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Soils Section—State Laboratories

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SOIL SURVEY

of Part of Parishes of

Tinamba, Winnindoo, Denison, Wooundellah, County of Tanjil, Victoria

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SUMMARY

An area of approximately 67,000 acres adjacent to the Maffra-Sale Irrigation District in Central Gippsland has been covered by a soil survey to determine its suitability for development under irrigation. Settlement of returned servicemen is contemplated on the better-class soils.Soil types, under general irrigation, capable of supporting permanent pastures suitable for dairying and fattening cattle comprise about 35,000 acres. A further category of soil types totalling 27,000 acres is recommended for restricted irrigation where situation permits. Fat lamb production, possibly with some dairying, is envisaged on such soils. About 2,300 acres are either unattractive or unsuitable for irrigation.

Sequences of post-Pliocene fluviatile sediments comprise the parent materials of the soils, which are associated with the present landscape of ridge and upland, plain, and river flats. The soils are developing on the sediments under a moderate rainfall and to some extent under the pedogenic influence of salt. The morphologies of thirteen soil types which have not been described previously, eight unnamed soil types, and three minor depression soils, are recorded both in detail and in summarised form. A landscape map is used to show the relation between the soil types and the physiographic features of the area, while the distribution of the individual soil types is given on a soil map produced at a scale of 1 inch to 40 chains.

Data from the mechanical analyses of 208 samples are used to illustrate physical relationships between the soil types. High clay content is characteristic of over 90% of the subsoils. The adverse effect of this on the downward penetration of water is offset by good structural properties in most of the soil types, but two soil series are inferior.

The surface soils possess normal reserves of nitrogen and magnesia, moderate amounts of potash, and low to moderate amounts of phosphoric acid and lime.

Data for exchangeable cations in seven major soil types are given. Compared with Victorian irrigated soils elsewhere, the total exchangeable metal ions and the exchange capacities of these soils are low. The absorbing complex is rather unsaturated in the surface soils but is nearly fully saturated in many of the subsoils. Although calcium is the dominant exchangeable metal ion in the surface soils, it is very largely replaced by magnesium and sodium in the subsoils.

Soluble salts are at a low level in the majority of the soils, but certain soil types are inherently saline to a moderate degree, while one is highly saline.

The physical and chemical characteristics, salinity, and topographical situation of each of the soil types are considered in relation to irrigation, and the direction which their development should take under irrigation is suggested.

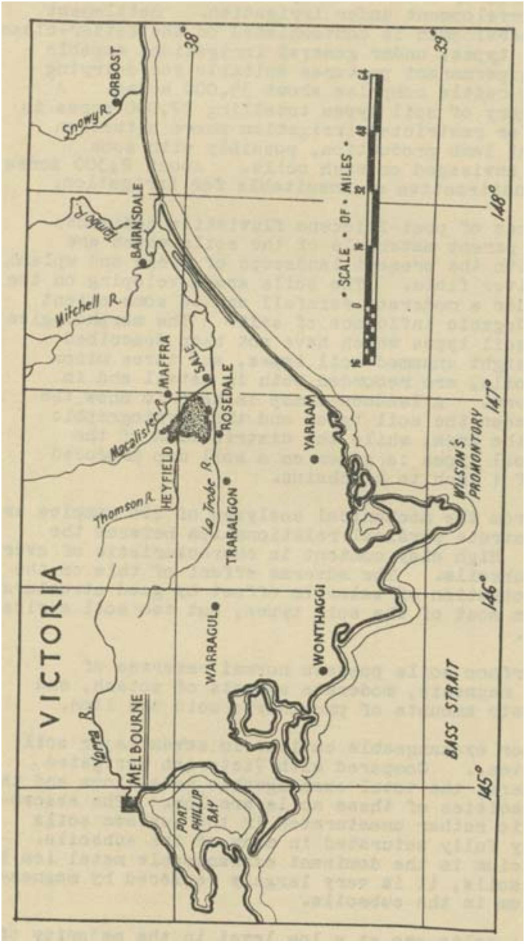

Fig. 1 – Location of the soil survey

Soil Survey of Part of Parishes of Tinamba, Winnindoo, Denison, Wooundellah, County of Tanjil, Victoria.

I. GENERAL FEATURES OF THE AREA.

I. Introduction.

The fertility and high productivity of soils under irrigation in the Maffra-Sale district have suggested the possibilities of neighbouring districts for irrigation. After investigating the water resources of the region, the State Rivers and Water Supply Commission selected an area of approximately 67,000 acres adjoining the Maffra-Sale Irrigation District as potentially suitable for development under irrigation. The present soil survey was carried out by the Department of Agriculture with the assistance of the State Rivers and Water Supply Commission, as part of a general investigation of this area as an irrigation project, but particularly in regard to its suitability for large scale settlement of returned servicemen.

The locality plan (Fig. 1.) shows the area to lie north and south of the Thomson River between the towns of Maffra and Heyfield in the north, and Sale and Rosedale in the south. It comprises parts of the parishes of Denison, Tinamba, Winnindoo, and Wooundellah in the County of Tanjil.

The supply of water to the area is part of the Central Gippsland Irrigation Project. It is intended that water supply to the country south of the Thomson River - referred to as the Nambrok-Denison Area - shall be by diversion of the summer flow of this river, and supplemented as required by reticulation from Glenmaggie Reservoir on the Macalister River. The irrigable area north of the Thomson River will form the Heyfield Extension of the present Maffra-Sale Irrigation District and will receive its water supplies entirely from Glenmaggie Reservoir. Increased storage on the Macalister River is contemplated to meet these requirements.

2. Agricultural Situation.

Originally land in the district was occupied in large holdings for pastoral purposes, but following on alienation under various Land Acts about 1870 much of the area was gradually put under cultivation. Cereals were grown extensively on the plains extending across the parishes of Winnindoo, Denison, and Wooundellah. Crops were good, yields of wheat of up to 40 bushels to the acre being recorded. Hay crops were very satisfactory and malting barley of high quality was produced. With the steady decline of wheat prices in the 1920's, coupled possibly with reduced yields due to heavy cropping over a long period, the land, for the most part, gradually reverted to pasture for sheep grazing and fat lamb raising. Very recently hay production has increased markedly in the district, due no doubt to demands caused by fodder shortages of the last few dry seasons.

The light soils of the ridges in the northern and southern parts of the area have always been used for grazing purposes.

There is a small amount of dairying carried on under dry-farming conditions. This is principally confined to the very fertile soils of the river flats along the Thomson, although several farmers away from the river manage to dairy with the aid of lucerne and by the grazing of oats.Although pumping costs are high, a few land holders on the Thomson River frontage have installed private plants. Excellent permanent pastures are grown with the aid of water, both on the river flats and on the adjacent higher soils. Under these conditions, dairying and cattle fattening have proved highly successful. Periodic flooding of the Thomson River is the main drawback.

Generally, the area of improved pasture in the district is not large, although some landholders have successfully established annual pastures of the subterranean clover-rye grass type.

Sub-division of the district originally was into allotments of from 80 acres to 320 acres, while certain areas were purchased and subdivided for soldier settlement after the 1914-18 war; but in the main, the lard is now aggregated into holdings of 320 acres to 3,000 acres.

Much of the area is entirely devoid of timber. Cultivation of cereals in the past has required clearing of the land, but it is doubtful whether some of the cultivated soils were ever more than sparsely timbered. Certain cleared areas were originally of the woodland type, the timber being chiefly red gum (*E. tereticornis*). Denser stands of red gum, mostly remaining as dead trees, occur on low areas of poor drainage. The vegetation on the relatively light soils of the higher grazing land is savannah woodland with red gum dominant, some sheoke (*Casuarina* spp.), and occasional clumps of apple box (*E. Stuartiana*). The ground cover is composed principally of species of Danthonia and Kangaroo grass (*Themeda triandra*).

3. Climate.[∅]

The climate of the area is influenced greatly *by* surrounding highlands, particularly those rising above 3,000 ft. which lie within 30 miles to the north and north-west, and to a lesser extent by an elevated area approximating 2,000 ft. in altitude in the south-west between Traralgon and Yarram. Whilst the average annual rainfall of these highlands varies from 40 in. to 60 in., the area concerned lies within a rain-shadow produced by the ranges and is probably the driest area in Gippsland. The only official rainfall recordings taken within the area are those for a twelve year period at Wandocka; but fuller climatological data is available for adjacent towns as shown in Table 1.

[∅] Data supplied by courtesy of the Meteorological Branch, Department of Interior.

Comparison of the Wandocka values with those of surrounding stations for the same twelve years has shown that this was a drier period in the district as a whole than the average over a greater number of years. When corrected relative to the sixty four years average at Maffra, the mean annual rainfall at Wandocka is 22.80 in. Possibly the yearly average would fall slightly below this value further to the south; however, generally the mean annual rainfall over the Nambrok-Denison Area can be said to be within the limits of 22 in. to 23 in.

The rainfall is fairly evenly distributed throughout the year and there are no distinct dry or wet seasons. October to March average rainfall slightly exceeds that of April to September for all stations. At Wandocka, the corrected averages for these periods are 12.45 in. and 10.35 in., respectively. The October-March rainfall is high compared with that of the northern irrigation districts, e.g., 6.97 in. at Numurkah and 6.71 in. at Kerang.

There is considerable fluctuation in the rainfall from year to year, e.g., the highest and lowest recordings at Maffra were 37.09 in and 13.35 in in 1935 and 1908, respectively. With an average of approximately 100 rainy days per year in the district, the rainfall per wet day averages 0.23 in. Whilst this value in itself is not indicative of ineffective showery conditions, there is evidence that the effectiveness of the rainfall may be reduced by a high incidence of winds. As an indication of the degree of reliability of the rainfall for the area, the percentage chances of receiving less than specified amounts of rain for the four seasons of the year at Maffra are shown in Fig. 2. For all seasons there is a greater chance of the rainfall being less, than there is of it being more, than the normal. This probability is greatest in the case of the summer rainfall (December -February) which can be expected to be less than its average of 5.97 in in nearly two out of every three years. On the other hand, wetter than normal summers occur fairly frequently, the probability being that the December - February rainfall will exceed 1½ times the normal, i.e. 8.96 in, about once in 6 years. Except that the spring (September-November) rainfall is slightly more reliable, there is little difference between the seasons in the expectation of very low rainfalls, e.g., the probability of receiving less than half the normal seasonal rain is 1 in 14 for the spring, 1 in 9 for the winter (June-August), and 1 in 8 for both the summer and the autumn (March-May) periods.

The average maximum temperature at Maffra varies from a minimum of 56.7°F in July to a maximum of 78.8°F in February which compares with 56.9°F and 88.5°F for the same two months, respectively, at Kerang. Considerably lower average temperatures and higher humidities during the October-March period at Maffra, compared with northern irrigation districts such as Kerang, contribute towards lower water requirements for irrigation in the former district. The temperature exceeds 100°F on about 5 days and exceeds 90°F on from 15 to 20 days per year. On the average, light frosts (36°F or lower) can be expected from the second week in May to the third week in September, the average frost-free period being about 230 days. Temperatures of 32^0F or under occur on an average of 12 days in the year.

TABLE 1 - Climatological Date for the District.

	No. of Years	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Rainfall (in.)														
Maffra	64	1.92	1.90	2.09	1.77	1.72	1.90	1.48	1.68	2.09	2.50	2.08	2.15	23.28
Sale	73	1.84	1.93	2.15	1.89	1.78	2.03	1.67	1.79	2.18	2.48	2.28	2.08	24.10
Rosedale	64	1.72	1.69	2.31	1.95	1.97	2.16	1.81	2.07	2.36	2.74	2.26	2.15	25.19
Heyfield	29	1.91	1.71	1.94	2.46	1.31	2.07	1.48	1.78	1.90	2.40	2.38	2.39	23.73
Wandocka	12	1.96	2.05	1.48	2.79	1.26	1.80	1.05	1.56	1.53	1.99	2.41	2.09	21.97
							Maffra							
Temp. °F. Mean Max.	38	78.1	78.8	74.8	68.7	62.8	57.5	56.7	59.5	63.5	67.9	72.0	76.1	68.0
Temp. °F. Mean Min.	38	54.5	55.1	52.6	47.8	42.8	39.7	38.3	39.9	42.9	46.0	49.2	52.5	46.8
Temp. °F. Average	38	66.2	66.9	63.7	58.3	53.1	48.6	47.5	49.7	53.1	56.8	60.6	64.3	57.4
Mean rel. humidity % at 9 a.m.	33	57	63	66	72	76	78	77	72	67	63	58	55	67
Evaporation (in.)		6.20	5.24	4.21	2.41	1.94	1.59	1.59	2.16	3.05	4.09	4.98	6.22	43.68
Rainfall / Evaporation		0.31	0.36	0.50	0.73	0.89	1.19	0.93	0.78	0.69	0.61	0.42	0.35	
Effective rainfall (in.)		1.93	1.73	1.47	1.00	0.86	0.74	0.74	0.93	1.17	1.44	1.66	1.94	

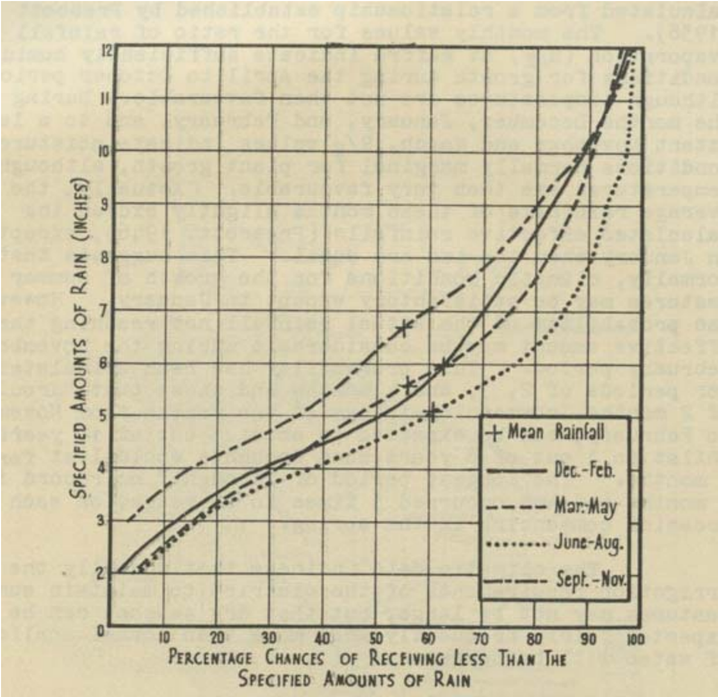

Fig. 2. Probability of Seasonal Rains at Maffra.

The aridity or humidity of the climate depends on total rainfall, temperature, and relative humidity. It is convenient to express the last two factors in terms of the evaporation from a free water surface, and the values for evaporation in Table 1 are approximations calculated from a relationship established by Prescott (1938). The monthly values for the ratio of rainfall to evaporation (R/E) at Maffra indicate sufficiently humid conditions for growth during the April to October period, although temperatures are not then favourable. During the months December, January, and February, and to a lesser extent November and March, R/E values indicate moisture conditions normally marginal for plant growth, although temperatures are then very favourable. Actually, the average rainfalls of these months slightly exceed the calculated effective rainfalls (Prescott, 1946), except in January when the two are equal. This suggests that, normally, climatic conditions for the growth of summer pastures may be satisfactory except in January. However, the probability of the actual rainfall not reaching the effective amount may be considerable during the November - February period. This probability has been calculated for periods of 2, 3, and 4 months and shows that "droughts" of 2 months, commencing in any of the months from November to February, can be expected in about 3 out of 10 years, whilst in 1 out of 8 years such droughts would last for 3 months. The longest period of "drought" on record is 6 months and has occurred 3 times in 68 years, on each occasion commencing in the spring.

The climatic data indicate that normally the irrigation requirements of the district to maintain summer pastures may not be large, but that dry seasons can be expected fairly frequently when more than normal applications of water will be necessary.

4. Physiography and Geology.

The district is within an area broadly classed as post-Pliocene which lies between the coast and the Alps in south-east Gippsland. Although unconsolidated fluviatile and lacustrine sediments of considerable thickness underlie the whole of the surveyed area, several periods of river activity are evident from the physiography. However, the microscopic examination[x] of the minerals present in the fine sand fractions of surface soils taken from the various landscape categories described below, does not suggest any wide differences in geological origin of the sediments throughout the area. The principal minerals are quartz and feldspar with some biotite, ilmenite, magnetite, haematite, and limonite. Other minerals recorded are zircon, tourmaline, epidote, apatite, fluorite, and hornblende.

Broadly the landscape is one of plain, intersected by the Thomson River with its present restricted flood plain, and fringed by ridges and uplands in the north-west, west, and south. These and other topographic features are illustrated in Fig. 3.

The ridges and upland country represent the earliest deposits, which are principally clay and sandy sediments. These were associated with turbulent rivers rising in the Dividing Range north of the area and whose courses are now marked by strata of waterworn stone and gravel. Such upland north of the Thomson River reaches an elevation of 180 ft. above sea level and falls away gradually in a south-easterly direction. Northern slopes to the lower woodland are steep, while an escarpment of 20 ft. to 40 ft. marks the southern boundary with the Thomson River flats.Similar upland in the parish of Winnindoo lies between the 70 ft. and 153 ft. contours, but its slopes are gentle and it represents the fringe of a more pronounced ridge westward of the area. The southern boundary of the surveyed area is marked by a line of hills, which rise sharply from about the 60 ft. contour to a maximum elevation of 154 ft. above sea level in the parish of Denison, and which is broken by a gap of about one mile just westward of Kilmany railway station. To the east of Kilmany, the intermediate slopes shown in Fig. 3 represent broadly a plain of lower ridgeland which includes low rises and areas of low-lying woodland.

[x] The mineralogical examination was made by the Department of Mines.

