occurs on the levees of *a prior stream sequence* which has been identified in the most northern part of the district. The original vegetation on the levees was Murray pine, grey box, and yellow box, but nearby lower land carries mainly black box.

Type J.

A 0 to 4 inches; brownish grey fine sandy loam or fine sandy clay loam, often with diffuse light grey and rusty coloured mottlings.

B 4 to 40 inches; mottled yellow-grey, light grey and rusty colours, fine sandy clay, or light clay passing to fine sandy clay; weak or moderate small subangular blocky structure, vesicular peds; hard dry; incipient buckshot.

40 to 60 inches; mottled fine sandy clay loam passing to silty and clay textures at variable depths.

Occurrence and Land Use.—This soil type is a component of the *prior stream sequence* mentioned under Type H. It occurs on low plain slightly below Type H. The vegetation is mainly black box, with some grey and yellow box in the better drained parts.

Type J is under natural pasture given to the grazing of sheep. Under irrigation it should be suitable for Group IV crops, although the soils may not be as permeable as the textures suggest.

Soils of the Prior Stream Beds.

The soils in this group are found in the beds of the more or less continuous depressions running through the higher parts of the depositional plains in northern Victoria. These are old non-functional streams.

The soils vary considerably, not only along and across the stream beds, but also with depth. The soil changes are too frequent to map, consequently the depressions can only be separated into broad types. Skene and Poutsma (1962) recorded Type 1, Type 1H and Type 2 depressions, based mainly on differences in the permeability of their soils. Only the Type 2 depressions have been found in the Deakin Irrigation Area.

Type 2.

These depressions have restricted downward drainage and water may lie in them for extended periods. The surface soil is from 2 to 12 inches thick and ranges from grey to grey-brown in colour and from loam to light clay in texture. The sub-surface is commonly bleached to light grey in the deeper soils and is separated sharply from the clay subsoil beneath. This is usually medium or heavy clay, with colours varying from mottled brownish grey to yellow-grey. The clay may extend down-ward for more than 6 feet, but eventually it grades into sandy materials.

Sometimes the soils in the upper 4 feet of the profile resemble those of Alta clay loam. Such occurrences are inscribed "Alta clay loam profile" on the soil maps.

***Land Use.*—**Since Type 2 depressions are liable to hold water for prolonged periods, they are not recommended for irrigation. They can sometimes be used for sites of constructed drains.

Unclassified Soils.

The soils of three kinds of rises, largely above gravity irrigation level, have not been examined in sufficient detail to enable them to be classified into soil types. However, the general nature of the soil in each of the three units is described below.

Cemented Sandy Soils.

This unit is one of low sandy rises characterised by the influence of iron on the colour and cementation of the sandy materials. Typically, the soils are bright red-brown with variable amounts of concretionary iron and cementation in the sub-surface. Subsoil textures are sandy loam passing to fine sandy clay loam and clay in the deep subsoil.

The soils are of very minor extent and are agriculturally unimportant.

Lunette Soils.

Lunettes are a very conspicuous feature of the landscape in the vicinity of Corop. They occur on the eastern perimeters of all the dry lakes and larger swamps. Some, such as that on the east side of Lake Cooper, are high and very extensive ; others fringing shallow swamps are subdued.

The lunettes occupy a large area and have only been omitted from detailed soil survey because nearly all of their soils are above present irrigation supply level.

The soils are all characteristically very friable in their subsoil horizons, but vary in other respects. The majority are brown barns and clay loams resting on well-structured brown or red-brown clay which passes to yellowish brown, friable light clay or clay loam. Calcium carbonate is usually present at variable depths below 18 inches. These soils occupy the crests and main slopes of the lunettes. Grey and grey-brown soils occur on the lower situations. Here, the surface may be calcareous and self-mulching and overlie well-structured yellow-grey clay which passes to more friable light clay.

***Land Use.*—**The timber was originally grey-box and buloke. but most of the land has been cleared for cereal cropping. Sheep are grazed on native and volunteer pastures.

The lunette soils are unlikely to be irrigated, but, if water could be supplied to them, they would be suitable for Group IV and in some situations for Group III crops.

Sand Rises.

This unit comprises brown, undifferentiated sands of variable depths. There are only a few small occurrences and these are above gravity irrigation level. However, as spray irrigation is recommended for these soils, their elevation may not prevent them from being irrigated. They are suitable for Group I. crops where there is a sufficient depth of sand.

LANDSCAPE RELATIONSHIPS AND GUIDE TO SOIL TYPES

Five broad landscape categories are recognisable; they are uplands, woodlands, treeless plains, swamp complexes, and swamps. The distribution of these is shown in Figure 2.

Three of the five categories, viz., the uplands, woodlands, and swamp complexes, each includes two or more distinct components or landscape units. In all, there are nine landscape units each with its own array of soil types. Whilst in all the units the soil types occupy definite positions in the landscape, in four of them the types are closely related to one another through their positions in slope sequences (toposequences). The toposequences are described and illustrated below. The illustrative diagrams represent idealised arrangements; each member of the toposequence is not necessarily present, and a soil type as found in the field does not necessarily occur next to the soil types shown adjoining it in the diagram.

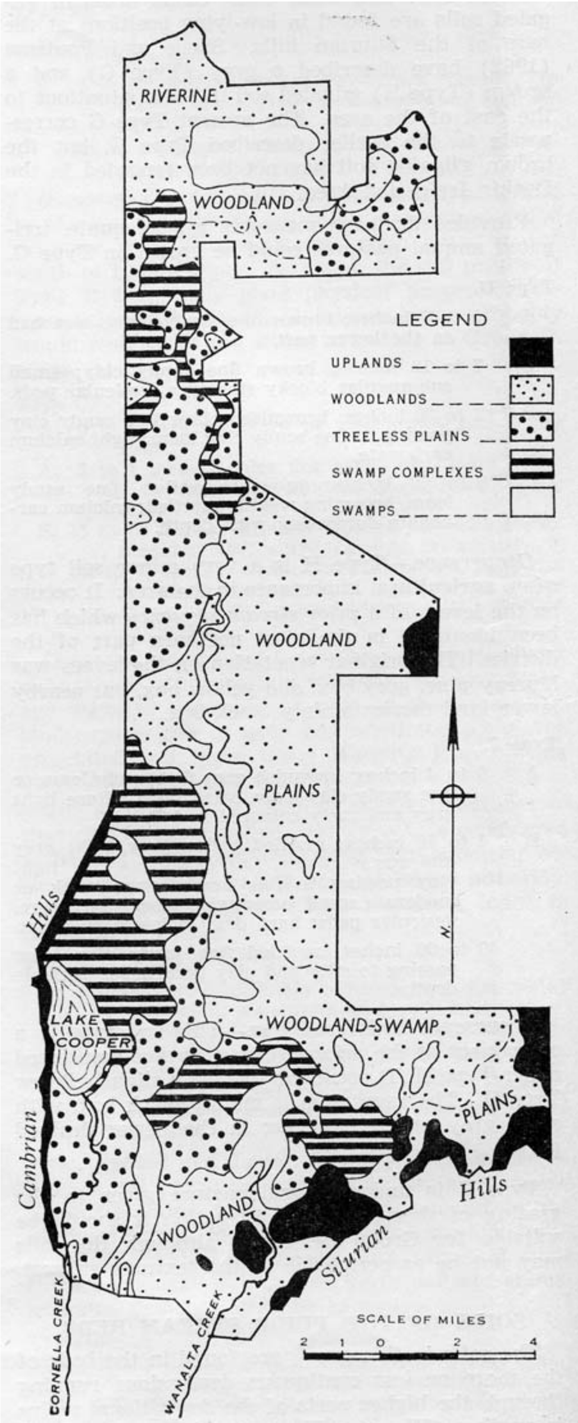


Figure 2 – Principal Landscape Features

Recurring soil patterns are evident in each of the landscape units. These are the *soil associations* described in the following section and shown on the Soil Association Map with this bulletin. The similarity between this map and Figure 2 is at once evident. The relationship between landscape, toposequences, and soil associations is shown in Table 2.

Table 2 - Relation between Landscape Features, Toposequences and Cetil Acenriatinne

Landscape.	Toposequence	Soil Association	Area Acres.
Uplands			
Silurian Hills	Silurian hill	Erwen ..	6,300
Cambrian Hills	“	Colbinabbin ..	1,800
Woodlands--			
Woodland Plains	Prior stream	Timmering ..	4,900
		Wanalta ..	45,400
		Kanyapella ..	10,000
Riverine Woodland	Karook	Karook ..	
Woodland Swamp			11,200
	Treeless plain	Koga ..	
Treeless Plains		Cornella ..	24,100
			6,400
	..	Corop ..	
Swamp Complexes		Yuga-Wallen-	12,000
Lunette-Swamp		joe	6,200
Low Plain-Swamp		Moora-Wallen-	4,300
		joe	14,600
		Wallenjoe ..	
Swamps		Carag ..	
			2,400

In the descriptions that follow, the component soil types in each landscape unit are shown in Italics, the main distinguishing features of adjacent :soil types are given, while, in some cases, reference is made to differences between equivalent soil types in other landscape units.

Uplands.

This landscape category includes two distinct limits. These are the lower slopes of the Colbinabbin Range of Cambrian rocks in the south-west, and slopes and outliers of the Silurian hills in the south-east of the area.

Silurian Hills.

This unit delineates the Erwen soil association.

The soil types are those of the Silurian hill toposequence described by Skene and Poutsma (1962) in the adjoining Rodney Irrigation Area. Figure 3 illustrates the usual topographic relationships.

Erwen loam is widespread on the crests and upper slopes, and even on the gentle lower slopes where these merge with the prior stream flood plain. It is a brown soil with a red-brown clay subsoil and is generally similar in the upper part of the profile to Wanalta loam. The main difference is in the presence of scattered, iron-impregnated fragments of the Silurian sandstone on the surface, and sometimes throughout the soil profile. Usually the underlying Silurian rock is deeper than 6 feet, but on the crests of *some of* the hills it occurs *within 36 inches.* These soils belong to *Erwen loam shallow phase.*

Wenora loam occurs on middle and lower slopes below Erwen loam and differs from that soil type in having a drab-coloured profile. Generally, it is a grey-brown soil with a yellowish brown subsoil. It may be compared with Wana loam, differing mainly in the presence of iron-impregnated sand-stone fragments.

Type G occupies poorly drained sites, particularly at the base of the hills. It is a grey, gilgaied soil with a shallow clay loam surface.

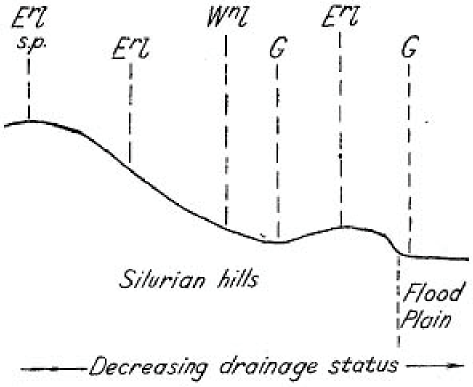


Fig. 3. Toposequence of soil types on the Silurian hill landscape.
Erl = Erwen loam; Wnl = Wenora loam; Type G. s.p. = shallow phase.

Figure 3 – Toposequence of soil types on the Silurian hill landscape

Cambrian Hills.

