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Soil Survey of Part of Shepparton Irrigation District, Victoria

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War-time economy has required publication of the soil maps in black and white instead of in the usual colours. Coloured maps may be viewed at the State Laboratories, Melbourne; the State Rivers and Water Supply Commission, Melbourne and Shepparton Offices; and the Soils Division, Council, for Scientific and Industrial Research, *Elite Institute, Adelaide.

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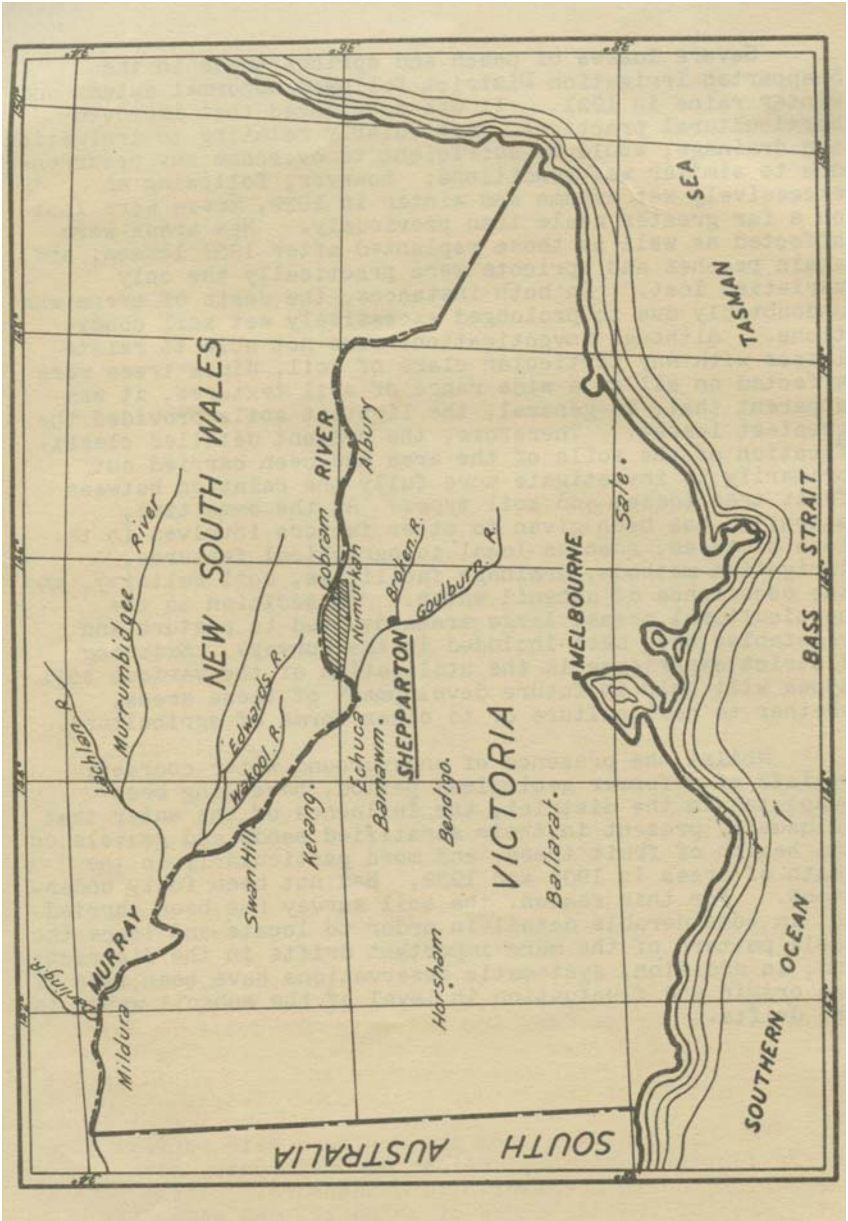
FOREWORD.

Severe losses of peach and apricot trees in the Shepparton Irrigation District followed abnormal autumn and winter rains in 1931. It was considered that improved horticultural practices, particularly relating to irrigation and drainage, would be sufficient to overcome any recurrence due to similar wet conditions; however, following an excessively wet autumn and winter in 1939, trees were lost on a far greater scale than previously. New areas were affected as well as those replanted after 1931 losses, and again peaches and apricots were practically the only varieties lost. In both instances, the death of trees was undoubtedly due to prolonged excessively wet soil conditions. Although investigations were not able to relate losses with any particular class of soil, since trees were affected on all of a wide range of soil textures, it was apparent that, in general, the lightest soils provided the greatest losses. Therefore, the present detailed classification of the soils of the area has been carried out primarily to investigate more fully the relation between fruit tree losses and soil type. At the same time, attention has been given to other factors involved in the loss of trees, such as local topographical features, irrigation methods, drainage facilities, soil salinity, and the occurrence of subsoil water. In addition to the horticultural areas, large areas devoted to pasture and vegetables have been included in the survey. Existing district experience in the utilisation of the various soil types will help in future development of these areas, whether to horticulture or to other forms of agriculture.

Whilst the presence of underground water courses, relicts of a former geological period, have long been suspected in the district, the influence of the water that is usually present in their stratified sands and gravels on the health of fruit trees, and more particularly on the death of trees in 1931 and 1939, had not been fully understood. For this reason, the soil survey has been carried out in considerable detail in order to locate-and trace the whole pattern of the more important drifts in the district; and, in addition, systematic observations have *been* made of the origin and fluctuation in level of the subsoil water in the drifts.


MURRAY
Mildura
Darling R.
Lachlan R.
Murrumbidgee
River
Swan Hill
Wakool R.
Edwards R.
NEW SOUTH WALES
RIVER
Kerang.
Echuca
Bamawm.
SHEPPARTON
Numurkah
Cobram
Albury
Broken R.
Goulburn R.
Bendigo.
Horsham
VICTORIA
Ballarat.
MELBOURNE
Sale.
TASMAN
SEA
BASS
STRAIT
SOUTHERN
OCEAN
SOUTH
AUSTRALIA

Soil Survey of Part of Shepparton Irrigation District, Victoria.

I THE SHEPPARTON SETTLEMENT

1. Location and Water Supply.

The Shepparton Irrigation District adjoins the town of Shepparton in the Parish of Shepparton, County of Moira, Victoria. The locality-plan (Fig.1) shows the situation of the area in relation to other surveyed areas in Northern Victoria, namely Bamawm and Ballendella (Penman 1936 b) and part of the Murray Valley Irrigation Area (Butler *et.al*. 1942), while Fig. 2 shows the situation in the Parish of Shepparton of the 17,820 acres that have been covered in this survey.

The Shepparton Irrigation and Water Supply District[x] is supplied with water by diversion from the Goulburn River. This river has an average yearly flow of 2,345,000 acre feet which has varied from 567,000 acre feet in a drought year to 6,202,171 acre feet in a particularly wet season. The storages on the stream, Goulburn Weir, Waranga, and Billion reservoirs, now hold some 660,100 acre feet to which may be added the water divertible directly from the spring and early summer flow.

Eildon Reservoir on the Upper Goulburn River has a capacity of 306,000 acre feet. Water released from, it flows down the river for 150 miles to the Goulburn Weir. Water is *here* diverted into two main canals. The Western Rain Channel fills Waranga Reservoir and also supplies the eastern portion of the Rodney Irrigation District.

The Eastern Main from the Goulburn Weir conveys water to the four irrigation districts of South Shepparton, Shepparton, North Shepparton, and Katandra. These have a total area of 193,843 acres of which 1114889 acres are irrigable. The Shepparton Irrigation District, itself has an area of 24,485 acres of which 214417 acres are irrigable.

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[x] The soil survey has been carried out by the Department of Agriculture with the collaboration of the State Rivers and Water Supply Commission.

2. Agricultural Development.

The original vegetation appears to have been predominantly grey box (*Eucalyptus hemiphloia*) woodland, with lesser occurrences of yellow box (*Eucalyptus melliodora*), more particularly on the lighter soils. This latter feature has be en of some help in locating the presence of sandy subsoils in certain soil types. There is evidence that some Murray pine (*Callitris robusta*) was associated with grey and yellow box on the sandier rises.

Intensive farming in the Shepparton area dates from the inception of irrigation in 1910. Prior to this, wheat growing and grazing sheep for wool production were the main agricultural pursuits. Associated with the advent of *water* to the district were Closer Settlement sub-divisions of 248 blocks in 1910 and 1911. The size of these blocks which were for general farming varied from about 20 to 60 *acres.* Early settlers, dependent on quick returns, mainly turned to dairying; but success of the nearby Ardmona area, where 4,000 acres of orchard were already under irrigation in 1910, naturally indicated future development of the fruit growing industry. By 1915, 3,000 acres in the Shepparton Irrigation District were in fruit trees), mainly peaches pears, and apricots' while shortly afterwards the industry was put on a firm basis by the establishment of a fruit preserving cannery which commenced operations in February, 1918. An additional 54 blocks for fruit growing were allotted to soldier settlers in 1919-20, and the orchard area has now grown from 8,000 acres in 1921 to 9,200 acres. Although there has been some private sub-division of lands for fruit growing, extension is controlled to a great extent by the capacity of the cannery. This, being a co-operative enterprise of *the* growers themselves, handles only fruit of its shareholders, and in addition imposes a quota system on certain varieties of fruit, notably pears. By far the major part of the fruit growing area is devoted to the canning varieties of peaches, pears, and apricots in that order, but there is some marketing of fresh fruit. Before the war this *was mainly* in export pears, although the local market absorbed a small amount of fruit unacceptable to the cannery. Dried fruit production of prunes, apricots, peaches, and pears is small, while pulp for jam making is the only subsidiary activity of the cannery.[x]

The distribution of the main horticultural crops in 1940 is given in Table 1; in addition there are small plantings of quinces, figs and cherries. In recent years, the area of citrus has declined considerably.

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[x] Excepting war-time processing of vegetables.

Table 1 - Areas of horticultural Crops in Acres.[Φ]

Crop	Peaches	Pears	Apricots	Plums	Citrus	Apples
In bearing	3,052	2,179	932	399	140	113
Non-bearing	893	962	297	80	-	25
Total	3,945	3,141	1,229	479	140	138

For the district as a whole, the average yield per acre of peaches acceptable to the cannery is very low. This is due to such causes as the indiscriminate planting of peaches in unsuitable soils, the heavy wastage due to dropping and to grading of fruit to meet the necessarily high quality standard of the cannery, and the unwillingness of many growers to remove declining and unprofitable trees.

The fruit industry suffered a set-back in 1931, when about 30,000 trees- of peach and apricot canning varieties died as the result of water-logging. Replantings after these losses were mainly with the same varieties, but recurrence of similar conditions in 1939 led to greater losses, estimated At 80,000 trees. The consequent misgivings as to the future of peach growing in the district have been reflected in the selection of pears for most of the later replacements, and in the greater care exercised in the choice of trees when planting new areas.

Tomato and pea growing have largely replaced dairying as a preliminary occupation to the establishment of a bearing orchard. In addition, many small areas of irrigated pasture have been leased for vegetable production. In 1939, the area in tomatoes was 806 acres, but under war-time stimulation this had increased to 1960 acres in 1943. Production of other vegetable crops has also been encouraged with the introduction of processing machinery by the cannery.

Although dairying has declined, there are still several thousand acres of irrigated pasture in the district devoted to dairying and to fattening stock. Small areas sown with oats within the irrigation district are mainly for settlers' own requirements.

Tobacco was grown rather extensively on the lighter soils several years ago. Decline of this activity is attributed to economic causes, although probably lack of experience and unsuitability of some of the soils planted were also factors. Tobacco production has been revived recently by several of the more experienced growers in possession of suitable soils.

[Φ] Figures other than for citrus supplied by courtesy of the Shepparton Fruit Preserving co.

3. Climate.

Average climatological data for Shepparton is given in Table 2, together with information for the wet years of 1931 and 1939. Saturation deficit has been derived from temperature and relative humidity, while evaporation from free water surface has been calculated from the relationship with saturation deficit established by Prescott (1938). Actually the calculated average monthly figures for evaporation agree well with the nearest evaporimeter recordings at Rutherglen, where climatic conditions are approximately the same.

The climate is similar to that of most of Northern Victoria, being warm and arid during summer and cool and humid in winter, with maximum and minimum average temperatures in January and July respectively.

Although on the average each month enjoys a fair rainfall, and only 57% of the total yearly rainfall of 19.45 inches falls during the half year April to September, this does not represent all climatic conditions. The ratio of monthly rainfall to evaporation (R/E) provides a better index than rainfall alone of the degree of aridity, (low (R/E) or humidity (high R/E) of the climate throughout the year. Rising values above 1.0 for denote increasingly favourable climatic conditions for soil Saturation. From November to March, temperatures are high, and relative humidities are low, with consequent high evaporation greatly exceeding the rainfall, resulting in R/E values much below 1.0 for this period; however, with falling temperatures and rising humidities, evaporation is so reduced that R/E. exceeds 1.0 from May to August, reaching an average maximum of 2.87 in July. As growth has practically ceased during these winter Months, losses of soil moisture by transpiration are also negligible, consequently this is *a* period when moisture accumulates in the soil, and may even cause over saturation unless surface run-off is greater internal drainage of the soil is good. April, and to a lesser extent March may be regarded as critical months in which abnormal rains can increase R/E to a point favourable for soil saturation. These conditions prevailed in 1931 when R/E greatly exceeded the normals for the months March to July, and again in 1939 for the months February to August (excepting May).

Summer rains may be confined to several heavy downpours, illustrated by the figures of 0.30 in. per wet day for the months October to March, as compared with 0.20 in. per wet day for April to September. In addition, closer examination of rainfall records reveals a fair degree of unreliability. For example 1931 and 1939, both excessively wet years, recorded 23.33 in. and 35.20 in. respectively, while less than 10 in. of rain fell during 1940; the effect of these two wet seasons on horticulture at Shepparton has already been mentioned. Although it was thought that such abnormally wet conditions as prevailed in the autumn of 1931 were unlikely to recur, the unexpected happened again in 1939. In view of probable recurrences, all precautionary measures should be taken to avoid future losses of trees. These may involve changes in orchard management and it would be of benefit to have some knowledge of the likely frequency of such visitations. Obviously it is autumn and winter, rather than total yearly rainfall that is important; but it is difficult to decide just what constitutes a horticulturally dangerous quantity for this period. Considering the six months April to September, the average fall is 11.32 in., while 16.59 in. and 21.53 in. were recorded for this period in 1931 and 1939 respectively. Although the 1931 rainfall for this period is only 4.37 in. above the average heavy rains also fell in March 1931 following on top of normal irrigation with consequent saturated soils at the onset of winter. Taking the less severe season of 1931 as critical for tree losses, it would appear that excessive March and April rains may be sufficient to provide saturated soil conditions capable of being maintained over winter by little more than normal rainfall. The expectation of 18.82 in. or more of April September rains at Numurkah (Butler *et.al.* 1942) is once in 20 years, while 14.86 in or more can be expected once in 10 years. Climatological data for Numurkah are very similar to those of Shepparton, except that the average yearly rainfall is 2.48 in. higher at Shepparton. On this basis, higher figures are likely at Shepparton for similar frequencies, with the possibility of autumn - winter rains reaching dangerous dimensions once in 10 years.

TABLE 2 - Climatological Data - Shepparton.