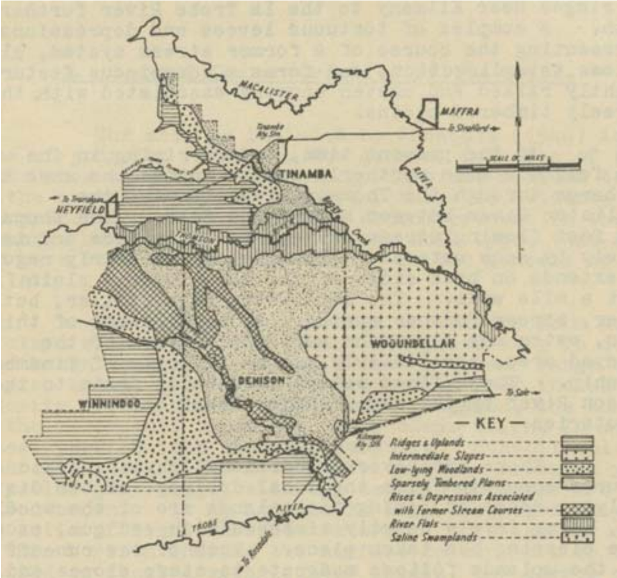

Fig. 3. Landscape Map.

Subsequent river activity has been responsible for deposits of fine alluvium which form the sparsely timbered plains in the broad valleys between the ridge-lands. South of the Thomson River, these plains are raised from 10 ft. to 20 ft. above the present river flats and from there fall gradually at about 8 ft. to the mile in a south-easterly direction. They merge with the low-lying woodlands which fringe the ridges in the west and south, and with the intermediate slopes of the ridgeland in the east of the area. Apparently at one time the natural drainage from the Alps followed a south-easterly direction and partly, at least, found an outlet through the ridges near Kilmany to the La Trobe River further south. A complex of tortuous levees and depressions, representing the course of a former stream system, also follows this direction, and forms a conspicuous feature of slightly raised and uneven country associated with the sparsely timbered plains.

At the present time, waters rising in the Alps follow a more northerly course across the area and discharge through the Thomson River to meet the Macalister River between Maffra and Sale. The Thomson is a fast flowing stream of very variable flow and is fed largely by snow waters. Flooding occurs fairly regularly and extends on both sides of the river over a plain about a mile wide. The Macalister is a similar, but larger, stream further north. At high floods of this river, water may reach the northern portion of the surveyed area, particularly in the vicinity of Tinamba township. These flood waters eventually drain to the Thomson River by the way of Boggy Creek and its tributaries.

There are several additional physiographic features connected with the local drainage of the district. Low-lying areas adjoining the uplands are of the woodland type, being fairly heavily timbered with red gum, except where clearing has taken place. Much of the run-off from the uplands follows moderate to steep slopes and, in such cases, has been the cause of considerable gully erosion. These eroded water courses, at certain times, discharge large amounts of water to the lower country fringing the ridges where the get-a-way is more restricted. In consequence, temporary swamps occur in these situations in most parts of the area.In the parish of Tinamba, they eventually drain to the Thomson River by way of shallow depressions. Nambrok Creek is the outlet for similar drainage from the upland in the northern section of the parish of Winnindoo. This creek traverses the plains of Denison in a south-easterly direction a well defined, although shallow depression, and finally discharges into the La Trobe River. It also receives drainage from the northern slopes of the ridges in the south of the parish of Denison through a series of swampy depressions.

An area of more permanent and saline swampland in the south of the parish of Winnindoo represents the edge of a morass extending further southward to the La Trobe River. It is maintained largely by drainage from higher country to the north. A similar, but smaller swamp caused by a restricted outlet for drainage from the country north-east of Nambrok Creek exists adjacent to steep ridgeland near Kilmany railway station.

Further eastward in the parish of Wooundellah, the drainage of the country finds its way through shallow depressions in an easterly direction to the Thomson River below its junction with the Macalister River.

II. THE SOILS AND THEIR CLASSIFICATION.

1. General Characteristics of the Soils.

The area is included by Prescott (1944) in the zone of podsols; however, the general features of the soils show that their morphology does not conform to that of the normal podsol. Moreover, there is evidence from the proportion of exchangeable sodium present in the exchange complex of certain of the soil types that salt may have been an important factor in the genesis of such soils.

The surface soils range in texture from sands to clays with clay loams predominant, and vary in colour from brown to grey, although a much narrower range of greyish brown, grey-brown, and brownish grey includes the majority of the soils. With one exception, the subsoils of the major soil types are heavy clays which, in most cases, persist into the deep subsoil. Subsoil colours generally show slight mottling within the brownish yellow to yellow-grey range, although certain subsoils are brown or red-brown. An A2 horizon[x] is well developed only in the soils of light surface texture. More usually colours in this horizon include the surface colour more or less mottled or flecked with lighter shades, the degree of mottling depending to some extent on drainage relationships due to topographical differences in situation. However, in general, the colour differences usually found in the profiles of soils hydrologically related are not well developed in the soils of the area.

Lime occurs fairly frequently in the profiles of most of the soils, but is not a constant feature of any soil type. When present, it is usually in small amount as rubble at about 30 in. or deeper.

Very small inclusions of gypsum are present in the A horizons of some soils, but the amounts are very alight.

Ferruginous concretions, as both hard and soft forms, are present to a varying degree in the A2 and B horizons of many of the soils, while outcrops of ironstone conglomerate occur in some upland areas.

In general, the soils are fairly acid in the A horizons and slightly acid to neutral in the B horizons, becoming mildly alkaline at between two and three feet from the surface. Deeper horizons are strongly alkaline.

Although obviously saline areas are of small extent, certain of the soils possess some degree of inherent salinity.

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[x] Explanatory notes on soil terms in common usuage are given in Appendix 1.

Table 2. Summary of the Soil Types.

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
Tanjil gravelly sand	Grey-brown sandy loam over light brownish grey gravelly sand 0"-16"	Brownish yellow heavy clay with gravel 16"-30"	Yellow-grey-red clay with heavy gravel 30"-60"	Crests of ridges and upland; associated with Tanjil sandy loam
Tanjil sandy loam	Grey-brown sandy loam over light brownish grey sand, with some gravel, 0"-10"	Brownish yellow heavy clay 10^{9}-36"	Brownish yellow gritty medium clay 36"-72" or sandy clay 48"-72"	Ridges and gently sloping upland; may be slightly crabholey
Tanjil loam	Brownish grey loam over light grey sandy loam 0"-8"	Brownish yellow heavy clay 8"-36"	Brownish yellow medium clay 36"-72"	Gently sloping and flat areas of upland; usually crabholey
Winnindoo loam	Grey loam passing to light grey and rusty flecked clay loam 0"-7"	Yellow-grey-rusty light clay with iron concretions 7"-10" (transitional) Yellow-grey heavy clay 10"-30"	Greyish yellow heavy clay 30"-72", slight limestone rubble 30^{9}-42"	Broad flat areas of indifferent drainage merging with upland slopes of Tanjil series. Shallow depressions associated with Wooundellah loam
Winnindoo clay loam	Grey clay loam passing to light grey and rusty flecked clay loam 0"-6"	Yellow-grey heavy clay, slight iron concretions, 6"-21"	Greyish yellow to yellow and grey heavy clay, slight lime-stone rubble, 21"-72"	Low-lying, crabholey and tussocky areas receiving run-off from bordering uplands
Heyfield clay loam	Brown friable clay loam, gradual transition to light clay, O"-18"	Gradual transition to red-brown crumbly medium clay 18"-30"	Brown light clay often passing to fine sandy clay, rarely with lime stone rubble, 30"-72"	On brown rises of undulating country formed by a complex of levees and depressions
Acre clay loam	Greyish brown clay loam becoming slightly flecked with light grey-brown 0"-15"	Defined junction with red-brown and dark brown heavy clay 15"-36"	Brown light clay, occasionally fine sandy clay, sometimes with lime rubble, 36-72"	With Heyfield clay loam and on levees of some drainage ways
Denison clay loam	Grey clay loam becoming flecked with light grey and	Dark yellowish grey passing to yellow- grey heavy clay	Greyish yellow medium clay, often with limestone rubble,	On plains outlying the Heyfield-Acre types and on gently sloping

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
	greyish yellow 0"-14"	14"-30"	30"-72"	banks of some drainage ways
Wandocka clay loam	Grey clay loam 0"-6". Grey, with light grey and rusty flecking, light clay 6"-12"	Dark yellowish grey becoming yellow-grey heavy clay, slight iron concretions , 12"-27"	Greyish yellow heavy clay, often with limestone rubble, 30"-72"	More or less crabholey areas of slow surface drainage on plains of Denison clay loam
Nambrok clay loam	Brownish grey clay loam 0"-7". Light grey and rusty light clay with slight iron concretions 7"-14"	Mottled yellow-grey, brown, red, heavy clay, crumbly, moderate iron concretions, 14"-20". Greyish yellow heavy clay 20"-42"	Greyish yellow or mottled grey-yellow- brown medium clay, often with lime rubble, 42"-72"	On plains associated with Denison clay loam and Wandocka clay loam
Thomson silty clay loam	Grey silty clay loam with rusty brown organic staining 0"-15"	Grey, with yellowish grey mottling, silty clay, becoming yellower with depth, 15"-72"		Flats subject to flooding from the Thomson River
Thomson silty clay	Grey silty clay with rusty brown organic staining 0"-12"	As for Thomson silty clay loam, 12"-72"		On shallow depressions of river flats
Type A	Brownish grey sandy loam passing to light brownish grey sand 0"-15"	Yellow and grey mottled sandy clay or medium clay with sand 15"-30"	Variable sandy sediments, usually yellow sandy clay or sandy clay loam, 30"-72"	On drainage ways of ridges and uplands, usually with Bullied watercourses
Type B	Grey-brown loamy sand over light grey-brown sand 0"-14"	Brownish yellow mottled with red gritty clay 14"-30"	Yellow sandy clay passing to sandy clay loam 30"-48"	On crests and slopes of pronounced ridges
Type C	Brownish grey loam with heavy quartz gravel 0"-12"	Brownish yellow mottled with red heavy clay with gravel 12"-40"	Brown-yellow-red-grey clay with heavy gravel 40"-60"	Localised occurrence above Thomson River flats extending to Wooundellah plains
Type D	Grey-brown passing to brown with slight light grey-brown silty clay loam 0"-14"	Reddish brown medium clay 14"-30"	Reddish brown medium clay passing to brown silty clay, with lime rubble, 30"-72"	Localised occurrence on banks of water ways leading to Boggy Creek

Soil Type	Profile			Occurrence
	Surface and subsurface	Subsoil	Deep subsoil	
Type E	Texturally similar to Type D with lime in the deep subsoil, but with grey surface and yellow-grey subsoil colours			Associated at lower levels with Type D
Type F	Grey, dark when moist, with rusty stainings, clay 0"-8"	Yellowish grey heavy clay, variable lime rubble ,8"-48"	Mottled yellow and grey heavy clay	On low badly drained areas and saline swamps; often crabholey
Type G	Dark brownish grey clay loam becoming brownish grey light clay 0"-20"	Brown or greyish yellow light clay or fine sandy clay 20"-42"	Similar to subsoil, occasionally grey and yellow silty clay, 42"-72"	On banks and hollows ad-joining the river flats, but at intermediate levels less subject to flooding
Type H	Grey light clay 0"-4"	Dark yellowish grey heavy clay, slight iron concretions, 4"-30"	Yellow-grey heavy clay 30"-48"	Low-lying crabholey area adjoining Wandocka clay loam
Minor Depression Soils.				
Type 1	Greyish brown becoming brown clay loam and then light clay 0"-24"	Brown with light brown light clay 24"-36"	Brown medium clay be-coming lighter, or fine sandy clay, 36"-72"	As winding depressions, associated only with the Heyfield-Acre series
Type 2	Grey, passing to grey and light grey, clay loam with iron concretions 0"-16"	Yellow-grey heavy clay 16"-30"	Greyish yellow heavy clay, sometimes becoming lighter, with lime rubble, 30"-72"	As landlocked depressions and shallow drainage ways associated with the Heyfield-Acre-Denison types
Type 3	Grey clay loam or light clay 0"-7"	Yellow-grey with grey heavy clay 7"-33"	Greyish yellow heavy clay with slight lime rubble 33"-72"	As drainage ways and land-locked depressions associated with the Denison-Wandocka -Nambrok types

2. Summary of the Soil Types.

The soils are classified into thirteen named soil types within nine soil series, eight unnamed minor types, and three minor depression soils.

The principal profile features and modes of occurrence of all the soil types which are described in detail in subsection 4, are summarised in Table 2 in order to present a ready means of assessing the major features of the soils and their relation to each other in the landscape.

3. Relation of the Soil Types with Physiography and Geology.

The principal physiographic features of the area are illustrated in Fig. 3 and. have been discussed previously. The relation of the soil types to these broad features is indicated in the following grouping of the soil types according to their situation on the landscape.

Ridges and Uplands. The three soil types of the Tanjil series occur on these situations. Tanjil gravelly sand is found on the crests and adjacent steep slopes of the ridges and as small knolls on the higher uplands. Tanjil sandy loam occurs on the gentle to moderate slopes, while Tanjil loam occupies the flatter upland areas which usually show a crabholey microrelief. The series is developed on clay alluvium containing moderate amounts of coarse sand and gravel. Two unnamed soils, Type A associated with drainage lines and Type B which is confined entirely to the high ridges in the south of the area, are soils of restricted occurrence formed over lighter materials.

Where the upland slopes are fairly steep as in the parishes of Tinamba and Denison and in the north of the parish of Winnindoo, there is a well defined junction with the low-lying woodlands. Here Tanjil sandy loam, and occasionally Tanjil gravelly sand, adjoins either Winnindoo loam or Winnindoo clay loam. The sequence is Tanjil loam to Winnindoo loam down the more gentle slopes.

Intermediate Slopes. This category, which includes most of the parish of Wooundellah and extends slightly into the eastern section of the parish of Denison, is comprised chiefly of the soil types, Wooundellah loam and Winnindoo loam, both of which are formed from the finer sediments of the ridge and upland deposits. Wooundellah loam is found at relatively higher levels than Winnindoo loam, although in some situations the difference in elevation is slight. The junction of the intermediate slopes with the sparsely timbered plains is clearly defined in the south-eastern portion of the parish of Denison, where Wandocka clay loam occurs at from 5 ft. to 15 ft. immediately below Wooundellah loam. Further north the intermediate slopes merge somewhat indefinitely with the heavier grey soils of the plains; here Wandocka clay loam and Nambrok clay loam are associated with low rises of Wooundellah loam. Type C, developed on gravelly clay sediments, is in the same region.

Low-lying Woodlands. Soils of the Winnindoo series have developed in these situations on the lower-lying and finer sediments of the ridge and upland deposits under conditions of indifferent to poor surface drainage. Winnindoo loam occurs on the broader expanses, and Winnindoo clay loam in the more definite depressions, which may persist as temporary swamps where drainage is restricted. A crabholey or tussocky microrelief is characteristic, particularly in areas of Winnindoo clay loam.

Sparsely Timbered Plains. The almost entire absence of timber and the generally heavier nature of the surface soils distinguish these plains from the adjoining, rather level country of the intermediate slopes, and the low-lying woodlands. The principal soil types are Denison clay loam, Wandocka clay loam, and Nambrok clay loam, all of which are derived from clay alluvium very low in the fractions above silt size. Wandocka clay loam, a crabholey occurrence, is situated below Denison clay loam and Nambrok clay loam in the topography, but differences in elevation may be only of a few inches.

Two minor depression soils - Types 2 and 3 -are found on the plains both as shallow drainage lines and as small landlocked depressions. In most cases, Denison clay loam forms the raised banks of these drainage ways, but occasionally the levees may be of Acre clay loam.

Types D and E, developed from silty clay sediments, are local occurrences confined to a small area between Boggy Creek and Tinamba township. The topography here is considerably broken by water ways leading to Boggy Creek, and is slightly undulating. Type D occurs on the higher levels adjacent to the banks of these waterways, while Type E occupies relatively lower situations.

Rises and Depressions Associated with Former Stream courses. Raised slightly above the general level of the landscape, the brown soils of this feature stand in contrast to the adjacent grey plains of Denison clay loam. The associated soil types in the complex are Heyfield clay loam and Acre clay loam on the rises and adjacent gentle slopes; the minor depression soil types 1, 2, and occasionally 3; and small occurrences of Denison clay loam in some hollows and on some low banks. Heyfield clay loam is the most extensive soil type in the complex, particularly where the system is most strongly developed in the north-west of the parishes of Denison and Winnindoo; however, the intermingling of soil types is so intimate that broad expanses of this type are unusual. The Type 1 depression soil is found in the more continuous depressions over strata of sandy sediments representing old stream courses. Depressions of Type 2 are small and are most frequent on the outskirts of the complex.

River Flats. The silty clay alluvium of the Thomson River flood plain has given rise to the immature Thomson silty clay loam and the Thomson silty clay. The topography of the flats is considerably broken by billabongs, lagoons, temporary swamps, and drainage ways. Thomson silty clay is found in the last two situations where water remains longer than on the higher areas of Thomson silty clay loam, although all the soils are subject to periodic flooding.

Restricted extents of benchland, comprising hollows and banks, are principally of Type G which outlies the Thomson series in these situations and passes to Denison clay loam at the higher level of the plains. It comes within the influence of the Thomson River only at very high flood levels.

<u>Saline Swamplands</u>. The principal occurrences are the two areas of saline swampland shown in Fig. 3 and classed as soil type F. These receive the accumulated drainage from a large part of the district, and, since there is no natural outlet for the saline waters, the soils may remain flooded for indefinite periods.

Type F also occurs in a few small depressions which are flooded at irregular intervals from Nambrok Creek.

4. Description of the Soil Types.

Tanjil series.