Three soil types occur in this landscape unit which defines the *Colbinabbin soil association.* The soil types are *Colbinabbin clay loam, Colbinabbin clay,* and *Binabbin clay.* Although all three soil types occur on slopes, Binabbin clay appears to occupy relatively lower and, perhaps, less well-drained sites.

Colbinabbin clay loam is characterised by strong reddish colours in both the surface and subsoil. The colour, moreover, changes only gradually down the soil profile. A strongly developed, fine sub-angular blocky structure in the surface soil is also characteristic. Besides being heavier, the surface of Colbinabbin clay is shallower than that of Colbinabbin clay loam. Also, profile colours tend more towards *brown.*

Binabbin clay is distinguished from Colbinabbin clay only by the drab colour of its profile. This is grey-brown in the surface and subsoil, although it gradually becomes brown, or even red-brown, in the deep subsoil.

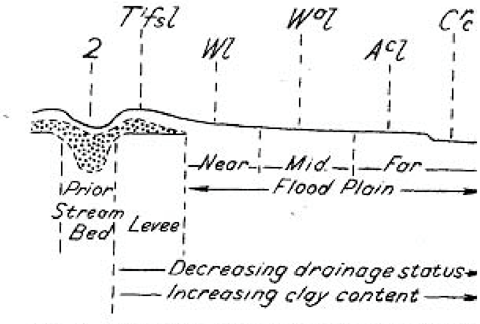
Woodlands.

The uplands, some swamps and lowland, and some plains were originally wooded. The present woodland category, however, is restricted to two landscape units which are distinguished by their vegetation rather than by any marked topographic features, *and* a third unit which is a combination of woodland and swampland.

Woodland Plains.

Although much of the timber has been cleared, sufficient remains to identify its original woodland character. Grey box is easily the dominant species with buloke a minor component. The lighter textured soils also carry yellow box while some Murray pine possibly was present before clearing. Black box still occupies the more pronounced depressions.

The soil types in this landscape are directly controlled by the prior streams and their deposits. They comprise a *prior stream toposequence* with the *prior* stream the focal point of the sequence. An idealised arrangement is illustrated in Figure 4.



A^c1 = Alta clay loam ; Crc Carag clay ; T^ifsl = Timmering fine sandy loam ; W^al = Wana loam ; Wl Wanalta loam.

Figure 4 – Toposequence of soil types on the prior stream landscape

A prior stream sequence has been described by Skene and Poutsma (1962) in the Goulburn Valley in which the soils in the beds of the channels vary from well-drained, brown, light and medium textured soils (Types 1 and 1H) to poorly drained, grey soils with clay profiles (Type 2). In the Deakin Irrigation Area the prior stream beds are mainly of the Type 2 kind. Although these soils are heavy textured in the upper part of the profile, strata occur at depth, but usually not before

Timmering loam and *Wanalta loam are* brown soils with red-brown clay subsoils occupy levee and near-flood plain positions, respectively Whilst the surface may become slightly shallow and heavier passing from Timmering loam Wanalta loam, the main distinguishing feat the presence of fine sandy clay or lighter to before a depth of 4 feet in Timmering loam contrast Wanalta loam has light or medium textures in the deep subsoil.

The catena *Wanalta loam, Wana loam* and *clay loam* forms a colour sequence on the gentle slopes of the flood plains. Passing downs the surface colours pass from brown through grey-brown to brownish grey, and the subsoil colours from red-brown through yellowish brown to yellow-grey. The colours merge gradually without any clear break in the topography; consequently the soil types are separated rather arbitrarily at the above points in the soil colour spectrum.

Carag clay, a heavy textured *grey* soil, is the lowest member of the prior stream landscape and occupies clearly defined depressions and super-imposed drainage ways. It is intermittently inundated and usually carries black box. Its relation-ship with other depression soils is described under "Swamp Complexes" later in this section.

A few low *sand rises* occur on the woodland plain. A regular pattern is not apparent; some, but not all, occur near prior stream channels.

The soil associations covered by this landscape unit are the *Timmering* and the *Wanalta associations.*

Woodland—Swamp.

This landscape unit is confined to the south-east of the area where swamps are frequent and the land between carries a *grey* box—yellow box—buloke woodland. The unit defines the *Karook soil association* while the principal soil types comprise the *Karook toposequence* which is illustrated in Figure 5.

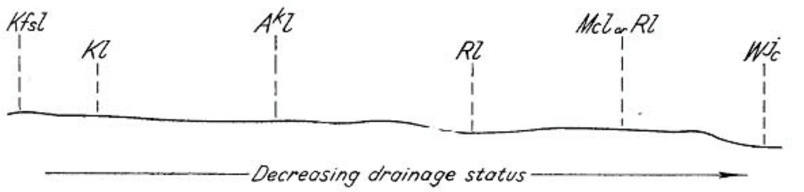


Fig. 5. Karook toposequence on the woodland-swamp landscape.

A^kl = Arkoo loam ; Kfsl = Karook fine sandy loam ; Kl = Karook loam ; Mcl = Moora clay loam ; Rl = Rooka loam ; W^lc = Wallenjoe clay.

Figure 5 – Karook toposequence on the woodland-swamp landscape

The soil types of the woodland areas comprise a catena equivalent to the Wanalta-Wana-Alta catena of the prior stream sequence. The equivalent soil types are, respectively: *Karook loam,* (sometimes *Karook fine sandy loam)* a brown surface soil with red-brown subsoil found on low rises, *Arkoo loam,* a grey-brown soil with mottled yellowish brown subsoil occupying intermediate levels, and *Rooka loam,* a grey soil with mottled yellowish grey sub-soil found in shallow depressions. The soil types of the Karook catena differ from those of the Wanalta in having friable subsoils and a gradual transition from surface to subsoil. The depth of surface and degree of friability decreases passing from Karook fine sandy loam to Rooka loam.

Although Rooka loam occupies drainage ways and some shallow swamps, there are pronounced swamps of *Wallenjoe clay* on the lowest parts of the landscape. Lowland of *Moora clay loam* usually adjoins these swamps, but sometimes the adjacent soil type is Rooka loam.

Riverine Woodland.

In the north of the area, there is a distinct drop of 10 feet or more from the general level of the depositional plain to an extensive lowland area of black box woodland and red gum forest. This low area receives much of the drainage from northward-flowing drainage lines and, prior to protection, it was also seasonally flooded by the Goulburn River. The riverine woodland unit described here comprises all of this landscape except the red gum forested swamp. It delineates the *Kanyapella soil association.*

Kanyapella clay loam occurs on fractionally higher levels of the lowland than *Kanyapella clay* and *Yambuna clay.* Yambuna clay is almost identical with Kanyapella clay, but differs in having a slightly heavier and more weakly structured sub-soil.

The above three soil types are heavy textured grey soils like Carag clay, although the clay con-tents of their subsoils are lower and the subsoils have superior physical qualities. Textures below 3 feet are light clay, or micaceous silty or fine sandy clay, but in Carag clay, they are heavier than light clay.

A minor prior stream occurrence at the northern extremity of the area has been included with the riverine woodland. Here, the black box is partly replaced by grey box, with some yellow box and Murray pine on the levees of the prior stream. The soil types are Type H on the levees, and Type J on the adjoining near-flood plain. Type H is a brown soil comparable in colour with Timmering loam, but with a lighter textured-profile. Type J is a grey, medium to light textured soil and has no counter-part in the prior stream sequence to the south. The grey colours are probably the result of seasonal flooding from the Goulburn River in relatively recent times.

Treeless Plains.

In this unit, the landscape is naturally devoid of trees, except for black box in some drainage ways, and there is but little alteration in surface relief. There are three soil types forming *a treeless plain sequence* which is illustrated in Figure 6. This sequence has been recorded previously by Skene and Poutsma (1962). The soil types are *Koyuga clay loam* on the fractionally highest situations, *Koga clay loam* on intermediate levels and *Yuga clay* on low plain. This catena of soils is equivalent to the Wanalta-Wana-Alta catena of the prior stream sequence in that colours grade down-slope from brown to grey. Differences lie in the slightly heavier and shallower surface horizons, the some-what darker, duller and more intractable subsoil clays, and the occasional presence of gypsum in the deep subsoils of the treeless plain soil types.

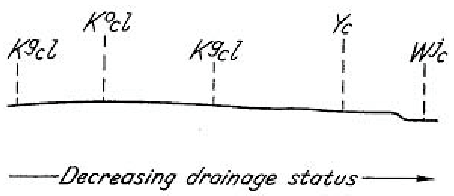


Fig. 6. Toposequence of soil types on the treeless plains.
Kgcl = Koga clay loam; Kocl = Koyuga clay loam;
Wlc = Wallenjoe clay; Yc = Yuga clay.

Figure 6 – Toposequence of soil types on treeless plains

Some shallow drainage ways in the unit have been included with Yuga clay, but more often the soils of the drainage ways have been classified as Wallenjoe clay. Such occurrences of Wallenjoe clay sometimes are little, if any, different in their profile characteristics from the Carag clay recorded in the woodland plain landscape unit.

Type A, a brown to grey-brown, and *Type B a* grey soil type are found only in the southern part of the area in the vicinity of Cornella Creek. Type A occupies low levee, and Type B inundated, positions. These soils differ from the Koyuga-Koga-Yuga sequence in having well-structured and friable profiles.

The treeless plain unit is identical with the Koga *soil association.*

South and west of Lake Cooper are rather extensive, treeless areas without the characteristic toposequence of soil types found on the treeless plains. These areas are low-lying and dominated by one soil type, *Cornella clay*, although minor occurrences of the treeless plain soil types are present. The unit identifies the *Cornella soil association.*

Cornella clay is a heavy textured grey soil. Its profile differs from those of the other low-lying grey soil types, Moora clay, Corop clay, Yuga clay, Carag clay, Wallenjoe clay and Kanyapella clay in being calcareous from the surface, or just below it, and, with the exception of Kanyapella clay, being more strongly structured and more friable.

Swamp Complexes.

Swamps are conspicuous throughout the Deakin Irrigation Area. Some of the swamps assume lake proportions and these have well-developed crescentic rises or lunettes on their eastern perimeters. In the vicinity of Corop township, the lunettes and lakes are strongly developed and comprise a recognizable landscape unit. The shallower swamps are usually accompanied by low plain; these form a second landscape unit. Both units are described below.

Lunette-Swamp.

The swamps and lakes in this unit may be either treeless or carry redgum. The soil type is *Wallenjoe clay* in the central parts of the swamp, but often there is a slightly raised area between this and the lunette, where the soil type is *Corop clay.* Corop clay may continue a slight distance up the inside slope of the lunette, and may also occur in the trough between inner and outer lunettes. *Unclassified variable* soils occur on the lunettes which have been cleared largely of grey box and buloke. The usual arrangement of soils is illustrated in Figure 7.

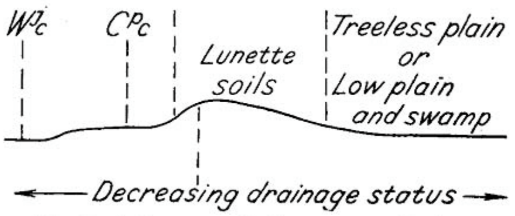


Fig. 7. Soil types on the lunette-swamp landscape.
CPc = Corop clay; Wlc = Wallenjoe clay; lunette soils are unclassified variable soils.

Figure 7 – Soil types on lunette-swamp landscape

Corop clay is a heavy-textured grey soil with resemblances to Moora clay. It differs from this soil type and the other heavy-textured lowland soils in having a friable subsoil containing gypsum at about 2 feet. It is also more saline.