		Years of record	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Rainfall (in)		1879-1942	1.21	1.13	1.39	1.60	1.73	2.29	1.88	1.92	1.80	1.94	1.28	1.28	19.45
		1931	0.49	0.18	3.41	3.22	2.86	4.66	2.14	1.21	1.50	1.75	1.69	0.22	23.33
		1939	0.22	6.20	2.27	8.32	0.91	4.12	1.81	4.95	1.42	2.38	2.41	0.19	35.20
Days of rain		1933-1942	5	3	3	7	7	10	11	11	9	7	4	5	82
		1931	3	4	10	10	16	16	14	15	12	5	5	1	111
		1939	2	8	4	12	5	17	9	21	9	10	9	2	107
Temp °F	Mean Max	1914-1942	86.3	85.7	79.9	71.3	63.6	56.6	55.7	59.1	64.1	71.1	77.6	82.9	71.2
		1931	79.0	84.1	77.3	66.6	60.1	54.0	53.8	56.2	61.5	68.2	75.7	85.6	68.5
		1939	94.6	89.4	77.8	70.0	65.0	54.2	53.5	55.5	62.7	68.7	73.0	80.6	70.4
	Mean Max	1914-1942	58.8	58.8	55.0	48.5	43.5	40.6	39.3	40.7	43.7	47.4	52.0	56.2	48.7
		1931	55.1	55.3	54.6	47.2	46.5	42.9	40.9	39.6	42.5	44.4	50.9	55.9	48.0
		1939	64.5	62.1	57.2	53.5	47.1	42.4	37.0	43.1	44.0	47.4	51.7	53.0	50.3
	Average	1914-1942	72.6	72.3	67.5	59.9	53.6	48.6	47.5	49.9	53.9	59.3	64.8	69.6	60.0
		1931	67.1	69.7	66.0	56.9	53.6	48.5	47.4	47.9	52.0	56.3	63.3	70.8	58.3
		1939	79.6	75.8	67.5	61.8	56.1	48.3	45.3	49.3	53.4	58.1	62.4	66.8	60.4
Mean rel. humidity % at 9 am		1919-1942	50	54	61	71	82	88	89	84	75	61	53	49	68
		1931	52	47	67	79	88	88	88	85	75	60	53	43	69
		1939	46	56	76	89	92	94	93	87	76	67	59	46	73
Saturation deficit in. of mercury		Average	0.40	0.36	0.26	0.14	0.07	0.04	0.04	0.06	0.11	0.20	0.29	0.37	
		1931	0.32	0.38	0.21	0.10	0.05	0.04	0.04	0.05	0.10	0.18	0.27	0.43	
		1939	0.55	0.39	0.16	0.06	0.04	0.02	0.02	0.05	0.10	0.16	0.23	0.36	
Evaporation (in)		Average	8.8	7.1	5.7	3.2	1.5	0.8	0.9	1.3	2.3	4.4	6.1	8.1	50.2
		1931	7.0	7.5	4.6	2.1	1.1	0.8	0.9	1.1	2.1	3.9	5.7	9.4	46.2
		1939	12.0	7.7	3.5	1.3	0.9	0.4	0.4	1.1	2.1	3.5	4.9	7.9	45.7
Rainfall Evaporation		Average	0.14	0.16	0.24	0.50	1.15	2.87	2.09	1.48	0.78	0.44	0.21	0.16	
		1931	0.07	0.02	0.74	1.53	2.63	5.82	2.38	1.10	0.71	0.44	0.30	0.02	
		1939	0.02	0.81	0.65	6.40	1.01	10.30	4.53	4.14	0.68	0.68	0.49	0.02	

The abnormally high temperatures recorded in the summer of 1939 - the January average being 79.8^{0}F compared with the normal 72.6°F - have been advanced as a contributory cause of tree losses in the following winter; however, this theory is not supported by the 1931 recordings when summer temperatures *were* lower than normal.

4. Topography, Geology, and the Significance of Drifts.

There are no very distinctive .topographical features. The irrigation area, which lies within the 365 ft. and 396 ft. contours, has a general fall of 4 ft, to the mile towards the north-west. Several more or less parallel, ill defined ridges, usually rising only 2 - 3ft. above the surrounding country, run in the same north-westerly direction. The most pronounced of these is in the southern part of the settlement. Between these slight ridges, roughly parallel and following the same general direction, are a series of shallow depressions, and in places, well defined drainage ways; these provide a natural outlet for the drainage waters of the district. They are normally dry but flow periodically in times of heavy rain. It is probable that originally some of the larger depressions drained slowly, remaining as swamps throughout the winter. Intermittent flooding from the Broken River has occurred in years of high rainfall, temporarily covering low lying parts of the district.

Geologically the area consists of unconsolidated sedimentary deposits of Recent origin. These are of great thickness since bedrock has not been reached within 100 ft. of the surface. Deep bores at Shepparton and in the neighbouring districts of Cosgrove, Kialla and Numurkah, disclose sequences of fine to relatively coarse strata, indicating periodic alterations in the natural drainage system of the country.

The survey has shown that the most recent buried system is one of distributary water-courses, now crossed by the existing rivers, namely, the Broken and possibly the Goulburn. The existence of these buried channels has long been recognised from the presence of wells and sandpits in the district, although the exact pattern has not been understood. Locally the term "drift" is widely used and has been retained in this survey; but it must be understood that it implies only the presence of strata of loose sands and gravels in the deep subsoil; that water is usually present is a secondary feature the importance of which is discussed in section IV. Whilst the pattern of the drift soils may be followed on the Soil Map, Fig. 2 shows more clearly the courses and inter-relationships of the drifts located in the area. The clay bed of the drift system outlined is usually reached within 20 ft. from the surface - spurs being considerably shallower while the channels are two chains or less in width. Four roughly parallel drifts, designated Nos. 1, 2, 3,and 4 from south to north, have been traced in a west-north-westerly direction following the present general fall of the Country. No. 1 drift has been located south of the Broken River, which apparently follows the old drift course for about mile before crossing it. This drift continues slightly west of north-west through the southern portion of the settlement into Shepparton, where it would appear to meet the Goulburn River near the present bridge. Whether all four are branches of the one system is unknown; certainly No. 2 and No. 3 are, as both these were traced from the sand pits on the Benalla Road about 7 miles east of Shepparton. That branching occurs periodically is shown in Fig. 2, most of the spurs becoming weaker until finally lost. Laterals follow the same general direction as the main course, indicating a distributary and not *a* tributary system.

The coarse nature of the material in the channel deposits indicates that these were fairly fast flowing streams, periodic flooding of the surrounding country giving rise to larger and more uniform areas of fine sediments.

A mineralogical examination[x] of the sand fractions of individual horizons to a depth of 7 ft. shows that all sediments, both fine and coarse, are of similar origin, viz., from the weathering of igneous rocks, probably of a granitic type. The fragments are fairly angular, but there is no evidence of material of windblown origin. The primary minerals present are very largely varieties of quartz, with only small amounts of micas, feldspars, and occasionally, tourmaline. The fact that feldspars are scarce throughout all horizons indicates that the sediments have undergone considerable weathering during some previous pedogenic cycle before transportation by water. Most of the soils of the area have developed from fine sediments already consisting of the secondary products of weathering, together with quartz, the latter being practically the only representative of the original primary minerals left. Concretionary iron, a secondary product of weathering in situ, is present with the primary minerals in the surface and to a lesser extent in the subsoil.

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

II. SOILS.

1. Scheme of Classification.

The soils occur in the zone of red-brown earths of Australia described by Prescott (1931). General features of this class are the sudden change in texture from the surface soil to the subsoil slue to downward leaching of the clay, the presence of a more or less bleached sub-surface, and the occurrence of a zone of calcium carbonate accumulation in the subsoil. Variation in leaching effects due to differences in local topography and in permeability of the sediments, together with the nature of the parent material, have caused variations in this general profile, with the resultant formation of a number of soil types. These are the ultimate units of soil classification which, therefore is based on certain definite features in the soil profile, namely, texture, colour, structure, and sequence of the soil horizons.[Φ] Described in general terms, the various sections of the soil profile have the following significance:-

surface = A1 horizon; subsurface = horizon; A2 horizon;
subsoil = B1 B2 horizons; lower subsoil = 2 ft. - 4 ft.; deep
subsoil = 4 ft. - 7 ft.; and substrata = below 7 ft.

Arbitrary limits have been adopted for the lower depths, based on the usual 4 ft. or 7 ft. bores put down during this survey. The above limits are understood wherever these zones are referred to throughout this bulletin.

[Φ] This and other soil terms are defined in Appendix I

Table 3. - Key to Soil Types.

Soil Type	Profile				Recorded variations from the normal profile	Occurrence
	Surface	Subsoil	Lower Subsoil	Deep Subsoil		
Broken Sand	Brown deep sand	Red-brown sandy clay loam	Brown sandy loam	Light yellow sand and gravel	Loamy sand surface: shallow phase: heavy deep subsoil: gravel in profile	Drift type: sandy rises.
Grahamvale sandy loam	" deep sandy loam	Red-brown, brown, or yellowish brown	Sandy clay and/or Sandy clay loam	" "	Loamy sand and loam surface: heavy profile: heavy deep subsoil: gravel in profile.	Drift type: as less pronounced rises or as slight depressions on crests of rises.
E. Shepparton sandy loam	" sandy loam	Red-brown light or medium clay (sandy)	Yellow sandy-brown clay to sandy loam	Continuing, or Yellow clay – grey	Loamy sand surface: deep surface: gravel in profile.	Associated with sandy rises of Broken sand.
Shepparton sandy loam	" "	" clay	Grey-yellow -brown sandy clay to sandy clay loam	Grey-yellow sandy clay to sand, or Yellow -grey clay	Deep surface: sand veins in subsoil: light profile: gravel in profile.	At higher levels of gentle slopes associated with Broken sand and Grahamvale sandy loam
Shepparton loam	" loam	" "	" "	Yellow -grey clay, or more rarely, sandy clays and sands	Sand veins in subsoil: gravel in profile.	At relatively high levels, often in association with Shepparton sandy loam
Lemnos sandy loam	" sandy loam	" "	" clay	Yellow -grey clay	Deep surface: sand veins in subsoil: light deep subsoil gravel in profile	"
Lemnos loam	" loam	" "	" "	" "	Sand veins in subsoil: light deep subsoil: gravel in profile.	On gentle slopes between soils of the Shepparton and Goulburn series.

Soil Type	Profile				Recorded variations from the normal profile	Occurrence
	Surface	Subsoil	Lower Subsoil	Deep Subsoil		
X Orrvale sandy loam	Greyish sandy brown loam	Brown clay or grey-yellow	Grey-yellow Sandy clay to sandy clay loam	Yellow clay, -grey or more rarely sandy clays and sands	Deep surface: sand veins subsoil: greyer profile; gravel in profile.	Small depressions, and areas of poor surface drainage.
Orrvale loam	" loam	" "	" "	"	Clay loam surface: greyer profile: gravel in profile: rarely sand veins in subsoil and deep surface.	Poorly drained flats and shallow depressions.
Goulburn loam	" "	" "	" clay	Yellow -grey clay	Grey brown, sandy loam, and deep surface: sand veins in subsoil; gravel in profile.	Flats associated with Lemnos loam, also fringing shallow depressions of clay loam types.
Goulburn clay loam	" clay loam	" "	" "	" "	Grey brown surface: gravel in deep subsoil.	Shallow depressions, and fringing Congupna clay loam.
Congupna loam	Grey-brown or grey loam	Yellow -grey "	Yellow -grey "	" "		Low lying flats, and as pronounced as depressions and drainage ways.
Congupna clay	" light clay	" "	" "	" "	Gravel in deep subsoil.	Creek like depressions and swamps.
Light profile depression soils	Greyish deep brown sand, to sandy grey loam or loam	Brown or grey-yellow	Sandy clay and/or sandy clay loam	Grey-yellow sandy clay to sand or yellow -grey clay	Gravel in profile: iron concretions in profile.	Small depressions, usually as offshoots from Broken sand and Grahamvale sandy loam

X More or less buckshot is usually present in the surface soils of all the following types.

The following description of some of the general, characteristic features of the soils of the district, will aid in identifying the individual types described later. Surface colours in order of increasing greyness are covered by the descriptive terms, brown, greyish brown, grey brown, brownish grey and grey., These indicate degrees of colour within the colour range, rather than absolute colour, as some slight greyness is characteristic of most of the brown soils and true greys are rare.: Frequently, under irrigated pasture, the immediate surface of brown soils may become modified to grey-brown without alteration of the colour of the sub-surface and the subsoil. Such changes are neglected in classification unless persisting into the subsoil, as the effect is lost after cultivation. Subsoil colours are described by the terms, red-brown, brown, grey-yellow, yellow-grey and grey. These shades, particularly the greys and yellows, may be the resultant combination of several colours, due to faint mottling of the clay subsoil. As some yellowishness is nearly always present in the greyest subsoils, the term yellow-grey is used to cover these soils, while the more truly yellow types are included under grey-yellow. Colours of the. subsoil and deeper strata are unimportant for purposes of classification of Shepparton soils. In these zones mottling often includes light grey, brown, red-brown and grey-brown shades, with the more usual greys and yellows.

Surface textures range from; sand to clay with a preponderance in the loam class. All show the characteristic tendency of Goulburn Valley soils to set when dry, forming hard clods, apparently heavier than the moist condition indicates. Even surface sands may show this coherent nature by weak clod formation, such soils being described as "loamy sands.”

Subsoils are generally massive, heavy, or medium clays plastic and intractable when wet, with a tendency towards nutty structure in the lower subsoil, particularly when there is an increase in fine sand in this region. Lighter subsoils of sandy clay loam texture are characteristic of some soils.

The lower subsoil which may be representative of the parent material, varies from sand to clay sediments, the latter being most frequent.

Except in the lighter soils, there is a slight concentration of calcium carbonate approximately 30 in. below this depth odd lime as hard small rubble may be found: throughout the profile. Occasionally moderate accumulations of large rubble occur in the deep subsoil.

Gypsum has not been observed except in small amounts in the clay substrata of deep bores at approximately 18 ft.

Table 3 summarises the main characters of the individual types described later and may be used as a key for their preliminary identification. The classification is based on texture and colour of the soil profile which are influenced by parent material and relative elevation respectively. Fourteen types in eight soil series are described. Each series has from one to three members which mainly differ from each other in the texture of the surface soil. Although the place name given to each soil series is intended to relate that series to its most extensive, occurrence, this has not always been possible. The soil series described in the Shepparton district are found with few exceptions throughout all parts of the area.

The coarser channel deposits have given rise to the light and poorly developed profile soils classed as Broken sand and Grahamvale sandy loam, whilst East Shepparton sandy loam, although derived from relatively coarse deposits, exhibits a well developed profile. Usually in close proximity to the drifts, sandy clays and light clays have provided the Shepparton and Orrvale series, both characterised by well defined A and B horizons above light material. The colour of the upper profile is used to differentiate these two series, the poorer drained Orrvale soils showing greyish brown and grey-yellow effects. The soils of the major part of the area have arisen from still finer clay sediments. From these have developed the Lemnos, Goulburn, and Congupna series, colour differences of these series being the outward expression of differences of internal drainage within the soil profile.

Broader relationships, depending on drainage differences, can be recognised between some of the types. These form catenas, the members of which occur together, but at different relative levels, and consequently exhibit well defined colour differences through the upper profile. The sequence Lemnos loam - Goulburn loam - Congupna clay loam form some such catena developed on fine sediments, while the Shepparton and Orrvale series are similarly, although more loosely, related. In the latter case, the more poorly drained Orrvale series has been broadened herein to include the relatively few occurrences of a third and lower member.

Minor variations from the normal profiles of the types, but insufficient to alter their main characters, are numerous in Shepparton soils. The most important of these is a "deep surface" phase recorded in those types where the depth to the subsoil, normally shallow, exceeds an arbitrary depth of 12 in. The presence of sand in the form of seams in certain subsoils, and occurrences of gravel are other variations of lesser importance common to several, types.

Although the substratum is considered not to be part of the soil profile for purposes of classification into types, examination of this region to a maximum depth of 31 ft. was made at random over the whole area. These substrata were found to be decidedly heterogeneous and are not necessarily related to the overlying soil type; however, descriptions of the substrata recorded, are conveniently given with the soil type descriptions that follow.

2. Description of Soil Types.

The following descriptions of the individual soil types are based on the principles previously outlined. The profile illustrations, therefore, primarily represent the basic character of each type in respect to colours, textures, and extent of horizons. It must be realised that even within one particular soil type there are minor variations from point to point, so that in the field individual holes will be found to vary from the "average" profile shown.

Texture descriptions and other data of representative profiles of each soil type taken in the field are given in Appendix 3

Broken sand.

This is essentially a type developed over relatively coarse channel deposits. The deep subsoil, therefore, always shows strata of water worn sand and gravel. The boundaries of the type closely conform to the outline of the original Watercourse consequently most areas of Broken sand are narrow and continuous, spreading out only very occasionally. The type is confined almost exclusively to the drift designated No. 1 (see Fig. 2), with major occurrences only in the extreme south-east of the settlement.

There is no very rigid profile form for this type owing to the coarse and variable nature of the parent stream deposits, but general characteristics are a sandy deep surface over a restricted sandy clay loam horizon (B1), with textures beneath rapidly lightening to stratified water worn sands and gravels. Colours are predominantly brown in the surface, although the high proportion of coarse quartz grains often confers greyishness, and red-brown in the subsoil.

Fig. 3 illustrates these profile features, although the occurrence of sandy clay loam in the subsoil is frequently before 36 in. forming a shallow phase.