Three soil types are included in this series which is found on the ridges and associated uplands in all four parishes. The parent materials one clay sediments with moderate to large proportions of the coarse mineral fractions, either of coarse sand or of gravel size, but rarely sufficient in amount to give rise to definite sandy clay textures except in the deeper strata below 4 ft. The soil types are related as a series through their close topographic association, similar colour profile, and parent material. The soils classified as Tanjil gravelly sand and Tanjil sandy loam are considered to be related as separate types within the same soil series, rather than as one soil type and its gravelly phase.

Tanjil gravelly sand.

This type occurs on the crests and adjacent steep slopes of the ridges and as small knolls on the higher upland country. The major occurrence is in the parish of Tinamba.

The average profile is as follows: -

A_1	0-4 in.	Grey-brown or brownish grey sandy loam or sand, with slight gravel; loose when dry, slightly coherent when moist.
A_2	4-12/18 in.	Light brownish grey gravelly sand, with iron concretions and cemented gravel at junction with the B horizon; loose when dry, incoherent when moist.
B	12/18-30 in.	Brownish yellow with slight red mottling, heavy clay, with slight to moderate gravel and slight iron concretions; massive structure; hard when dry, stiff when moist.
	30-60 in.	Yellow and grey with some red mottling, gravelly clay, or medium clay with sand and gravel increasing with depth.

The gravel is well rounded and increases rapidly in size and amount with depth in the A horizon and may reach pigeon egg size.

Areas in which the gravelly A horizon exceeds 18 inches are inscribed "very gravelly profile" on the soil map. Such occurrences have been worked extensively for their gravel.

Tanjil sandy loam.

This type is widely distributed, viz.; in the parish of Tinamba, with Tanjil gravelly sand and with Type *A* on undulating upland; in the parish of Winnindoo, with Tanjil loam on gentle upland slopes; and in the parish of Denison, with Type B on moderate slopes of ridge land.

The principal morphological features of the type are given below.

A_1	0-4 in.	Grey-brown or brownish grey sandy loam; loose when dry, slightly coherent when moist,
A_2	4-10 in.	Light brownish grey sand, with slight to moderate gravel and iron concretions, sometimes cemented at the junction with the B horizon; loose when dry, incoherent when moist.
B	10-36 in.	Brownish yellow with slight red mottling, heavy clay; massive structure; hard. when dry, stiff when moist.
	36-72 in.	Brownish yellow, gritty medium clay, sometimes sandy clay below 48 in.

There is no obvious zone of lime accumulation, although lime has been recorded at 30-36 in. on rare occasions.

Recorded variations from the normal profile are "light deep subsoil" in which sandy clay textures occur in the profile before 48 in., and "sandiness in profile" in which admixture of sand occurs throughout the clay B horizon.

On some areas of gentle slope when the A horizon is shallower than normal, the B horizon may be exposed in places as mounds 3-4 ft. in diameter. This "crabholey" effect, however, is not nearly as strongly developed as in the loam member of the Tanjil series.

Tanjil loam.

The principal occurrence of Tanjil loam is in the parish of Winnindoo, where it occurs in close association with Tanjil sandy loam on gently sloping and flat areas of upland. It merges with Winnindoo loam at lower levels.

A crabholey microrelief, usually with conspicuous yellowish brown mounds, is not invariable but is very common in the occurrences of Tanjil loam found within the surveyed area.

The following description represents the morphology of the average profile, except that the surface texture of the weathered B horizon where it is exposed on banks may be clay loam or heavier.

A_1	0-4 in.	Brownish grey loam; loose when dry, coherent when moist.
A_2	4-8 in.	Light grey with slight rusty-brown flecks, sandy loam or loam; loose when dry, coherent when moist Iron concretions at junction with B horizon. (These frequently occur on the surface of clay banks.) This horizon may be very restricted.
B	8-36 in.	Brownish yellow heavy clay; massive structure; hard when dry, stiff when moist.
	36-72 in.	Brownish yellow medium clay becoming sandier with depth.

On very rare occasions lime may occur in the profile below 36 in.

Occasionally sandy clay textures occur before 48 in. to form a "light deep subsoil" phase.

Wooundellah loam.

This type is exclusive to the plains and low rises which comprise the intermediate slopes of the ridge and upland in the parish of Wooundellah. It is associated principally with the Winnindoo series, but at higher levels on the landscape.

Features of the soil profile are:—

A_1	0-6 in.	Brownish grey or grey-brown loam; cloddy structure; brittle when dry. mellow when moist.
A_2	6-14 in.	Light brownish grey with rusty flecks, clay loam; compacted and brittle when dry, open when moist. Iron concretions and heavier texture at the junction with the B horizon.
B_1	14-27 in.	Mottled brownish yellow, greyish yellow and red, heavy clay with from slight to heavy iron concretions; nutty structure; friable when dry, plastic when moist.
B_2	27-38 in.	Yellow heavy clay with black staining on cleavage planes, with soft black inclusions and decreasing iron concretions; massive structure; brittle to hard when dry, stiff when moist.
	38-60 in.	Greyish yellow medium clay passing to lighter textures, usually with slight limestone rubble.
	60-108 in.	Strata of clays and sandy clays.

The flatter occurrences are sometimes crabholey.

Areas on the soil map inscribed "light profile" have sandy clay and/or lighter textures in the deep subsoil.

Winnindoo series.

Two soil types are included in this series which is widely distributed throughout the district on broad, low-lying areas and depressions of poor drainage adjoining the uplands. These areas are moderately timbered with red gums.

Winnindoo loam.

The normal characteristics of the soil profile are as follow: -

A_1	0-3 in.	Grey, occasionally brownish grey, loam; cloddy structure; compacted and brittle when dry, coherent when moist.
A2	3-7 in.	Grey and light grey with rusty flecks, clay loam or sandy clay loam with slight iron concretions; massive structure; hard when dry, plastic when moist.
A_2	7-10 in.	Yellow-grey with light grey and rusty flecks, clay loam to medium clay with slight iron concretions.Transitional between the A2 and B1 horizons with the texture gradually increasing.
B1	10-30 in.	Faintly mottled yellow-grey heavy clay with decreasing iron concretions; massive structure; hard when dry, sticky when moist.
B_2	30-42 in.	Greyish yellow heavy clay, sometimes with limestone rubble.
	42-72 in.	Greyish yellow heavy clay or mottled yellow-grey-red stratified clay.

Some areas are faintly crabholey, but not to such an extent as to expose the B horizon on the banks.

Widely separated soils of this type show some variations from the morphology given above. The most extensive areas of Winnindoo loam occur on the plain country contiguous with the gently sloping uplands the parishes of Winnindoo and Denison. Here the type outlies Tanjil loam at lower levels and is developed on slightly finer alluvium. Heavy clays persist in the subsoils to 72 in.In the parish of Tinamba, upland slopes are steeper, and the change is from Tanjil gravelly sand or Tanjil sandy loam to Winnindoo loam at a fairly definite break in slope. Borings in this area of Winnindoo loam frequently reveal horizons of brown, instead of the normal yellow-grey clays below 3 ft. As similar brown clays occur in the deep subsoils of the adjoining Acre and Denison series in this area, but not in the Tanjil series, it would. appear that Winnindoo loam in the parish of Tinamba is derived, in some instances, from colluvial material from the adjacent upland. In addition, coarse sand is more evident in the A horizon of the Tinamba than in the other occurrences of Winnindoo loam. Areas in which this influence is pronounced are denoted on the soil map by the inscription "light surface", whilst an occurrence with 15 in. to the clay subsoil is inscribed "deep surface". In the parish of Wooundellah, where Winnindoo loam bears a catena relationship with Wooundellah loam, light clay and sandy clay textures are fairly frequent in the deep subsoils of both series. Areas inscribed "light deep subsoil" on the soil map have sandy clay or lighter textures below 42 inches.

The inscriptions "sandy wash" and "clay wash" on the soil map, on both this and the Winnindoo clay loam soil types, refer to alluvial fans formed where watercourses carrying materials from the ridges and uplands discharge onto the lower country. The deposits which are usually less than 12 in. in depth are recent and overlie normal Winnindoo loam and Winnindoo clay loam profiles.

Winnindoo clay loam.

The major occurrence is on a broad, low-lying area in the south of the parishes of Winnindoo and Denison which receives drainage from the neighbouring uplands of the Tanjil series. Here, Winnindoo loam occurs at slightly higher levels, and Type F at lower levels in the generally low-lying topography. Elsewhere, smaller areas fringe the Tanjil series where drainage from the ridgeland slopes is restricted. Whilst in no way permanent swampland, water may lie on the surface of Winnindoo clay loam for considerable periods after heavy rain.

The following morphology describes the average soil profile:-

A_1	0-3 in.	Grey clay loam; cloddy structure; brittle when dry, plastic when moist.
A_2	3-6 in.	Grey and light grey with rusty flecks, clay loam with slight iron concretions; hard when dry, plastic when moist.
B_1	6-21 in.	Faintly mottled yellow-grey heavy clay with slight iron concretions; massive structure; hard when dry, sticky when moist. A transitional zone due to the penetration of the A2 into the top of the B1 horizon may be present.
B_2	21-42 in.	Greyish yellow heavy clay, sometimes with limestone rubble; massive structure; hard when dry, sticky when moist.
	42-72 in.	Mottled yellow and grey heavy clay; massive structure; hard when dry, sticky when moist.

Typically, the surface is crabholey but it is sometimes tussocky. One area in which crabholiness is above the average for the type is inscribed "very crabholey" on the soil map.

Variations from the average profile described above are principally in the depth and texture of the A horizons. Such variations are normal to a crabholey microrelief, and clay textures are usual in this type where the weathered B horizon is exposed as banks. However, some situations which *are* tussocky rather than crabholey have an A1 horizon exceeding the normal 3 in., and a well developed transitional A2B1 horizon of light or medium clay texture. In such cases, the depth to the B1 horizon may exceed 12 in. Portion of the large occurrence in the south of the parishes of Winnindoo and Denison is of this type.

The inscription "heavy surface" on the soil map refers to two, somewhat swampy depressions in the south of the area, which are not crabholey, but have clay surface textures throughout the occurrence.

Heyfield clay loam.

This type occupies the brown rises of the complex of undulating brown and grey-brown soils representing earlier stream activity, and which traverses the parishes of Winnindoo and Denison.

The morphology of the soil type is as follows: -

A	0-8 in.	Brown or greyish brown clay loam; crumb structure; friable when dry, when moist. Gradual transition to,
A	8-14 in.	Light red-brown clay loam; crumb structure; friable when dry, mellow when moist. Gradual transition to,
AB	14-18 in.	Red-brown light clay; nutty structure; friable when dry, plastic when moist. Gradual transition to,
B	18-30 in.	Red-brown medium clay with black staining on the cleavage planes; small nutty structure; friable to brittle when dry, plastic when moist.
	30-48 in.	Brown light clay with some black staining, more rarely, medium clay passing to light clay.
	48-96 in.	Brown light clay or fine sandy clay, very rarely with limestone rubble.

Brown surface soils are not extensive in the area and are restricted to this type and some occurrences of Acre clay loam. Characteristically, the junction between the A and B horizons of Heyfield clay loam is indistinct and in this respect differs from Acre clay loam. Again lime is rarely present whilst it is frequently, although not always, found in Acre clay loam. In addition, the profile of Heyfield clay loam is well structured, being noticeably friable throughout.

Soils in the south of the parish of Denison included in this type are generally duller than normal in their profile colours, tending toward grey-brown surface and brown subsoil shades. However, only one small occurrence is sufficiently abnormal to be inscribed "brownish grey profile" on the soil map.

In the same locality, fine sandy clay textures sometimes occur before 4 ft. and these soils are inscribed "light profile."

Acre clay loam.

Besides occurring with Heyfield clay loam and the depression soil types in the complex of undulating brown and grey-brown soils, Acre clay loam is found elsewhere in the parishes of Tinamba, Winnindoo, and Denison on the banks of drainage ways and low rises. In such situations, Denison clay loam may adjoin at slightly lower levels.

On the average, the type conforms to the following profile:-

A_1	0-8 in.	Greyish brown or grey-brown clay loam; crumb structure; brittle when dry, mellow when moist.
A_2	8-15 in.	Similar with slight light grey-brown flecks; nutty structure. This horizon is often very weakly developed.
B_1	15-36 in.	Red-brown and dark brown heavy clay with black staining on the cleavage planes; large nutty structure; hard when dry, stiff when moist.
	36-72 in.	Brown light clay passing to fine sandy clay, sometimes with limestone rubble.

There are many small occurrences of Acre clay loam throughout the area, consequently the type is fairly wide in its profile characteristics. The colour of the profile approaches that of Heyfield clay loam when associated with that type, but, although the A2 horizon is very weakly developed, the B horizon is quite distinct. However, when in proximity to Denison clay loam, the profile shows duller colours, being grey-brown to brownish grey in the A horizon and somewhat mottled brown-greyish yellow in the B1 horizon.

Tinamba occurrences nearly all have lime in the profile and some have fine sandy clay before 48 in. The latter are recorded as "light deep subsoil" while "light surface" is another variation of the type.

Denison clay loam.

In the parish of Tinamba, this type occurs on benchland between the ridges and the Thomson River and Boggy Creek. Elsewhere in the area, it outlies the undulating brown soils on plains and occurs on the low banks of some drainage ways. In these situations, it is associated with Nambrok clay loam and with Wandocka clay loam, the latter at slightly lower levels.

The following morphology represents the soil profile:-

A_1	0-8 in.	Grey or brownish grey clay loam; crumb structure; friable when dry, mellow when moist.
A_2	8-14 in.	Grey with light grey and greyish yellow flecking, clay loam, occasionally light clay; compacted and brittle when dry, mellow when moist.
B_1	14-30 in.	Dark yellowish grey with slight red mottling, heavy clay with black staining on cleavage planes, passing to yellow-grey heavy clay; large nutty to blocky structure; hard when dry, stiff when moist.
	30-60 in.	Greyish yellow medium or heavy clay, sometimes with limestone rubble.
	60-120 in.	Mottled grey-yellow-brown stratified clay.

The soils are developed on sediments very low in both the coarse and fine sand fractions, consequently the surface soils are of fairly heavy and smooth texture. Some differences, although insufficient to differentiate the soils morphologically, are noticeable between profiles developed on banks, particularly in the south Denison locality, and the plain areas. The former soils are slightly darker in surface colour with a more restricted A2 horizon, are rather more friable, and generally appear somewhat more attractive soils. These features appear to be linked mainly with a higher content of organic matter.

A "light surface" variation has a loam surface texture instead of the normal clay loam.

Wandocka clay loam.

The occurrence is practically entirely in the parish of Denison. Low areas receiving drainage from the surrounding plain country of Denison clay loam are usually of Wandocka clay loam.

Morphological features of the soil profile are as follow: -

A_1	0-6 in.	Grey clay loam; small cloddy structure; brittle when dry, plastic when moist.
A_2	6-12 in.	Grey with light grey, yellow-grey and rusty flecking, light clay; cloddy structure; hard when dry, plastic when moist.
B_1	12-27 in.	Dark yellowish grey passing to yellow-grey, heavy clay with slight small iron concretions; large nutty passing to blocky structure; hard when dry, stiff when moist.
	27-60 in.	Greyish yellow heavy clay, sometimes with limestone rubble and odd small inclusions of gypsum.
	60-114 in.	Mottled grey and yellow stratified heavy clay.

The soils are developed on similar fine alluvium to that giving rise to Denison clay loam, and the morphology of the type illustrates the close relationship between these two soil types. A type, rather than a phase, relationship for these two soils has been determined because of a number of small morphological differences important in their agricultural use. The main difference lies in the nature of the A_1 and A_2 horizons which are shallower, of heavier field texture, (although the A_1 horizon is clay loam in both types), and of less attractive structure in Wandocka clay loam. In addition, the surface of Wandocka clay loam, unlike Denison clay loam, is typically crabholey - a condition also known locally as "bucketty." Situations of above average crabholiness, although not delineated, are inscribed "crabholey" on the soil map. Where such areas also have only a few inches of A horizon, they are defined and inscribed "shallow" or "shallow and heavy surface."

Nambrok clay loam.

This is not an extensive type and occurs in the parish of Denison associated with low plains of Denison clay loam and Wandocka clay loam. Some areas in the north-east of the parish of Wooundellah adjoin Wooundellah loam at lower levels.

The profile characteristics are normally as follow: -

A_1	0-7 in.	Brownish grey clay loam; nutty structure; brittle when dry, mellow when moist.
A_2	7-14 in.	Grey, light grey, and rusty yellow and brown, mottled clay loam or light clay; nutty structure; brittle when dry, plastic when moist.
B_1	14-20 in.	Mottled yellow-grey, brown and red, heavy clay with moderate iron concretions; small nutty structure; friable when dry, stiff when moist.
B_2	20-42 in.	Greyish yellow heavy clay with decreasing iron concretions and with slight small inclusions of gypsum; blocky structure; hard when dry, stiff when moist.
	42-72 in.	Mottled grey-yellow-brown medium clay sometimes with limestone rubble and slight inclusions of gypsum.

This type differs from Denison clay loam and Wandocka clay loam by features of colour, structure, and concretionary material in the A and B horizons, resulting from the influence of iron. However, as concretionary iron also may be present in Wandocka clay loam, although not usually in Denison clay loam, the three types tend to merge with each other in these profile features. Ideally, Nambrok clay loam has a yellowish A2 horizon, and a crumbly B_1 horizon containing appreciable iron concretions and which is characteristically orange in colour, due to grey, yellow, brown, and red mottlings; but some profiles may have these colour characteristics with few iron concretions, whilst others may have considerable concretions with less red and brown in the mottled horizons. A similar influence of iron on the profile is noticeable in some soils of Wooundellah loam.

Thomson series.

Two soil types are included in this series which comprise the soils of the flats fringing the Thomson River.

The series, which is developing on silty clay alluvium, has an immature soil profile. Changes in colour and texture in the profile are gradual and there is no illuvial lime horizon, but occasional soft iron concretions may be present.