The lunette-swamp landscape unit delineates the *Corop soil association.*

Low Plain-Swamp.

This is a unit of intermittent swamps and accompanying low plain. Much of the drainage from the hills south of the area finds its way northward through this part of the landscape.

Wallenjoe clay occurs in the swamps, and *Yuga clay*, *Moora clay loam* and *Moora clay* on the low-land bordering the swamps.

Moora clay is a slightly more intractable clay than Yuga clay. Also it does not contain gypsum in the subsoil, whereas gypsum is sometimes present in Yuga clay.

Two soil associations have been recognized according to whether the soil type co-dominant with Wallenjoe clay is Yuga clay or Moora clay. These are the *Yuga-Wallenjoe* and *Moora-Wallenjoe* associations. Both associations define land which is agriculturally unattractive, particularly for irrigation or cultivation.

Swamps

The Deakin Irrigation Area is notable amongst the other northern Irrigation Areas for the relatively large proportion of swamps subject to varying degrees of intermittent inundation. Swamps are major or minor components of all the landscape units described except the Silurian Hill and Cambrian Hill units.

The swamp soil types are *Carag clay* and *Wallenjoe clay,* and the soils of most of the defined drainage ways and depressed areas from which water drains very slowly consist of either one or other of these two soil types. However, in times of above-average rainfall the swamp-lands may extend, and include some situations of Rooka loam, Yuga clay, Corop clay, Moora clay loam and Moora day, while Kanyapella clay loam, Kanyapella clay and Yambuna clay comprise part of a former flooded area.

Wallenjoe clay differs from Carag clay in the extent to which inundation has modified the colour and structure of their profiles and their vegetation. The former soil in its extreme development is a steel grey clay, very sticky when wet and extremely hard and cloddy when dry. It is either treeless or forested with redgum. Carag clay on the other hand has brownish grey and yellow-grey colours in its profile and supports black box.

The soils of the larger swamps have been separated into *a Carag* and *a Wallenjoe association,* each of which is practically a pure soil type.

SOIL ASSOCIATIONS

The soil types have been combined into larger units called soil associations; these are shown on the Soil Association Map contained in the envelope at the back of this publication. This map enables the over-all soil pattern of the area to be seen readily.

A soil association is a grouping of adjoining soil types which occurs in a pattern that may be repeated in different parts of the area. The pattern is dominated by one, and sometimes by two of the component soil types. The soils grouped in this way occupy a particular and usually distinctive part of the landscape. Thirteen soil associations have been recognized. The relationship of these to landscape features is indicated in the section " Landscape Relationships " and is set out in Table 2. The areas of the individual soil associations are also given in the table.

The soil associations, in alphabetical order, are described below in terms of their dominant, sub-dominant and minor soil types, and general agricultural use. Any one soil type may occur in two or more different soil associations, assuming a different degree of importance in each. Each soil association has been given the name of its dominant or co-dominant soil type, except that in two cases both names of the co-dominant soil types have been used. The dominant soil type, together with co-dominant types where present, occupies at least two-thirds of any occurrence shown on the Soil Association Map.

Carag Association.

The dominant soils of this association occupy some of the well-defined drainage ways and swamps which are superimposed on the far-flood plain of the prior stream depositional landscape. The soils are predominantly grey clays carrying, characteristically, black box.

Dominant soil type:
Carag clay.

Minor soil types are Alta clay loam on low plain adjoining Carag clay, and, occasionally, Wanalta loam and Wana loam on the low levees flanking some depressions.
In general, this association delineates areas subject to severe intermittent flooding and, in consequence, is not suitable for irrigation unless special provision is made for drainage. It is used mainly for grazing sheep and cattle on native and volunteer pastures.

Colbinabbin Association.

The Colbinabbin association occurs on the slopes of the Cambrian hills which flank the south-western part of the area. The dominant soils are friable red-brown and brown clay loams and clays.

Dominant soil types:
Colbinabbin clay loam. Colbinabbin clay.

Sub-dominant soil type:
Binabbin clay.

The soils are cultivated extensively for cereals and produce above-average crops for the district. A little irrigation is practised adjacent to the Waranga Western Main Channel.

Cornella Association.

The Cornella association is confined to treeless low plain adjacent to the extensive swamp-lands in the south-west of the area. The soils are principally friable, dark grey, calcareous clays and the surface may be gilgaied.

Dominant soil type:
Cornella clay.

Minor soil types are Yuga clay, Carag clay, and Wallenjoe clay in depressions, and Koga clay loam on slightly elevated plain.

The soils are cropped to cereals and are productive. Their generally low situation is a drawback to irrigation, but they would support irrigated pastures satisfactorily if adequate provision for drainage were made.

Corop Association.

This association covers the soils of the *lunette-swamp landscape unit* which is well-developed north-east of Corop on Lake Cooper. A very high lunette on the eastern perimeter of Lake Cooper is included in the unit. The soils range from relatively light-textured soils on the high lunettes to grey heavy clays in the swamps and on adjoining plains. Several terminal drainage lakes included in the unit hold water almost permanently.

Dominant soil types:
Corop clay.

Unclassified soils on lunettes

Subdominant soil type:—Wallenjoe clay.

Towards the southern part of the association Corop clay is absent and is replaced as a dominant soil type by Wallenjoe clay. Cornella clay, Yuga clay, Moora clay loam, and Moora clay are minor occurrences on associated low plain, while Koyuga clay loam and Koga clay loam occur occasionally on the outer slopes of lunettes where these are gentle.

The lowland parts are used only for grazing on native and volunteer pastures, but the lunettes are cultivated for cereals in places. The Corop association defines an area which has a low irrigation potential for two reasons. The lowland is mostly unsuitable because of intermittent flooding and an inherent salinity hazard, and the lunette soils be-cause they are mostly above present supply level. The latter would be suitable for pastures and perhaps other crops if they could be irrigated.

Erwen Association.

The Erwen association corresponds to the *Silurian hill sequence.* It is found in the south-eastern part of the area and has been recorded previously where the Silurian hills encroach into the Rodney Irrigation Area (Skene and Poutsma 1962).

Dominant soil type:
Erwen loam, normal and shallow phases. Wenora loam and Type G are minor components.

Nearly all of this association is above the present gravity irrigation supply system, consequently it is used exclusively for dry-farming. However, if water were available, much of the association would be suitable for the irrigation of pastures and some horticultural crops.

Kanyapella Association.

This soil association is identified with the *riverine woodland landscape unit.* The soils are mainly moderately permeable, heavy textured, grey soils.

Dominant soil type:
Kanyapella clay.

Subdominant soil types:
Kanyapella clay loam.
Yambuna clay.

Minor components of the soil association are Wallenjoe clay and Types H and J. The last two soil types are associated with a prior stream which takes up a small part of the black box woodland landscape in the extreme north of the area.

Much of this association has not been cleared or is only partially cleared, and is utilized for light grazing. However, when protected from flooding, the soils are capable of supporting good perennial pastures under irrigation, and some such development has taken place in the western section. The soils are intensively developed for dairying in the adjoining Echuca Village settlement.

Karook Association.

A Karook sequence has been described as a minor occurrence in the adjacent Tongala–Stanhope Irrigation Area (Skene and Poutsma 1962). The Karook association includes all of the soil types of this sequence, but also includes some low plain and swampland. The soils are characteristically well-structured and friable on the high parts, but pass to dense, heavy clays on some of the lowland.

Dominant soil types:
Karook loam.
Arkoo loam. Moora clay loam.

Subdominant soil types:
Rooka loam.
Karook fine sandy loam. Wallenjoe clay.

Sometimes Karook loam is reduced to a sub-dominant or even to a minor occurrence. Moora clay is a minor soil type occasionally present.

The grazing of sheep on the native and volunteer pastures is the present common argicultural pursuit, but, at some time, much of the relatively higher land has been cultivated for cereals.

Little irrigation has been practised and in general the association demarks an area only part of which is at all attractive for irrigation. The higher woodland situations are suitable, but the swamps and adjoining lowland present drainage problems.

Koga Association.

The Koga association covers the soil types found at the intermediate and lower levels of the *treeless plain sequence.* The very limited Koyuga association recorded in the Tongala-Stanhope Irrigation Area (Skene and Poutsma 1962) can be considered to be part of the more widespread Koga association.

Dominant soil type:
Koga clay loam.

Subdominant soil type:
Yuga clay.

In places, Yuga clay may be co-dominant with Koga clay loam. Koyuga clay loam is a subdominant soil type in the Wyuna area, but elsewhere is only of minor importance. Other minor soil types are Wallenjoe clay, Moora clay loam, Moora clay and the unnamed soils, Types A and B.

The soils which are generally shallow with heavy clay subsoils are used for the greater part for dry-farming. Cultivation for cereals on the better drained parts has given way largely to grazing pursuits on native and volunteer pastures. There is a small amount of irrigated annual pasture, and it would seem that this is the direction development should take with extension of irrigation onto the soils of this association. However, adequate provision for surface drainage will be necessary on the lower parts.

Moora-Wallenjoe Association.

This is an association of heavy textured soils found in swamps and on adjoining low plain.

Dominant soil types:
Moora clay loam. Wallenjoe clay.
Yuga clay.

Subdominant soil type:
Moora clay.

This association delineates a locality generally unattractive for irrigation, because of its heavy textured soils and propensity to intermittent inundation. It is used mainly for grazing sheep on unimproved pastures.

Timmering Association.

The Timmering association, is an extension of the Shepparton association which Skene and Poutsma (1962) have shown to be extensive over much of the Goulburn Valley. It covers the soil types which occur on the levees and near-flood plain parts of the *prior stream sequence*, *i.e.*, on the highest and best drained situations on the depositional land surface. The soils are mainly brown loams over-lying red-brown clay subsoils, with lighter textures in the deep subsoil.

Dominant soil type:
Timmering fine sandy loam.

Subdominant soil type:
Wanalta loam, light phase.

Sometimes Wanalta loam light phase may be co-dominant with Timmering loam. The minor soil types are Wana loam, Alta clay loam, Carag clay and soils of the prior stream beds.

Much of the Timmering association is under either annual or perennial irrigated pastures, and supports fat lamb raising and dairying successfully. Experience with the equivalent soil types in the Goulburn Valley show that most of the Timmering association could be used for fruit growing, and some parts would be suitable for stone fruits.

Wallenjoe Association.
The dominant soils are very heavy impermeable clays, subject at times to very prolonged inundation. The more severely inundated situations carry redgum or are treeless in contrast to the black box which dominates the Carag association.

Dominant soil type:
Wallenjoe clay.

Moora clay, Yuga clay, and, in the south, Type D are the minor soil types associated with Wallenjoe clay.

The Wallenjoe association is used mainly for grazing purposes. It is generally unsuitable for irrigation.

Wanalta Association.
The Wanalta association occupies nearly level plain extending from the near - to the mid-flood plain parts of the *prior stream sequence.* The component soil types have close affinities with those found on similar situations in the Goulburn Valley. There, Skene and Poutsma (1962) record a Lemnos association on near-, and a Goulburn association on mid-floodplain positions. The Wanalta association has close affinities with the former where Wanalta loam is dominant, and with the latter where Wana loam is dominant.

Dominant soil types:
Wanalta loam.
Wana loam.

Subdominant soil type:
Alta clay loam.