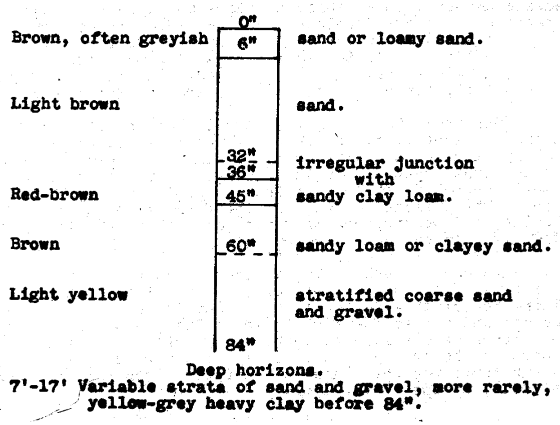


Fig 3. Broken sand

Irregular junctions are common between the upper horizons and normally drift, is present from 5 ft. to 17ft least. However, sometimes the strata of drift sands are restricted to the extent that the clay bed of the channel is reached before 7 ft. The light nature of the soil allows free penetration of water, resulting ground water being nearly always present in the deep subsoil of this type. Occasionally lime-cemented, sandy aggregates occur in the upper region of the water-logged strata, but there is no definite zone of lime accumulation. Variations with more or less gravel throughout the entire profile are common, while frequently the course of the underlying drift can be traced by small surface indications of gravel.

Grahamvale sandy loam.

This is also a type developed directly over drift, consequently it is closely related to Broken sand. There are no large areas of the type, all occurrences being associated with No. 2 and No. 3 drifts and laterals. Although usually on slightly higher levels. Grahamvale sandy loam does not form the pronounced ridges common to Broken sand; in fact it often occurs as a very shallow depression, either on the top or side of a rise, or crossing nearly flat country. This topography, together with the light texture of the soil type, has resulted in high water tables in these soils within the irrigation area, causing variation of soil colours in the subsoil zone of water accumulation. The alluvial clay horizon may therefore vary from the normal red-brown, through brown, to yellow-brown, and even show grey shades in the deeper subsoil. That colours have been modified by local hydrological conditions is apparent, since profiles of Grahamvale sandy loam with low ground water, examined outside the irrigation area, exhibit warm colours normal to well drained soils. Considerable variation is therefore necessarily allowable in profile form, the essential factor being channel development as with Broken sand, but differing in the heavier profile and with possibly modified colours. Surface textures are sandy loam, and less often, loamy sand.

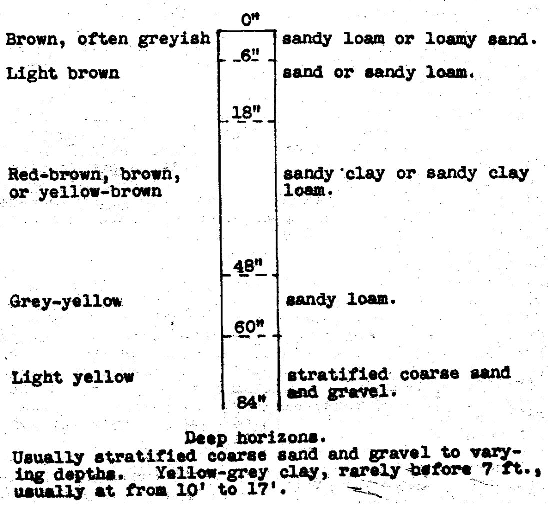


Fig 4 Grahamvale sandy loam

The sandy clay loam subsoil, which may also include sandy clay textures, frequently extends from one to four feet before there is any falling off in texture, differing in this way from the closely linked shallow phase of Broken sand, which usually has less than 18 in. of sandy clay loam subsoil. There is no recognisable zone of lime accumulation.

A few small areas with loam surface and generally heavier profile which have been included with the type, are marked by inscription on the soil map. A small amount of gravel is normal, but fairly large accumulations throughout the profile are not infrequent. The presence of high water tables, often within 3 ft. of the surface, interfere with sampling, making selection of representative profiles of this type difficult. Four variations of the type are recorded in Appendix 3, of which two, viz., series 6284 - 6289, and series 10067 - 10072 are located outside the settlement. These both show rather lighter textures in the subsoil than is usually found, while series 9606 - 9611 represents a heavy profile with under-lying drift. The soils Nos. 6303 - 6308 have developed on a narrow channel lateral from a larger drift. In this case no loose sands are present, the bed of the channel being the light clay at 57 in Many of the drift laterals Are of this form, although usually slightly deeper and with some accumulation of drift sand. Fig. 4 shows a common type of profile, the broken lines indicating that the horizons may fluctuate considerably from the depths shown.

East Shepparton sandy loam.

East Shepparton sandy loam is associated with the major sandy rises of Broken sand. These are mainly in the south-east of the settlement and include the best peach soils of the Shepparton district. Minor occurrences are found in other parts of the area developed on slightly elevated accumulations of coarse sediments.

A pronounced profile has developed as shown in Fig. 5, although several variations are recognised. The surface colour is brown, usually with the same characteristic greyishness and gritty texture of Broken sand. Loamy sand occurs nearly as frequently as sandy loam, consequently surface features are often insufficient to distinguish the type from Broken sand. Depth of surface (A1 and A2 horizons) varies from 10 in. to 20 in., the greater depth tending to be more characteristic of the type. The first foot, or even less, of subsoil (B1 horizon) is red-brown light or medium clay with definite sandiness apparent, plastic when wet, and brittle and crumbly when dry. Textures below this horizon normally fall off rapidly through sandy clay to sandy clay loam and even to lighter textures before 3 ft., although in marginal occurrences, the lightest subsoil texture may be sandy clay. Coarse sand is usually prominent in these lighter horizons, but sometimes fine sandy textures may be more pronounced. Owing to close association with drift deposits, there is considerable variation in the deep subsoil which may vary, from the more usual clay strata (Fig. 5b) to drift sand (Fig. 5a). Calcium carbonate does not occur in any well defined zone, although there may be traces of soft lime in the subsoil, with odd small rubble throughout the heavier types of deep subsoil.

Besides deep surface, other variations from the normal, suitably indicated on the soil map, are:- loamy sand surface, occurrences of gravel, and greyish profile. The latter variant applies to marginal areas of the type where soil drainage conditions have introduced grey influences into the colour profile. Usually water tables are present only where the deep subsoil consists of sandy clay or lighter textures, i.e., at junction with Broken sand; but the texture of the profile is such that free subsoil water can readily develop under unfavourable conditions.

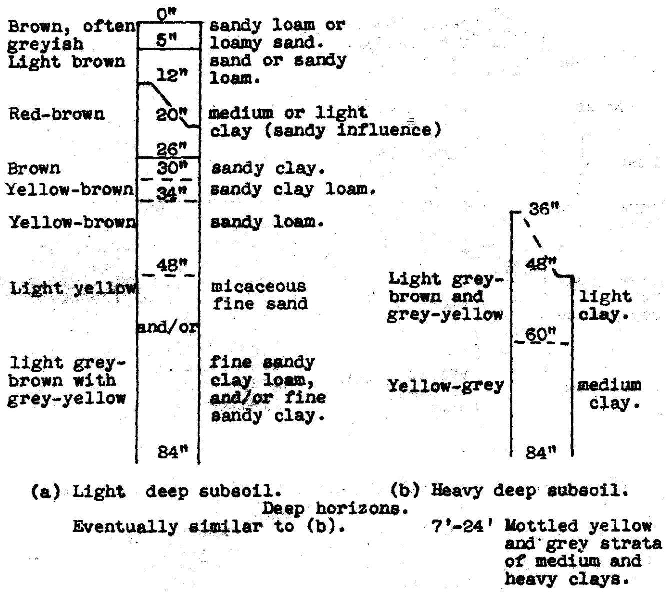


Fig 5. East Shepparton sandy loam

Shepparton series.

Soils of this series are most commonly found on very gentle slopes, although these have not always *been* sufficient to provide adequate surface drainage under horticultural conditions. The series has developed on finer alluviums but is usually in close proximity to the types previously discussed. Two members distinguishable by the texture of the surface soil are described.

Shepparton sandy loam.

The normal profile of this type is of the form shown in Fig. 6. There is some variation in the type of sandy loam surface depending on the relative amounts of coarse and fine sands present. Coarse sand, whilst always subordinate to fine sand, may be sufficient to confer grittiness on the surface soil, as in soils 6276 and 6646 (Appendix 3). More usually, as in soil 6768, coarse sand is insignificant, with resultant fine-sandy loam textures. Both types of surface are coherent, forming fairly hard clods which appear heavier than sandy loam texture until wetted. A narrow bleached subsurface (A2 horizon) is characteristic of the normal profile, but this may become extensive to form a deep surface phase. The massive red-brown clay subsoil (B1 horizon) is stiff when wet and without the sandiness characteristic of East Shepparton sandy loam, although a variant with some penetration of sand as seams into the upper clay subsoil has been recorded on the map by the inscription "sand veins in subsoil." Examples of this variation are shown by soils, 6648 and 6770 (Appendix 3), the latter exhibiting the usual slight effect on average texture, as evidenced by mechanical analysis, while the exceptionally light average texture shown by the former soil is unusual. Sandy clay and/or lighter textures, typically, but not necessarily, of fine sandy nature, are found in the lower subsoil before the arbitrary depth of 4 ft. These horizons, when fine, sandy, have a nutty structure, crumbling readily when dry, and are plastic or mellow when moist; on the other hand, coarse sandy horizons usually with some gravel, form strata of hard pan when dry. Light textures, even to drift sand and gravel, may persist in the deeper subsoil, although medium and heavy clays are more normal to this part of the profile, calcium carbonate occurs both as soft lime and as rubble in slight amounts from 30 in., usually a maximum concentration being at this depth with odd rubble, below.

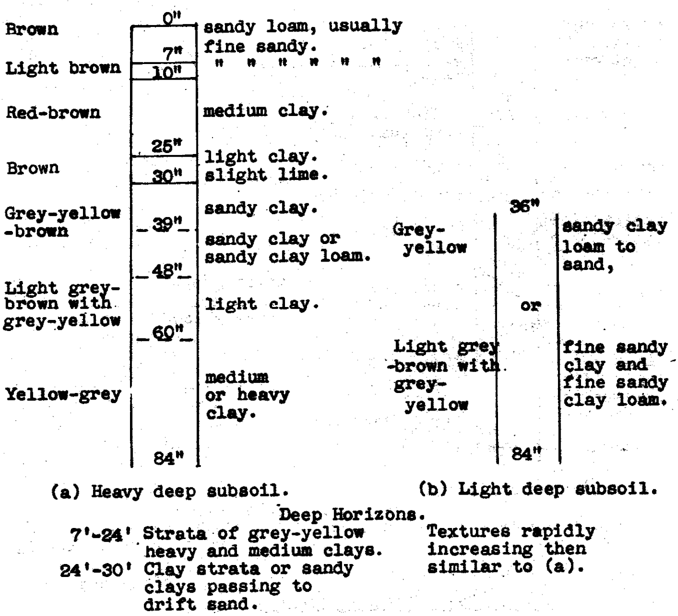


Fig. 6 Shepparton sandy loam.

When gravel occurs, it is rarely distributed throughout the whole profile but is concentrated in a definite zone.

Besides a fairly common "deep surface" phase, another recorded is that of "light profile" with sandy clay before 2 ft., linking this type with East Shepparton sandy loam.

Occasionally high water tables have been established, but taken as a whole, ground water, although often present in the deep subsoil of lighter profiles, is not normally a serious feature of this type.

Shepparton loan.

The surface loam is nearly always of the fine sandy type, other essential profile features, illustrated in Fig. 7, being similar to Shepparton sandy loam. Textures in the subsoil are similar, except that the heavy deep subsoil frequently occurs within 4 ft. of the surface with the elimination of horizons lighter than sandy clay. These heavier profiles, closely approach Lemnos loam. Light deep subsoils are infrequent and, except in such cases, water tables are absent.

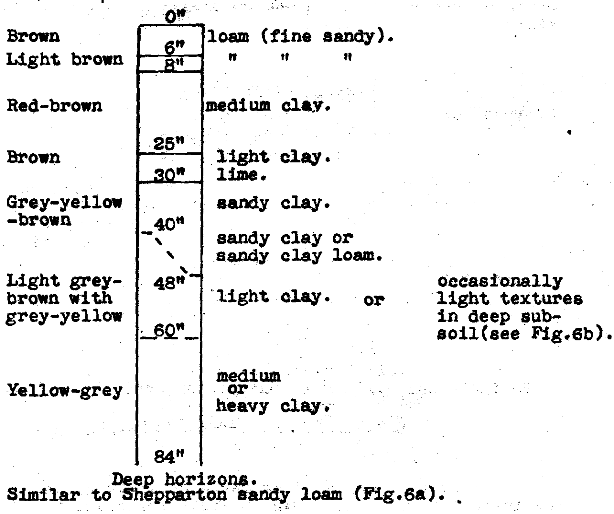


Fig.7 Shepparton loam.

Orrvale series.

This series has arisen on alluvium similar to the Shepparton series, but occurs at intermediate and lower contours, with resultant, periodic accumulations of surface drainage water. These soils, therefore have developed greyer shades in profiles of texture similar to those of Shepparton sandy loam and Shepparton loam.

Orrvale sandy loam.

The texture of the surface sandy loam is commonly of the gritty type due to the influence of coarse sand. Slight buckshot may be present on the surface, sometimes with greater accumulation in the subsurface. Besides a deep surface phase, recorded variations from the average profile illustrated in Fig. 8 are:- “sand veins in subsoil," ;gravelly occurrences, and “greyer profile." The last applies to small lower-lying areas which have developed decidedly grey shades in the upper profile, but which are insufficient in number to warrant a separate type. Drift sands and gravels in the deep subsoil of this type occur in the western section of the district, and in such cases water is usually present; generally light deep subsoils are not as common as in Shepparton sandy loam. Subsoil water is not a feature of the normal form except, perhaps, under excessively wet conditions, but the topographical situation of this type renders these soils particularly liable to trouble from surface water.

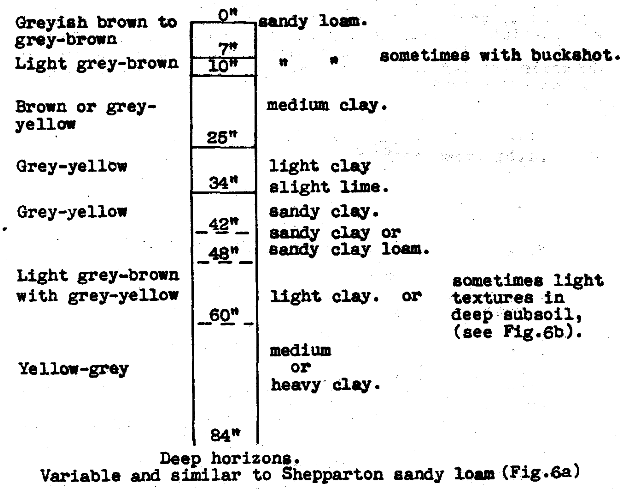


Fig. 8 Orrvale Sandy loam. Orrvale loam.

Whilst the loam surface may also include clay loam, the texture profile as shown in Fig. 9 resembles that of Shepparton loam and the colour profile that of Goulburn loam. Buckshot may be present in the surface horizons. Variations from the normal form of the type are: occurrences of gravel, "greyer profile" associated particularly with clay loam surface, and to a very minor extent "sand veins in subsoil" and deep surface. Surface drainage is frequently defective resulting in disabilities similar to Orrvale sandy loam, although the heavier nature of the upper profile may allow eventual drainage of surface water before excessive saturation of the root zone of the tree can occur.

Lemnos series.

Two types, viz., Lemnos sandy loam and Lemnos loam are included in this series, both having developed over clay sediments under naturally well drained conditions, although these conditions frequently have been modified artificially to cause temporary accumulations of surface water. The colour profile is brown at the surface with red-brown subsoil becoming grey-yellow with depth. This series differs from the Shepparton series by the absence of sandy clays from the upper four feet of the soil profile, textures below the red-brown clay being not lighter than

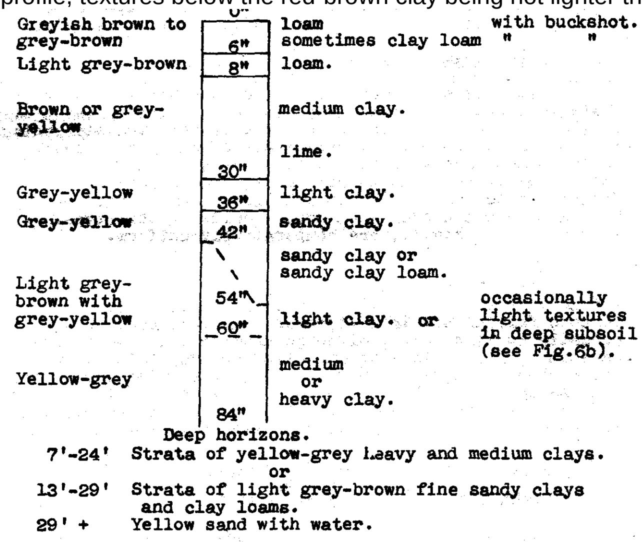


Fig.9 Orrvale loam.