Thomson silty clay loam.

The following is the average soil profile:-

0-15 in. Grey silty clay loam with rusty stainings of organic matter; nutty structure; friable when dry, mellow when moist.

15-72 in. Grey with yellowish grey mottling, becoming more yellow with depth, silty medium clay with occasional small soft iron concretions; blocky structure; hard when dry, stiff when moist.

Thomson silty clay.

The normal soil profile described below differs only from that of Thomson silty clay loam in the slightly heavier and shallower surface soil of rather less attractive structure.

0-12 in. Grey silty clay with rusty staining of organic matter; cloddy structure; brittle when dry, plastic when moist.

12-72 in. Grey with yellowish grey mottling, becoming more yellow with depth, silty medium clay; blocky structure; hard when dry, stiff when moist.

Minor Soil Types (Unnamed).

The following soil types are all of limited occurrence within the surveyed area, although some, viz., Types B, D, E, and F may be widespread in adjoining districts. Types A and G, from their occurrence, are naturally irregular in their profile features. In all cases, the profile descriptions recorded below are based on a small number of borings, insufficient to determine fully the morphology of these soils.

Type A.

This is a soil type found in the drainage ways of the uplands of the Tanjil soil series. Owing to the light nature of the materials, gullying is usual in these water ways.

A_1	0-7 in.	Brownish grey to grey-brown sand or sandy loam.
A_2	7-15 in.	Light brownish grey sand.
B	15-30 in.	Yellow and grey mottled sandy "clay.
	30-48 in.	Yellow sandy clay loam or sandy clay.
	48-72 in.	Variable strata of sand and clay textures.

Some areas inscribed "heavy profile" on the map have a sandy medium clay type of subsoil and deep subsoil, although horizons of sandy clay and sandy clay loam may occur also.

Type B.
The only occurrences are on moderate slopes of ridgeland in the south of the parishes of Denison and .Wooundellah.

A_1	0-5 in.	Grey-brown loamy sand.
A_2	5-14 in.	Light grey-brown sand, frequently with large concretionary ironstone.
B	14-30 in.	Brownish yellow with red mottling, gritty heavy clay with slight iron concretions.
	30-48 in.	Yellow sandy clay passing to sandy clay loam. (Occasionally textures do not reach sandy clay, although sandiness is always apparent).

Type C.
An area of gravelly soils adjacent to, and some 20 ft. above, the Thomson River in the parish of Wooundellah is included in this type. The occurrence is associated with the intermediate upland slopes of Wooundellah loam.

A	0-12 in.	Brownish grey loam with large water worn gravel increasing from moderate to heavy. Iron cemented gravel at junction with B horizon.
B	12-40 in.	Brownish yellow, mottled with red, heavy clay with heavy gravel.
	40-60 in.	Yellow-brown-red-grey mottled clay with heavy gravel.

Type D.
Type D is found on low rises and banks of drainage ways north of Boggy Creek near Tinamba township. High floods reach this area very occasionally.

A_1	0-6 in.	Grey-brown silty clay loam; crumb structure; friable when dry, mellow when moist.

A_2	6-14 in	Brown with slight light grey-brown flecks, clay loam; crumb structure; friable when dry, mellow when moist.
B_1	14-30 in.	Reddish brown medium clay with black staining on cleavage planes; small nutty structure; friable when dry, plastic when moist.
B_2	30-42 in.	Reddish brown medium to light clay with decreasing black staining; slight, increasing to light, limestone rubble.
	42-72 in.	Brown silty light clay with slight limestone rubble.

Type E.

This type occurs at lower levels with Type D, and slightly below Denison clay loam when adjoining that type.

Textures and sequence of horizons in the profile are similar to Type D, colours being grey in the A and yellow-grey in the B horizons.

Type F.

A saline soil type found in the south of the area on badly drained swampland and in shallow depressions subject to flooding from Nambrok Creek and other drainage ways.

A	0-8 in.	Grey, (black when moist), with rusty stainings; light or medium clay.
B	8-48 in.	Grey and yellowish grey, becoming more yellow with depth, heavy clay with limestone rubble; massive structure; hard when dry, very sticky when moist.
	48-72 in.	Mottled yellow and grey heavy clay.

Some occurrences are strongly crabholey.

Type G.

This type is found mainly on banks and in hollows outlying the Thomson series at levels between the river flats and the adjacent plains.

0-12 in.	Dark brownish grey clay loam; small nutty structure; friable when dry, mellow when moist. Gradual transition to,
12-20 in.	Brownish grey light clay; nutty structure; brittle when dry, plastic when moist.
20-42 in.	Brown or greyish yellow light clay or fine sandy clay; large nutty structure; hard when dry; plastic when moist.
42-72 in.	ditto, or more rarely passing to mottled grey and yellow silty clay.

There may be considerable variation from the average profile given above according to the situation, e.g., the profiles of soils in hollows are greyer and on banks are browner than the average.

Type H.

The only occurrence it7 in the north-east of the parish of Denison where a rather extensive area adjoins Wandocka clay loam, but at a lower level. The shallow A horizon and the uneven surface of this soil resemble the shallow and more crabholey variations of the Wandocka clay loam. However, there is a much more extensive exposure of the B horizons as clay banks and a large proportion of the occurrence recorded has the B horizon at the surface. Elsewhere, the surface is shallow and of heavy texture. Some quartz and ironstone gravel lie on the surface of the clay banks.

A	0-4 in.	Grey, with rusty staining, light clay; cloddy structure; hard when dry, plastic when moist.
B	4-48 in.	Dark yellowish grey passing to yellow-grey, heavy clay with slight iron concretions and quartz gravel.

Minor Depression Soils.

The three types recorded are associated entirely with the Heyfield clay loam - Acre clay loam complex and the adjoining Denison and Nambrok soil series.

Type 1. Brown and Grey-brown Soils.

The situation of these soils is in crescent shaped hollows and narrow, tortuous depressions, continuous except for raised bars, which, in all cases, are bounded by Heyfield clay loam or Acre clay loam.

0-6 in.	Greyish brown or grey-brown clay loam; crumb structure; friable when dry, mellow when moist. Gradual transition to,
6-12 in.	Brown clay loam; crumb structure, friable when dry, mellow when moist. Gradual transition to,
12-24 in.	Brown light clay; granular structure; friable when dry; plastic when moist.
24-36 in.	Brown with light brown, light clay with small soft black concretions; porous nutty structure; friable when dry, plastic when moist.
36-48 in.	ditto, or medium clay, occasionally fine sandy clay.
48-72 in.	Brown light clay or sandy clay.
72-178 in.	Sandy clay passing to stratified sands.

The strata of sands found in the deep horizons of the winding depressions suggest that the complex represents a buried stream system. The soils are particularly well drained and water never lies in the hollows for more than an hour or so, even after heavy rain. The more continuous depressions finally pass to Types 2 or 3 at lower contour levels.

Type 2. Grey Soils.

This type occurs as shallow drainage ways and small landlocked depressions associated with the Heyfield, Acre, and Denison soil series.

A_1	0-7 in.	Grey clay loam; crumb structure; friable when dry, mellow when moist.
A_2	7-16 in.	Grey and light grey, or light grey, clay loam, frequently with moderate amounts of small iron concretions; compacted and brittle when dry, mellow when moist.
B_1	16-30 in.	Yellow-grey heavy clay with black staining on cleavage planes; nutty structure; hard when dry, stiff when moist.
	30-72 in.	Greyish yellow heavy clay, usually with limestone rubble; sometimes fine sandy clay below 48 in.

A greater surface depth of soil is the most obvious difference from the Type 3 profile, but some Type 2 soils also are better drained internally. Whilst not as good as Type 1 in this respect, internal drainage may be reasonably good in certain grey, winding depressions, where sandy clay horizons occur in the deep subsoil.

Such Tyne 2 depression soils, which also may be lighter than normal in the B horizon, are inscribed "light profile" on the soil map.

Type 3. Shallow and Heavy Grey Soils.

The soils of the more definite drainage ways and small depressions on the plains of the Denison and Nambrok series are included in this type.

A_1	0-4 in.	Grey clay loam or light clay; cloddy or massive structure; brittle or hard when dry; plastic when moist.
A_2	4-7 in.	ditto with rusty brown staining.
B_1	7-33 in.	Grey and yellow—grey heavy clay; massive structure; hard when dry, stiff when moist.
	33-72 in.	Greyish yellow heavy clay, frequently with limestone rubble.

Unclassified Soils.

Two small, low rises with several feet of red—brown sand have not been classified but are delineated and inscribed "sandy rise" on the soil map. A small, unclassified area adjacent to Boggy Creek is inscribed "deep loam surface" and for agricultural purposes can be included with the adjoining Denison clay loam.

5. Extent of the Soil Types.

Table 3. Areas of Soil Types.

Soil Type	Acres	As % of total area
Tanjil gravelly sand	1,670	2.6
Tanjil sandy loam	4,280	6.7
Tanjil loam	5,320	8.3
Wooundellah loam	4,950	7.[7]
Winnindoo loam	9,350	14.6
Winnindoo clay loam	4,640	7.3
Heyfield clay loam	3,54C	5.5
Acre clay loam	1,960	3.1
Denison clay loam	9,610	15.0
Wandocka clay loam	4.99[0]	7.8
Nambrok clay loam	2,600	4..1
Thomson silty clay loam	3,520	5.5
Thomson silty clay	1,330	2.1
Type A	1,060	1.7
" B	490	0.8
" C	380	0.6
" D	210	0.3
" E	150	0.2"
" F	1,250	1.9
" g	250	0.4
" H	490	0.8
Minor depression soils		
Type 1	380	0.6
" 2	760	1.2
" 3	780	1.2
Total	63.960	

The areas of the individual soil types determined by the State Rivers and Water Supply Commission from planimeter readings are given in Table 3. These show that the Denison clay loam is the main occurrence but is closely followed by the Winnindoo loam. However, there are substantial areas of most of the other named soil types.

The soil types considered the most suitable for general irrigation, viz., the Heyfield, Acre, Denison, Wandocka, Nambrok, Thomson, and Wooundellah series, the Types D, E, and G, and the Types 1 and 2 of the minor depression soils together total 34,490 acres or 53.9% of the area surveyed. Soils recommended for restricted irrigation, viz., the Tanjil and Winnindoo series and Types A, B, and C aggregate to 27,190 acres (42.6%). There are 1,030 acres (1.6%) of soils unattractive for irrigation (Type H and Type 3) and 1,250 acres (1.9%) of unsuitable, saline soils (Type F).

III. PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS.

A brief summary of the methods used in the laboratory examination of the soils is given in Appendix 2.

1. Mechanical Analysis.

The mechanical analyses of soils from representative profiles of all the soil types recorded in the area are given in the tables in Appendix 3.

The field determinations of texture of the sandy loam and loam surface soils agree with the proportions of sand, silt, and clay as expressed by the mechanical analysis. However, the clay loam soils are higher in silt than is indicated by the field textures. Although the fine-textured nature of these soils has been recognised, and is supported by the mechanical analyses, only the Thomson series has been described as silty. Silt values in both the clay loam and silty clay loam soil types are within the range of 32% to 46%, but, in the clay loom soils, the amount of fine sand present, viz., from 17% to 43%, is sufficient to reduce the effect of the large amount of silt on the field texture of most of these soils. But in the Thomson silty clay loam, fine sand is lower (approximately 10%), and the silt to fine sand ratio is 4.1 compared with an average ratio of 1.4 for the clay loams. Further, a smaller median diameter of the mineral particles in the fine sand to silt range in the Thomson series compared with other clay loam soil types is probable, and this may have affected the field estimate of siltiness in the soils. The surface soil of the Thomson silty clay loam has a high clay content, e.g., 44% in soil 7238, but this is offset in its effect on field texture by a fairly large amount of organic matter. The field textures of the subsoils agree reasonably with the mechanical analyses except in soils 1023, 5622, and 7276, representing the A2B1 horizons of the Winnindoo loam profiles. These soils show lower clay contents than are expressed by the field textures. This is probably due to the added stickiness conferred on the clay by sodium ions, since sodium is known to reach high proportions in the exchange complex of the subsoils of this soil type.

Summation curves of the A and B horizons of the principal soil types are presented in Fig. 4. The curves show that the soil types can be grouped into six classes on the basis of their similarity in mechanical composition.

The Tanjil series forms one group in which the most striking features are the great contrast in texture between the A and B horizons, and the very high percentages of clay in the latter horizon. These soils, and the minor soil types A and B, are the only types in which coarse sand approaches fine sand in amount. Actually, it slightly exceeds fine sand in the Tanjil gravelly sand. Silt values are low in both horizons.

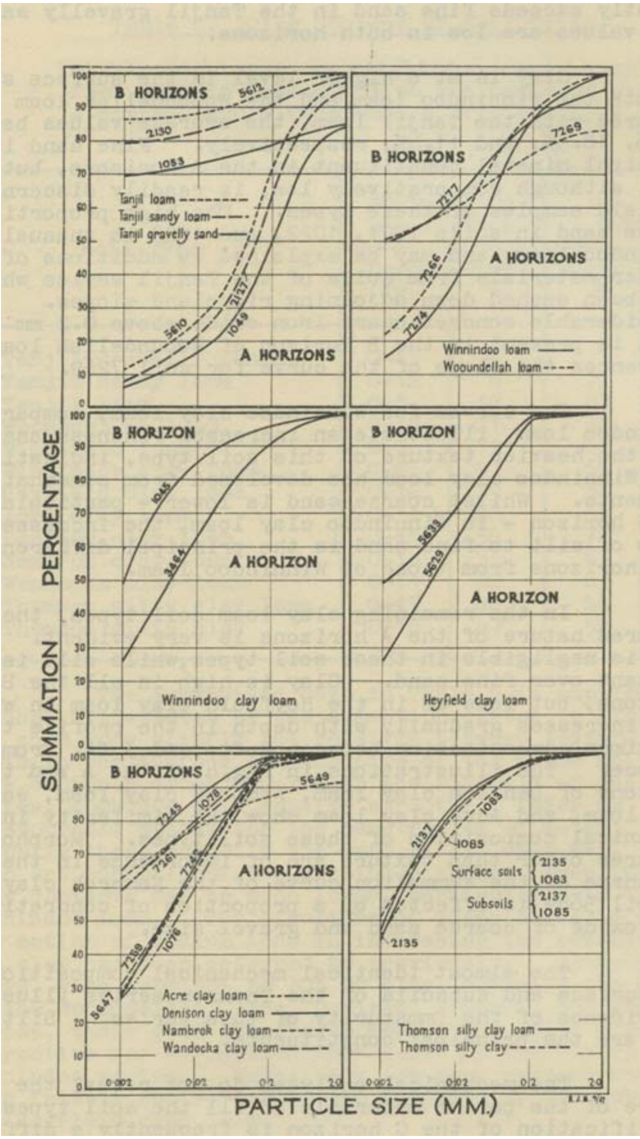

Fig. 4. Summation Curves of A and B horizons of soil types.

Clay is at a higher level in the surface soils of both the Winnindoo loam and the Wooundellah loam compared with the Tanjil loam, the average values being 15.0%, 18.5%, and 11.4%, respectively. Fine sand is the principal mineral constituent in the A horizons, but coarse sand, although comparatively low, is readily discernible in field samples of these types. The high proportion of coarse sand in soils 1021, 1022, and 1023 is unusual for Winnindoo loam, and may be explained by additions of coarser materials from soils of the Tanjil series which have been washed down adjoining ridgeland slopes. Considerable concretionary iron oxide above 0.2 mm in size which is present in the B horizon of Wooundellah loam influences the slope of the curve for soil 7269.

The curves for Winnindoo clay loam, compared with Winnindoo loam, illustrate an increased fineness associated with the heavier texture of this soil type, indicating that Winnindoo clay loam has developed from somewhat finer sediments. Whilst coarse sand is lower — particularly in the B horizon — in Winnindoo clay loam, the increased ratio of silt to fine sand is the principal difference of both horizons from those of Winnindoo loam.

In the remaining clay loam soil types, the fine—textured nature of the A horizons is very evident. Coarse sand is negligible in these soil types, while silt is dominant over fine sand. Clay is high in all the B horizons, but less so in the Heyfield clay loam in which clay increases gradually with depth in the profile to reach a maximum concentration between 2 ft. and 3 ft. from the surface. The illustrations in Fig. 4 of the A and the B horizons of Denison clay loam, Nambrok clay loam, Wandocka clay loam, and Acre clay loam show the similarity in mechanical composition of these soil types. Morphological features other than texture are of importance in these soils. The shape of the summation curve of the Nambrok clay loam subsoil 5649 is affected by a proportion of concretionary iron oxide of coarse sand and gravel size.

The almost identical mechanical composition of the surface and subsoils of the Thomson series illustrated, is evidence of the immaturity of this series. Silt and clay are the principal constituents.

The mechanical analyses do not reveal the true nature of the parent materials of all the soil types. Identification of the C horizon is frequently a difficulty with sedimentary soils owing to heterogeneity of the sediments. In most of the profiles, clay content falls off in the deeper horizons which suggests the formation of normal B_1 horizons by illuviation of clay; however, deposition of sediments under conditions of progressive diminution of flooding has also been a factor in the formation of some texture profiles. This, as well as the difficulty of identifying the C horizons, is illustrated by comparing the Acre clay loam profile 1076-1081 with the Wandocka clay loam profile 5638-5645. Both these profiles have an almost identical mechanical composition to 24 in. which would suggest a common parent material; yet the clay content of the Acre clay loam soil falls gradually from 54.6%, at 15-25 in. to 19.3% at 45-78 in., whereas, in the Wandocka clay loam, the clay content of 56.0%; at 12-21 in. rises gradually to 66.8% at 38-64 in.

Table 4. Clay Content of Soil Types.

(Clay percentages are weighted averages compiled from data in Appendix 3 on the basis of gravel + coarse sand + fine sand + silt + clay = 100%).