Wanalta loam and Wana loam vary considerably in dominance, while in some situations Alta clay loam may reach co-dominance with the first two soil types. Carag clay, generally a minor soil type, is subdominant in a few places. Other minor soil types are Timmering fine sandy loam, Types C and D in the south, and soils of the prior stream beds.

Both dry-farming and irrigation are practised on the Wanalta association. The grazing of native and volunteer pastures has largely superseded cereal culture in the dry-farming areas. Under irrigation, both annual and perennial pastures are grown successfully for fat lamb raising and dairying. Part of the association would be suitable for horticulture, but little is likely to be suitable for stone fruits.

Yuga–Wallenjoe Association.

This association delineates an area of swamp and lowland which carries drainage northward to the River Murray. The heavy textured soils are very similar to those of the Moora–Wallenjoe association.

Dominant soil types:
Yuga clay. Wallenjoe clay.

Koga clay loam is a minor soil type present occasionally.

The heavy soils and liability to inundation make the association generally unattractive for irrigation. The grazing of native pasture is the main agricultural pursuit.

CHEMICAL AND PHYSICAL PROPERTIES

Twenty-nine profiles taken from the principal soil types have been examined in the laboratory. Their locations are shown by numbers on the soil maps. The analyses of a selection of 26 of these profiles are presented in Appendix I. This, there-fore, provides a reference to the more important measurable characteristics of the principal soil types. The analytical methods employed are given in Appendix II.

Particle Size Distribution.

All the profiles sampled, with the exception of the minor soil types, Types H and J, are characterized by high clay contents in their B, horizons. The prevalent clayey nature of the subsoils is illustrated by the selected profiles given in Table 3. Clay contents between 60 per cent and 80 per cent in the B_1 horizons are common and occasionally they exceed 80 per cent.

Table 3 - Clay Content of Principal Soil Types.

Soil Type.	Profile No.	Surface.		Subsoil.			
		A Horizon.		B_1 Horizon.		C Horizon.	
		Depth. in.	Clay. %	Depth. in.	Clay. %	Depth. in.	Clay. %
Prior Stream Toposequence-							
Timmering fine sandy loam	18	0-8	22	10-20	60	20-32	41
Wanalta loam	16	0-5	24	6-15	60	21-33	55
Wana loam	21	0-5	22	5-22	62	30-41	50
Alta clay loam	3	0-3	33	4-16	69	16-32	62
Karook Toposequence-							
Karook loam	7	0-6	26	12-16	83	16-25	75
Arkoo loam	6	0-6	25	11-16	78	16-26	72
Rooka loam	15	0-5	33	10-18	88	18-35	79
Treeless Plain Toposequence							
Koyuga clay loam	2	0-4	26	4-12	68	19-33	59
Koga clay loam	24	0-2	35	2-13	73	21-32	70
Yuga clay	11	0-2	40	2-13	73	13-23	71
Low Plain and Swamp							
Cornella clay	12	0-5	55	5-24	61	24-39	59
Moora clay	9	0-2	52	2-11	76	18-36	63
Corop clay	14	0-3	54	3-18	77	24-41	77
Carag clay	22	0-3	53	3-12	72	27-36	62
Riverine Woodland							
Kanyapella clay	29	0-4	29	12-50	56	50-72	52
Yambuna clay	25	0-7	43	7-24	62	39-54	50
Uplands							
Erwen loam	5	0-5	29	5-19	74	30-45	66
Colbinabbin clay	13	0-2	44	2-14	65	26-42	60

The data in Table 3 also clearly demonstrate the clay pan nature of all the principal soils, except Cornella clay. Even soils with more than 50 per cent, clay in their A horizons (Corop, Moora and Carag clays) still show a marked increase in clay in their B, horizons.

As would be expected, the clay contents in the C horizons[*] are slightly less than in the B, horizons.

The non-clay fractions in all of the profiles are finely graded. Coarse sand is virtually absent, the amount in the B, and deeper horizons being about 1 per cent. Slightly higher amounts occur in some of the A horizons due to secondary iron oxide concretions.

[*] These horizons may only approximate to the parent materials; C horizons in the sense of unchanged materials are probably not present in these soils.

Low fine sand to silt ratios in the majority of the profiles is further evidence of the fineness of all of the parent materials. These ratios in the C horizons vary from 0·3 in the Carag clay to 2·0 in one of the Wanalta loam profiles, but the great majority of the C horizons have ratios in the range 0·8 to 1·3.

The fine sand to silt ratio decreases, often markedly, from the A to the B_1 horizon and some-times decreases still further passing to the C horizon. This trend points to the dominance of weathering of the silt fraction in the A horizons over any eluviation of silt that may have occurred.

The high clay contents coupled with fine grading of the non-clay fractions draw attention to the possibility of low permeability in the subsoils under irrigation. However, adverse particle size distribution is countered by good structural characteristics in at least some of the soil types. For example, Cornella clay and Colbinabbin clay are obviously well-structured and water does not lie on these soils for long after rain. Also, experience with Kanyapella clay under irrigation shows that the permeability of this soil is quite good. Further, the subsoils of the Karook–Arkoo–Rooka sequence appear to have good structural properties, although they have the highest clay contents of all the profiles sampled. There is more reason to expect low permeability in the soils of the Wanalta-Wana-Alta and the Koyuga-Koga-Yuga catenas, while the Carag, Wallenjoe, Moora and Corop clays are clearly slowly permeable since water lies on them for long periods.

Reference above to the good structural qualities of the subsoils of the Karook sequence draws attention to a discrepancy between the field texture descriptions and the particle size analyses of the A_2B1 horizons of the soils of this sequence. These horizons have clay loam and light clay field textures and it is rather surprising to find that they have clay contents of from 65 to 73 per cent.

Calcium Carbonate.

Cornella clay is the most calcareous soil type in that calcium carbonate occurs from the surface down to depths of 4 feet or more. The profile analysed shows a maximum concentration of nearly 10 per cent in the fine earth at 1 to 2 feet, with slightly less but more concretionary lime in the next foot.

At the other extreme the Yambuna clay profile is very strongly acid between 2 and 5 feet. This profile, however, many not be typical since slight amounts of calcium carbonate have been recorded in the field. A similar erratic occurrence of lime has been noted in the associated Kanyapella clay.

Carbonate is present consistently in all the other soil types, although the amounts are variable. The zone of first appearance and maximum concentration, both of fine earth and concretionary calcium carbonate, is commonly between 2 and 3 feet, but it occurs within the second foot in the treeless plain soils and in some depression soils. Below these depths, usually only slight amounts of lime are present.

The profiles analysed show that the main lime horizons usually contain from 1 to 3 per cent. of calcium carbonate in the fine earth, although one profile of Wana loam has 7·5 per cent, while several of the profiles from low-lying soil types (Rooka loam, Corop clay and Yuga clay) have as little as 0·2 per cent.

Concretionary calcium carbonate in the main lime horizons normally varies from negligible amounts up to about 4 per cent. of the field sample, but in a few profiles appreciable amounts have been recorded. These Iarge amounts are usually due to a few big concretions and do not necessarily reflect a generally high concentration of lime over a wide-spread area.

pH.

Considered generally, the profile data show the soils to be slightly acid in their surface horizons with pH values nearly all within the limits of 6·1 to 6·8. The pH increases with depth to slightly or moderately alkaline in the B_1 horizons, the values mostly being within the range 7·5 to 8·5. Deeper horizons are usually strongly alkaline, pH values of 8·5 to 9·5 being common.

Exceptions to this general pH profile are shown by the Cornella clay and Yambuna clay profiles. The former is alkaline from its surface which is normal for this soil type, but the latter has very strongly acid pH values in the subsoil horizons and these may be unusual.

The pH data indicate that liming practices are unnecessary on soils in the Deakin Irrigation Area.

Exchangeable Cations.

The exchangeable calcium, magnesium, potassium and sodium in selected horizons of nine pro-files are given in Appendix I. Exchangeable hydrogen has not been determined as the pH values indicate that only the surface horizons are likely to have small amounts of exchangeable hydrogen. Thus the surface soils (Cornella clay excepted) are slightly unsaturated and the subsoils 100 per cent. or more saturated (pH 7·0 reference point).

Calculated on a clay basis the total exchangeable metal ions in 13 of the 17 subsoil horizons analysed range from 35 to 55 m.e. per 100 g of clay. Such values approximate to the exchange capacity of the clay and are comparable with those found in the Goulburn Valley (Skene and Freedman 1944, Skene and Poutsma 1962). They are of the usual order for mixed, but dominantly illite type, clay minerals. The Arkoo loam sample from the 16 to 26-in depth has a lower value at 29 m.e. per 100 g of clay. Whilst there are insufficient data to draw definite conclusions, nevertheless this value does suggest that the constitution of the clay in the soils of the Karook-Arkoo-Rooka catena may be slightly different from that in other soils on the depositional plain. Field observations on the comparative ineffectiveness of the high clay content in subsoils of the Karook catena supports this possibility.

Only two surface soils have been analysed and these show approximately equal proportions of calcium and magnesium at about 42 per cent., potassium 11 per cent., and sodium 6 per cent. In the B_1 horizons (eight samples), the proportions are, calcium 24 per cent; magnesium, 58 per cent; potassium, 6 per cent; and sodium, 12 per cent. These compare with average values of 38, 47, 6 and 9 per cent, respectively, for the same cations reported by Skene and Poutsma (1962) in soils of the Goulburn Valley.

In the C horizons exchangeable sodium increases to average 18 per cent, calcium being reduced correspondingly, but the proportions of magnesium and potassium remain practically unchanged.

The above cation proportions suggest slightly greater solonising influences in the soils of the Deakin Irrigation Area compared with soils in the Goulburn Valley. This is consistent with known trends in soil salinity passing north-westward from the Goulburn Valley.

Exchangeable potassium contents are quite high in both surface and subsoils indicating that potash is not needed in fertilizer programmes. However, the main agricultural interest is in the effect of exchangeable sodium on the permeability of the soils. Levels of 15 per cent or more are considered to cause dispersion of the clay, and levels of this order occur in the B_1 horizons in six of the eight profiles analysed. The soils concerned are mainly heavy-textured, low-lying, soil types, but one profile of Wanalta loam has a high exchangeable sodium level, whereas a second Wanalta loam profile, and also the Timmering fine sandy loam profile, show low sodium levels in their B_1 horizons. There are insufficient analyses to be able to make comparisons between soil types; the data available can only indicate the possibility of low subsoil permeability due to the influence of sodium, particularly in the treeless plain and lowland soils.

All the C horizons examined, except in the Timmering loam, have more than 15 per cent of exchangeable sodium.

Organic Matter.

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

Total nitrogen varies from 0·07 to 0·20 per cent in 25 surface soils, averaging 0·11 per cent. In the same soils, organic carbon ranges from 0·81 to 2·50 per cent and averages 1·27 per cent. The average carbon-nitrogen ratio is 11. These levels are comparable with those found in surface soils over wide areas in northern Victoria.

Soluble Salts.

Total Soluble Salts.—Low amounts of soluble salts, usually less than 0·04 per cent, are present in the surface soils. The highest amount recorded is 0·10 per cent in the Colbinabbin clay profile.

Slightly higher levels occur in the B_1 horizons, but these are usually less than 0·08 per cent. However, there are several exceptions, values ranging from 0·12 per cent to 0·25 per cent being recorded in the Colbinabbin clay, Corop clay, Kanyapella clay and Erwen loam profiles.