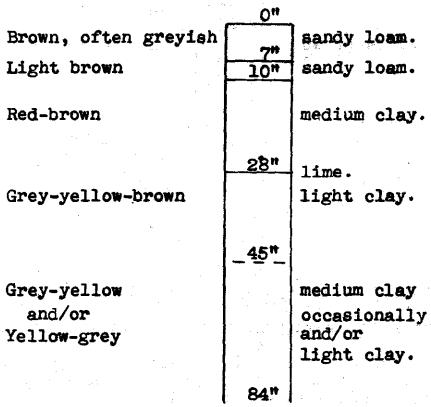


Fig. 10 Lemnos sandy loam

Lemnos sandy loam.

Although sandy clays are absent from the subsoil, the presence of a relatively large amount of coarse sand in the parent material has given rise to a typically gritty sandy loam surface, and to fairly common occurrences of deep surface and "sand veins in subsoil" variations. Whilst texturally the upper profile is very similar to Shepparton sandy loam, the heavier lower subsoil of this type does not develop free water. A typical profile is shown in Fig. 10.

Lemnos loam.

This type occurs extensively on the better drained *flats* that gradually fall away from the slight rises. It is therefore commonly found as areas of intermediate contour in association with the lower levels of Shepparton loam.

Unlike Lemnos sandy loam, coarse sand is not a feature of the alluvium, and consequently surface soils are typically fine textured loams, occasionally clay loams, that readily become hard and cloddy when dry. Soils of this type, illustrated in Fig. 11, are comparatively uniform.

The bleached subsurface (A2 horizon) is very restricted, or absent, while the massive medium or heavy clay subsoil occurs at less than 12 in. from the surface. There is some falling off in texture in the lower subsoil, normally to light clay, although heavier textures frequently persist. Slight lime accumulation occurs at 30 in. with odd rubble throughout lower depths. A limited variation with sandy clay or lighter strata below four feet has been recorded as "light deep subsoil." Gravel in the profile is the only other widespread variation of the type.

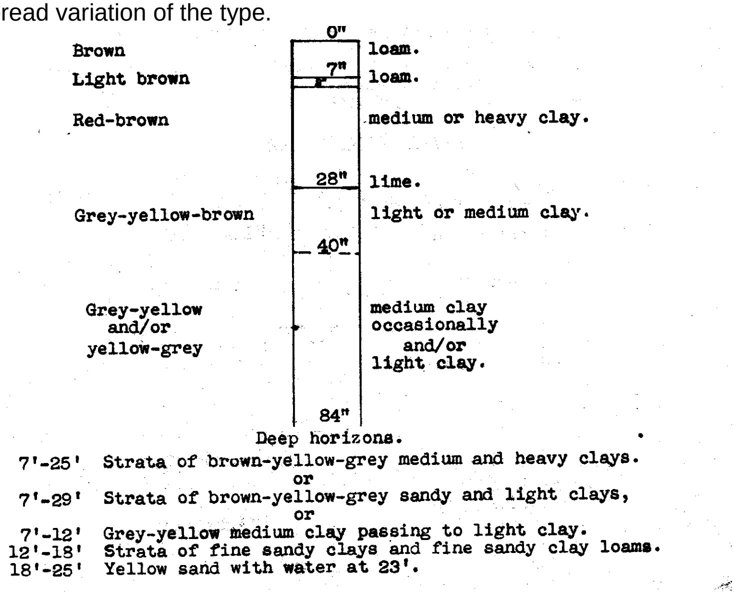


Fig. 11 Lemnos loam.

As Lemnos loam is subject to surface drainage water from soils higher up, removal of this water will depend on the get-away to lower levels. If this is restricted, water may be on the surface for considerable periods after excessive rain, as penetration into the subsoil is slow. Because of this slow penetration into the subsoil, water tables have not developed in this type, even under irrigation.

Goulburn series.

The two members of this series are commonly found on flat country with little fall and fringing more definite depressions. As these two types form the middle members of the Lemnos-Goulburn-Congupna catena systems which comprise over 50% of the soils of the whole district, their distribution is naturally extensive, particularly as there is a tendency to include marginal soils of both the upper and lower types of the catena with the middle type. A greater degree of latitude, therefore, is allowed in the soil colours of this series.

Goulburn loam.

Soils of this type are closely associated topographically with Lemnos loam, very small differences in level being sufficient to modify the colour profile. Except in so far as this is An indication of probable poorer surface drainage in Goulburn loam soils, these two types are closely related, having developed on similar alluvium under practically identical conditions. As shown in Fig. 12, the general color, of the upper profile differentiates the type from Lemnos loam and Congupna loam. The type includes soils having greyish brown surface with brown or even grey-yellow subsoil, and also soils with grey-brown surface and brown subsoil, since frequently additional greyness has been induced in the surface under such conditions as the irrigation of pasture. The surface loam, which may be either of the fine Sandy or gritty type, is hard and cloddy when dry and frequently contains small amounts of buckshot. A restricted and bleached A2 horizon is usually present, occasionally forming a localised type of hard pan. Subsoil textures and the occurrences of lime are similar to Lemnos loam, except that medium clay is more frequent than light clay in the lower subsoil. Variations from the normal, all of limited extent, are:- “sand veins in subsoil”, occurrences of gravel, deep surface, and sandy loam surface.

Although surface water may accumulate unless adequate provision is made for its removal, the problems associated with water tables do not arise with this type.

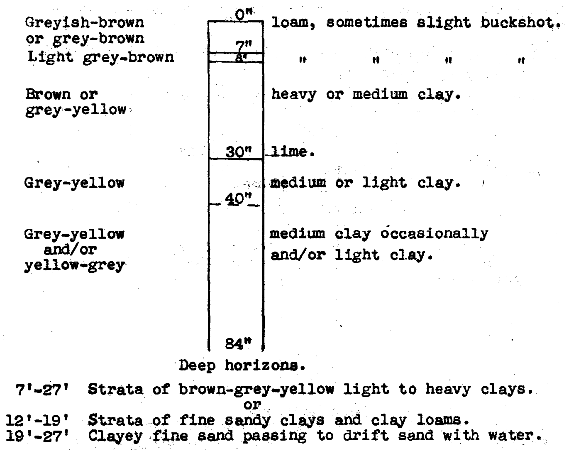


Fig. 12 Goulburn loam.

Goulburn clay loam.

This type occurs as ill-defined depressions or fringing the more pronounced hollows, and is therefore mainly associated with Congupna clay loam, Goulburn loam, and less frequently with Lemnos loam. Fig. 13 represents an average profile, differing from Goulburn loam in the shallower and heavier surface, absence of a bleached A2 horizon, and generally heavier character of the lower subsoil strata. Except in the deep subsoil, gravelly variations are uncommon. Small amounts of buckshot are often present in the surface.

Owing to their topographical situation and retentive subsoils, water may remain on the surface of these *soils* for fairly long periods after heavy rain, unless provision is made for drainage.

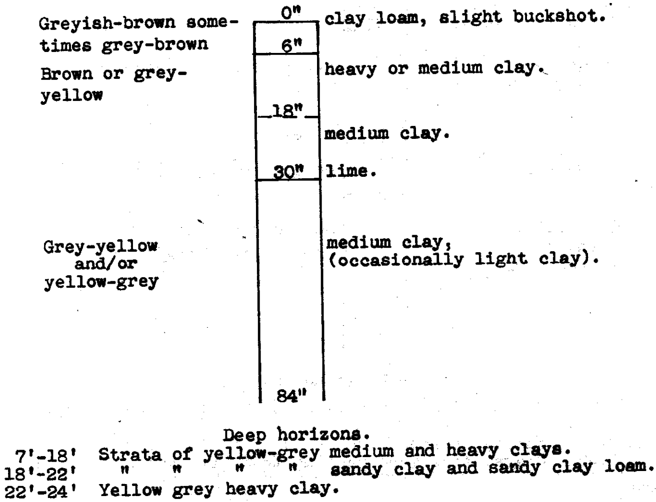


Fig. 13 Goulburn clay loam.

Congupna series.

Situated in .the depressions and lower lying flats are the definitely grey-brown and grey soils of this series. They have developed on clay alluvium in areas, either with no outlet for drainage water from surrounding country, or in shallow continuous creek-like depressions, under intermittent (although possibly prolonged) periods of water accumulation. Subsoil colours are yellowish grey, more. rarely grey. Buckshot is always present to some degree in the surface, in which fine sand always dominates coarse sand and silt may be high. The soils described as Congupna clay loam and Congupna clay are the heaviest of the district.

Congupna loam.

Although loam textures are not general in the Congupna series, a considerable number of small lighter-surfaced depressions occur through the area. The aggregate of these is too large to include with Congupna clay loam, and, in addition, these small areas frequently show features not found in Congupna clay loam, such as fairly deep surface often with heavy buckshot accumulation. The type Congupna loam includes all such occurrences where the underlying profile is heavy, as distinct from the minor depressions described later in which light textures occur in the subsoil. Characteristics of the profile are illustrated in Fig. 14. Lime occurs as a soft accumulation at 30 in., and then as odd hard rubble through the lower profile. Gravel does not occur in the upper profile, but is sometimes present in the deep subsoil.

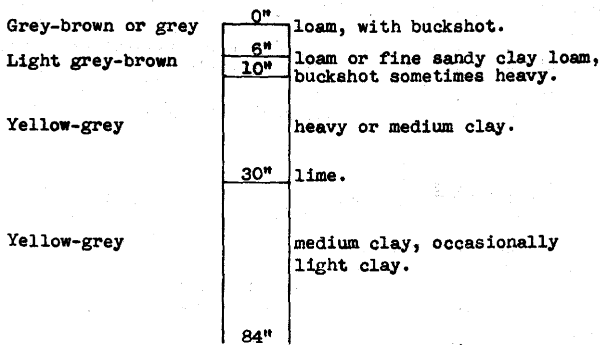
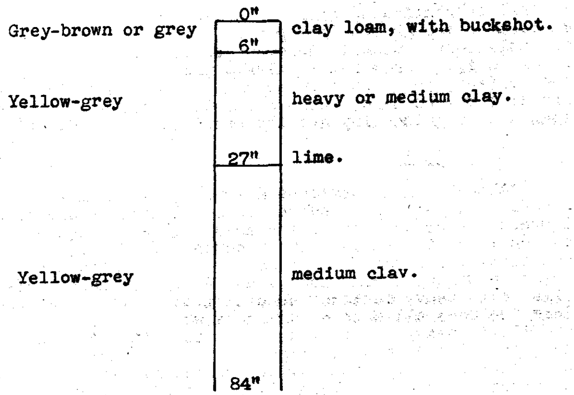


Fig. 14 Congupna loam.

Congupna clay loam.

Features of the type shown in Fig. 15 are the shallow grey-brown heavy surface, and the heavy yellowish grey subsoil with slight lime from 27 in. A poorly developed light brownish grey A2 horizon may sometimes be present. The surface is cloddy while the massive subsoil tends to crumble fairly readily below 30 in. Penetration of water into soils of this type is slow and free water does not occur in the Subsoil. Except in the deep subsoils, gravel is absent. In close proximity to the Broken River increased siltiness has been recorded by inscription on the map as "silty profile."

This type, illustrated in Fig. 16, is mainly represented by the more continuous depressions now frequently utilised as part of the district drainage Scheme. Probably the larger expanses of these soils were originally swamps, holding water for long periods in wet seasons, but normally dry except in Winter.



Deep horizons.

7'-13' Strata of yellow-grey medium clay.
13'-19' " " clayey sand and sand (dry).
19'-28' Yellow-grey heavy clay.
or
7'-27' Strata of yellow-grey light to heavy clays.
27'-31' Grey-yellow sandy clay (moist).

Fig. 15 Congupna clay loam.

Congupna clay.

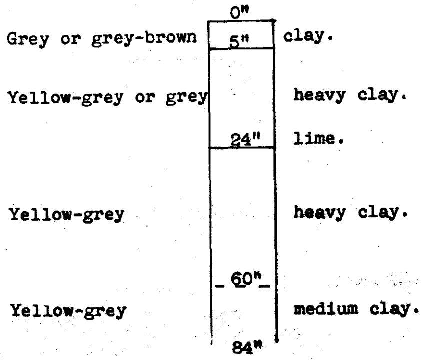


Fig. 16 Congupna clay.

The shallow surface is frequently-grey mottled with grey-brown, while the upper grey heavy clay subsoil shows only slight yellowishness which becomes more pronounced with depth. Slight lime may occur through the profile from 24 in. below the surface. Cracking of the surface on drying out does not extend more than a few inches into the subsoil. The type frequently shows weak crabhole formation.

Light profile depression soils.

Usually depression soils exhibit *a* heavy profile and can be allotted to one of the types previously described, however, small areas occur in which the profile is of a permeable type. Such soils are of very minor occurrence and have not been classified, but grouped as "light profile depression soils." They are usually associated with drift types. All are essentially grey-brown or grey deep sands, sandy loams or loams, overlying grey-yellow sandy clay subsoils, with lighter textures in the deep subsoil resting on clay substrata. Ground water which is always present is frequently close to the surface, and concretionary iron is commonly found through the subsoil.

3. General Soil Relations.

Other soils in the red-brown earth zone have been described previously by Penman (1936a and 1936b)', and Butler *et.al* (1942). Penman (1936a) describes five types on a small area at Tatura which conform generally to the types of the Shepparton district. Lemnos loam and the slightly poorer drained Goulburn series of this survey show similar but slightly lighter textural profiles to Type A of Tatura. Some buckshotty areas of Congupna clay loam resemble Types B and C, Congupna clay compares with; the heavy phase of Type C, while Shepparton loam and its light phase have affinities with Types D and R respectively.

Penman (b) has also described a group of soils developed on unconsolidated sediments at Balsam and Ballendalla. Of these, Lockington loam appears to be very like Lemnos loam while several other types described possess similarities to Shepparton loam and Shepparton sandy loam.

With the probable expansion of horticulture in the adjacent Murray Valley area partly surveyed by Butler *et.al*. (1942), the relationship, between the soils of the two districts is of importance in order that benefit may be derived from Shepparton experience. Textural differences appear to be mainly due to the nature of original sedimentary deposits. Although profiles are generally lighter in the catena, Lemnos loam - Goulburn loam - Congupna clay loam of the Shepparton area, this catena may be compared with the Moira loam Naringaningalook loam - Boosey loam catena further north. The sequence of horizons in the Shepparton loam and Cobram loam types are similar, although textural differences are noticeable in the field. For instance, it has been observed that fine sandy clay from a Cobram loam profile has a much lighter field texture than fine sandy clay with practically identical mechanical analysis taken from a Shepparton loam subsoil. Possibly for this reason, the friable subsoils encountered by Butler *et.al* have not been observed at Shepparton. Orrvale loam is probably comparable with "grey-brown" occurrences of Cobram loam. Cobram sandy loam bears closer resemblance to East Shepparton sandy loam, particularly to the deep surface phase, than to Shepparton sandy loam. Of the lighter soils, types similar to Broken sand and Grahamvale sandy loam have not been recorded by. Butler *et.al*. while Sandmount sand, a wind blown occurrence, is not found within the Shepparton irrigation district.

Soil Associations.

Owing to the numerous changes in soil type within comparatively short distances, the soil map does not provide a concise picture of the soils of the district as a whole. The term soil association has been used previously by Butler *et. al.* (1942) to describe broadly a group of soils within a particular landscape and this term, although here used in a narrower sense, has been found convenient to describe soil groups recognised within the Shepparton irrigation district. By grouping the soil types into associations according to the nature of their parent sediments, the broad relationship is apparent between the light soils associated with the drifts, the types of intermediate texture, and the heavy soils of the depressions. These soil associations, each of which has been given the name of the dominant soil type within the association, are shown in Fig.2 on a small scale map of the district.

The soil associations mapped are:-

I. **Broken association**. This is dominated by the light soil types, viz., Broken sand and Grahamvale sandy loam, formed over the coarse deposits of the drifts. East Shepparton sandy loam which is closely associated with the drifts is included and is actually the largest area within this soil association.

II. **Shepparton association**. This association represents the soils of intermediate texture derived from finer sediments than those of the Broken association, but is usually found in proximity to the drifts. The soil types are mainly Shepparton sandy loam and Shepparton loam, while Orrvale sandy loam and Orrvale loam occur to a lesser extent. Lemnos sandy loam is a minor occurrence.