Soil Type	Surface and sub-surface		Subsoil	
	Depth in.	Clay %	Clay %	Depth in.
Tanjil gravelly sand	0-13	4	70	14-24
Tanjil sandy loam	0-12	6	79	13-26
Tanjil loam	0-8	10	87	9-33
Wooundellah loam	0-12	21	58	13-28
Winnindoo loam	0-9	19	41	9-32
Winnindoo clay loam	0-6	27	65	6-21
Heyfield clay loam	0-14	29	38	14-22
Acre clay loam	0-14	28	60	14-27
Denison clay loam	0-14	34	70	13-25
Nambrok clay loam	0-14	31	63	14-27
Wandocka clay loam	0-11	32	63	11-25
Thomson silty clay loam	0-15	46	48	15-25
Thomson silty clay	0-14	47	52	14-26

The summarised data in Table 4 is supplementary to that illustrated by the summation curves in Fig. 4, and show more clearly the relation between texture and depth in the surface and subsoils of the major soil types. Clay contents exceeding 70% in the subsoils of the Tanjil series, combined with massive structure, infer an unfavourable status for the penetration of water; and actually these subsoils are very sticky when wet. So also are subsoils of the Winnindoo series, even though clay contents may be much lower, particularly in the Winnindoo loam. The structure of these soils is poor, while the action of sodium ions in increasing the effectiveness of the clay has been referred to previously. Although heavy clays, with from 58% to 70% of clay, comprise the subsoils of the Wooundellah, Acre, Denison, Nambrok, end Wandocka series, their good structures make these soils more attractive for irrigation than soils of the Tanjil and Winnindoo series. Relatively low clay content coupled with friable nut structure are features of the subsoil of the Heyfield clay loam.

Four profiles show measurable amounts of lime -stone rubble, the highest concentration being 8.8% in an Acre clay loam profile at 25-34 in. Calcium carbonateis present in very small amounts in many profiles, but exceeds 1% in only two soils.

2. Reaction.

The reaction (expressed as pH units) of each horizon for all profiles sampled is given with other data in Appendix 3, while the frequency distribution of all available determinations for different zones of the soil profile, as shown in Table 5,illustrates more clearly the nature of the reaction trend for the soils of the area generally.

Table 5. Frequency Distribution of Reaction Values of Soils.

Horizon	5.0 -5.4	5.5 -5.9	6.0 -6.4	6.5 -6.9	7.0 -7.4	7.5 -7.9	8.0 -8.4	8.5 -8.9	9.0 -9.4	No. of values	Median pH
A_1	3	24	8	4						39	5.9
A_2		9	17	5						31	6.1
B_1 x		3	6	9	8	3	2			31	6.8
2-3 ft.		1	1	6	3	2	10	5	1	29	8.0
3-4 ft.		2			7	1	5	9	4	28	8.4
4-5 ft.				1	4	2	5	10	4	26	8.7
5-6 ft.				1	2	2	6	10	4	25	8.5

[x] Approximately 1-2 ft.

The median pH values indicate that for the soils as a whole there is an increase of pH with depth in the soil profile. From being fairly acid in the A_i, and somewhat less acid in the A_2 horizon, the reaction rises to near neutrality in the B_4 and becomes strongly alkaline in the subsoil below 2 ft. The scatter of values in the frequency table shows that the reactions of 80% of the A horizons are within a comparatively narrow range, viz., 5.5 - 6.4, however, there is a wider distribution in the values for the B1 horizons and the deeper zones, these reactions falling into the 5.5 to 8.4 and 5.5 to 9.4 groups, respectively. The frequency with which reactions above pH 8.0 occur in the subsoils below 2 ft. shows that many of the soils have a high metal ion saturation of the exchange complex in this region of the soil profile. Further, the high proportion of these values which lie within the 8.5 - 9.14 range indicates that magnesium and/or sodium are influential ions in the exchange complex.

Examination of the reactions for the individual soil types shows that all profiles of the Denison, Nambrok, Wandocka, and Wooundellah series, Type D, and the Type 3 depression soil approximate to the above median values. Limestone rubble occurs fairly frequently below 3 ft. in the subsoils of these soil types.

In the Heyfield clay loam profile, apart from being slightly acid in the surface the reaction is practically neutral to 54 in., becoming alkaline below this depth. Such reactions are in accordance with the morphology of Heyfield clay loam. The internal drainage of this soil type is good and visible lime is only rarely present; also, the amount of sodium salts in the profile is small. For similar reasons, the reaction of the profile below the surface horizon of the Type 1 depression soil, which is always associated with the Heyfield series, shows but little variation from neutrality with increasing depth. Two profiles of the Acre clay loam have reactions approaching those of the Heyfield clay loam profile, while the other two sampled are similar in this respect to the above Denison group of soil types. Acre clay loam is linked morphologically with both the Heyfield and the Denison series consequently these variations are normal. Lime, which occurs much more frequently than in the Heyfield clay loam, has been recorded in about 25% of the Acre clay loam soils.

Two of the profiles recorded of the Winnindoo series have the acid to highly alkaline trend with depth typical of the majority of the soils of the area, and probably most occurrences of the Winnindoo series are of this type since these soils are amongst the more saline and sodium clays can be expected in the subsoils. However, that the intensity of leaching of the soil profile, resulting from the variable hydrological conditions natural to the low-lying situation of this series, is an important factor in contributing to the reactions in the deeper subsoils is shown by the quite acid reaction to 4 ft. of one profile of Winnindoo clay loam. Also one profile of Winnindoo loam only reaches a slightly alkaline reaction at this depth.

Of the profiles of Type A and the Tanjil series, the Tanjil loam profile is the only one in which reactions depart materially from the median values given in Table 5. In this case, the soils are slightly acid to 6 ft. This may be attributed to the crabholey microrelief of the type which produces local conditions favourable for more intensive than normal leaching.

Good internal drainage, associated with a low-lying situation, is responsible for the absence of highly alkaline reactions in the deep subsoil of the Type 2 depression soil. However, all such occurrences are not so well drained and consequently strongly alkaline reactions may be expected in these deep subsoils elsewhere. In this connection, the very alkaline B1 horizon and deep subsoil of the poorly drained Type 3 depression soil is notable.

The Thomson series and Type G, which are immature soils, are slightly acid to neutral in their upper horizons, but may be either acid or alkaline at lower depths. Lime is absent from these soils and the alkaline reactions recorded can be attributed to the influence of sodium ions, since sodium chloride occurs erratically throughout the river flats.

3. Nitrogen and Organic Carbon.

The average nitrogen, organic carbon, and C/N values for the surface soils grouped in three textural classes are given in Table 6.

<u>Table 6. Average Nitrogen and Organic Carbon in Surface Soils.</u>

Textural Group	No. of Soils	N %	C %	C/N
Sandy loam	4	0.126	1.78	14.1
Loam	8	0.153	2.06	13.5
Clay loam	19	0.202	2.99	14.8

Allowing for the usual increase of organic matter with texture, the values for nitrogen and carbon indicate that the organic status of the soils as a whole is good. Also, the average C/N values for each group of soils are normal and favourable for the nitrification of the organic matter.

The individual values for nitrogen, organic carbon, and C/N ratio of the surface soils of the representative soil type profiles are given in Appendix 3. The figures for nitrogen do not reveal any significant differences between soil types of the same surface texture, although high values of 0.35% and 0.36% for soils Nos.1030 and 2135, representing Denison clay loam and Thomson silty clay loam, respectively, confirm field experience that these soil types in some localities are rather well supplied with organic matter. In general, the organic carbon follows the nitrogen trend of the soils to give C/N ratios within the range 11.2 - 14.8; however, three soils show C/N ratios above 23. It is significant that these are from profiles of the Thomson series and Type G, immature soils subject to fairly frequent flooding. The high C/N values indicate a proportion of undecomposed organic material in these soils and a balance between carbon and nitrogen unfavourable for its further decomposition.

4. Hydrochloric Acid Extract.

The phosphoric acid, potash, lime and magnesia in the hydrochloric acid extracts of the surface soils of the principal soil types are set out in Table 7.

Table 7. Chemical Analyses of Surface Soils.

(Expressed as percentages of air-dry soil)

Soil Type	Soil No.	Depth (in.)	P_2O_5	K_2O	CaO	MgO
Tanjil sandy loam	2127	0-3	.028	.104	.063	.077
Tanjil loam	5610	0-4	.031	.135	.074	.063
Wooundellah loam	7266	0-4	.041	.284	.114	.188
Winnindoo loam	5620	0-5	.022	.191	.071	.101
Winnindoo clay loam	1043	0-3	.054	.282	.109	.179
Heyfield clay loam	5629	0-4	.087	.490	.109	.169
Denison clay loam	7228	0-6	.074	.446	.121	.229
Nambrok clay loam	5647	0-6	.043	.310	.069	.179
Wandocka clay loam	5638	0-3	.054	.393	.099	.177
Thomson silty clay loam	2135	0-7	.158	.578	.441	.461

Allowance should be made for texture when assessing the relative mineral status of the soils. Since the finest particles of the soil contribute most to the materials soluble in hydrochloric acid, these constituents are usually at their highest level in soils of high clay content. However, it does not follow that such soils always possess a higher fertility level than soils of lower mineral content but of lighter texture.

The phosphoric acid content of the Thomson silty clay loam is fairly high, but, in the remaining soil types, the range is from moderate in the Heyfield clay loam to low in the Winnindoo loam. The evidence suggests that all the soil types will require liberal dressings of phosphate to attain full productiveness under irrigation.

The potash values indicate adequate reserves in all the soil types. However, the potash status of the soils is low when clay content is taken into consideration, reaching only an average for all soils of 1.4 g. K20 per 100 g. of clay.

The values for lime are low in all soil types except the Thomson silty clay loam, whilst magnesia contents are normal in all the soils examined.

The hydrochloric acid extract, as an estimate of the inherent mineral fertility of the soils, rates the Thomson silty clay loam well above the other soil types. Of these, the Heyfield clay loam is placed highest, slightly above the Denison clay loam and the Wandocka clay loam, with the Nambrok clay loam and the Winnindoo clay loam at slightly lower levels. The Wooundellah loam which compares favourably with the last two soil types is rated above the Tanjil loam and the Winnindoo loam.

5. Exchangeable Cations.

The exchangeable metal ions present in the surface and subsoils of representative profiles of the main soil types are given in Table 8.

Table 8. Exchangeable Metal Ions.

Soil Type	Soil No.	Depth (In.)	pH	Clay %	Total Ex Me. ions.	% of total metal ions as			
						Ca	Mg	K	Na
Tanjil loam	5610	0-4	5.6	11.4	3.7	54	34	7	5
	5612	9-19	6.8	80.0	18.7	13	69	3	15
Wooundellah loam	7266	0-4	6.6	20.1	6.6	54	36	7	3
	7269	13-27	6.7	54.7	15.4	24	58	5	13
	7271	37-57	8.9	40.7	13.2	3	73	3	21
Winnindoo loam	5620	0-5	6.3	16.3	3.7	41	45	9	5
	5623	17-34	6.9	42.7	12.0	10	67	3	20
	5624	34-45	7.5	54.3	16.5	6	66	3	25
Winnindoo clay loam	1043	0-3	5.9	24.7	7.6	46	41	10	3
	1044	3-6	6.0	25.9	5.4	38	49	9	4
	1045	6-12	6.1	55.1	9.2	24	65	3	8
Heyfield clay loam	5629	0-4	5.9	25.1	5.4	61	21	13	5
	5631	8-14	6.6	29.9	4.6	47	41	10	2
	5632	14-22	6.6	36.0	5.6	37	53	5	5
	5633	22-32	6.7	46.1	9.2	33	57	5	5
	5634	32-40	6.7	40.2	8.9	31	56	5	8
Denison clay loam	7228	0-6	6.0	32.0	6. 2	62	29	5	4
	7229	6-10	5.7	35.6	5.3	48	41	5	6
	7231	14-21	6.4	68.1	15.0	11	71	4	14
	7233	28-37	8.4	66.2	19.5	19	60	3	18
	7242	0-4	5.8	25.4	8.7	54	36	6	4
Wandocka clay loam	5638	0-3	6.3	25.4	5.7	52	37	7	4
	5640	6-12	6.0	33.1	4.0	32	51	7	10
	5641	12-21	6.5	56.0	11.8	21	56	5	18
	5643	26-38	8.3	67.4	17.9	15	59	4	22

[x] Total exchangeable metal ions as milligram equivalents per 100 g. of air dried soil.

The total exchangeable metal ions present in the soils depend on the nature, amount, and degree of saturation of the absorbing complex. Considering that the surface soils contain appreciable amounts of organic matter, and, in most cases, have fairly high clay contents, the values for these soils in all the soil types are particularly low. Additional exchange data for four major soil types given in Table 9 suggest that this is due to partial saturation[x] coupled with low exchange capacity of the absorbing complex.

Since cation absorption resides almost entirely in the clay of the subsoils, the values for total exchangeable metal ions tend to follow the clay content in the B horizons, deviations from a proportional relationship being due to differences in saturation and possibly in the nature of the clay colloid. When calculated to an equivalent clay basis, the B1 horizons have the following total exchangeable metal ion contents in m.e. per 100 g of clay:- Tanjil loam (5612) 23.4, Wooundellah loam (7269) 28.2_2. Winnindoo loam (5623) 28.1, Heyfield clay loam (5632)[∅] 15.6, Denison clay loam (7231) 22.0, and Wandocka clay loam (5641) 21.1. The reactions of these horizons which range from pH 6.4 to 6.9 indicate that these rather low values partly, at least, are due to unsaturation of the absorbing complex. Actually the percentage saturation values for soils 5612, 5623, 5632, and 7231 are 68%, 84%, 59%, and 64%, respectively. The evidence suggests that differences in saturation (although not entirely reflected by the pH values) and in clay contents are sufficient to account for differences in the amounts of total exchangeable metal ions present in the B_1 horizons of the soil types.

The deeper subsoils, except in the Heyfield clay loam, are nearly saturated, consequently the total exchangeable metal ion values calculated on a clay basis are higher than in the B1 horizons, but even so the values are only moderate. For example, at approximately 3 ft soils 7271, 5624, 7233, and 5643, from the soil profiles illustrated above, with pH values of 8.9, 7.5, 8.4, and 8.3, respectively, have 32.4, 30.4, 29.5, and 26.6 m.e. per 100 g of clay. The Heyfield clay loam profile is rather different in that, at the same depth (soil 5634), the pH and the percentage saturation are lower at 6.7 and 715 while the total metal ions are only 22.1 m.e. per 100 g of clay.

The exchange capacities of the A and B horizons of the four major soil types given in Table 9 are moderately low when clay and organic matter contents are taken into consideration. Calculated on a clay basis, the exchange capacities of the B horizons are very similar at 34.5, 34.2, and 33.5 m.e. per 100 g. of clay in the Tanjil loam, Denison clay loam, and Winnindoo clay loam respectively, and slightly lower at 31.1 m.e. per 100 g. of clay in the Heyfield clay loam.

The nature of the clay minerals has not been determined, but the rather low exchange capacities of the soils suggest that the clay complex is not a simple montmorillonite type.

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[x] Equilibrium with excess calcium carbonate is the reference point for saturation.

[∅] This is more truly an AB horizon.

Table 9. Exchangeable Hydrogen, Exchange Capacity and Percentage Saturation.

Soil Type	Soil No.	Depth (in.)	pH	Clay %	Exchange-able Hydrogen m.e. per 100g. soil	Exchange capacity m.e. per 100g. soil	Exchange capacity m.e. per 100g. clay	Saturation %
Tanjil loam	5610	0-4	5.6	11.4	6.9	10.6		35
	5612	9-19	6.8	80.0	8.9	27.6	34.5	68
Winnindoo loam	5620	0-5	6.3	16.3	3.5	7.2		51
	5623	17-34	6.9	42.7	2.3	14.3	33.5	84
	5624	34-45	7.5	54.3	1.4	17.9	33.0	92
Heyfield clay loam	5629	0-4	5.9	25.1	7.9	13.3		41
	5632	14-22	6.6	36.0	3.9	9.5	26.4	59
	5634	32-40	6.7	40.2	3.6	12.5	31.1	71
Denison clay loam	7228	0-6	6.0	32.0	8.6	14.8		42
	7229	6-10	5.7	35.6	8.2	13.5		39
	7231	14-21	6.4	68.1	8.3	23.3	34.2	64
	7233	28-37	8.4	66.2	<1.5	<21.0		>93

Although calcium is the principal metal ion in the absorbing complex of the surface soils, it represents only a small proportion of the total exchangeable metal ions in the subsoils except in the Heyfield clay loam. Percentages of less than 15 for calcium, as occur in subsoils 5612, 7271, 5623, 5624, and 7231, are remarkably low for Victorian soils.Calcium is replaced largely by magnesium in the subsoils, but sodium also is an important cation in these horizons in most of the soil types. These are more particularly the grey soils of indifferent surface drainage such as the Winnindoo loam (5623, 5624) and the Wandocka clay loam (5641, 5643), while the proportion of exchangeable sodium also exceeds the limit for soils free from the pedogenic influence of salt in the B horizons of the Tanjil loam (5612), the Wooundellah loam (7269, 7271), and the Denison clay loam (7231, 7233), Sodium is at a lower level and appears to have been of less pedogenic importance in the Heyfield clay loam. Exchangeable potassium is of the low order normal for soils of this type.

6. Soluble Salts.

Specific conductivity, as a measure of total soluble salts, and chloride values are given in Appendix 3 for representative profiles of the soil types.

The relationship between specific conductivity and total water soluble salts is irregular at low concentrations owing to variability in composition of the salts. However, it has been determined that, for specific conductivity values above 20 in these soils, multiplication of such values by 0.0032 gives the approximate percentage of total water soluble salts present. The data in Appendix 3 show that soluble salts increase from very low concentrations in the surface soils to reach maximum values at between 3 ft. and 4 ft., after which there is generally a slight decrease. Analyses of water extracts of selected soil samples indicate that sodium chloride is the principal soluble salt, consequently chlorides follow a similar trend in the soil profile.