Soluble salts usually reach moderate amounts between 2 and 3 feet in the profile and increase to maximum concentrations at varying depths below this. The maximum contents recorded range from 0·15 to 0·59 per cent in 20 out of 22 profiles. In a further four profiles considerable visible gypsum is present below the B_1 horizon and, in consequence, soluble salts have not been determined in these horizons.

Sodium chloride.—Chlorides have been estimated in all the profiles shown in Appendix I. and are reported as sodium chloride. Levels in general parallel the total salt values. In most horizons, sodium chloride comprises from one-half to two-thirds of the total salts, but in about 25 per cent of the cases, nearly all with low total salts, the proportion is less than one-half. The constituent cations and anions (except chloride) of the soluble salts have not been determined.

The distribution of salt in the soils over the whole area has been investigated systematically in order to assess salinity hazards under irrigation. During the course of the field work 2,177 samples were taken from the same number of sites and analysed for chloride content. The 3 to 4-ft depth was selected as an index to the salt risk as this is approximately the zone of maximum salt concentration under the pertaining climatic conditions of the area. These analyses have enabled broad areas with different degrees of risk to be delineated. This aspect is considered in the section "Potential of the Area for Extension of Irrigation", whereas in Table 4 presented here the data are summarized to provide a guide to the relative salinity of the individual soil types. The only major soil type omitted is Wallenjoe clay, which was too consistently inundated at the time of the survey to allow an adequate number of soil samples to be taken.

Table 4. - Sodium Chloride in Subsoils (3 to 4-Ft.) of Principal Soil Types.

Soil Type.	Number of Samples.	Proportion of Samples in which the percentage of salt was -				Median Salt Percentage.
		Below 0·10.	0·10- 0·20.	0·21- 0·30.	Above 0·30.	
Prior Stream Toposequence-						
Timmering fine sandy loam	48	67	27	6	0	0·07
Wanalta loam	597	60	34	6	1	0·08
Wana loam	326	49	40	10	1	0·10
Alta clay loam	142	52	34	13	1	0·10
Karook Toposequence						
Karook loam and fine sandy loam	55	78	19	3	0	0·06
Arkoo loam	66	61	26	10	3	0·09
Rooka loam	53	50	26	19	5	0·10

Soil Type.	Number of Samples.	Proportion of Samples in which the percentage of salt was -				Median Salt Percentage.
		Below 0·10.	0·10- 0·20.	0·21- 0·30.	Above 0·30.	
Riverine Woodland						
Kanyapella clay loam and clay	88	57	44	8	1	0·10
Yambuna clay	62	55	32	11	2	0·09
Uplands						
Colbinabbin clay loam and clay	47	48	27	17	8	0·10
Erwen loam	61	18	36	38	8	0·18
Treeless Plain Toposequence						
Koyuga clay loam	91	19	47	22	12	0·18
Koga clay loam	167	23	41	20	16	0·18
Yuga clay	85	15	31	34	20	0·21
Low Plain and Swamp						
Cornella clay	55	55	27	7	11	0·09
Moora clay loam and clay	126	17	32	33	18	0·20
Carag clay	63	29	17	21	33	0.20
Corop clay	45	17	14	18	51	0.30

The median salt percentage provides an index to the salinity of each soil type, and may be used conveniently to compare one soil type with another. The values show that Colbinabbin clay, Cornella clay, and the soil types of the riverine woodland and the prior stream and Karook sequences all have low median values within the range 0·06 to 040 per cent. Moderate median values within the limits 0·18 to 0·30 per cent, occur in the Erwen loam, the treeless plain sequence, and in the low plain and swamp types, except Cornella clay. The low level in the Cornella clay reflects the good internal drainage of this soil type.

Agriculturally, interest lies most in the distribution of the higher salt contents in those cases where the median is 0·10 per cent or less. The situation can be pictured from the frequency distributions given in Table 4. Thus Wanalta loam is likely to have only about 7 per cent of its area with salt contents above 0·2 per cent - a subsoil figure which might be regarded as presenting some risk of salt reaching harmful concentrations in the surface under irrigation. The figure is even lower at 3 per cent in Karook loam, but rises to a maximum of 25 per cent in Colbinabbin clay. Higher proportions, ranging from 34 per cent in Koyuga clay loam to 69 per cent in Corop clay, occur in the case of soil types with moderate median percentages, i.e. greater than 0·10 per cent sodium chloride.

The data show clearly that salinity increases with deterioration of surface drainage status in related soil types. For example, compared with 7 per cent of Wanalta loam, 11 per cent of Wana loam and 14 per cent of Alta clay loam have more than 0·2 per cent of subsoil salt. The Karook and Koyuga catenas show similar trends.

CLASSIFICATION AND FORMATION

Classification.

The area lies in the red-brown earth zone originally defined by Prescott (1944) and more recently modified by Stephens (1961).

The soils on the well drained positions fit reasonably well into the general description of the red-brown earths given by Stephens (1962). These are the Timmering, Wanalta, Erwen, Koyuga, Karook and Colbinabbin soil series. The first four soil types are normal red-brown earths, but the Karook series deviates in having a crumbly, transitional AB horizon, and the Colbinabbin series in having uniformly coloured and friable A and B horizons. Downslope the soils lose their red-brown colouring and commonly are considered to be hydromorphic variants; the soil series concerned are Wana, Alta, Arkoo, Rooka, Wenora, Koga and Binabbin.

The low-lying, grey soils, comprising the Yuga, Moora, Kanyapella, Yambuna, Corop, Carag and Wallenjoe soil series are all regarded as grey soils of heavy texture (Stephens 1962), although the Kanyapella and Yambuna soils show greater differentiation between the A and B horizons than is usual in this great soil group.

Cornella clay has a calcareous profile and perhaps could be best regarded as a calcimorphic grey soil of heavy texture.

Northcote (1962) has produced a new soil map of part of southern Australia in which he includes the Deakin Irrigation Area in a landscape unit of dominantly, *hard setting loamy soils with red clayey subsoils, an alkaline trend through the pro-file, and with sporadically bleached A, horizons.* He records a complex soil pattern and classifies the component soils into categories based on new concepts (Northcote 1960). He has not named his classificational units, but identifies them by a notation system.

No attempt has been made to fit the Deakin soil types into Northcote's classification using the profile descriptions given in this bulletin, because these were derived before his classificational differentiae (Northcote 1960) were known and are not adequate in all respects. For example, some A_2 horizons are not described in sufficient detail, or have been disregarded, because they are often thin or weakly developed in the Deakin soils. Also, the data on hard setting and seasonal cracking characteristics are incomplete, not only because their classificational significance was unrealized, but also because their recognition was rendered uncertain due to wet conditions prevailing for an unduly long period at the time of the soil survey.

Formation.

The soils on the plains and lowlands are all formed from fine textured parent materials. Practically all of the material is less than 50 microns* and most of it is less than 2 micros. Some of the parent material is known to be riverine and some may be parna. But irrespective of whether the depositions are riverine, aeolian or both, they contain much clay.

The upland soils are also derived from materials with a high clay fraction, both on the Silurian sandstone and shale hills and on the interbedded basic lavas of the Cambrian hills. However, the high iron oxide component present in the Cambrian hill materials has produced strong red colours, well-developed structure, and friable peds in the profiles of the Colbinabbin soils series.

Cornella clay is the only soil type with appreciable calcium carbonate throughout its profile. It has developed from calcareous clayey materials, and through the influence of the lime, has a uniform texture profile, dark coloured and "self mulching" surface, and generally well structured profile. The origin of the calcium carbonate is explained by the situation and drainage status of the Cornella clay landscape. Cornella clay is found mainly at the base of the Cambrian hills in an area of restricted drainage. Such restriction has led to enrichment of the clayey materials with calcium carbonate derived probably from the basic materials of the adjacent hills.

It is suggested that the majority of the texture profiles illustrated in Appendix I. can be explained from the particle size data by eluviation of the parent clay. Contribution to the clay from weathering of the non-clay fraction is small, although there is some evidence of the weathering of silt.

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* **Unpublished data**

The presence of appreciable exchangeable sodium in the subsoils and deep subsoils suggests that clay may have moved from the surface downward under the solonizing influence of sodium ions. But the columnar solonetzic morphology of the B_1 horizon commonly attributed to sodium has not been found in the Deakin soils.

GENERAL INFORMATION ABOUT THE AREA

Location.

While the location and outline of the surveyed area can be found from the locality plan (Fig. 1) and the "Index to Soil Maps", additional information about locality references is given here.

The Deakin Irrigation Area at its nearest point lies about 100 miles due north of Melbourne. There are no towns within the area, but the hamlets of Corop and Colbinabbin are situated on its western boundary.

The parishes covered by the soil maps, either wholly or in part, are: Burramboot, Burramboot East, Carag Carag, Colbinabbin, Corop, Girgarre, Kanyapella, Koyuga, Kyabram, Moora, Timmering and Wyuna, all in County Rodney.

The soil maps accord with the standard mapping areas of the Military Map Series. However, for convenience, parts of more than one standard mapping area have been placed on a few of the soil map sheets. The standard mapping areas are shown on the Soil Association Map of the district and this map may be used to locate the military sheet reference for any of the soil maps.

The Deakin Irrigation Area is part of the Goulburn–Murray Irrigation District; other Irrigation Areas in the District which have been soil-surveyed previously are Shepparton (Skene and Freedman 1944), North Shepparton, South Shepparton, Rodney and Tongala–Stanhope (Skene and Poutsma 1962). These Irrigation Areas are all administrative divisions set up by the State Rivers and Water Supply Commission for the control and distribution of water in particular, defined locations.

The total area covered by the above soil surveys is 726,000 acres. This includes some land outside the six statutory Irrigation Areas.

Settlement, Water Supply and Government Centres.

The district formed part of the large sheep runs of early settlement but, after the decline of the 1853 gold boom, subdivision of the large holdings was intensified and considerable areas of wheat were grown. However, large tracts of low-lying country were unsuitable for cropping and have always been used exclusively for sheep raising. Wheat production has declined in the last 30 years and the grazing of sheep for wool production is now the principal agricultural pursuit. Beef cattle are grazed only to a small extent.

Limited irrigation was introduced about 1910 from the Goulburn Irrigation System. Water is diverted from the lower Goulburn River at the Goulburn Weir, near Nagambie, to the Waranga Reservoir. From there, it is supplied to the Deakin Irrigation Area via the Waranga Western Main Channel, and the Waranga–Deakin Channel.

The Deakin Irrigation Area comprises 161,045 acres* of which only 21,040 acres were classified as irrigable in 1961-62. The area actually irrigated was 13,217. Almost all of this is under pastures (mainly annual), supporting dairy cows and fat lambs. A few hundred acres of lucerne and cereals are grown, but other crops are negligible. The acreages of the various crops irrigated in 1961-62 were:

	Acres.
Pastures—annual	8,444
perennial	3,064
native	66
Lucerne	443
Cereals	868
Summer fodder crops	132
Orchards	38
Market gardens	15
Miscellaneous	147

* This and other statistics given in this section are taken from the 1961-62 Annual Report, State Rivers and Water Supply Commission.

Consequent on the enlargement of the Eildon Reservoir on the upper Goulburn River from 306,000 to 2,750,000 acre feet in recent years, greatly increased supplies of water are becoming available for the irrigation of lands commandable from the Goulburn Irrigation System. This, in fact, led to the soil survey of the Deakin Irrigation Area, with the principal object of selecting the most suitable soils for irrigation extensions. Expansion of irrigation is now taking place, the area irrigated increasing from 10,388 acres in 1960-61 to 13,217 acres in 1961-62, and the water delivered to the area from 10,209 to 19,226 acre feet.