III. **Goulburn association**. Soils of intermediate texture developed from clay sediments. Goulburn loam and Lemnos loam are the major types with Lemnos sandy loam subordinate.

IV. **Congupna association**. This comprises the heavy soils of the depressions. Congupna clay loam is the major type, with Goulburn clay loam and Congupna clay subordinate types, and Congupna loam a minor occurrence.

The map of soil associations illustrates that, even on a broad classification, the soils of the area are extremely variable. In general, however, the lighter soils, represented by the Broken and Shepparton associations, are most extensive in the neighbourhood of No. 1 drift and particularly in the south-eastern part of the settlement; whilst the Goulburn and Congupna associations predominate in the Lemnos and Grahamvale areas.

4. The Soil Map.

A map of the soil types of the area is issued in four sections as a supplement to this bulletin. It has been compiled from data recorded in the field on aerial photographs[x] enlarged to a scale of 1 inch to 5 chains. These photographs also provide a useful permanent record of tree plantings in the district. The published map has been produced on a scale of 1 inch to 10 chains in order to show important detail of the survey. The location of each sectional map is shown on the small scale plan (Fig. 2) at the back of the bulletin. The pattern of shallow drifts disclosed, beyond as well as within, the surveyed area, is also shown on this plan.

Minor soil variations within the types have been recorded on the soil map by appropriate inscriptions. These are self-explanatory except that "gravelly profile" denotes a larger accumulation of gravel than that in areas described by the term "gravel in profile."

5. Distribution of Types.

Table 4. Distribution of Soil Types.

Soil Type	Acres	As % of total area
Broken sand	260	1.5
Grahamvale sandy loam	225	1.3
East Shepparton sandy loam	318	4.2
East Shepparton deep surface	430	
Shepparton sandy loam	2,060	14.2
Shepparton sandy deep surface	476	
Shepparton loam	719	4.0
Orrvale sandy loam	384	3.5
Orrvale sandy deep surface	230	
Orrvale loam	977	5.6
Orrvale loam deep surface	21	
Lemnos sandy loam	505	3.7
Lemnos sandy deep surface	151	
Lemnos loam	2,441	13.7
Goulburn loam	3,582	20.7
Goulburn loam deep surface	113	
Goulburn clay loam	1,415	7.9
Congupna loam	379	2.1
Congupna clay loam	2,012	11.3
Congupna clay	1,041	5.8
Light profile depressions	81	0.5
Total	**17,820**	

[x] The aerial photography was ably carried out by the R.A.A.F., and provided photographs of inestimable value for purposes of this survey.

The extent of the individual soil, types is shown in Table 4. It is seen that Goulburn loam is easily the main occurrence with Shepparton sandy loam, Lemnos loam, Congupna clay loam, and Goulburn loam, following in that order. These types total nearly 70% of the area. When considered as light, intermediate, and heavy soils on the basis of surface texture, the six light sand and "Sandy loam" types comprise 29%, the five intermediate loam types (mainly Goulburn loam and Lemnos loam) 46%, and the three heavy clay loam and clay types 25%, of the whole area.

Deep surface phases of all types total 1,421 acres or 8% of the area.

Many of the water troubles of the district have been attributed to underground drifts. The extent of all types with drift sand and gravel in the profile is given in Table 5.

Table 5. Extent of Drifts in Relation to Soil Types.

Soil Type	Acres	As & of total area
Broken sand	260	1.5
Grahamvale sandy loam	225	1.3
East Shepparton sandy loam	38	0.2
Shepparton sandy loam	134	0.7
Shepparton loam	17	0.1
Orrvale sandy loam	21	0.1
Orrvale loam	27	0.2
Total	**722**	**4.1**

The practical significance of the distribution of soil types is discussed in Section V.

III. PHYSICAL AND CHEMICAL PROPERTIES OF 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 32 profiles, representative of the recorded types and their major variations, are given in the tables in Appendix 3.

Texture as described in the field is the resultant of several soil factors of which clay content is the most important in Shepparton soils, consequently the field textures of the soils are generally found to conform with those expressed by the mechanical analyses.

Whilst coarse sand never exceeds fine sand in the surface, except in Broken sand, it is sometimes sufficient to influence the texture of the sandy loams and may occasionally confer grittiness on certain loam soils. More frequently, however, fine sand, together with an appreciable amount of silt, dominates the mineralisation of the soils, an important factor contributing to known "setting" properties of many Goulburn Valley soils.

The textural trend within the soil profile for all types, as evidenced by clay content, is illustrated by the figures in Table 6.

Table 8. Clay Content of Soil Types.

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

	Surface and sub-surface		**Subsoil**		**Lower subsoilΦ**	
	Depth in.	**Clay %**	**Depth in.**	**Clay %**	**Depth in.**	**Clay %**
Broken sand	0-34	7	34-43	28	55-70	4
Broken sand shallow phase	0-14	7	14-32	22	32-57	16
Grahamvale sandy loam	0-6	14	6-32	18	32-78	7
East Shepparton sandy loam	0-11	8	11-28	35	28-41	19
Shepparton sandy loam	0-9	11	9-27	48	27-47	31
Shepparton loam	0-8	13	8-35	51	35-60	28
Orrvale sandy loam[x] deep surface phase	0-14	7	14-34	45	34-59	21
Orrvale loam	0-8	16	8-31	46	31-59	26
Lemnos sandy loam	0-10	8	10-26	43	26-66	45

	Surface and sub-surface		Subsoil		Lower subsoilΦ	
	Depth in.	Clay %	Depth in.	Clay %	Depth in.	Clay %
Lemnos loam	0-7	15	7-29	54	29-46	39
Goulburn loam	0-7	16	7-30	46	30-50	41
Goulburn clay loam	0-8	26	8-34	50	34-66	49
Congupna loam	0-11	19	11-33	54	33-51	44
Congupna clay loam	0-9	24	9-34	49	34-50	49
Congupna clay	0-5	36	5-29	65	29-63	58

Φ Including part of deep subsoil.
x Sand surface variation.

These data show the types to fall into the following three broad textural groups.

(1) Light profile, viz., Broken sand and Grahamvale sandy loam, in which the maximum clay content is within the range of 18-28% and is reached in a variable but restricted zone of the subsoil.

(2) Heavy subsoil and light lower subsoil, viz., the types of the East Shepparton, Shepparton and Orrvale series in which the surface clay (7-16%) increases sharply before one foot to give subsoil textures within the clay range of 35 - 51%, afterwards breaking back to lighter textures (clay 19 - 31%) in the lower subsoil. East Shepparton sandy loam, the lightest member, connects this group with (1).

(3) Heavy subsoil and heavy lower subsoil, viz., the types of the Lemnos, Goulburn, and Congupna series. The clay content of the surface ranges from 8 - 36% increasing rapidly as in group (2) to heavy textures (clay 43 - 65%) before one foot, and continuing as such in the lower subsoil (clay 39 - 58%). Lemnos sandy loam, although much lighter in the surface than the other types of this group, is included because of its heavy lower subsoil.

A notable feature of the types as a whole is the large proportion (86.7%) of soils of the area in which there is a similar and extensive concentration of clay in the subsoil, viz., approximately 50% from about 9 in. to a depth of 30 in. or more (Table 6), the exceptions being Broken sand, Grahamvale sandy loam, East Shepparton sandy loam, and Congupna clay which together comprise only 12.8% of the whole area (Table 4). Summation curves of the mechanical analyses of representative B horizons are shown in Fig. 17 to illustrate this general similarity in the texture of the majority of the subsoils, compared with the lighter and heavier textures of Broken sand and Congupna clay, respectively.

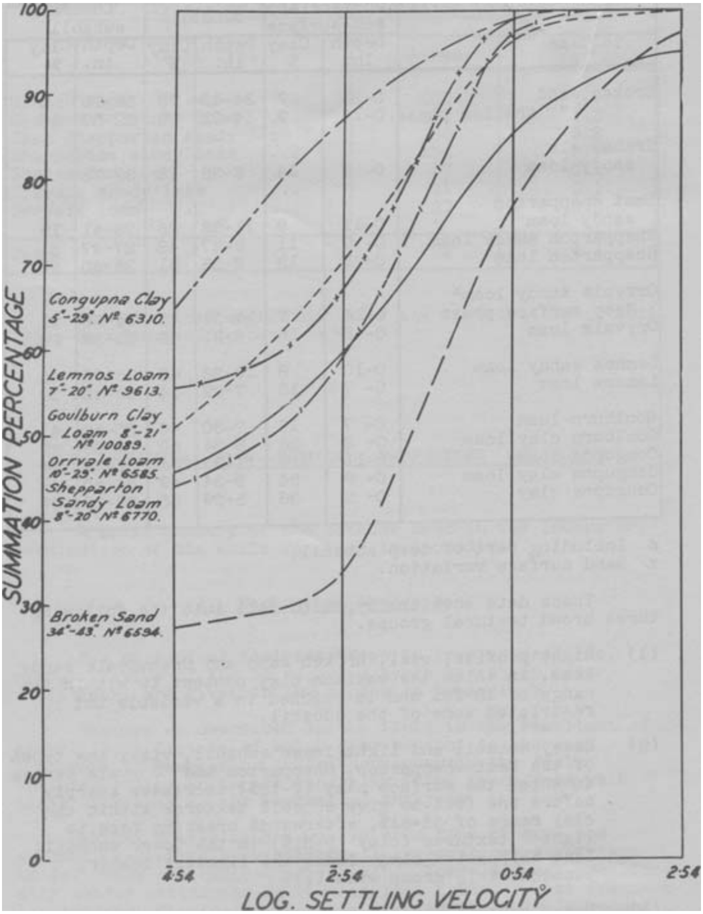


Fig. 17

The absence of a well developed texture profile, as in the Broken sand and Grahamvale sandy loam types, is frequently regarded as evidence of a soil's immaturity; it might be expected that the large proportion of sand and silt fractions in these types would provide weatherable minerals for future soil forming processes. However, the primary minerals present in the soil profiles of these types consist very largely of varieties of quartz, with only small amounts of the weatherable feldspars and micas. The other and heavier soil types have reached a slightly higher stage of weathering, since feldspars have practically disappeared entirely from their A and B horizons, although present in small amount in the C horizons. Thus, regardless of textural differences, the soil types may be considered as varying only slightly in maturity. The characteristic texture profiles of the types that have developed, have been dependent mainly on the extent of mechanical eluviation of clay, as influenced by the relative amounts of the coarse fractions - chiefly quartz - and the fine fractions - secondary clay minerals - in the original sediments. This influence of the parent material on clay pan formation is revealed by critical examination of the mechanical analysis data (Appendix 3).

Since the soils are products of secondary weathering of heterogeneous sediments, the actual parent material itself may not exist now as a true C horizon in the soil profile, although its approximate nature may be indicated. For example, soils 6592 - 6597 represent a profile of Broken sand in which clay has been leached from sandy alluvium to the 34 - 55 in. zone; however, the sediment (6596) immediately below this horizon obviously contains more coarse fractions than the immediate parent material from which the soil profile developed. In the shallow phase of Broken sand, the illuvial clay zone is nearer the surface, e.g., soils 9588 - 9593 represent such a profile derived from fine sandy loam alluvium in which eluviation of the clay has been to the 15 - 33 in. zone.

The Grahamvale sandy loam soils have developed from sandy loams under similar conditions to Broken sand, i.e., directly on the channel deposits where water movement has favoured rapid grading of the relatively coarse sediments. The type profiles indicate eluviation of clay to approximately 30 in.

The East Shepparton sandy loam profile 9572 - 75 has developed from sandy clay loam rather similar to 9576, with illuvial clay extending from 11 in. to 28 in.

Although sandy clays or lighter textures are always present in the lower subsoils of the Shepparton and Orrvale types, these soils have frequently developed from finer superimposed alluvium, e.g., soils 6565 - 7 are derived from light clay similar to soil 6568 and not from the lower sandy clay (6569). In these types the zone of illuvial clay is from about 9 in. to 25 in.

Light and medium clays, with leaching of clay to about 22 in., have resulted in Lemnos loam and Goulburn loam soils, while Goulburn clay loam and Congupna clay loam have also developed from similar alluvium but containing slightly more silt. Eluviation of clay in soils of the latter types probably has not been beyond 18 in. The rather narrow range in the composition of the parent alluvium providing the loam and clay loam types of the Shepparton, Orrvale, Lemnos, Goulburn, and Congupna series has been responsible for the prevalence of medium to heavy clays in the B1 horizons of these types.

The parent material of Congupna clay is a heavy clay with fine sand subordinate to silt. Leaching of clay has possibly been confined to the 5 - 12 in. zone.

Broken sand and Grahamvale sandy loam show no definite zone of calcium carbonate accumulation, although small amounts of about 0.02% are present throughout the profile. Slightly greater quantities are present in all the other types, with a slight but visible zone of accumulation of soft lime and rubble at approximately 30 in. Soft lime is rarely noticeable much below this depth, but odd rubble frequently occurs in the deep subsoil and substrata. Gypsum is absent except that small occlusions have been found in deep bores at about 18 ft.

2. Reaction.

Soil reaction (expressed as pH units) of all type samples is given in Appendix 3, while Table 7 shows the frequency distribution of these figures for four zones in the soil profile; the two light profile types are grouped separately.

The subsoil refers to the first sample from the B1 horizon, the lower subsoil to the approximate region 30 - 48 in., which includes illuvial calcium carbonate, and the deep subsoil from 48 - 72 in.

Table 7 - Frequency Distribution of Reaction Values of Soils.

	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
Light profile types[x]									
Surface			3	2	3				
Subsoil		1	2	2	2	1			
Lower subsoil		2		2	1	2	1		
Deep subsoil		1		1		2	2		
Other types									
Surface			5	11	7	1	1[Φ]		
Subsoil	1	2	3	3	5	7	3	1	
Lower subsoil					1	4	4	14	2
Deep subsoil							2	17	6

[x] Broken sand and Grahamvale sandy loam.
[Φ] Recently limed.

The surface soils are normally slightly acid to neutral, all falling within the range 6.1 - 7.4. Similar values are recorded in the lower zones of the light profile group of soils, although the range is extended slightly.

In the second group, the general trend is towards increased alkalinity with depth, as shown by median pH values of 6.8, 7.3, 8.5,and 8.7 for the four zones. The reaction of the subsoil varies over a wide range, viz., 5.1 - 8.6, Goulburn clay loam, Congupna clay loam, and Congupna clay contributing the more alkaline reactions. All lower subsoils and deep subsoils of this group are alkaline, falling into the ranges 7.4 - 9.1 and 8.2 - 9.2 respectively, indicating high metal ion saturation of the exchange complex.

Reactions are widely divergent in the substrata, but fall clearly into two groups. The highly alkaline values of the deep subsoils either persist, as in the series 6611 - 6626 to 29 ft., or there may be a rapid change to very acid reactions, as in the series 6598 - 6610 where the pH drops from 8.0 to 5.2 at 13 ft. 6 in. There appears to be no relation between reaction and texture in the substrata.

3. Nitrogen and Organic Carbon.

The organic material present in the surface of representative soils is shown by the individual figures for nitrogen, organic carbon, and carbon-nitrogen ratio in Appendix 3, and as averages based on surface texture in Table 8.

Table 8. Average Nitrogen and Organic Carbon in Surface Soils.

Surface texture	No. of soils	N %	C %	C/N
Sand	4	0.057	0.71	12.5
Sandy loam	12	0.074	0.85	11.5
Loam	12	0.089	1.12	12.5
Clay loam	3	0.103	1.28	12.4

Nitrogen and organic carbon values are of the normal order found in surface soils of Northern Victoria and show the usual increase with soil texture. The average C/N ratio is fairly constant for the different surface textures and indicates that generally the carbon nitrogen balance is favourable for nitrification of organic matter.

4. Hydrochloric Acid Extract.

Phosphoric acid, potash, lime, and magnesia in the hydrochloric acid extracts of soils of the main types are recorded in Appendix 3. These figures show that generally the soil types are fairly well supplied with these constituents.

Moderate amounts of phosphoric acid, varying from 0.057% in Broken sand to 0.136% in Goulburn clay loam, are present in the surface soils, and low concentrations in the subsoils. Actually, with the exception of Broken sand, there is a proportional relationship with clay content for all soil types, but at different levels for the surface soils and subsoils, viz., respectively, 0.0057 g. and 0.0006 g. of phosphoric acid per unit of clay; on this basis, the Broken sand soils are better supplied with phosphoric acid than the other types.