During the survey, the distribution of salt in the area has been investigated systematically. Some 3,766 soil samples have been analysed for chloride content for this purpose. This information is summarised for the principal soil types in Table 10.

The salt data suggest that salinity, except in certain occurrences of the Thomson series, is unlikely to be an injurious factor in the soil types recommended as suitable for general irrigation. The salt status of the Heyfield clay loam and the Acre clay loam is very satisfactory, since over 80% of the samples from the 3-4 ft. zone, which may be regarded as a significant horizon, contain less than 0.05% of sodium chloride. Generally, the Nambrok clay loam, Denison clay loam, Wandocka clay loam, Wooundellah loam and the Type 2 depression soils have low salt contents of below 0.1%; but some occurrences show higher concentrations of between 0.1% and 0.25 in the 3-4 ft. layer. Salt values of this order should not be detrimental to the establishment of irrigated pastures on these soil types, provided water is used rationally and there is adequate surface drainage. The distribution of salt is somewhat erratic in the Thomson series. Taken as e whole, the present salinity level does not preclude irrigation of these soils, but there are a few areas on the river flats obviously too saline for irrigation. These are mainly in situations with restricted drainage outlets, adjacent to the rising ground of the plain country. Irrigation of this higher country may increase the salt hazard in these and similar situations irrespective of whether the lower flats are irrigated or not.

Inherent salinity reaches a higher level in tier soil types recommended for restricted irrigation. Whilst the majority of the 3-4 ft. samples of the Tanjil series record less than 0.1% of salt, concentrations frequently exceed this level. However, only rarely is the salt content above 0.25 and soil salinity is not a factor limiting development of these soils under irrigation. The salt status of the Type 3 minor depression soils is much the same also, but their locations are more favourable for accumulations of salt under irrigation.

Table 10. Frequency Distribution of Salt (NaCl).

Soil Type	Depth (ft.)	Proportion of samples in which percentage of salt was :- below .050	.051-.100	.100-.200	.200-.300	above .300	No. of Samples
Soil Types Suitable for General Irrigation							
Heyfield clay loam	1-2	98	2				160
	3-4	86	11	3			188
	5-6	74	22	4			49
Acre clay loam	1-2	93	7				90
	3-4	82	15	3			114
	5-6	75	25				20
Nambrok clay loam	1-2	97	3				29
	3-4	65	25	10			77
	5-6	60	40				10
Denison clay loam	1-2	93	7				220
	3-4	52	35	13			359
	5-6	36	51	10	3		39
Wandocka clay loam	1-2	94	6				115
	3-4	29	38	31	2		193
	5-6	25	63	12			8
Wooundellah loam	1-2	98		2			52
	3-4	68	21	9	2		123
	5-6	73	27				15
Thomson series	1-2	77	10	6	2	5	161
	3-4	34	34	26	4	2	240
	5-6	25	25	50			31
Minor depression soil - Type 2	1-2	96	4				48
	3-4	44	39	16	1		71
	5-6	33	42	25			12
Soil Types Suitable for Restricted Irrigation							
Tanjil sandy loam ø	1-2	46	32	18	4		44
	3-4	11	45	43	1		102
	5-6	26	48	26			23
Tanjil loam	1-2	48	34	18			65
	3-4	22	43	33	2		137
	5-6	25	50	25			12
Winnindoo loam	1-2	32	39	25	4		84
	3-4	4	16	59	20	1	226
	5-6	3	49	46	2		39
Winnindoo clay loam	1-2	24	32	27	9	8	78
	3-4	2	11	48	30	9	110
	5-6	7	3	73	14	3	29
Minor depression soil - Type 3	1-2	55	38	7			73
	3-4	12	36	46	6		118
	5-6	31	23	46			13
Soil Type Unsuitable for Irrigation							
Type F	1-2	7	24	34	7	28	29
	3-4			38	32	30	34

ø Including Tanjil gravelly sand.

Salt contents are generally moderate or high in subsoils of the Winnindoo series. Moderate concentrations within the 0.1 - 0.2% range are most frequent, but values above 0.25 occur in 21% of the Winnindoo loam, and in 39% of the Winnindoo clay loam 3-4 ft. samples. The fairly high inherent salinity of the subsoils, coupled with low-lying situation are hazards under irrigation, but with efficient irrigation practices and layout the Winnindoo loam and much of the Winnindoo clay loam can be utilised.

The salt contents of the Type F samples illustrate the saline nature of the profile of this soil type.

IV. THE RELATION OF THE SOILS TO IRRIGATION.

Few of the soils of the area would not respond to irrigation with suitable management, but economic considerations in handling the soils under irrigation largely determine the direction their development should take. On certain of the soil types, the growth of permanent pastures under normal irrigation practices should present no unusual difficulties, and therefore, can be recommended for general irrigation with a view to dairying and fattening cattle.

On other soil types, because of topographic situation, fertility limitations, or inherent salinity, pastures developed under light irrigation and suitable for fat lamb raising should be a more economic proposition. A third category of soils is too saline for economic development. The special problem of subdivision for soldier settlement requires that the better types of irrigable soils be selected for development in the first instance. If sufficient water is available after the full water requirements of these soils are provided for, irrigation can be extended to the less attractive soils. No great practical difficulties in the reticulation of water and the subdivision of the land are envisaged to treat the area in this way, since the pattern of soil types is such that those most suitable for intensive development occur contiguously to form a large and fairly compact unit within the district. To assist in planning the subdivision of holdings into satisfactory farm units, the soil types are grouped for discussion of their individual agricultural potentialities under the above three categories.

1. Soil Types in Areas Suitable for General Irrigation.

Thomson silty clay loam and Thomson silty clay. These alluvial soils of the river flats are of high fertility. Some areas are irrigated privately and under these conditions sown pastures are very productive for dairying and fattening cattle. The presence of numerous depressions is an obstacle to lay-out for irrigation in many situations, while the liability of flooding from the river is a further disadvantage. Several saline areas exist and there is evidence of fairly high salt contents in some of the deep subsoils, although generally salt is not a harmful factor in these soils at present. However, with the inception of irrigation on adjacent, higher land salinity may extend on the river flats. The rational use of water and an efficient drainage system in the area as a whole will minimise this risk.

Type G. This fertile soil, associated with the Thomson series, can be utilised for intensive development where topography permits.Some occurrences are subject to flooding from the Thomson River.

Heyfield clay loam. Under dry-farming, this soil is productive and has been favoured for cereal cropping in the past. In years of more than average rainfall, it is second only to the river flats in productivity, but is said to be inferior to the grey clay loam plains in dry seasons. This indicates that Heyfield clay loam can be expected to respond particularly well to irrigation and should be ideally suited for permanent pastures supporting dairy and fat cattle. It is a well structured soil and should be the most suitable of the soil types for lucerne. It apparently has a high field moisture capacity and will probably take relatively large waterings. Under irrigation, there is some possibility of percolation of water into the deep subsoil of this soil type, particularly where this is of sandy clay texture. Judicious handling of water should be advocated at the outset to prevent the formation of elevated water tables in this and adjoining soil types; although fortunately salinity is not a factor in this type. Further some channels will necessarily be formed in Heyfield clay loam because of its relatively high elevation, and their design may be influenced by the greater permeability of this soil relative to most of the other soil types.

The uneven topography of the landscape is the main handicap to irrigation of the Heyfield clay loam. It is so closely associated with depression soil types that the lay-out of head ditches and drains may present a problem in some areas. Labour costs for irrigation on farms in these situations are likely to be above the average for the area, owing to the additional attention required to apply water efficiently to an irrigation layout of short runs and variable slopes.

Acre clay loam. Whilst the fertility of this soil type is good, individual occurrences are of small extent and are unlikely to influence subdivision since the associated soil types also are suitable for general irrigation. Salt is not a hazard but ground water may develop in some areas, particularly those where light deep subsoils have been recorded.

Denison clay loam. This soil type represents good quality land suitable for the establishment of permanent, irrigated pastures. Water should penetrate fairly readily through the surface soil, and, although the subsoil is heavy, its structure should enable moisture to reach the full root zone of most plants. It should be possible to avoid the formation of water tables in the heavy deep subsoils of this type. Under these conditions, the risk of salinity is remote, particularly as salt concentrations in the soil profile rarely reach detrimentally high proportions.

Slopes generally are very suitable for irrigation and a minimum of grading should be necessary; in any case, the depth of surface soil is seldom less than 1 foot which allows a fair margin for this purpose.

Wandocka clay loam Wandocka clay loam may be compared with Denison clay loam since these types occur together and comprise the bulk of the heavier soils of the grey plain country. Although Wandocka clay loam is a rather less attractive soil than Denison clay loam, it should support a similar type of irrigated pasture. Compared with Denison clay loam, the chemical fertility of Wandocka clay loam is slightly lower and the surface soils are rather more compact, probably owing to a lower content of organic matter; slower penetration of water can be expected on this account. Although the incidence of salt is at a higher level than in Denison clay loam, the salt contents of the subsoils do not suggest that salinity is likely to be a hazard provided provision is made for adequate surface drainage. This may require special consideration in certain areas because of the generally flat topography and relatively low-lying situation of Wandocka clay loam.

Crabholiness and a rather shallow surface soil are drawbacks of the type to grading for irrigation. Some occurrences are particularly uneven in the surface and it may take considerable working before the surface settles sufficiently to be graded to a permanently even lay-out. Several areas inscribed on the soil map as "shallow" are less attractive soils for irrigation.

Nambrok clay loam. This soil type has general characteristics similar to Denison clay loam and should be capable of supporting good permanent pastures under irrigation.

Wooundellah loam. This soil type is texturally the lightest of those recommended for general irrigation, but should be suitable for subdivision into dairy farms. It appears to be of lower fertility and, therefore, of probable lower carrying capacity under irrigation compared with the clay loam types recommended for general irrigation. It would be wise to recognise these facts in planning the sizes of holdings. There is unlikely to be any difficulty in the penetration of water into this soil, although its water requirement may be lower than that of the heavier soil types. The tendency to light textures in the deep subsoils need not be conducive to waterlogging if water is used rationally. Salt is not regarded as serious in this soil type as concentrations in the subsoils are generally low.

The gentle and even slopes and good depth of surface soil favour the easy lay-out of farms for irrigation.

Types D and E. Although of very limited extent in the present area, these soil types have proved highly productive for dairying under irrigation in the Tinamba district.

Type H. This soil type is unattractive for irrigation, but its situation within an area suitable for general irrigation suggests that it should be utilised. The possible hazards associated with such a soil type make it advisable to plan subdivision so that each allotment carrying this soil has also a reasonable area of better-class soil.

Minor Depression Soils.

Type 1. Brown and Grey-Brown Soils. These soils are important in that they are associated with Heyfield clay loam and contribute to the difficulty of designing a satisfactory irrigation lay-out. The Type 1 depression soils are permeable but, with carefully controlled irrigation, provision for removal of drainage from these hollows may not be necessary. The whole aspect of drainage in this class of country is very much simplified by the low salt content of the soils.

Type 2. Grey Soils. The deep surface of this soil and the additional moisture due to its low-lying situation are advantages for plant growth in dry-farming; consequently, crops and pastures are normally satisfactory in this soil type and may even be better than on the Heyfield clay loam in dry seasons. The usefulness of the soils under irrigation will depend on making effective provision for their drainage. Whilst small landlocked depressions of this type may be difficult to drain, the more continuous depression lines are a relatively simple problem and, in some cases, represent natural drainage outlets. A few Type 2 "light profile" soils are fairly permeable and may not be suitable for constructed drains.

Type 3. Shallow and Heavy Grey Soils. Most occurrences are unattractive soils, and allowance should be made for this when planning subdivision. The surface soils are shallow and heavy and plant growth is frequently poor even though favoured by moisture conditions. In some situations, salt is a further drawback to irrigation of these soils.Many of the continuous depressions can be utilised in the drainage system of the area. Local circumstances will determine whether drainage of the landlocked occurrences is feasible.

2. Soil Types in Areas Suitable for Restricted Irrigation.

Tanjil gravelly sand and Tanjil sandy loam. These soil types which occur together on the higher uplands are utilised for grazing sheep and have been cultivated only to a very small extent. The soils are of light texture and of low fertility and carrying capacity, while few attempts have been made to improve them. They dry out rapidly with the onset of warm weather and provide but little feed during the summer months.

Much of this type of country is above water supply level while, in some cases, slopes are excessive for controlled irrigation. These topographical considerations, together with the light texture and the low fertility of the soils, make this class of country generally unsuitable for development under intensive irrigation. However, where the situation permits, occasional light waterings would enable establishment of annual pastures of the subterranean clover type, and the fertility of these soils could be improved by this means.

Tanjil loam. Grazing sheep for wool and fat lamb production is the main agricultural pursuit on the Tanjil loam, although some cereal cropping has been practised in the past. Of better fertility than Tanjil sandy loam, this soil appears to carry about one dry sheep to the acre in its natural state, but is capable of improvement with subterranean clover and superphosphate to more than double this capacity. It appears better suited under irrigation for this annual type of pasture than for the permanent types with their higher soil fertility and water requirements. Extension of limited irrigation to these soils with a view to establishing and maintaining annual pastures suitable for fat lamb production would be an advantage.In general, slopes are suitable for irrigation, although crabholiness in some areas may be an initial difficulty in grading.

Winnindoo loam. Agriculturally, this soil has been treated similarly to the Tanjil loam. The surface soils are shallow, have a rather hungry appearance and tend to set hard when dry. However, water appears to penetrate readily enough through the surface, although the massive, heavy subsoil is not favourable for quick wetting of this region. With liberal manuring and some irrigation, good growth of grass has been obtained on this soil type, although the soil may support dairy pasturage under good management, a system of light irrigation of pastures suitable for fat lamb production appears to be the best treatment for

.7innindoo loam. Also, under such a system, harmful effects resulting from the naturally indifferent surface drainage of this soil type and from a degree of salinity inherent in the subsoils, are at a minimum. The farm lay-out for irrigation should present no difficulties, although the shallow depth of the surface soils is a disadvantage in grading.

Winnindoo clay loam. Most of the soils remain in their native state and are utilised for rough grazing of sheep and cattle.A small proportion, representing the less swampy occurrences, has been cleared and cultivated. Generally, this soil type is not attractive for irrigation. Its low fertility, situation in the topography, shallow and crabholey surface, and the relatively high salt content of the subsoils are the principal disadvantages. It is possible that under good management these disabilities can be overcome and reasonable irrigated pastures can be grown on, at least, some of these soils. Provided that the more swampy and saline areas of Winnindoo clay loam are not included, and drainage facilities are made available, this type can be developed most conveniently with Winnindoo loam under conditions of restricted irrigation.

Type A. This soil type is of small extent and most occurrences are suitable for light irrigation only. The indiscriminate application of water to these light textured soils is to be avoided.

Type B. This soil is situated on light grazing ridgeland, principally above water supply level. In any case, it is to be regarded similarly to Tanjil gravelly sand and Tanjil sandy loam in its relation to irrigation.

Type C. This minor soil type occurs in proximity to some of the better classes of irrigable soils. Whilst not wholly unattractive for irrigation, allowance should be made for the lower potential productivity of these soils when subdividing this area.

3. Soil Types in Areas Unsuitable for Irrigation.

Type F. Most occurrences are obviously saline and swampy on the surface, whilst others possess a high degree of salinity in the subsoil. Other disadvantages are heavy textures, and excessive crabholiness in some cases. Whilst the major areas can be excluded, some small depressions of this type occur in areas otherwise suitable for general irrigation. Due allowance should be made for these poorer areas in subdivision.

In addition to Type F, the more saline occurrences of Winnindoo clay loam, and those areas of soil types of doubtful productivity viz., Tanjil gravelly sand, Tanjil sandy loam, and Type B, which would require special provision for the supply of water, are included as unsuitable soils for irrigation.

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APPENDIX 1.
Soil Terms and Definitions.

The *morphology* of the soil is the physical constitution of the various horizons and their arrangement in the soil profile.

The soil profile is the succession of soil horizons down to the parent material or substrata. It embodies all the processes of soil formation and is the unit of soil study.

A soil horizon is a layer of soil with similar characteristics. The horizon may be distinguished by differences in one or more of the following soil characters:- colour, texture, structure, organic matter content, and the presence of visual products of weathering such as calcium carbonate and iron concretions. The sequence of horizons from the surface downwards in the soils described is :-

A_1 - The surface layer in which organic matter has accumulated, and partly leached of clay and soluble material.

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

- *A* zone of accumulation of some materials, chiefly clay, from A_1 and A_2 horizons.

B_2 - A zone of accumulation of calcium carbonate leached from upper horizons.

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

Illuvial material is material deposited as the result of translocation during soil weathering processes. It is customary to refer to the *A* horizons as *eluvial* horizons, and to the B horizons as *illuvial* horizons, the whole process being one of eluviation.

Lime is calcium carbonate and may occur as illuvial material in the B and C horizons, both in a soft form and in concretions described as rubble.

Gypsum is illuvial calcium sulphate.

Ferruginous concretions are more or less rounded nodules of variable size and composition formed by the deposition of iron oxide (sometimes with other materials) in the lower A2 and the B horizons.

A soil type is a group of soils derived from similar parent material under similar conditions of development, giving rise to the same general profile characteristics. It is the unit of soil mapping.

A soil series consists of one or more soil types of the same general profile form, but differing in the texture of the surface soil. Such a series is named after the locality of its most common occurrence within the area in which it was first described.

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

A variation is a minor modification of a soil type and is usually indicated by suitable notation on the soil map.

A catena is a group of soil types derived from similar parent material and associated together, but differentiated by topographical and hydrological conditions into distinct soils.