Pasture improvement by sowing introduced grasses and legumes is of small extent in the area and is confined to the irrigated sections. Similarly, there has been but little top-dressing with super-phosphate outside the areas of irrigated pasture.

There are no Government centres within the Deakin Irrigation Area. This is administered by the State Rivers and Water Supply Commission from its district office at Tongala in the adjoining Tongala-Stanhope Irrigation Area.

The Department of Agriculture provides advisory services from its District Office at Rochester. It also has two research stations, the Irrigation Research Station, Kyabram, and the Horticultural Research Station, Tatura, which offer research and advisory services to pastoralists, orchardists and vegetable growers in the region generally.

Climate.

No reliable records are available within the area, but meteorological data for Rochester a few miles to the west are considered representative. These are given in Table 5.

Table 5. - Meteorological Data-Rochester.

Month.	Rainfall (51 Years).	Temperature (14 Years). Maxi-mum.	Mini-mum.	Mean.	Evapo-ration.
	In	°F	°F	°F	In
January	1·12	85·9	58·5	72·2	8·9
February	1·38	83·1	58·5	70·8	7·1
March	1·32	78·2	54·5	66·3	5·5
April..	1·12	67·6	48.8	59·2	3·5
May	1·71	61·7	43·7	52·7	1·8
June	1·88	55·7	39·7	47·7	1·1
July	1·76	54·4	38·6	46·5	0·9
August	1·57	57·7	39·0	48·7	1·6
September	1·52	63·5	42·6	53·1	2·4
October	1·69	68·1	46·8	57·5	4·1
November	1·20	74·7	50·9	62·8	6·1
December	1·16	82·2	55·5	68·9	8·2
Year	17·43	69·4	48·1	58·8	51·2

The average annual rainfall is about 17½ inches, but this varies from about 19 inches in the south to 15½ inches in the north. Winter rainfall is a little higher than summer rainfall, 9·56 inches falling on the average in the period April to September and 7·87 inches in October to March.

The rainfall varies considerably from year to year. Data are not given, but the rainfall in the summer and autumn months is markedly more erratic than the winter and the spring rainfall.

Monthly mean temperatures range from 47·7° in June to 72·2° in January.

The evaporation figures given in Table 5 are calculated values from relative humidity readings at Rochester adjusted slightly on the basis of evaporimeter tank readings at Tatura about 30 miles away. Yearly evaporation exceeds the rainfall by 33·8 inches. June and July are the only months in which rainfall is higher than the evaporation.

Physiography and Geology.

The surveyed area is situated on the most southern part of the Riverine Plain of south-eastern Australia, a huge depositional plain ex-tending over northern Victoria and New South Wales. This physiography unit is in turn a component of the Murray-Darling basin.

An elaborate, braided system of non-functional or prior streams traverses the Riverine Plain in a north-westerly direction. The prior streams have ceased to carry water and materials from the mountain catchment and their old courses are now largely filled. Usually they are recognizable features of the landscape, but in places they have been obliterated. Also, present-day watercourses and drainage lines sometimes coincide with the old prior stream channels, although usually they follow separate courses.

The Riverine Plain is built up of a considerable thickness of unconsolidated sediments of Tertiary and Quaternary age. The exposed prior streams have been held responsible by Butler (1950) and others for most of the superficial deposits. However, the proposition that the uppermost layer over part, but not all of the Plain is aeolian clay or parna has been put forward more recently by Butler (1956). This, and other aspects of depositional theories as they apply to the Goulburn Valley have been mentioned by Skene and Poutsma (1962). Their remarks apply also to the Deakin Irrigation Area and will not be repeated here.

The Deakin Irrigation Area lies between about 375 and 320 feet above sea level. The southern part of the area is bounded by the Waranga Western Main Channel which closely follows the 375-ft. contour. The plain has an average northerly gradient of a little less than 2 feet to the mile.

Hills fringing the south of the area are a maturely eroded part of the Eastern Australian Highland, rising in places moderately steeply above the plain. They are composed of Silurian or late-Devonian sedimentary rocks, mostly fine grained sandstones and siltstones. Some remnants of this eroded landsurface also occur as outliers of various sizes on the plain.

The Colbinabbin Range flanks the western boundary of the area, running northerly from Colbinabbin to Corop townships. The hills rise rather steeply from the plains to about 800 feet above sea level, but only the gentle, lower slopes are included in the surveyed area. The rocks are principally Cambrian basic lavas interbedded with cherts and shales.

Prior streams enter the Deakin Irrigation Area at several points along its eastern boundary. The pattern is shown on the Soil Association Map with this bulletin. One system, evidenced by its slightly raised levees and central drainage line, is a conspicuous feature of the landscape in the east-centre of the district in the parishes of Carag Carag and Timmering, while a more subdued system occurs towards the north of the parish of Kanyapella. The channel and levee deposits are relatively coarse textured, as are a few small sand rises, but the deposits on the plains generally are all fine.

The principal landscape features of the plains are associated with the drainage of the country. Considerable run-off from the hill country in the south reaches the plains through intermittently flowing drainage ways and watercourses, although there are no permanent streams. The Cornella and Wanalta Creeks are two such well-defined water-courses. Cornella Creek discharges into Lake Cooper, near Corop, where a system of seasonal lakes, with attendant crescentic ridges or lunettes on their eastern perimeters, is strongly developed. Wanalta Creek discharges onto low-lying plain. Drainage from the plains follows a northerly direction through a network of swamps and depressions to the Goulburn and Murray Rivers.

At irregular intervals the natural drainage system is unable to cope with incoming waters and temporary flooding occurs. The proportion of land subject to such inundation is large in relation to the rest of the area.

North of the Murray Valley Highway a large area of lowland about 10 feet below the general level of the depositional plain may have its origin in bedrock movements.

The principal recognizable physiographic features are uplands, prior streams, plains, lunettes and swamps. These give rise to nine landscape units which are discussed in relation to the soils on them in the section "Landscape Relationships and Guide to Soil Types", and are illustrated in Figure 2.

Vegetation.

The above physiographic features originally carried their own distinctive tree communities. However, the landscape has been greatly modified by clearing for agricultural purposes and, in places, only remnants of the original timber remain.

Grey box *(Eucalyptus hemiphloia),* buloke *(Casuarina Luehmannii),* yellow box *(E. melliodora)* and Murray pine *(Callitris columellaris)* were the tree components of the savannah woodlands which covered the prior stream landscape and some plains. Grey box was generally dominant with buloke subdominant, yellow box and Murray pine occurring only on the relatively light textured Timmering fine sandy loam and Type H, and, in the case of yellow box, on the well-drained Karook soil series. The few trees standing on the Cambrian hills and on the larger lunettes indicate that these originally supported a grey box-buloke woodland, with grey box the dominant species. However, it is possible that these situations were always rather sparsely timbered.

The Silurian hills show evidence of having been more heavily timbered, again with grey box the dominant species and buloke subdominant. Yellow gum or white ironbark *(E. leucoxylon)* occurs occasionally on the hills and on nearby woodland plain.

Some swamps are treeless, but most of them carry either black box *(E. bicolor)* or red gum *(E. camaldulensis).* Red gum occurs in more severely inundated situations than black box and is commonly found in swamps of Wallenjoe clay. Two of the larger red gum swamps, viz., Wallenjoe Swamp and Red Gum Swamp are rather heavily forested and have been preserved as State Forest Reserves.

Black box is associated with the continuous drainage lines found in the lowest parts of the prior stream landscape. The soil type is Carag clay. Black box also occurs on some situations of Yuga clay, while it is conspicuous as the tree component of the riverine woodland in the north of the area. Here the soil types are Kanyapella clay loam and clay and Yambuna clay.

The ground cover, although varied, is dominantly Wallaby grass *(Danthonia* spp.,*)* spear grass *(Stipa* spp.*)* and, to a lesser extent, barley grass *(Hordeum murinum),* cape weed *(Cryptostemma calendula),* windmill grass *(Chloris truncata)* and species of *Poa, Festuca* and *Bromus.* Salt tolerant plants such as beaded glasswort *(Salicornia australis)* are found in some of the few very saline areas, while billy buttons *(Craspedia uniflora),* beauty heads , *(Calocephalus citreus)*, common sneezeweed *(Centipedia cunninghamii),* native pennyroyal *(Mentha satureioides)* and common rush *(Juncus polyanthemus)* are peculiar to the wetter situations.

Saffron thistle *(Carthamus lanatus)* occurs extensively in the cropped areas and grows particularly profusely on Cornella clay.

On the irrigated soils, improved pastures are mainly of the annual, subterranean clover *(Trifolium subterraneum)—Wimmera* rye grass *(Lolium rigidum)* type. Some perennial pastures are grown; these are based on perennial rye grass *(L. perenne)* and white clover *(T. repens),* with cocksfoot *(Dactylis glomerata),* paspalum (*Paspulum dilatatum)* and strawberry clover *(T. fragiferum)* sometimes present. Lucerne *(Medicago sativa)* is grown, but not extensively.

Cumbungi or bulrush *(Typha spp.)* is conspicuous as tall dense stands in irrigation channels.

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APPENDIX I – Analytical Data for Representative Profiles.

SYMBOLS USED: FSL, fine sandy loam; L, loam; CL, clay loam; FSCL, fine sandy clay loam; SiCL, silty clay loam; FSC, fine sandy clay; LC, light clay; MC, medium clay; HC, heavy clay; E.C., electrical conductivity; *, gravel is mainly calcium carbonate; ‡, visible gypsum is present. A blank space indicates that the analysis has not been done. A dash indicates that only a trace or none of the constituent is present.

All analyses are based on the oven-dry weight of soil.