All the soils are well supplied with potash, while again there is a direct relationship with clay content, which in this case varies only slightly between the surface soils and the subsoils. The high values for potash in the subsoils of high clay content are evidence that potash-bearing minerals, such as feldspars, were present in the original parent rock material; since feldspars are practically absent now from the entire soil profile, this would indicate that the sediments, when deposited, were already highly weathered.

Although not high, the lime content of the surface soils is mainly in the exchangeable form, consequently these values vary directly with the clay content of the soils. Considerable replacement of calcium by magnesium results in lower values for lime in the hydrochloric acid extract of the subsoils than in the surface soils, except when significant amounts of calcium carbonate are present in the subsoil.

In all types magnesia increases to fairly large amounts from the surface to the subsoil following the trend in clay content.

5. Cations.

The exchangeable cations, exclusive of hydrogen, present in the surface and subsoils of representative profiles of the main soil types are given in Table 9.

Table 9 - Exchangeable Cations.

Soil Type	Soil No.	Depth (In)	pH	Clay %	Total Ex. Me. Ions[x]	% of total metal ions as			
						Ca	Mg	K	Na
Broken sand	6592	0-8	6.5	6.4	4.7	45	30	22	3
	6593	8-34	6.6	6.4	3.5	42	23	30	5
	6594	34-43	7.2	27.3	8.7	42	44	12	2
	6595	43-55	7.2	13.1	6.9	30	63	5	2
Shepparton loam	9617	0-4	6.8	12.9	9.7	55	29	14	2
	9619	7-24	7.0	47.8	19.3	51	37	8	4
	9621	30-38	8.9	27.2	14.4	37	41	14	8
Lemnos loam	6611	0-7	7.3	13.0	99	64	21	14	1
	6612	8-28	7.8	56.6	23.4	71	21	6	2
	6613	28-39	8.2	32.9	13.0	46	39	10	6
	6614	39-51	8.3	45.3	17.0	44	51	4	1
Goulburn clay loam	10088	0-8	7.3	25.7	14.2	79	12	7	2
	10089	8-21	7.5	47.9	18.7	41	43	10	6
	10091	34-44	8.4	41.1	16.9	25	62	6	7
	10093	66-90	8.7	42.2	17.3	16	60	12	12
Congupna clay loam	6598	0-8	7.0	22.5	13.3	67	25	7	1
	6599	10-34	8.0	47.3	19.1	33	54	8	5
	6600	34-50	8.7	45.3	25.2	26	51	11	12
Congupna clay	6309	0-5	6.5	34.6	13.0	38	44	12	6
	6310	5-29	8.6	60.2	30.6	36	46	7	11

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

Although exchangeable hydrogen has not been estimated, the reaction of the soils indicates that the absorbing complex of the surface soils is slightly unsaturated[x], while the subsoils and lower subsoils are either fully saturated or nearly so. The total exchangeable metal ions of these latter soils exhibit a close relationship with clay content for all types, viz., 43 m.e. per g. of clay, small deviations from this average value being due to slight variations in the degree of saturation of the clay. The constitution of the clay would therefore appear to be similar for all soil types. For the surface soils, the cationic absorptive capacity of the organic matter is added to that of the clay complex, consequently these soils, although not fully saturated, are at a relatively higher cation level than the subsoils.

Calcium is the dominant cation in all surface soils, except No. 6309, and in the subsoils of Broken sand, Shepparton loam and Lemnos loam; however, magnesium largely replaces calcium in the subsoils of the heavier Goulburn clay loam and Congupna clay types, and the lower subsoils of all types. Exchangeable potassium is present in average proportions in all soils except Nos. 6592 and 6593 in which higher values are recorded. Sodium is unimportant in all soils.

6. Soluble Salts.

Specific conductivity, as a measure of total water soluble salts, and chloride values are given in Appendix 3 for the representative profiles of the soil types. Chlorides are very low in all surface soils and subsoils, the greatest concentration with one exception being 0.016%. Slightly higher values occur in the heavier lower and deep subsoils, consequently moderate concentrations are present in some such samples of the Lemnos, Goulburn, and Congupna types.

Specific conductivity and total water soluble salts for a selected range of soils, together with more detailed analyses of the total salts, are given in Table 10. When considered on the basis of equivalent weights, the sulphate radicle is most frequently the dominant anion in the total soluble salts, although the chloride or bicarbonate anion is dominant in some soils. This variability in composition of the total salts results in an irregular relationship with specific conductivity, although as an approximation only, total soluble salts is given by specific conductivity x 330. On this basis, specific conductivity values (x 10^5) above 50 would indicate possibly injurious concentrations of salts. From this point of view, all profiles are satisfactory except Congupna clay series 6310 - 6312, and Lemnos loam series 9615 - 9616. Odd high values are recorded in restricted horizons of some other types.

Sodium is the dominant cation in the soluble salts of the samples analysed.

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[x] With reference to equilibrium with excess calcium carbonate. The pH of such soils is about 8.4.

Table 10. Analysis of Soluble Salts.

Soil Type	Soil No.	Depth (In)	K^x	Total soluble salts	Pp of 100,000 of air dried soil							
					Cl	SO_4	HCO_3	CO_3	Na	K	Ca	Mg
Broken sand	6593	8-34	3	32	2	4	5	Nil				
Grahamvale sandy loam	6284	0-6	8	30	2		7	“				
	6285	6-19	5	33	2		5	“				
	6286	19-40	4	26	3		5	“				
E. Shepparton sandy loam	6278	9-15	10	33	3	9	5	“				
	6772	28-49	25	76	20	17	12	“				
Shepparton loam	10073	0-6	14	57	9	16	18	“	4		4	3
	10075	11-20	31	92	7	37	5	“	16	10	4	5
	10078	40-60	34	95	18	24	34	“	33	7	11	3
Orrvale sandy loam	6297	14-26	9	48	3	13	5	“				
Orrvale loam	6567	8-23	10	41	4	15	5	“				
	6569	31-42	23	84	8	24	27	“				
	6638	0-6	6	30	1		5	“				
	6640	8-29	12	48	4		5	“				
	6641	29-38	17	55	10		8	“				
Lemnos sandy loam	6290	0-7	7	26	3		5	“				
	6291	9-19	9	32	3		7	“				
	6293	28-45	27	80	10		10	“				
	6294	45-72	37	127	27		42	“				
Lemnos loam	9612	0-6	9	19	2	12	7	“				
	9613	7-20	28	98	10	49	6	“	25	9	2	3
	9616	40-72	82	241	94	37	56	“	86	8	2	4
	6611	0-7	6	35	1	5	10	“				
	6612	8-28	8	50	3	9	15					
Goulburn loam	6271	0-7	8	22	4	12	8	“				
	6273	18-30	39	130	7	72	10	“	22	10	9	6
	6275	50-78	31	114	14	35	20	“	30	8	2	2
Goulburn clay loam	10092	44-66	35	133	34	25	23	“				
Congupna clay	9604	51-72	45	132	33	21	51	“				
Congupna clay loam	6627	0-6	14	43	2		29	“				
	6629	10-39	6	33	2		7	“				
	6630	39-84	15	45	4		17	“				
	6600	34-50	58	166	36	29	46	“				
Congupna clay	6309	0-5	15	33	2	38	8	“				
	6310	5-29	58	151	66	23	65					

^{x} K = Specific conductivity of 1:5 soil water suspension at 20^{o}C in mhos x 10^5

IV - SALINITY AND WATER PROPERTIES OF SOIL TYPES.

1. Soil Salinity.

Relatively few cases of definite injury to crops due to soil salinity have been reported, but the salt status of the soils generally has been examined during the survey. The results from 3,017 soils taken from all soil types and grouped in Table 11, show that 94% of the 1 - 2 ft., 81% of the 3 - 4 ft., and 83% of the 6 - 7 ft. samples record satisfactory figures of less than 0.05% salt (NaCl). Concentrations of salt higher than 0.05% are therefore mainly confined to the lower and deep subsoils.

Table 11 - Distribution of Salt (NaCl) with Depth in Soils.

Depth		1-2 ft %	3-4 ft %	6-7 ft[x] %
Proportion of	(<0.020%	72	56	64
soils with salt	(0.021 – 0.030%	12	11	10
	(0.031 – 0.040%	6	8	5
	(0.041 – 0.050%	4	6	4
	(0.051 – 0.075%	4	11	8
	(0.076 – 0.100%	1	4	5
	(>0.100%	1	4	4
Number of samples		627	1,675	75

[x] Including samples taken from 5 - 6 ft.

The figures in Table 11 suggest that generally there has not been re-distribution of salt throughout the soil profile as the result of irrigation.

Further examination of the higher concentrations of salt in each soil type is given in Table 12 by the proportion of soils at each of three depths in which salt exceeds 0.05%.

The level at which soil salt concentrations become toxic to the plant depends on the type of crop, including its physiological condition due to age and treatment, the texture of the soil, and the distribution of salt through the soil profile. Although a concentration of 0.05% of salt throughout the major portion of the root zone may produce toxic effects in the less tolerant crops, peaches, pears, and apricots probably tolerate concentrations up to 0.10% in the heavier soils.

Table 12 shows that apart from rather higher frequencies in Shepparton loam and Congupna clay, the 1 - 2 ft. zone of all types is generally free from injurious amounts of salt. This is not so, however, with the deeper horizons in which the trend is towards more frequent high concentrations in the heavier types. The effect of this situation on tree growth is that, although the lower subsoils of the Lemnos, Goulburn, and Congupna types very often contain moderate amounts of salt, the water properties of these soils are such that this salt is not brought into the root zone. This may not be the case in the East Shepparton, Shepparton, and Orrvale types in which ground water has developed, but these types are inherently less salty than the heavier types. Possibly due to the absence of high salt concentrations from the profiles of Broken sand and Grahamvale sandy loam, trees have not greatly suffered from the effects of water prevalent in the deep subsoils of these types.

Table 12 - Proportion of Soils for Three Depths of Each Soil Type in which Salt (NaCl) exceeds 0.05%.

Depth	1-2 ft %	3-4 ft %	6-7 ft %
Broken sand	0	3	0
Grahamvale sandy loam	8	0	6
East Shepparton sandy loam	5	5	7
Shepparton sandy loam	8	12	12
Orrvale sandy loam	9	10	18
Orrvale loam	5	20	21
Lemnos sandy loam	5	12	19
Lemnos loam	4	21	28
Goulburn loam	3	25	28
Goulburn clay loam	7	35	41
Congupna loam	0	35	17
Congupna clay loam	0	48	36
Congupna clay	15	52	-

The salt contents of 102 samples of subsoil water taken from various soil types at depths from 18 in. to 84 in. below the surface show the following distribution:-

% NaCl	<.05	.51 - .100	.100 - .200	.201 - .300	>.300
No. of Samples	87	5	5	4	1

With two exceptions, one being from a small salt pan, 29 samples taken from Broken sand and Grahamvale sandy loam soils record values below 0.05%. Low figures are also general for subsoil waters from East Shepparton sandy loam. The high recordings, therefore, fall almost entirely in the Shepparton and Orrvale types.

Whilst the death of trees in the district is rarely attributable to the effects of salt, there is some evidence that concentrations are occasionally sufficiently high for salt to be a contributing factor towards unthriftiness of fruit trees.

As compared with Murray Valley irrigation settlements experiencing salt problems, the Shepparton soils are inherently less salty, particularly the lighter permeable types, while the subsoils of the heavier types are sufficiently impermeable to inhibit localisation of salt by water movement. Most of the more obvious cases of salt injury have developed in conjunction with subsoil water, in the types of intermediate salt status, viz., Shepparton sandy loam, Shepparton loam, Orrvale sandy loam, and Orrvale loam. Generally however, the settlement has withstood the test of time with regard to soil salinity, and any further extension from the present situation would not be anticipated.

2. Water Properties of Soil Types and Relation of Drifts to Occurrence of Subsoil Water.

From the foregoing descriptions of soil types, it is evident that Shepparton soils cover a wide range of permeability to water. In Broken sand and Grahamvale sandy loam, water rapidly penetrates through the upper profiles and almost invariably forms water tables. On the other hand, the lower subsoils of the Lemnos, Goulburn, and Congupna types are always relatively dry, even after irrigation, but water may lie on the surface of these soils for long periods. These conditions in the soil types just mentioned reflect the high degree of impermeability characteristic of the majority of the subsoils of the Shepparton district; because of this feature, water tables have not developed over large areas as they have in many other irrigation districts.

Lower subsoils of the East Shepparton, Shepparton, and Orrvale types are capable of becoming water-logged, but the presence of ground water in these types depends mainly on their situation. When in proximity to Broken sand or Grahamvale sandy loam, water is usually present due to underground seepage from the drift types through the pervious lower horizons. This rarely extends laterally for more than a chain or two. Such water is usually below the root zone of the tree, although it may fluctuate with the water level in the adjoining drift. When situated away from the influence of underground water, the lower subsoils of the Shepparton and Orrvale types are normally dry, since the subsoils of these types as a rule do not readily allow downward penetration of free water from the surface. Light profile phases, and areas of Orrvale sandy loam and Orrvale loam of poor surface drainage, are exceptions.

Because water penetration is rapid through the surface and sub-surface, and is then frequently impeded by the clay subsoil, temporary water-logging above the latter zone may occur in many soils, but particularly in the deep surface phases of East Shepparton sandy loam, Shepparton sandy loam, Orrvale sandy loam and Lemnos sandy loam. Although this water may be regarded as a very much perched water table, these conditions are not comparable with those due to the relatively more permanent ground water occurring in the drifts. It must be recognised, however, that even the latter represents a perched water table, as impeding clay substrata are usually encountered before 20 ft.

It is apparent from the nature of the soil types generally, that many of the so-called water tables observed in the wet season of 1939 were of the surface and temporary type, permanent only in so far as abnormal weather conditions did not allow evaporation or drainage of the saturated surface. Observation of the water level in bores, as indicating free water conditions in the soil, must be interpreted with caution. Bores in soils suffering from surface water-logging will readily fill with water draining downwards from the saturated surface, but this does not necessarily indicate a saturated subsoil; actually, the retentive sub- soil may cause water to remain in such bores long after free water has disappeared from the surface. In other cases, such as in relative depressions associated with the drifts, water may be constrained at depth in porous strata below more or less impervious layers, but will rise considerably in the bore when the pressure is released.

Drifts. The origin and fluctuation in level of the water in the drifts and in adjoining soil types, has been investigated in considerable detail by means of systematic observation of permanent test wells. These were installed prior to irrigation in 1941, and readings continued into the irrigation season of 1942 - 43. Only the more important data from this section of the work are presented in Table 13. This shows fluctuations in the ground water level at critical periods for six widely separated locations (see Fig. 2), along drift No. 1 in Shepparton East and Orrvale.

The soil type is Broken sand throughout.

Table 13 - Water Table Readings in Inches from the Surface at Critical Periods for Six Locations in Broken sand.

Well No.	Location	Aug. '41 before channels filled	Oct. '41 after channels filled	Irrigation Period (Nov. '41 to Mar. '42)		Aug. '42 before channels filled	Oct. '42 after channels filled
				Highest	Lowest		
5	Allot	105	83	82	57	65	69
8	Allot 108	51	51	30	41	41	41
12	Allot 109	76	62	49	64	64	53
17	Allot 60	77	61	54	62	62	57
20	Allot 38	87	80	52	62	77	70
24	Allot 61A	75	52	45	54	56	50

The figures in column 3 of Table 13 indicate that water levels were generally low during the winter of 1941, variation in depth from the surface depending to some extent on local variations in surface contour. This is exemplified by wells Nos. 5, 8,and 12, No. 8 being approximately midway between Nos. 5 and 12 which are about 3/4 mile apart.

Surface contours are 394.5 ft., 391.3 ft., and 392.0 ft., respectively, whereas the corresponding reduced water levels are respectively, 387.5 ft., 387.0 ft., and 385.7 ft., showing a slight gradient in accordance with the general fall of the country.

The figures in column 4 show the alteration in ground water level due to the filling of the channel system in 1941. They represent readings when the channels were fairly full, but before any widespread irrigation had commenced, and certainly before irrigation at each particular location. Actually, readings were made every few days from the time when water first entered the channels. The effect on the wells was usually noticeable immediately by a rise of 2 – 3 inches. As the head of water in the channels increased, so did the level of water in the wells rise. Wells Nos. 5 and 8 were not affected by the filling of the channels, presumably because the No. 1 drift was not intercepted by a channel containing water to the east (at a higher contour level) of No. 5 well; and the increased head in the subsoil water at No.12, due to an adjacent channel, was still insufficient to overcome the pressure gradient of 1.3 ft. between Nos. 8 and 12.