The *structure* of the soil refers to the morphology of the soil aggregates. The types of structure in the soils described are crumb, nutty, cloddy, blocky, and massive.

The consistence of the soil refers to the stability of the soil aggregates in both the dry and the moist state. The terms used are:- in the dry state; loose, friable, brittle, and hard:- in thy moist state; open, coherent, mellow, plastic, sticky, and stiff.

APPENDIX 2. Analytical Methods.

All estimations were carried out on the air dried fine earth, i.e., material passing a 2 mm. round hole sieve. In the case of calcium carbonate, nitrogen, and organic carbon estimations, the samples were weighed from subsamples which had been ground until all passed through an eighty mesh sieve.

Mechanical Analysis. The procedure adopted followed that of the International "A" pipette method. Dispersion was with caustic soda, results being corrected for the sodium hydroxide weighed with the clay fraction.

Specific Conductivity. This was determined at 20°C on a 1:5 soil-water suspension previously shaken for one hour. Results are expressed in reciprocal ohms multiplied by 100,000.

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

Chlorides. These were determined by Best's electrometric titration method (Best, 1929). Results for samples from the salt survey are expressed as % sodium chloride.

Calcium Carbonate. Determinations were made by Hutchinson's and MacLennan's vacuum method (1914).

Nitrogen. This was determined by the Kjeldahl method.

Organic Carbon. The wet combustion method of Walkley (1935) was used, substituting phenyl anthranilic acid for diphenylamine as indicator. Results have been multiplied by the arbitrary recovery factor of 1.25.

Hydrochloric Acid Extract. The extract was obtained by boiling 30 g. of soil with 150 ml. of hydrochloric acid (S.G. 1.115) for 2 hours. Aliquots of this were used to determine :- potash, by precipitation as chloroplatinate and weighing as platinum; lime, by titration of the calcium oxalate; magnesia, by weighing as magnesium pyrophosphate; phosphoric acid, by separation as ammonium phosphomolybdate and weighing as magnesium pyrophosphate.

Exchangeable Metal Ions. After leaching with 40% alcohol to remove soluble salts, the soils were extracted with normal ammonium chloride to obtain the exchangeable metal ions. Aliquots of the leachate were used to determine potassium, calcium, and magnesium by the above methods and sodium by precipitation and weighing as sodium uranyl magnesium acetate. Four of the subsoils examined had calcium carbonate contents of less than 0.3%. In these cases, the values for exchangeable calcium have been corrected for calcium present as carbonate, as determined by Hutchinson's and MacLennan's method.

Exchangeable Hydrogen. The meta-nitrophenol buffer method of Piper (1936) in which results are interpolated to a pH value of 8.4 was used.

Exchange Capacity. This is the sum of the total exchangeable metal ions and the exchangeable hydrogen determined, as above.

The total exchangeable metal ions, exchangeable hydrogen, and exchange capacity are expressed in milli-equivalents per 100 g. of air dried soil, while the individual metal ions are given as percentages of the total metal ions. The percentage saturation is the ratio of the total exchangeable metal ions to the exchange capacity expressed as a percentage.

APPENDIX 3.
Mechanical Analyses and other Data for the Soil Types.

Gravel, concretionary iron oxide, and limestone rubble are expressed as percentages of the field samples, and specific conductivity as reciprocal ohms $x10^5$; while all other figures, except those for depth, reaction, and C:N ratio, are percentages of air dried soil passing a 2 m.m. sieve.

The following abbreviations are used to describe field texture:-

S	- sand
LS	- loamy sand
SL	- sandy loam
L	- loam
CL	- clay loam
SCL	- sandy clay loam
SC	- sandy clay
FSCL	- fine sandy clay loam
FSC	- fine sandy clay
LC	- light clay
MC	- medium clay
MC	- heavy clay
Cl	- clayey
Gr	- gravelly
Si	- silty

SOIL TYPE	TANJIL GRAVELLY SAND					TANJIL SANDY LOAM					
Soil No.	1049	1050	1051	1053	1054	2127	2128	2129	2130	2131	2132
Depth (in.)	0-3	3-8	8-13	14-24	24-43	0-3	3-7	7-12	13-26	26-42	42-57
Texture	LS	S	Gr S	HC	Gr C	SL	SL	S	HC	HC	MC
Gravel	18.2	62.6	63.0	16.2	66.4	5.1	11.4	46.3	1.4	8.0	2.1
Coarse sand	39.1	40.0	45.1	7.1	52.7	30.6	32.1	34.5	7.3	19.7	22.2
Fine sand	36.8	39.2	34.6	5.8	11.6	45.8	44.8	42.6	7.9	17.8	19.9
Silt	12.2	13.0	11.0	3.8	4.1	14.5	13.8	14.5	3.0	5.4	3.5
Clay	6.5	6.4	6.3	75.8	29.0	7.7	8.0	7.2	73.9	52.5	49.7
Moisture	1.2	0.7	0.5	6.8	2.3	1.1	0.5	0.3	6.6	4.3	3.7
Loss on acid treatment	0.4	0.6	1.6	0.9	0.3	0.6	0.5	0.4	0.6	1.0	1.1
Loss on ignition	4.3	2.0	1.3	9.8	3.6	4.2	1.8	1.0	9.5	6.5	5.9
Calcium carbonate											0.01
Specific conductivity	6	4	3	13	10	12	4	5	38	37	47
Chlorides (Cl)	.004	.003	.003	.008	.009	.007	.004	.006	.041	.049	.064
Nitrogen	.149					.144					
Organic carbon	2.10					2.00					
C : N ratio	14.1					13.9					
Reaction (pH)	5.9	6.2	6.6	7.1	6.5	6.9	6.1	6.3	6.3	7.9	8.2

SOIL TYPE	TANJIL LOAM.								WINNINDOO LOAM								
	Normal profile						"clay bank"										
Soil No.	5610	5611	5612	5613	5614	5615	5618	5619	1021	1022	1023	1024	1025	1026	1027	1028	1029
Depth (in.)	0-4	4-8	9-19	19-33	35-42	42-74	1½-7	7-16	0-2	2-5	5-9	9-14	14-29	29-38	38-54	54-61	61-75
Texture	L	SL	HC	HC	HC	SC	LC	HC	L	L-SCL	LC	HC	MC	MC	LMC	LC	LC-FSC
Gravel ø	2.1	8.7															
Coarse sand	26.0	33.4	4.6	3.3	13.5	29.2	7.7	2.5	27.6	26.9	28.0	13.8	9.4	3.1	0.8	2.3	0.9
Fine sand	44.5	43.3	6.6	3.9	13.7	22.0	13.9	6.5	29.9	27.5	16.2	7.2	27.6	18.0	28.9	39.3	46.3
Silt	13.6	12.9	1.5	2.4	6.3	10.7	3.8	2.7	27.4	27.4	24.4	24.7	18.4	21.4	22.1	18.4	17.1
Clay	11.4	9.8	80.0	84.1	61.5	33.4	66.0	80.6	14.2	14.0	27.0	48.5	38.3	52.6	44.1	37.1	32.4
Moisture	1.1	0.4	5.3	5.4	5.4	2.8	4.7	6.2	1.0	0.8	1.8	3.3	3.7	4.7	3.2	2.6	2.3
Loss on acid treatment	0.7	0.4	1.1	1.3	0.6	0.3	1.6	1.8	0.0	0.3	0.5	0.8	1.0	0.9	0.8	1.0	0.5
Loss on ignition	4.7	1.8	7.0	4.6	7.6	4.0	11.0	11.5	4.3	2.6	3.2	4.6	3.9	4.5	3.6	3.5	3.0
Calcium carbonate				0.10	0.02									0.05	0.04	0.10	
Specific conductivity	7	13	9	30	43	24	16	15	4	4	11	30	56	80	55	44	39
Chlorides (Cl)	.008	.003	.009	.043	.066	.029	.008	.015	.004	.004	.012	.038	.085	.126	.088	.066	.060
Nitrogen	.153								.144								
Organic carbon	2.01								2.01								
C : N ratio	13.1								14.0								
Reaction (pH)	5.6	6.2	6.8	6.6	5.8	6.6	6.0	6.5	6.1	6.3	6.7	7.3	8.2	8.6	8.6	8.7	8.7

ø ferruginous concretions

SOIL TYPE	WINNINDOO LOAM						WINNINDOO LOAM							
Soil No.	5620	5621	5622	5623	5624	5625	7274	7275	7276	7277	7278	7279	7280	3444
Depth (in.)	0-5	5-11	11-16	17-34	34-45	45-63	0-4	4-8	8-16	16-33	33-44	44-56	56-76	0-4
Texture	L	CL	MC	MC	HC	HC	L	SCL	MC	HC	MC	FSC	LC	L
Gravel ø	Tr	3.0	8.6	3.0	1.1	1.4		0.1	5.7	4.7	0.9	0.9	5.2	
Coarse sand	11.2	14.7	14.9	7.8	4.7	3.5	13.3	14.5	15.2	8.8	5.8	9.4	3.3	19.6
Fine sand	47.8	42.5	34.2	28.6	19.3	15.3	44.3	42.6	29.3	22.5	29.9	42.8	24.0	46.6
Silt	21.1	20.3	18.6	19.6	16.4	18.1	23.9	21.7	17.7	14.3	15.1	17.7	34.4	16.2
Clay	16.3	21.4	30.5	42.7	54.3	58.4	14.4	19.0	33.4	49.7	45.4	27.9	36.4	11.8
Moisture	0.7	1.2	2.0	2.5	4.1	4.4	1.1	1.2	2.8	4.3	3.3	1.8	2.3	1.1
Loss on acid treatment	1.3	0.7	1.2	0.8	0.8	1.3	0.2	0.8	0.5	0.8	1.1	0.8	0.5	0.5
Loss on ignition	3.5	3.1	3.5	2.1	4.7	4.7	4.1	3.3	4.2	6.3	4.6	3.3	3.8	4.8
Calcium carbonate					0.01	0.03				Tr	0.02	0.06	0.11	
Specific conductivity	5	5	10	58	76	70	5	5	16	69	75	49	46	
Chlorides (Cl)	.003	.004	.011	.087	.114	.106	.002	.023	.021	.118	.073	.067	.060	
Nitrogen	.117						.113							
Organic carbon	1.54						1.63							
C : N ratio	13.2						14.4							
Reaction (pH)	6.3	6.6	6.9	6.9	7.5	7.9	6.0	6.3	7.0	8.1	8.4	9.0	8.9	5.8

ø ferruginous concretions.

SOIL TYPE	WINNINDOO CLAY LOAM								
Soil No.	1041	1042	1043	1044	1045	1046	1047	1048	3464
Depth (in.)	0-4	4-22	0-3	3-6	6-12	12-21	21-51	58-75	0-3
Texture	CL	HC	CL	CL	HC	HC	HC	HC	CL
Gravel					Tr	Tr		0.7	
Coarse sand	3.6	1.9	3.0	4.2	4.1	2.9	5.4	13.3	7.7
Fine sand	11.3	4.6	17.9	19.3	8.8	6.4	8.5	19.7	24.9
Silt	41.7	20.1	46.4	45.4	25.2	21.0	20.7	11.7	33.0
Clay	33.7	65.8	24.7	25.9	55.1	65.0	60.3	49.7	23.4
Moisture	3.0	5.7	1.9	1.3	3.0	3.7	3.4	3.5	2.6
Loss on acid treatment	0.7	0.7	1.0	1.0	2.0	1.7	1.5	0.9	1.3
Loss on ignition	7.4	7.4	7.8	4.3	6.7	7.2	5.6	5.4	8.3
Calcium carbonate									
Specific conductivity	7	9	14	5	5	7	18	19	
Chlorides (Cl)	.006	.006	.005	.004	.004	.006	.028	.027	
Nitrogen	.195		.230						
Organic carbon	2.69		3.40						
C : N ratio	13.8		14.8						
Reaction (pH)	6.1	6.1	5.9	6.0	6.1	5.9	5.5	7.3	5.9

SOIL TYPE	WOOUNDELLAH LOAM								WOOUNDELLAH LOAM						
Soil No.	5652	5653	5654	5655	5656	5657	5658	5659	7266	7267	7268	7269	7270	7271	7272
Depth (in.)	0-4	4-10	10-12	13-21	21-29	29-38	38-48	48-60	0-4	4-8	8-13	13-27	27-37	37-57	57-86
Texture	L	L-FSCL	CL	HC	HC	HC	MC	MC	L	FSCL	CL-SC	HC	HC	MC	SC
Gravel ø		Tr	4.7	6.3	3.0	1.3	1.6	0.2			0.1	18.0	5.5	3.8x	2.9
Coarse sand	10.7	12.0	16.3	6.4	4.5	3.8	1.4	2.2	10.8	12.6	14.1	16.0	6.0	4.8	11.5
Fine sand	44.1	43.5	36.0	11.0	11.5	13.4	15.0	19.0	32.1	37.4	32.6	9.2	10.2	20.9	34.9
Silt	25.2	25.2	23.0	11.7	13.7	18.4	26.2	29.9	30.1	27.1	24.8	11.5	17.7	30.3	26.6
Clay	16.9	17.3	22.6	66.2	65.0	59.1	51.2	42.7	20.1	19.4	24.9	54.7	59.9	40.7	25.5
Moisture	1.0	0.7	1.3	4.2	4.4	3.8	3.9	3.2	1.6	0.8	1.3	5.0	5.0	3.0	1.7
Loss on acid treatment	0.9	0.8	0.5	1.1	0.8	0.8	0.7	0.6	1.1	0.4	0.4	0.5	1.2	0.8	0.8
Loss on ignition	3.9	2.5	2.9	8.1	7.4	6.6	5.8	5.0	6.1	2.7	2.8	6.7	5.8	4.3	3.2
Calcium carbonate					0.04	0.08	0.05	0.10					0.02	0.22	0.02
Specific conductivity	8	5		11	23	40	32	31	10	4	4	23	56	49	28
Chlorides (Cl)	.007	.006	.013	.010	.027	.037	.042	.034	.004	.002	.002	.003	.081	.069	.035
Nitrogen	.122								.203						
Organic carbon	1.53								2.50						
C : N ratio	12.5								12.3						
Reaction (pH)	5.7	6.1	6.0	6.8	7.7	8.4	8.7	9.0	6.6	6.3	6.4	6.7	7.9	8.9	8.7

ø mainly ferruginous concretions   x includes limestone rubble

SOIL TYPE	HEYFIELD CLAY LOAM										ACRE CLAY LOAM							
Soil No.	5629	5630	5631	5632	5633	5634	5635	5636	3440	3441	1012	1013	1014	1015	1016	1017	1018	1019
Depth (in.)	0-4	4-8	8-14	14-22	22-32	32-40	40-54	54-75	0-8	12-20	0-3	3-7	7-10	10-20	20-33	33-52	52-82	82-106
Texture	CL	CL	CL	LC	MC	LC	LC	LC	L	CL	L	L	LC	HC	MC	LC	LC-FSC	LC-FSC
Gravel																		
Coarse sand	2.2	1.8	1.4	1.2	1.7	2.1	6.3	1.1	1.3	1.4	4.1	4.8	3.6	1.5	0.6	0.3	0.6	0.3
Fine sand	33.0	34.9	34.3	30.5	24.6	30.3	35.2	18.3	33.3	34.2	36.2	40.7	22.7	7.2	10.4	26.3	39.8	44.8
Silt	35.0	34.7	31.8	28.0	21.4	19.7	20.4	38.7	39.7	27.2	35.2	37.1	28.1	25.5	27.2	32.5	26.9	28.0
Clay	25.1	27.2	29.9	36.0	46.1	40.2	30.4	36.7	20.9	31.8	15.0	13.3	41.0	62.6	57.7	38.1	27.3	22.2
Moisture	1.7	1.5	1.6	2.1	3.1	2.8	2.2	2.3	1.6	1.4	1.5	0.8	2.4	4.0	3.3	2.2	2.3	1.9
Loss on acid treatment	1.6	0.8	1.0	0.4	0.9	0.6	0.8	1.0	0.8	0.7	0.8	0.4	0.9	1.1	0.9	0.6	0.6	0.5
Loss on ignition	6.5	3.8	3.3	3.8	5.0	4.6	3.9	4.2	4.7	3.4	7.0	2.7	3.9	5.5	4.7	3.5	3.1	2.6
Calcium carbonate							0.03	0.02							0.03	0.04	0.05	
Sp. conductivity	9	10	4	5	8	13	18	27			12	6	13	33	53	49	46	32
Chlorides (Cl)	.007	.009	.001	.003	.007	.016	.026	.038			.010	.004	.012	.044	.080	.076	.072	.054
Nitrogen	.208										.242							
Organic carbon	2.47										3.35							
C : N ratio	11.9										13.8							
Reaction (pH)	5.9	6.4	6.6	6.6	6.7	6.7	7.3	8.3	5.9	6.1	5.6	6.3	7.1	7.4	8.0	8.6	8.7	8.9