Depth	Field Texture	pH	Gravel	Particle Size: Coarse Sand	Particle Size: Fine Sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Loss on Ignition	Calcium Carbonate (CO_3 x 1·67)	Soluble Salts (E.C. mho/cm x 320)	Sodium Chloride (Cl x 1·64)	Nitrogen	Organic Carbon	Exchangeable Metal Cations (m.e.% — milliequivalents per 100 g of soil; % — percentage of total metal cations): Ca		Mg		K		Na		Total	Sample No.
in.			%	%	%	%	%	%	%	%	%	%	%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	
ALTA CLAY LOAM: PROFILE 3—MAP 2																								
0–3	CL	7·3	6	1	41	24	33				0·03	0·02	0·09	1·16	5·1	41	5·3	43	1·2	10	0·7	6	12·3	4616
4–16	HC	8·5	—	—	16	13	69				0·08	0·04			7·1	23	17·4	58	2·0	7	3·6	12	30·1	4617
16–32	HC	9·4	2*	—	18	16	62	3·7	5·8	2·1	0·15	0·04												4618
32–44	HC	9·3	—	1	19	17	61			1·4	0·17	0·06			6·0	20	17·0	57	1·7	6	5·1	17	29·8	4619
44–60	HC	8·9	—	—	18	18	63	1·8			0·15	0·07												4620
60–84	HC	8·6	—	—	29	19	51				0·11	0·06												4621
ALTA CLAY LOAM: PROFILE 20—MAP 8																								
0–2	CL	6·3	—	4	41	25	27	1·0	5·1		0·02	0·01	0·14	1·74										8706
2–8	HC	7·4	—	2	17	18	61	1·3	5·4		0·02	0·01												8707
8–19	HC	8·5	—	—	12	18	68	1·5	5·7		0·05	0·02												8708
19–30	HC	8·9	1*	1	22	19	56	1·9	4·4		0·09	0·04												8709
30–42	LC	9·0	—*	2	37	22	38	1·5	3·0		0·14	0·08												8710
42–78	FSC	8·5	—	1	49	21	29	0·5	3·4		0·22	0·16												8711
ARKOO LOAM: PROFILE 6—MAP 4																								
0–3	L	6·2	1	2	42	33	21	0·3	3·9		0·02	0·01	0·09	0·93										4666
3–6	L	6·3	—	2	37	31	29	0·4	3·7		0·01	—												4667
6–11	LC	6·8	—	1	17	16	65				0·01	0·01			3·3	27	6·9	56	0·9	7	1·2	10	12·3	4668
11–16	MC	7·5	—	1	11	10	78				0·02	0·01												4669
16–26	HC	7·8	—	1	14	13	72			—	0·03	0·02			4·1	20	12·0	58	1·1	5	3·4	17	20·6	4670
26–46	HC	9·3	—*	1	16	23	58	2·1	5·3	0·9	0·15	0·05												4671
46–60	MC	9·3	9*	2	13	29	55			2·9	0·19	0·09												4672
CARAG CLAY: PROFILE 22—MAP 8																								
0–3	MC	6·8	—	1	16	29	53	1·3	6·4		0·02	0·01	0·12	1·11										8732
3–12	HC	7·6	—	1	6	20	72	1·3	7·1		0·04	0·02												8733
12–27	HC	8·3	—	—	5	20	73	1·6	6·9		0·13	0·06												8734
27–36	HC	8·0	—	—	6	24	62	7·7	6·2	1·2	‡	0·17												8735
36–44	HC	8·5	1*	—	6	32	58	3·6	5·1		‡	0·19												8736
44–72	MC	8·3		—	8	34	55	2·2	4·8		0·40	0·24												8737
COLBINABBIN CLAY: PROFILE 13—MAP 3																								
0–2	LC	6·6	—	3	31	21	44				0·10	0·03												4629
2–6	HC	7·5	—	2	22	15	61	1·1			0·08	0·04												4630
6–14	HC	8·1	—	2	15	14	67	2·6	7·1		0·16	0·09												4631
26–42	MC	8·0	—	1	17	13	60	8·7	5·8	2·0	‡	0·32												4633
42–63	MC	8·6	—	1	16	14	59	10·2			0·70	0·32												4634
CORNELLA CLAY: PROFILE 12—MAP 3																								
0–5	MC	8·1	—*	2	22	20	55			0·6	0·06	0·01	0·09	1·02										4610
5–12	HC	9·3	2*	2	18	14	60			6·0	0·08	0·01												4611
12–24	HC	9·6	1*	1	15	11	62	11·6	10·6	9·7	0·15	0·06												4612
24–39	HC	9·6	4*	1	16	14	59	11·3	9·1	9·0	0·24	0·08												4613
39–53	HC	9·3	2*	1	18	15	66			0·9	0·38	0·15												4614
53–72	HC	8·7	—	1	18	16	65				0·48	0·23												4615
COROP CLAY: PROFILE 14—MAP 6																								
0–3	LC	6·5	—	3	27	14	54				0·04	0·01	0·15	1·40										9717
3–18	HC	8·1	—	1	12	10	77				0·16	0·08			9·4	25	19·8	54	1·6	4	6·2	17	37·0	9718
18–24	HC	8·0	—	1	10	8	77	4·4	6·6		‡	0·28												9719
24–41	HC	8·0	1*	1	8	10	77	4·9	6·0	0·2	‡	0·45												9720
41–72	HC	8·0	—	1	7	13	77	3·2	6·3	—	0·81	0·51												9721

Depth	Field Texture	pH	Gravel	Particle Size: Coarse Sand	Particle Size: Fine Sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Loss on Ignition	Calcium Carbonate (CO_2 x 1·67)	Soluble Salts (E.C. mho/cm x 320)	Sodium Chloride (Cl x 1·64)	Nitrogen	Organic Carbon	Ca		Mg		K		Na		Total	Sample No.
															Exchangeable Metal Cations (m.e.% — milliequivalents per 100 g of soil; % — percentage of total metal cations)									
in.			%	%	%	%	%	%	%	%	%	%	%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	
										Erwen Loam: Profile 5—Map 1														
0–3	CL	6·7	15	2	50	19	28				0·05	0·03	0·11	1·51										4641
3–5	CL	7·5	17	2	48	19	31				0·04	0·03												4642
5–19	HC	8·4	2	1	17	7	74	2·0			0·25	0·15												4643
19–30	HC	8·8	3	1	19	9	70			1·3	0·41	0·24												4644
36–45	HC	8·5	2	—	20	13	66	2·8			0·47	0·33												4645
										Kanyapella Clay: Profile 29—Map 11A														
0–4	CL	6·3	—	6	32	30	29	1·2	6·7		0·03	0·01	0·20	2·50										8718
4–12	LC	7·6	—	3	25	28	42	1·4	4·9		0·04	0·02												8719
12–17	MC	8·9	—	2	16	28	52	1·5	4·9		0·18	0·10												8720
17–34	MC	8·7	—	1	14	28	57	1·8	4·8	0·4	0·32	0·20												8721–2
34–50	MC	8·2	—	2	12	27	57	1·5	4·7	—	0·36	0·21												8723
50–72	LC	8·1	—*	2	16	29	52	1·4	3·3		0·34	0·23												8724
										Karook Loam: Profile 7 Map 4														
0–3	L	6·7	2	2	49	21	25				0·02	—	0·08	0·81										4658
3–6	CL	6·8	1	2	49	20	28				0·01	—												4659
6–12	LC	6·8	—	1	17	9	73				0·01	—												4660
12–16	HC	7·4	—	—	10	7	83				0·04	0·02												4661
16–25	HC	8·1	—*	—	14	11	75			—	0·10	0·04												4662
25–35	HC	9·2	4*	1	13	12	70			4·1	0·15	0·06												4663
35–60	HC	9·4	3*	1	19	15	64			1·7	0·17	0·07												4664
										Koga Clay Loam: Profile 10—Map 3														
0–3	CL	6·1	—	1	43	23	32				0·04	0·02	0·11	1·19										4636
3–11	HC	8·1	—	—	17	12	70				0·06	0·04			6·1	21	16·8	57	1·4	5	4·9	17	29·2	4637
11–20	HC	8·7	—	—	17	12	69			—	0·15	0·09												4638
20–25	HC	8·9	3*							1·0	0·28	0·15			5·4	18	16·4	55	1·5	5	6·4	22	29·7	4639
25–36	HC	9·0	2*	—	19	14	65			0·7	0·37	0·21												4640
										Koga Clay Loam: Profile 24—Map 9A														
0–2	CL	6·5	—	2	36	25	35	1·0	5·6		0·02	0·01	0·12	1·26										8700
2–13	HC	7·4	—	1	12	13	73	1·9			0·04	0·02												8701
13–21	HC	8·3	—	1	11	13	74	2·0	7·8		0·12	0·04												8702
21–32	HC	8·4	—	—	13	15	70	2·0	6·5		0·36	0·15												8703
32–40	MC	8·1	1*	1	16	25	52	5·1	6·0		‡	0·16												8704
40–72	MC	8·7	—	1	19	23	53	3·2	5·2		0·41	0·22												8705
										Koyuga Clay Loam: Profile 2—Map 2														
0–4	L	6·8	—	2	42	26	26				0·03	0·01	0·11	1·05										4603
4–12	HC	7·8	—	1	16	14	68				0·06	0·03												4604
12–19	HC	9·0	23*	1	19	15	64			1·4	0·17	0·06												4605
19–33	MC	9·3	6*	1	20	18	59			0·9	0·22	0·09												4606
33–42	MC	8·9	—	1	18	19	59			0·1	0·24	0·13												4607
42–66	HC	8·8	—	—	17	17	65	2·4			0·40	0·20												4608
66–84	HC	8·0	—	—	14	17	67				0·44	0·24												4609
										Moora Clay: Profile 9—Map 4														
0–2	LC	7·2	—	2	26	19	52				0·03	0·01	0·11	1·22										4653
2–11	HC	7·9	—	1	11	11	76		—		0·05	0·03			6·7	25	15·0	57	1·4	5	3·3	13	26·4	4654
11–18	HC	8·1	—	1	12	13	74			—	0·15	0·10												4655
18–36	HC	8·5	—	—	16	20	63	1·8		—	0·32	0·22			4·5	18	14·7	59	1·0	4	4·8	19	25·0	4656
36–72	HC	8·2	—	—	14	23	63	1·7		—	0·39	0·27												4657

Depth	Field Texture	pH	Gravel	Particle Size: Coarse Sand	Particle Size: Fine Sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Loss on Ignition	Calcium Carbonate (CO_2 x 1·67)	Soluble Salts (E.C. mho cm x 320)	Sodium Chloride (Cl x 1·64)	Nitrogen	Organic Carbon	Exchangeable Metal Cations (m.e.% — milliequivalents per 100 g of soil; % — percentage of total metal cations): Ca		Mg		K		Na		Total	Sample No.
in.			%	%	%	%	%	%	%	%	%	%	%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	
Rooka Loam: Profile 15—Map 5																								
0–5	L	6·6	—	2	29	33	33	0·8			0·01	—	0·09	0·84										4674
5–10	LC	6·9	—	1	15	17	67				0·01	—												4675
10–16	MC	6·8	—	—	5	7	88				0·03	0·02												4676
18–35	HC	8·5	—	—	8	13	79			0·1	0·14	0·07												4677
35–57	HC	8·7	—	—	8	18	74			0·1	0·18	0·11												4678
Timmering Fine Sandy Loam: Profile 18—Map 7																								
0–5	FSL	6·4	—	1	52	24	20				0·02	—	0·12	1·40										9709
5–8	FSCL	7·3	—	1	48	25	26				0·01	—												9710
10–20	MC	8·1	—	—	20	19	60	1·3			0·04	0·01			5·4	28	11·0	57	1·4	7	1·6	8	19·4	9712
20–32	LC	8·9	3*	1	29	27	41			2·1	0·13	0·04												9713
32–44	FSCL	8·9	5*	—	47	24	29			0·3	0·16	0·09			2·0	18	7·2	64	0·7	6	1·4	12	11·3	9714
46–68	FSL	8·7	—	2	63	16	19	1·0			0·13	0·07												9715
Wana Loam: Profile 4—Map 1																								
0–3	L	6·7	—	1	46	31	20	0·5	4·6		0·03	0·01	0·09	1·37										4646
5–12	HC	7·9	—	—	28	18	53				0·04	0·02												4647
12–24	HC	8·8	—	—	17	18	64				0·12	0·03												4648
24–35	MC	9·3	2*	—	17	20	55			7·5	0·16	0·04												4649
42–52	LC	9·3	—	—	21	30	48			0·1	0·11	0·05												4650
52–66	LC	8·8	—	—	24	31	44				0·05	0·03												4651
66–84	MC	8·8	—	—	23	20	56				0·06	0·03												4652
Wana Loam: Profile 21—Map 8																								
0–5	L	6·5	—	8	40	27	22	0·5	4·6		0·02	0·01	0·11	1·33										8712
5–22	HC	8·2	—	2	18	16	62	1·2	6·1		0·04	0·01												8713
22–30	HC	8·9	—*	3	21	17	58		5·7		0·14	0·05												8714
30–41	MC	8·8	—	2	24	23	50	1·5	4·5		0·18	0·07												8715
41–63	LC	8·5	—	2	24	26	47	1·2	3·9		0·14	0·06												8716
63–78	LC	8·4	—	2	26	26	45	1·0	3·8		0·10	0·05												8717
Wanalta Loam: Profile 1—Map 2																								
0–4	FSL	6·6	—	1	60	20	17				0·03	0·01	0·07	0·96	3·4	44	3·0	39	0·9	12	0·4	5	7·7	4596
4–16	HC	8·1	—	—	32	13	53				0·07	0·04			4·0	18	12·9	59	1·9	9	2·9	14	21·7	4597
16–23	MC	8·6	—	—	32	14	53				0·13	0·08												4598
23–34	LC	9·3	19*	1	37	19	40			2·8	0·18	0·09			4·3	20	12·6	58	1·5	7	3·4	15	21·8	4599
34–45	LC	9·2	—	—	30	22	47			0·4	0·18	0·09												4600
45–60	HC	9·0	—	1	21	20	57	3·2			0·24	0·11												4601
60–84	HC	8·9	—	—	18	21	60				0·26	0·13												4602
Wanalta Loam: Profile 16—Map 5																								
0–3	L	6·1	—	1	41	34	22	0·9			0·02	0·01	0·15	1·76										9694
3–5	FSCL	6·6	—	1	40	31	27				0·01	—												9695
6–15	HC	7·5	—	—	18	21	60	1·5	6·3		0·04	0·02												9696
15–21	HC	8·6	—	1	20	22	54			0·1	0·08	0·04												9697
21–33	MC	9·1	8*	1	16	26	55			1·5	0·18	0·09												9698
33–47	LC	9·1	3*	1	17	31	49			0·4	0·17	0·09												9699
47–63	SiCL	8·8	1*	—	25	35	38				0·16	0·10												9700
Wanalta Loam: Profile 17—Map 7																								
0–5	L	6·2	1	3	44	24	25				0·02	0·01	0·16	1·72										9702
5–13	HC	7·9	—	1	21	13	64				0·02	0·01			7·8	38	10·9	53	1·3	6	0·5	3	20·5	9703
13–22	MC	8·9	—	1	19	18	58	4·5	6·7		0·07	0·01												9704
22–33	HC	8·4	—*	1	19	14	64			0·2	0·04	0·01			6·5	28	14·2	62	1·5	6	0·9	4	23·1	9705
33–54	MC	9·2	1*	1	17	20	58			3·0	0·08	0·01												9706
66–84	FSC	9·5	—	—	46	21	33				0·03	0·02			1·9	15	7·5	58	0·8	6	2·7	21	12·9	9707