The general effect of irrigation at the various locations is shown by the figures in column 5. Although most wells were still rising slowly, commencement of irrigation at the actual location of the wells produced a further sharp rise, following which, levels usually fell slowly until the next irrigation. The range between which the wells fluctuated after irrigation had commenced, is given by columns 5 and 6, the highest readings usually being recorded in December, and the lowest at the end of February. Levels at five of the six locations illustrated, fluctuated within the zone 4 ft. to 5 ft. 6 in., from the surface, and apparently the trees benefit rather than otherwise from these seemingly normal summer conditions, since peaches and apricots at these locations are growing vigorously; however, considerations of ripening and quality of fruit are also involved. At well No. 8 present conditions are unsuitable for the best growth of fruit trees. Although the very high water table established in Nov. 1941 was due to irrigation of tomatoes, the area is also under young apricots, which will require careful irrigation to prevent an undue rise in the present high water table.

The winter of 1942 was considerably wetter than that of 1941, and water remained in the channels for longer periods. In addition, the Goulburn River was nearly at flood level for two weeks in July, and again for six weeks from mid-August. It is possible that this state of the river may have impeded natural drainage from No. 1 drift. These factors contributed to higher water tables in August 1942 than in August 1941, as shown by comparison of the figures in column 7 with those in column 3, while column 8 shows that the filling of channels in 1942 caused a slightly smaller rise in the test wells than in 1941, although the nett result was higher water tables when irrigation commenced.

In July 1942, additional wells were installed on Nos.2 and 3 drift lines. Within the irrigation area, ground water in these drifts was frequently at less than 4 ft. from the surface, but was below 7 ft. to the eastward of the settlement. Filling the channel network did not affect some of these wells, including those outside the irrigation area, but in other cases, brought the water table to within 2 ft. of the surface. For example, in July, water levels in wells Nos.35, 36, and 37 (Fig. 2) were respectively, 114 in., 96 in., and 41 in. from the surface, while in October these were respectively 114 in., 94 in., and 23 in. The corresponding reduced water levels in July were 385.0 ft., 386.1 ft., and 389.0

ft., showing a downward gradient from west to east. Any flow at this time, therefore, would be from the settlement towards the east against the natural fall of the country. Progressing eastward from well No. 35 along No. 3 drift, the ground water level gradually became deeper from the surface, reaching 14 ft.6 in., after 1¼ miles. Still further eastward from this point, the drift links with the Benalla Rd., sand pits which are dry to the clay bottom of the drift at about 17 ft. These facts indicate the irrigation water of the settlement as the source of water in this drift in normal seasons. That this is the case also in the No.1 drift, was shown by the ground water levels in 1941 - 2, which were much lower in the non-irrigated country eastward of the settlement, compared with those within the irrigated area. In addition, at the intersection of the Broken River and this drift (Fig. 2), slight seepage from the drift at 17 ft. below the surface into the river showed water movement to be away from the settlement towards the east.

From these observations, it would appear that the drifts do not carry water into the settlement in normal years; however, since water can readily accumulate in their continuous strata of loose sand and gravel, which have a natural gradient from east to west, it could be possible for movement of underground water to take place in this direction under certain conditions. From the evidence available, it is impossible to state whether this happened to any degree in the wet seasons of 1931 and 1939; but in any case, it could only have been a contributory factor to subsoil water already present.

V - HORTICULTURAL SITUATION IN RELATION TO SOIL TYPES, IRRIGATION AND DRAINAGE.

As the result of over thirty years' experience, district practice in orchard planning follows a definite system based on soil requirements of the different varieties, but also giving due regard to rational balance in plantings. Distribution of varieties is necessary, not only to spread risk, but to provide a sequence of orchard operations involving the most economical use of labour available. Few orchards consist entirely of uniform soil suitable for every variety. Most include several soil types, ranging on the surface from sandy loams to clay loams. The general practice is to use the sandy loams for peaches where possible, as these are recognised as most exacting in their soil requirements; the intermediate loam soils for apricots, although they grow well over a fairly wide range of soils, and the heavier depression soils for the less exacting varieties such as pears, plums, and quinces. This distribution has provided a satisfactory basis for plantings under normal conditions, and when interpreted in terms of the described soil types, shows the following relationships:-

The soil type classed as East Shepparton sandy loam is ideal for peaches and has produced the highest yields in the district, but unfortunately represents only 4.2% of the area. Peaches grown on the Broken sand and Grahamvale sandy loam types produce big trees and yield well with fruit of good size, while Shepparton sandy loam and Lemnos sandy loam are also suitable peach soils. Deep surface phases of these types give better growth than the normal types. The influence of soil texture on the size of peach trees, in fact of all fruit trees, is frequently very noticeable in rows planted across changes of soil type by the decreasing size of the trees with increasing texture of the surface soil. When orchards do not include sufficient sandy loam types, peaches of necessity are planted on heavier soils. Although the trees are smaller, satisfactory crops are usually obtained on Shepparton loam and Lemnos loam. Clay loam types are definitely unsuitable for peaches, while the drainage difficulties usually associated with Orrvale sandy loam, Orrvale loam, Goulburn loam, and Congupna loam have been responsible for such failures with peaches as have occurred on these soil types.

Apricots have, generally, similar soil requirements to peaches and are suited to the above soil types; however, they tolerate a slightly wider range of soil conditions, being grown very successfully on Shepparton loam and Lemnos loam. As they are gross surface feeders, they do particularly well where there is a fair depth (12 in.) of surface soil.

Pears and plums thrive on all the soil types except Congupna clay, and although some growers state a preference for heavy soils for these crops, this is largely a matter of necessity rather than preference. Pears on sandy loam soils grow into very large trees, making picking and spraying operations difficult, but yield as well, if not better, than trees on heavy types. However, their greater tolerance of excessive water is the main factor that makes them suitable for the poorer drained soil types, such as Goulburn loam, Goulburn clay loam, and Congupna clay loam, in which they are largely and successfully grown. Congupna clay is considered an unsuitable horticultural soil, even for pears.

The losses of trees in 1931 and 1939 led to the belief that the above relations between tree variety and soil type were not entirely satisfactory for peaches and apricots. Excessive moisture in the root zone during the winter period, due to inadequate removal of surface water accumulated as a result of abnormal seasonal conditions, had been established previously as the cause of death of fruit trees (Report 1931). The recurrence of tree losses in 1939 in relation to the water properties of the soil types now described has confirmed this finding in most cases. Nevertheless, water rising from below may have contributed to injury in the following instances:- The drift soil types, Broken sand and Grahamvale sandy loam, undoubtedly act as underground reservoirs of water, normally derived from channels and irrigation within the settlement, there being no evidence today that any subterranean flow contributes to this water. Probably during 1931 and 1939, in Broken sand and Grahamvale sandy loam soils, the high rainfall was sufficient to raise this water nearly to the surface and, in such cases, contribute to the death of trees. Water from the drifts usually appears only in the deep subsoils of adjoining East Shepparton, Shepparton, and Orrvale soil types, but, with added water in the drifts, this ground water may have risen within the root zone of the trees; consequently deep subsoil water may have contributed to some cases of water-logging in such marginal soils of these soil types. In general, this lateral movement of water below the immediate subsoil, which occurs freely within Broken sand and Grahamvale sandy loam, soils, is not a serious factor in the East Shepparton, Shepparton, and Orrvale types, and does not occur at all in soils of the Lemnos, Goulburn, and Congupna series.

Table 5 shows only 722 acres of drift in the whole area of 17,820 acres. Of this, a considerable portion, mainly Grahamvale sandy loam, is not under fruit trees, and water in the drifts below soils of the Shepparton and Orrvale series, in most cases, would not rise sufficiently into the heavier subsoils of these types to be the sole cause of death of the trees. Trees grown on the usual pronounced rises of Broken sand were unaffected; however, there were losses on the relatively low occurrences of this type, and also on the planted areas of Grahamvale sandy loam. Although severe losses were incurred on these two soil types, they amounted to a relatively small part of the total trees lost in the district.

By far the greatest aggregate of trees were lost on soils with impeded free downward movement of water, and not under conditions of a rising water table. Excepting in the Broken sand and Grahamvale sandy loam types, the subsoils are all of the clay pan type in which there is a sudden change from a surface soil of relatively low, to a subsoil of high water holding capacity. These subsoils, however, do not absorb water quickly, and even when eventually wetted restrict downward movement of water. In addition, surface slope is usually slight. Consequently conditions are favourable for accumulation of water and saturation of the surface, particularly in winter when evaporation and transpiration of moisture is negligible. These adverse conditions are intensified with increased depth of surface, as in the deep surface phases. The severity of tree losses experienced by each grower, therefore, has been dependent mainly on varying combinations of these several factors, viz., texture of soil, depth of surface soil, and nature of surface drainage at the time. Naturally, losses have been heaviest on the sandy loam types, as these are practically planted only with peaches; but these types also tend towards greater depth of surface, even in the normal type, besides providing most of the areas occurring as deep surface phases. In these soils, a considerable part of the root zone of the tree tends to fill with water, although, owing to their generally high elevation, water may not be present on the surface. The anomaly of peach and apricot trees surviving in the presence of surface water on the relatively heavier types such as Shepparton loam and Lemnos loam, and even on the lower lying Orrvale loam and Goulburn loam, is explained by the shallow nature of the surface of most of these soils and the fact that sufficient roots are established in the clay subsoil, out of range of saturated soil conditions, for the trees to survive temporary water accumulations. However, prolonged flooding resulted in death of peaches and apricots on these soil types.

Although differentiation of the soils into types is partly based on relative elevation, and therefore provides a natural division of the soils into types of good and poor surface drainage, local conditions at the time have frequently determined the adequacy of water removal, with consequent effect on the health of the fruit trees. Therefore, although peach tree losses have been particularly heavy on the naturally poorly drained, but texturally suitable Orrvale sandy loam, losses have also occurred, but to a lesser extent, on the normally well drained East Shepparton sandy loam soils in cases where surface slope has been critical. This has been particularly so on the few lower areas of East Shepparton sandy loam recorded as "greyer profile." Similarly, trees have died on Shepparton sandy loam where surface drainage has been ineffective.

Factors involving orchard management have contributed to tree losses. Inadequate provision for surface drainage has been the main factor, but this has not always been within control of the orchardist. Drainage of some of the deep surface soils is difficult, if not impossible, owing to the natural tendency for the upper layers of these soils to fill with water even in the elevated occurrences. Where ploughing was delayed, wet conditions developed before drainage furrows could be opened out. In such cases, the usual thick summer growth of grass remained as an added obstruction to the removal of water; generally, losses were less severe where these operations had been completed. Thus the importance of ploughing and providing drainage furrows as soon as possible after picking operations have ceased is apparent.

The abnormal rains commenced in March 1931 and in February 1939, immediately on top of irrigation. Soils, therefore, had very little opportunity to dry out in late summer and autumn. Careful control of water in the latter part of the irrigation season would help to minimise these effects.There is some evidence that heavy watering of tomatoes grown between the rows of young trees contributed to losses in this way. Although many fruit-growers find this practice necessary, the risk taken, particularly on light soils, should be realised.

Following losses of peaches and apricots in 1931, most growers replanted with the same varieties. These trees, and in addition trees in areas previously unaffected, were lost in 1939. Where large blocks of trees died, replanting since has been mainly with pears; where losses were confined to a relatively few trees, replacements frequently have been with the variety lost. Some orchardists have adopted the safest principle of replanting all losses with pears or plums, irrespective of location, but the disadvantage of mixing varieties is obvious. The present position, therefore, is that most affected areas, have been either replanted with pears, or left unplanted. Consequently, for this reason, further losses of peaches and apricots on the scale of 1939 are unlikely, although two new factors may operate in future very wet seasons. Firstly, the ability of pears to withstand continuous water-logging in light soils, whilst undoubtedly greater than peaches and apricots, is not unlimited. Secondly, in order to maintain a sufficient acreage of peaches and apricots, orchardists are increasing plantings on the heavier soils, mainly Lemnos loam and Goulburn loam. Since surface drainage of these intermediate and lower lying soil types is often defective, the opportunity for substantial losses still exists unless full attention is given to providing drainage facilities for the adequate removal of surface water.

The suitability of the various soil types for peaches and apricots may now be summarised as follows:- No one soil type is reliable under all conditions, but certain types are more likely to prove unsatisfactory. These are Grahamvale sandy loam, Orrvale sandy loam with its deep surface phase, and the light profile depressions, which are all light types with poor surface drainage; and to which may be added the low lying and texturally unsuitable types, Goulburn clay loam, Congupna loam, Congupna clay loam, and Congupna clay. Texturally, the most suitable types are East Shepparton sandy loam, Broken sand, Shepparton sandy loam, and Lemnos sandy loam in that order. However, local conditions for adequate surface drainage govern their suitability, and particularly the suitability of their deep surface phases. The few small areas of East Shepparton sandy loam marked "greyer profile" should not be planted with these varieties. Although yields are lower than on the lighter types, peaches and apricots can be grown satisfactorily on Shepparton loam and Lemnos loam, and these are probably the most reliable soil types under adverse climatic conditions. Orrvale loam and Goulburn loam are generally unsuitably situated, and should only be used for peaches and apricots when provision can be made for removal of possibly large amounts of surface water.

Table 4 shows that a maximum of 4,200 acres of the total area of 17,820 acres - 8,620 acres of which are not under fruit trees - may be classed as sandy loam types suitable for peaches and apricots; while a further maximum of 3,160 acres of loam soils are generally satisfactory for these varieties. In consequence of the many factors operating, it is not possible to estimate the actual area considered suitable and available for these varieties. The above total of 7,360 acres would certainly be considerably reduced, even after allowing for an additional area of plantings in the more suitable locations of the doubtful Goulburn loam and Orrvale loam types. The present area of peaches and apricots in all soil types is approximately 5,174 acres. Assuming that this does not include any great area of the unsuitable soil types, it is seen that the margin for future expansion of these varieties within the settlement is not large. Therefore, in order to maintain a satisfactory acreage of peaches and apricots, it becomes necessary to consider measures to reduce future tree losses to a minimum on the soils recommended as suitable, most of which are already planted with these varieties, rather than to plan large scale plantings on new areas. The question is largely one of water usage, involving water supply and irrigation practices, together with the inseparable problem of drainage.

Supply of water throughout the area is practically entirely by earthen channels. As a whole, these have proved satisfactory, although in some few cases, erosion of the banks and water losses have been so severe that concrete supply channels were found necessary. An attempt to minimise seepage losses was made by lining affected parts of the channels with a thin concrete on heavy paper, but this has proved unsatisfactory and the practice has been abandoned. Later, open intercepting drains about 6 ft. deep were installed, adjacent and parallel to main channels where seepage was severe. These seepage drains connected with the ordinary surface drainage system of the area. They proved effective in that they reduced water levels in headland soils; however, they suffer from the following disabilities:- For the drains to be effective, the seepage water must have a rapid get-away, otherwise the drain fills with water and merely functions as a subsidiary channel. Therefore, it is essential that weed growth and siltation over all sections of the drains be removed frequently, although this leads to very high maintenance costs. Usually a considerable length of drain necessarily passes through soils themselves not subject to seepage in order to tap the affected area, so adding to these costs. In some cases, continual collapse of the walls has made functioning of the drains impossible. Maintenance of seepage drains has now generally ceased, and in some cases, the drains have been filled in; unless whole sections are treated, this may cause further banking of water in upper parts of the seepage drain, and in so doing, may accentuate seepage into adjacent headlands of light soil type.

Some growers have attributed tree losses to seepage from channels, when examination of the water properties of the soil types concerned, shows that seepage would be impossible. Severe seepage from channels is considered possible in Broken sand, Grahamvale sandy loam, and East Shepparton sandy loam types. It has also been observed in light profile variation of Shepparton sandy loam due to the bed of the channel resting in the pervious sandy clays of this type; however, seepage usually does not occur in the normal Shepparton sandy loam type. Where channels cross deep surface phases of any soil type, or are built well above the natural surface of the soil, seepage occasionally occurs when the channels are full. The extent of seepage in the district is magnified by the fact that the Broken sand and Grahamvale sandy loam types are situated on the higher contours. Frequently, a main channel repeatedly crosses a drift type with the result that seepage is apparent at intervals over long stretches of the channel, without extending into adjoining soil types. The situation of all supply channels is shown on the soil map, and this should aid in locating the exact source of seepage water.