SOIL TYPE	ACRE CLAY LOAM						ACRE CLAY LOAM					ACRE CLAY LOAM						
Soil No.	1076	1077	1078	1079	1080	1081	5664	5665	5666	5667	5668	7198	7199	7200	7201	7202	7203
Depth (in.)	0-6	6-15	15-25	25-34	34-45	45-78	0-8	8-13	14-32	32-40	40-48	0-8	8-12	12-15	15-32	32-46	46-72
Texture	CL	CL	MC	LMC	FSC	FSCL	CL	CL	MC	MC	LC	CL	LC	LC	MC	LC	LC
Gravel				8.8x	Trx												
Coarse sand	3.6	3.3	0.7	0.7	0.6	2.1	1.3	2.1	0.9	0.5	0.4	0.6	0.5	0.4	0.2	0.2	0.2
Fine sand	33.0	33.4	17.0	25.8	41.7	57.3	43.1	40.9	22.5	28.4	35.7	22.5	22.5	21.1	11.2	22.2	21.1
Silt	32.0	33.9	19.8	22.7	22.7	19.7	32.6	31.7	21.6	25.3	22.7	35.4	35.5	32.8	24.6	32.1	37.5
Clay	25.3	25.5	54.6	44.0	32.1	19.3	20.3	24.4	51.9	45.2	37.7	33.1	37.7	41.0	57.9	42.2	38.0
Moisture	2.1	1.6	4.6	3.4	2.6	1.8	1.1	1.1	2.7	2.5	2.3	2.3	2.6	2.3	4.0	2.9	2.5
Loss on acid treatment	1.4	1.3	3.3	4.2	1.0	0.5	1.4	0.5	0.9	1.1	1.8	1.1	1.0	2.3	1.6	1.2	0.9
Loss on ignition	7.0	4.3	7.0	6.1	3.7	2.8	3.6	2.6	5.4	4.8	4.6	8.2	5.7	5.9	6.7	4.9	4.4
Calcium carbonate			0.03	3.15	0.17	0.04				0.02	0.03					Tr	Tr
Specific conductivity	14	12	36	73	77	74	9	7	34	45	107	10	7	8	21	23	23
Chlorides (Cl)	.013	.015	.049	.094	.119	.101	.010	.006	.058	.069	.191	.008	.003	.008	.028	.018	.008
Nitrogen		.103					.113					.237					
Organic carbon		1.23					1.26					3.50					
C : N ratio		11.9					11.2					14.8					
Reaction (pH)	5.7	6.2	8.0	9.3	9.0	9.0	5.4	5.9	5.9	6.9	7.2	5.7	5.8	5.9	6.3	7.4	8.3

x limestone rubble

SOIL TYPE	DENISON CLAY LOAM											DENISON CLAY LOAM						
Soil No.	1030	1031	1032	1033	1034	1035	1036	1037	1038	1039	1040	7242	7243	7244	7245	7246	7247	7248
Depth (in.)	0-5	5-9	9-12	12-21	21-36	36-58	58-72	72-84	84-96	96-110	110-122	0-4	4-10	10-14	15-26	26-37	37-58	58-78
Texture	CL	CL	LC	HC	HC	MC	MC	MC	LC	SiC	SiC	CL	CL	CL	HC	HC	MC	LC
Gravel																		
Coarse sand	3.1	3.3	3.4	1.5	1.0	6.0	6.4	5.8	1.7	0.2	0.8	1.1	1.3	1.5	0.7	0.3	0.2	0.2
Fine sand	18.8	19.0	17.4	5.6	5.7	16.1	17.7	20.2	29.5	6.6	12.6	29.1	29.6	29.2	11.4	8.8	17.1	12.4
Silt	37.8	39.3	39.4	20.1	26.7	24.1	18.4	17.0	20.6	37.5	42.2	36.8	36.5	35.2	20.2	23.7	33.5	43.2
Clay	31.2	33.4	34.6	66.4	61.3	50.2	51.6	52:1	44.1	50.1	40.8	25.4	26.8	29.2	60.6	62.1	46.1	40.6
Moisture	2.9	2.3	1.5	4.4	3.2	2.1	4.4	4.5	3.9	4.1	3.5	1.7	1.5	1.5	4.3	4.5	3.3	2.9
Loss on acid treatment	0.9	0.7	1.0	2.0	2.0	1.8	1.2	0.9	0.9	1.4	0.8	2.1	1.3	2.1	1.5	1.5	0.7	0.5
Loss on ignition	10.0	6.1	4.3	7.4	5.2	4.2	4.3	4.5	4.0	4.6	4.1	7.4	5.4	4.3	7.6	6.0	4.7	4.6
Calcium carbonate				0.03	0.05	0.05	0.06									0.60	0.05	
Sp. conductivity	15	8	7	27	41	36	19	8	34	37	36	11	6	6	19	40	29	27
Chlorides (Cl)	.016	.010	.010	.034	.051	.050	.046	.046	.047	.047	.047	.009	.002	.003	.022	.033	.034	.033
Nitrogen	.351											.218						
Organic carbon	4.36											3.06						
C : N ratio	12.4											14.0						
Reaction (pH)	5.7	6.1	6.5	7.4	8.7	9.0	8.9	9.0	9.0	8.8	8.7	5.8	5.8	6.0	6.6	8.7	8.7	8.8

SOIL TYPE	DENISON CLAY LOAM									NAMBROK CLAY LOAM				
Soil No.	7228	7229	7230	7231	7232	7233	7234	7235	3436	5647	5648	5649	5650	5651
Depth (in.)	0-6	6-10	10-14	14-21	21-28	28-37	37-60	60-78	0-3	0-6	6-14	14-27	27-44	44-58
Texture	CL	CL	LC	HC	HC	HC	HC	HC	CL	CL	CL-LC	HC	HC	HC
Gravel ø												8.1	3.3	Tr
Coarse sand	1.2	1.0	1.2	0.4	0.3	0.2	0.4	0.4	0.6	1.9	2.3	4.5	2.0	1.1
Fine sand	16.8	15.4	13.5	5.0	3.0	2.6	4.9	6.1	24.8	31.0	30.1	9.6	10.1	16.3
Silt	44.6	43.2	38.0	20.5	19.6	25.2	27.6	22.4	35.3	35.4	32.2	15.2	18.5	18.3
Clay	32.0	35.6	43.0	68.1	70.3	66.2	62.9	65.7	25.4	27.3	31.8	63.4	66.7	62.0
Moisture	1.7	1.6	1.9	4.0	4.4	4.2	3.5	4.2	2.7	1.5	1.5	3.8	3.7	4.0
Loss on acid treatment	0.9	1.3	1.6	2.3	1.4	1.3	1.0	1.1	1.9	0.6	0.7	0.8	1.3	1.2
Loss on ignition	5.8	4.7	4.8	7.9	7.5	6.3	5.4	5.4	10.4	4.8	3.6	6.7	5.5	5.3
Calcium carbonate						0.03	0.04						0.04	0.17
Specific conductivity	15	8	8	14	21	25	33	35		10	5	11	21	23
Chlorides (Cl)	.013	.005	.006	.013	.019	.026	.036	.041		.005	.004	.013	.022	.019
Nitrogen	.169									.142				
Organic carbon	1.96									1.68				
C : N ratio	11.6									11.8				
Reaction (pH)	6.0	5.7	5.9	6.4	7.6	8.4	8.7	8.7	5.8	6.5	6.0	6.5	8.2	8.9

ø ferruginous concretions

SOIL TYPE	WANDOCKA CLAY LOAM								WANDOCKA CLAY LOAM							
Soil No.	5638	5639	5640	5641	5642	5643	5644	5645	7259	7260	7261	7262	7263	7264	7265	3427
Depth (in.)	0-3	3-6	6-12	12-21	21-26	26-38	38-64	64-87	0-5	5-11	11-15	15-25	25-48	48-66	66-72	0-6
Texture	CL	CL	LC	HC	HC	HC	HC	HC	CL	LC	HC	HC	HC	HC	HC	CL
Gravel ∅					0.5	Tr										
Coarse sand	2.7	2.7	3.1	2.2	3.5	1.4	0.6	0.5	3.4	1.8	3.1	6.0	1.4	0.2	0.1	1.5
Fine sand	33.3	33.1	31.6	18.3	11.5	10.5	10.1	9.7	29.2	28.8	16.7	11.9	12.7	9.5	5.4	20.8
Silt	31.9	32.2	29.6	18.3	16.7	16.9	17.8	21.2	31.8	29.6	18.6	13.6	18.4	19.2	16.4	36.3
Clay	25.4	28.3	33.1	56.0	63.6	67.4	66.8	63.4	29.0	36.1	55.3	61.7	61.7	64.9	70.7	33.7
Moisture	1.4	1.1	1.3	2.7	3.8	3.5	4.4	4.3	2.1	2.3	4.4	5.1	4.8	4.3	4.7	2.2
Loss on acid treatment	0.4	2.5	0.9	1.7	0.8	1.1	1.0	1.1	0.5	0.4	0.6	1.4	1.8	2.1	4.4	0.7
Loss on ignition	5.7	3.8	3.5	6.1	6.4	5.9	5.8	5.7	6.2	4.9	6.9	7.5	5.9	5.8	7.1	5.2
Calcium carbonate					0.02	0.03	0.04						0.02	0.23	2.08	
Specific conductivity	8	5	5	12	18	27	10	16	11	7	10	27	66	76	82	
Chlorides (Cl)	.004	.003	.007	.010	.018	.030	.037	.041	.009	.004	.009	.039	.095	.108	.105	
Nitrogen	.193								.188							
Organic carbon	2.28								2.39							
C : N ratio	11.8								12.7							
Reaction (pH)	6.3	5.8	6.0	6.5	7.6	8.3	8.8	8.8	5.6	6.0	6.5	7.3	8.5	8.9	9.1	5.6

∅ ferruginous concretions

SOIL TYPE	THOMSON SILTY CLAY LOAM						THOMSON SILTY CLAY LOAM					THOMSON SILTY CLAY			
Soil No.	2135	2136	2137	2138	2139	2140	7238	7239	7240	7241	3423	1083	1084	1085	1086
Depth (in.)	0-7	7-15	15-25	25-45	45-65	65-93	0-6	6-11	11-15	15-28	0-4	0-6	6-14	14-26	26-68
Texture	SiCL	SiLC	SiC	SiC	SiC	SiC	SiCL	SiCL	SiLC	SiC	SiCL	SiLC	SiLC	SiC	SiC
Gravel										1.5					
Coarse sand	1.9	1.8	1.7	1.1	0.8	2.0	1.4	0.9	2.0	2.1	0.9	2.1	1.9	1.4	1.2
Fine sand	12.0	10.6	11.6	13.4	12.6	15.5	4.8	5.2	7.5	6.5	11.1	17.8	18.3	15.5	13.2
Silt	35.5	34.7	35.3	41.0	41.9	35.7	34.8	32.8	33.2	32.4	35.4	28.8	28.9	29.4	33.9
Clay	39.3	43.2	44.9	40.5	41.5	41.1	44.0	47.7	47.7	49.2	35.8	41.9	45.4	49.2	48.5
Moisture	4.1	3.5	3.1	2.7	2.5	2.7	3.4	3.1	3.0	3.0	4.9	3.7	3.1	2.8	2.7
Loss on acid treatment	2.0	1.9	1.7	1.3	1.6	1.5	2.3	1.9	1.9	1.7	2.5	2.7	1.5	1.2	1.0
Loss on ignition	11.9	8.8	7.2	5.2	4.8	4.6	12.8	8.3	7.5	6.5	17.9	10.9	6.1	4.8	4.4
Calcium carbonate				0.03	0.02										
Sp. conductivity	13	8	12	23	37	44	28	17	14	17		15	13	22	39
Chlorides (Cl)	.006	.006	.017	.030	.060	.072	.016	.008	.016	.022		.019	.018	.038	.060
Nitrogen	.358						.196					.158			
Organic carbon	4.84						4.84					4.23			
C : N ratio	13.5						23.6					26.8			
Reaction (pH)	6.5	6.3	6.9	8.6	8.7	8.5	5.4	5.5	5.8	5.8	5.8	5.9	6.1	5.8	7.1

SOIL TYPE	TYPE A										TYPE D					
Soil No.	1055	1056	1057	1058	1059	1060	1061	1062	1063	1064	1067	1068	1069	1070	1071	1072
Depth (in.)	0-3	3-7	7-10	10-15	15-23	23-28	30-35	38-48	48-54	54-78	0-5	5-12	12-21	21-28	28-42	42-57
Texture	S	S	S	S	Gr+S -/	SCL+C	SC+S	CSC	ClS	LC	CL	CL	MC	MC	LMC	LC
Gravel		3.9	5.8	11.3	32.9	7.0	19.2	24.8	3.8						Tr x	0.3 x
Coarse sand	39.0	36.2	36.0	35.1	47.0	58.5	64.0	64.6	54.7	14.6	3.8	5.1	2.2	2.2	0.9	0.8
Fine sand	42.0	43.8	44.0	46.3	28.4	19.9	11.7	8.1	27.7	37.2	18.1	13.4	4.7	5.2	4.6	11.1
Silt	10.9	12.8	11.9	13.0	10.8	1.8	1.2	3.3	0.3	21.2	45.7	49.3	27.5	31.3	36.8	39.9
Clay	4.9	4.8	4.2	4.6	14.1	18.5	21.1	21.3	14.4	24.8	27.2	27.9	56.3	55.9	52.4	44.3
Moisture	0.7	0.4	0.3	0.2	0.9	1.6	1.9	1.3	1.0	2.0	2.2	1.8	4.8	4.7	3.7	2.9
Loss on acid treatment	0.7	0.3	2.4	0.4	0.6	0.6	0.5	1.7	0.3	0.8	1.5	2.2	1.0	1.4	1.7	2.4
Loss on ignition	3.1	1.3	0.9	0.6	1.4	2.2	2.2	2.2	1.5	2.8	6.4	3.4	6.3	5.1	4.4	4.4
Calcium carbonate															0.45	0.73
Specific conductivity	7	5	5	4	6	9	11	14	13	29	20	9	13	12	20	23
Chlorides (Cl)	.007	.005	.006	.005	.006	.010	.012	.015	.013	.034	.012	.005	.007	.007	.009	.013
Nitrogen	.109										.160					
Organic carbon	1.59										2.20					
C : N ratio	14.6										13.8					
Reaction (pH)	6.0	6.2	6.5	6.6	7.4	7.9	8.0	8.1	7.9	8.3	5.4	5.6	6.4	7.9	9.0	9.2

-/ cemented x limestone rubble

SOIL TYPE	TYPE G							TYPE F	MINOR DEPRESSION SOIL, TYPE 1							
Soil No.	7191	7192	7193	7194	7195	7196	7197	3461	7210	7211	7212	7213	7214	7215	7216	7217
Depth (in.)	0-10	10-14	14-19	19-32	32-55	55-65	65-78	0-6	0-5	5-11	11-25	25-36	36-50	50-65	65-72	72-87
Texture	SiCL	CL-LC	LC	CL	LC	FSC	FSCL	MC	CL	CL	LC	LC	MC	MC	LC	SC
Gravel											0.2	0.3				
Coarse sand	1.1	1.0	1.4	2.5	0.3	0.3	0.1	5.3	9.6	2.0	3.3	7.6	8.3	13.3	20.3	28.9
Fine sand	13.8	14.7	18.2	30.7	29.5	34.1	46.2	16.8	29.1	21.5	19.6	19.0	13.6	15.2	22.8	26.1
Silt	34.1	35.2	34.5	31.6	25.2	27.5	25.7	16.0	31.7	41.1	37.3	30.2	22.8	17.7	15.2	14.1
Clay	41.0	44.1	42.4	32.9	41.4	33.8	24.1	48.1	25.6	32.3	37.2	38.5	50.2	49.8	37.4	26.1
Moisture	3.3	2.5	2.2	1.6	3.0	2.5	1.9	5.0	1.7	1.8	2.0	2.4	3.2	3.1	2.3	1.7
Loss on acid treatment	1.4	1.1	0.8	0.5	0.7	0.7	0.7	2.1	0.9	0.7	0.7	0.8	1.0	0.9	0.7	0.6
Loss on ignition	11.9	7.3	5.8	3.7	4.8	4.6	3.8	11.8	5.7	4.1	3.7	3.9	4.9	7.8	3.8	4.9
Calcium carbonate																
Specific conductivity	9	7	7	5	7	6	5		5	4	4	4	5	5	4	4
Chlorides (Cl)	.007	.005	.005	.004	.004	.006	.002		.003	.001	Tr	Tr	.001	Tr	.001	.001
Nitrogen	.187								.179							
Organic carbon	4.72								2.08							
C : N ratio	25.2								11.6							
Reaction (pH)	6.2	6.7	6.8	7.0	7.1	7.5	7.8	6.2	5.9	6.5	7.2	7.1	7.3	7.3	7.5	7.7

SOIL TYPE	MINOR DEPRESSION SOIL, TYPE 2						MINOR DEPRESSION SOIL, TYPE 3					
Soil No.	7221	7222	7223	7225	7226	7227	7204	7205	7206	7207	7208	7209
Depth (in.)	0-7	7-12	12-15	17-32	32-54	54-78	0-5	5-7	8-22	22-34	34-39	39-48
Texture	CL	CL	CL	HC	MC	FSC	CL	LC	HC	HC	HC	HC
Gravel				0.8 ø					1.4 ø			5.5 x
Coarse sand	0.6	0.6	1.1	0.7	0.2	2.3	1.2	0.7	2.1	1.5	0.3	0.4
Fine sand	23.6	25.8	25.2	10.4	25.7	44.6	19.9	19.1	8.7	7.8	6.1	15.8
Silt	43.4	44.9	43.4	25.7	25.8	21.9	42.8	43.6	25.8	24.6	22.8	24.6
Clay	26.5	26.3	27.4	56.7	43.2	26.8	29.3	33.2	58.8	62.1	62.9	57.9
Moisture	1.5	1.1	1.2	3.8	3.0	2.1	2.2	2.1	4.8	4.8	4.6	3.5
Loss on acid treatment	1.0	0.9	1.2	0.8	1.0	0.8	1.0	1.0	0.8	1.2	1.5	2.6
Loss on ignition	5.7	3.7	3.1	6.0	5.0	3.9	6.7	5.3	6.1	5.6	5.5	5.5
Calcium carbonate											0.19	1.58
Specific conductivity	7	4	5	6	8	7	25	18	45	79	93	85
Chlorides (Cl)	.001	.002	.003	.004	.006	.006	.022	.032	.067	.130	.140	.123
Nitrogen	.167						.196					
Organic carbon	2.24						2.61					
C : N ratio	13.4						13.3					
Reaction (pH)	5.6	5.8	5.8	6.2	7.0	7.4	5.6	5.9	8.1	8.2	8.8	9.2

ø ferruginous concretions x limestone rubble

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