Depth	Field Texture	pH	Gravel	Particle Size: Coarse Sand	Particle Size: Fine Sand	Particle Size: Silt	Particle Size: Clay	Loss on Acid Treatment	Loss on Ignition	Calcium Carbonate (CO_3 x 1·67)	Soluble Salts (E.C. mho/cm x 320)	Sodium Chloride (Cl x 1·64)	Nitrogen	Organic Carbon	Exchangeable Metal Cations: Ca		Mg		K		Na		Total	Sample No.
															m.e.% — milliequivalents per 100 g of soil; % — percentage of total metal cations									
in.			%	%	%	%	%	%	%	%	%	%	%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	%	m.e.%	
Yambuna Clay: Profile 25—Map 12																								
0–7	LC	6·4	—	4	28	23	43	1·2	5·8		0·02	0·01	0·09	1·02										8674
7–24	HC	5·3	—	2	17	19	62	0·8	5·6		0·05	0·04												8675
24–39	HC	4·7	—	1	13	20	65	1·7	6·2		0·15	0·11												8676
39–54	MC	4·7	—	1	23	25	50	0·4	4·6		0·14	0·10												8677
54–64	LC	4·7	—	3	35	24	37	1·2	3·6		0·13	0·11												8678
64–84	FSCL	5·2	—	21	47	12	19	0·5	2·6		0·09	0·08												8679
Yuga Clay: Profile 11—Map 3																								
0–2	LC	6·8	—	1	34	24	40				0·04	0·02	0·10	1·16										4622
2–7	HC	7·7	—	1	15	13	70				0·06	0·03			6·2	20	19·8	63	1·3	4	3·9	13	31·2	4623
7–13	HC	8·4	—	1	12	10	76				0·13	0·07												4624
13–23	HC	8·8	—*	—	13	15	71			0·1	0·22				4·3	12	22·2	64	1·3	4	6·9	20	34·7	4625
23–45	HC	8·7	—	—	13	16	71	2·1	5·1	0·1	0·45	0·27												4626
45–64	HC	8·2	—	1	16	15	67	2·1	5·0		0·59	0·37												4627
Yuga Clay: Profile 23—Map 9A																								
0–3	MC	7·2	—	2	25	18	53	1·9	6·4		0·03	0·01	0·11	1·05										8694
3–14	HC	7·7	—	1	15	16	67		6·4		0·04	0·02												8695
14–26	HC	8·0	1*	1	11	15	73	1·5	7·0		0·18	0·11												8696
26–38	HC	8·5	—*	—	15	18	66		5·6	1·6	0·43	0·25												8697
38–54	HC	8·6	—	—	19	18	60	3·6	5·3		0·44	0·26												8698
54–72	MC	8·7	—*	—	23	22	53		5·4		0·41	0·26												8699
Type H: Profile 28—Map 11A																								
0–4	FSL	6·6	—	2	59	22	15	0·8	4·2		0·02	0·01	0·13	1·42										8725
4–6	FSCL	7·9	—	2	50	21	26	0·8	3·1		0·02	0·01												8726
6–11	LC	8·4	—	1	40	20	39	0·8	4·3		0·03	0·01												8727
11–17	FSC	9·2	12*	1	42	23	34				0·06	0·01												8728
17–30	FSCL	9·4	8*	1	45	24	26	3·6	4·4		0·18	0·09												8729
30–42	FSL	9·6	2*	—	50	30	18	2·1	3·6		0·18	0·10												8730
42–66	FSL	9·2	—	—	61	18	21	0·3	2·7		0·07	0·03												8731
Type J: Profile 27—Map 12																								
0–2	FSL	6·2	—	2	63	19	13				0·02	0·01	0·08	0·86										8680
2–4	FSL	7·0	—	3	57	22	16				0·01	0·01												8681
4–18	FSC	7·6	—	2	46	19	33	0·9	3·3		0·03	0·01												8682
18–40	FSC	6·9	—	2	42	21	35		3·5		0·03	0·02												8684
40–60	FSCL	6·3	—	1	55	19	24				0·04	0·02												8686
70–84	MC	7·1	—	1	19	24	55	1·8	4·9		0·08	0·03												8687

APPENDIX II. – Analytical Methods

All estimations were carried out on the air-dried fine earth, i.e., material passing a 2 mm. round hole sieve. For calcium carbonate, nitrogen and organic carbon analyses, the fine earth was further reduced to pass through a 0·5 mm. sieve. All results except pH and gravel, 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 where indicated otherwise are essentially as described by Piper (1950).

***Particle Size Distribution*.—**For the majority of the soils the procedure adopted followed that of the International "A" pipette method. In some cases, the Bouyoucos hydrometer was used to determine silt and clay, the soils being agitated in a motor dispersion unit with sodium hexa-metaphosphate and caustic soda, followed by overnight end-over-end shaking.

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

T.S. = E.C. x 320.

where E.C. is expressed in mho./cm. and the factor 320 was derived from a number of gravimetric determinations of total soluble salts. This factor is not materially different from that found by Skene and Poutsma (1962) for soils of the Goulburn Valley.

***pH*.**—After determination of electrical conductivity (soluble salts), the same suspension was used to deter-mine pH by the glass electrode.

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

Calcium Carbonate.—Carbon dioxide was determined by the vacuum method of Hutchinson and MacLennan and expressed as calcium carbonate.

***Nitrogen*.**—The Kjeldahl method was used.

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

***Exchangeable Cations*.**—The soil was first leached with 60 per cent ethanol to remove soluble salts. It was then leached with N/1 ammonium chloride and potassium and sodium were determined in the leachate, and calcium and magnesium only if the soil contained no carbonate. Soils containing carbonate were leached with two successive litres of N/1 sodium chloride, the difference in calcium and magnesium in the two leachates being taken to represent the exchangeable cations.

Calcium, magnesium and sodium in the leachates were determined by gravimetric methods and potassium by the cobaltinitrite method.

APPENDIX III – Explanation of Soil Terms

Bleached: Describes a horizon which has become pale 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 is the behaviour of the soil when manipulated. It indicates its resistence to 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: crumbly, friable, labile, plastic, tough, hard, intractable.

Ferruginous concretions: Concretions, mainly of iron oxide, deposited in the A_2 and B, horizons.

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

Gypsum: Hydrated calcium sulphate.

Illuvial: Material deposited 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 H horizons as *illuvial* horizons.

Impermeable: Describes soils which are very slowly permeable to water.

Lime: Calcium carbonate either finely divided or hi concretions.

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

Munsell colour: This is the soil colour determined by matching against the Munsell colour chart and ex-pressed in its notation of hue, value and chroma. The notations given in this report are for dry soils. These, in general, are about two intervals higher in value than for the soils in their moist states. The written descriptions of the surface soils also refer to their dry state.

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.

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

Soil horizon: A layer of soil with similar characteristics throughout. The horizon may be distinguished by differences in one or more of the following characteristics: colour, texture, 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 verticle section of a soil exposing the sequence of horizons from the surface to an arbitrary depth, in this case, to at least 4 feet. The horizons in the soils described are:

A_1 The surface layer in which organic matter has accumulated and partly leached 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, subsurface 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 have formed.

Soil phase*: A* modification of a soil type in which one feature is accentuated without altering the main pro-file 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.

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

Solonetzic: Describes a soil having resemblances in the structure of its B1 horizon to the columnar structure of a solonetz.

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

Subplastic: This describes a soil, which increases in plasticity with continued manipulation in the moist state and, in consequence, increases in field texture.

Texture: This is the grading of the soil material in respect of the size of the primary particles.

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 drain-age, 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 making this soil survey, the soil surveyors listed at the front of this report walked over the land and bored holes at intervals varying from 4 to 20 chains apart, depending on the complexity of the soil pattern. The soil profile at each spot was exposed with a 4 inch Jarrett soil auger, usually to a depth of 4 feet, but sometimes to 7 feet, 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 inch to 20 chains) and a boundary drawn to show where one soil type changed another. Surface features such as change of slope, depressions and rises, which often show on aerial photos ere helpful in determining where the change occurred. But it should be appreciated that a soil boundary line own on a soil map represents a zone of 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 inch to 20 chains were constructed by transfering the soil boundaries from the aerial photographs onto 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 size of the soil maps for publication consequently, the scale of the maps in this bulletin has been reduced to 1 inch to 40 chains.

The smallest area that can be shown on the soil map at the scale used is about 11 acres, i.e., 4 chains across. This means that any area shown as a single soil type may have small areas of one or more soil types with it, *but not to a greater extent than about one sixth of the occurrence*. 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 has been mapped as a *complex* of both soil types and is shown by diagonal hatchuring.

Where soil types are intermingled, it is not always practicable to make separations, even though the individual soil types occupy areas greater than 1½ acres. Consequently, in some of the complexes mapped, the areas of the component soil types are much greater than this. Also, some complexes are comprised of three soil types.

A soil association 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.