It has been shown in Section IV that application of irrigation water to the land itself has contributed to existing ground water in the light soil types. Not only for this reason, but also to provide as far as possible optimum soil moisture conditions for the growing plant, it becomes important for the individual grower to examine his irrigation methods in relation to the water properties of his soil types, and to the crops grown. An ideal watering is one that supplies just sufficient water to raise the soil moisture within the root zone of the plant from wilting point[x] to field moisture capacity[x]. An ideal system of irrigation, therefore, provides for periodical applications of water coinciding with reduction of soil moisture by the plant to the vicinity of the wilting point. But many factors, among which are soil type, fall of the land, length of run, and method of application of water, make attainment of this ideal system difficult in practice. Broad principles only, and in so far as they relate to the soil types, are offered here as a guide for better irrigation. Textural differences of the soil types are responsible for differing water properties; hence, some types require different treatment at irrigation. Obviously, in a district such as Shepparton with rapid soil changes, separate irrigation of the individual soil types is impossible, nor is it necessary. However. widely differing soil types should not be irrigated together. For instance, Broken sand or Grahamvale sandy loam frequently occurs on headlands above Shepparton sandy loam and Shepparton loam. Irrigation of these soils in the one run invariably results in over saturation of the higher light type before the lower soils are watered adequately. In such cases, the temporary head ditch should be made to skirt the drift type if possible. The practice of locating these ditches in either Broken sand or Grahamvale sandy loam is particularly conducive to waterlogging of these types. Unfortunately, the location of the head ditch in these soil types is often unavoidable because of their high situation., Concreting the affected section is recommended where the ditch can be installed permanently. Failing this, rapid irrigation of these soil types with large streams will give the best economy of water provided the irrigation run is not more than several chains. Generally, East Shepparton sandy loam and deep surface soils also should

[x] See Appendix for definition

be irrigated in short runs and apart from other soil types. Normal soils of the Shepparton, Orrvale, Goulburn, and Congupna series usually occur in associations that do not require differential watering of the soil types providing irrigation runs are not abnormally long. The longest runs can be used with the heaviest soil types, but control of water generally becomes inefficient with runs longer than 8 chains.

Late irrigations and the watering of vegetables between young fruit trees, in relation to adverse soil moisture conditions have been referred to previously.

The conditions under which excessive water may accumulate in the soil have been indicated, together with some suggested methods to minimise this trouble. Of these, drainage is all important. Surplus irrigation water in the district occurs in two forms, viz., as underground, and as surface water, both of which may be increased by abnormally heavy rains. The present district scheme, except for the seepage drains, is designed to cope with surface water only. The capacity of this scheme has to be such that the semi-flood conditions, known to occur periodically, can be relieved quickly, otherwise drainage within the orchard becomes ineffective with detriment to the health of the fruit trees. It is useless educating growers on internal orchard drainage unless full facilities are available to put the methods into practice under the severest conditions. Given the necessary district scheme, it is incumbent upon the orchardist to take full advantage of the facilities provided by attending to drainage details every year, and not waiting to be caught by the weather when it may be too late.

Any project to deal with underground water will require careful consideration. The survey has shown that the soil types mainly affected, i.e., Broken sand and Grahamvale sandy loam are small in aggregate, although widely spread. The ground water level in many of these soils is sufficiently high to be harmful at all times, and in others, although trees may not be affected, would rise rapidly under adverse conditions. It is not sufficient to attempt to deal only with the individual areas of Broken sand and Grahamvale sandy loam that are obviously affected, since their deeper subsoils are such that water may move freely from one point to another. However, some of the few instances of detrimentally high water tables in soil types other than Broken sand and Grahamvale sandy loam may respond to individual treatment. Steps taken to prevent entry of excess water into the soil may prove sufficient, provided there is co-operation amongst the community as a whole. Concrete lining of channels at points shown by the soil survey will only be partly effective, unless growers themselves control the applications of water on light soils by the methods indicated previously. In this, vegetable growers and pastoralists irrigating on Broken sand and Grahamvale sandy loam are equally concerned.

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APPENDIX I. - Soil Terms and Definitions.

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.
B_1 - A zone of accumulation of some materials, chiefly clay, from A1 and A2 horizons.
B2 - A zone of accumulation of calcium carbonate leached from upper horizons.
C - A layer representing unchanged material from which the above horizons have formed.

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.

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

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.

A phase is a modification of a soil type in which one feature is accentuated without altering the main profile form. The most important phase in the soil types described is that in which the depth of surface soil is greater than normal.

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.

Lime is calcium carbonate and may occur both in a soft form and in concretions described as rubble.

Buckshot is more or less rounded ferruginous concretions varying from shot to marble size.

The wilting point of the soil is the moisture content at which the soil is no longer able to supply moisture sufficiently rapidly to the plant to replace losses by transpiration. Loss of turgidity results and the plant wilts, even when placed in an atmosphere saturated with water vapour, and does not regain turgidity unless water is added to the soil. This point is a characteristic of the soil and is related to the soil colloids present. It, therefore, varies directly with soil texture.

The field moisture capacity is the moisture content of the soil following attaining of equilibrium by natural drainage after thorough wetting under field conditions. Any excess water over field moisture capacity, added by rain or irrigation, if not removed by drainage or deep penetration into the soil, may detrimentally affect vegetation. Field moisture capacity is also related to the colloids present in the soil and increases directly with soil texture.

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.

Soluble Salts. These were determined in a 1:5 soil-water suspension shaken for one hour and filtered through a Chamberland filter. Aliquots of the extract were used to determine:- total salts, by drying to constant weight at 130°C.; sulphate, by weighing as barium sulphate; calcium, by titration of the oxalate; magnesium, by weighing as magnesium pyrophosphate; potassium, by precipitation as chloroplatinate and weighing as platinum; sodium, by weighing as sodium uranyl magnesium acetate; bicarbonate and chlorides by direct titration.

Chlorides. These were determined by Best's electro-metric titration method (Best, 1939). 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.

Nitrogen. This was determined by the Kjeldahl method.

Organic Carbon. The wet combustion method of Walkley and Black (1934) was used, substituting phenyl anthranilic acid for diphenylamine as indicator. Results have been multiplied by an average recovery factor of 1.32 determined from the estimation of organic carbon in several representative soils by the dry combustion method.

Hydrochloric Acid Extract. Determinations were made on the extract obtained by boiling 30 g. of soil with 150 ml. of hydrochloric acid (3.G. 1.115) for 2 hours. Potash, lime, and magnesia were determined by the above methods, and phosphoric acid by separation as ammonium phosphomolybdate and weighing as magnesium pyrophosphate. Results are expressed as % of air dried soil.

Exchangeable Cations. After leaching with 40% alcohol to remove soluble salts, the soils were extracted with normal ammonium chloride to obtain the exchangeable cations. Potassium and sodium, and also calcium and magnesium in soils with calcium carbonate less than 0.3k were determined by the above methods on aliquots of the leachate. The values for exchangeable calcium have been corrected for calcium present as carbonate, as determined by Hutchinson and MacLennan's method. In a few soils with calcium carbonate contents greater than 0.2%, the effect of calcium and magnesium soluble in the leaching solution was corrected for by double extraction, using normal sodium chloride instead of normal ammonium chloride for the exchangeable calcium and magnesium determinations. The exchangeable metal ions are expressed as a total in milli-equivalents per 100 g. of air dried soil, and individually, as percentages of the total.

APPENDIX 3. - Mechanical Analyses and other Data for Shepparton Soil Types.

Gravel and buckshot are expressed as percentages of the field samples and specific conductivity as reciprocal ohms x 10^5 while all other figures except those for depth, reaction, and C/N ratio are percentages of air dried soil passing a 2 mm. sieve.

The following abbreviations are used to describe field texture:-

S -sand,
LS - loamy sand,
CS - coarse sand,
FS - fine 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, HC - heavy clay, Cl - clayey,
Gr - gravel or gravelly,
Si - Silty,
(S) - sandiness apparent, as applied to light and medium clay.

TYPE	BROKEN SAND ∅					BROKEN SAND ∅						BROKEN SAND ∅					
Soil No.	9567	9568	9569	9570	9571	9588	9589	9590	9591	9592	9593	9624	9625	9626	9627	9628	9629
Depth (in.)	0-5	6-17	21-27	27-35	35-48	0-6	6-15	15-18	18-26	26-33	58-68	0-4	4-7	7-15	15-27	27-42	42-54
Texture	S	S	SCL	SCL	FS	S	S	SC	SCL	SL	S	S	SL	SCL	ClS	ClS	S
Gravel	Tr	Tr.	-	-	41.3x	-	-	-	-	-	-	3.8	4.4	11.5	17.0	16.6	16.5
Coarse sand	37.7	33.9	15.0	10.9	5.4	10.4	9.6	6.5	6.3	7.5	38.1	44.6	44.0	41.6	49.3	52.8	48.3
Fine sand	46.7	52.2	47.8	51.5	58.0	65.6	67.2	50.2	52.3	54.1	43.0	31.9	34.6	28.9	25.2	18.9	24.9
Silt	6.9	7.3	8.1	6.9	9.2	14.9	14.9	13.1	15.6	13.0	4.7	12.1	11.8	10.2	7.8	6.3	7.0
Clay	5.3	4.8	26.5	26.4	15.0	8.8	8.3	27.9	24.1	22.6	13.5	9.1	9.9	17.5	13.6	17.6	18.0
Moisture	0.6	0.3	2.2	2.6	1.7	0.6	0.4	1.9	1.6	1.7	1.5	0.9	0.6	1.1	1.0	1.4	1.5
Loss on acid treatment	0.5	0.3	0.4	0.5	8.6	0.5	0.2	0.5	0.5	0.4	0.2	0.5	0.2	0.4	0.3	0.3	0.8
Loss on ignition	1.8	1.0	2.9	3.0	4.6	2.0	1.1	3.0	2.7	2.5	1.7	2.7	1.3	1.9	1.5	2.0	2.0
Calcium carbonate	.01	.01	.01	.02	10.2	.03	.01	.02	.01	.02	.02	.03	.02	.01	.02	.02	.02
Specific conductivity	12	6	11	11	22	26	10	15	15	11	7	11	4	8	7	8	7
Chlorides (Cl)	.001	.001	.008	.008	.010	.011	.005	.008	.010	.010	.003	.002	.001	.002	.003	.004	.001
Nitrogen	.044					.053						.086					
Organic carbon	.66					.56						1.09					
C/N ratio	15.0					10.6						12.7					
Reaction (pH)	7.3	7.6	7.6	8.1	8.9	6.8	6.7	6.1	5.4	5.6	8.0	7.2	7.8	7.4	7.3	7.7	7.4

∅ Shallow phase.

x Sand cemented with calcium carbonate.

SOIL TYPE	BROKEN SAND						GRAHAMVALE SANDY LOAM x						GRAHAMVALE SANDY LOAM.					
Lab. No.	6592	6593	6594	6595	6596	6597	9606	9607	9608	9609	9610	9611	6284	6285	6286	6287	6288	6289
Depth (in.)	0-8	8-34	34 -43	43 -55	55 -70	70 -90	0-6	6-11	11 -22	22 -34	34 -51	51 -60	0-6	6-19	19 -40	40 -55	55 -74	74 -90
Texture	S	S	SCL	SL	CS	CS	L	FSCL	FSC	MC	SC	SCL	SL	SCL	SL	ClS	S	CS+Gr
Gravel	2.0	4.8	2.4	3.6	11.3	14.0	0.7	0.7	1.4	2.2	4.5	11.9	1.0	2.0	2.2	4.8	4.8	21.2
Coarse sand	31.6	38.6	20.3	33.4	65.6	80.4	8.4	8.3	8.5	14.2	26.6	39.6	20.8	20.6	43.5	51.4	69.7	92.0
Fine sand	51.6	46.3	42.8	46.3	26.5	10.5	44.2	43.6	38.6	27.7	33.1	31.9	45.5	43.7	32.1	28.4	18.7	2.9
Silt	8.2	6.0	6.2	5.1	1.5	2.3	24.3	25.2	22.4	20.3	14.6	15.1	18.5	15.2	8.7	6.7	4.5	2.0
Clay	6.4	6.4	27.3	13.1	4.2	5.3	17.6	21.9	29.1	35.9	24.0	12.9	12.6	20.0	14.7	11.7	5.8	3.0
Moisture	0.5	0.6	2.1	1.1	0.2	0.8	1.2	1.2	1.5	2.3	1.5	0.6	0.9	0.8	0.9	0.6	0.4	0.4
Loss on acid treatment	0.4	0.3	0.5	0.1	0.2	0.2	0.7	0.4	0.4	0.6	0.6	0.6	0.9	0.3	0.2	0.1	0.3	0.0
Loss on ignition	1.9	1.0	3.1	1.7	0.7	0.8	3.3	2.7	3.0	3.4	2.4	1.5	2.8	1.6	2.2	1.4	0.9	0.4
Calcium carbonate	.01	.01	.01	.01	.01	.00	.02	.02	.02	.02	.02	.01	.00	Tr.	.01	Tr.	Tr.	Tr.
Sp. conductivity	6	3	5	7	5	67	12	10	16	21	15	10	8	5	4	4	2	2
Chlorides (Cl)	.002	.002	.002	.005	.001	.060	.009	.005	.009	.016	.010	.006	.002	.002	.003	.005	.001	.001
Nitrogen	.043						.087						.066					
Organic carbon	.54						.81						.72					
C:N ratio	12.6						9.3						10.9					
Hydrochloric acid extract P_2O_5	.057	.031	.050															
K_2O	.111	.114	.468															
CaO	.090	.074	.132															
MgO	.132	.119	.304															
Reaction (pH)	6.5	6.6	7.2	7.2	7.9	7.6	7.4	7.1	6.9	7.9	7.9	7.7	6.4	6.8	6.9	6.8	6.9	7.1

x Heavy profile.

SOIL TYPE	GRAHAMVALE SANDY LOAM x						GRAHAMVALE SANDY LOAM ø					
Lab No.	6303	6304	6305	6306	6307	6308	10067	10068	10069	10070	10071	10072
Depth (in.)	0-5	5-16	16-30	30-49	57-70	70-90	0-4	4-9	9-22	26-47	69-83	83-110
Texture	SL	S	SC	SCL	LC	MC	L	CL	SCL	S	S	08
Gravel	0.7	1.4	4.8	8.1	-	-	2.5	3.9	3.6	9.7	12.5	15.6
Coarse sand	17.6	24.6	26.9	40.5	17.4	15.7	18.0	21.2	23.1	48.7	67.8	89.9
Fine sand	56.3	56.[illegible]	37.9	35.1	24.5	25.0	36.7	36.1	36.9	29.2	19.9	4.5
Silt	15.7	13.8	9.9	8.1	17.7	15.8	27.6	19.1	20.2	15.5	4.9	1.4
Clay	8.8	5.4	23.9	15.7	37.0	39.9	13.8	22.4	18.8	6.2	5.7	2.8
Moisture	0.8	0.1	1.1	1.0	2.8	3.0	1.0	1.3	1.0	0.4	0.2	0.3
Loss on acid treatment	0.6	0.3	1.3	0.6	0.7	1.4	0.9	0.2	0.2	0.3	0.2	0.0
Loss on ignition	2.4	0.9	2.9	1.8	3.3	3.7	2.8	2.3	1.0	1.1	0.8	0.6
Calcium carbonate	.00	.01	.00	.00	.00	.07	.02	.03	.03	.02	.02	.04
Specific conductivity	8	7	18	9	15	21	4	5	3	3	2	4
Chlorides (Cl)	.003	.001	.003	.006	.009	.010	.006	.002	.003	.001	.002	.002
Nitrogen	.077						.059					
Organic carbon	.77						.61					
C:N ratio	10.0						10.3					
Reaction (pH)	6.1	6.3	5.6	6.5	8.1	8.6	6.4	6.3	6.3	5.9	5.9	6.3

x Deep surface and heavy deep subsoil.
ø Loam surface.

SOIL TYPE	EAST SHEPPARTON SANDY LOAM								EAST SHEPPARTON SANDY LOAM x								
Soil No.	9572	9573	9574	9575	9576	9577	9578	9579	3380	3381	3382	3383	3384	3385	3386	3387	3388
Depth (in.)	0-3	5-11	11 -16	16 -28	28 -34	34 -41	41 -58	58 -72	0-5	5-13	13 -18	18 -27	27 -60	60 -70	74 -90	90 -102	102 -126
Texture	SL	S	LC	MC(S)	SCL	ClS	LC	LC-SC	SL	S	S	GrC	ClS	GrS	LC	LC	SiMC
Gravel	Tr.	0.9	-	Tr.	1.1	1.6	2.6	1.3	7.2	11.0	14.0	19.0	19.1	22.4	1.2	-	-
Coarse sand	18.1	18.1	13.7	5.1	28.5	39.9	21.8	26.1	36.6	38.7	41.7	37.9	44.5	63.6	2.1	3.3	4.7
Fine sand	59.8	62.0	46.7	46.0	42.1	36.1	23.7	28.7	38.2	38.1	37.1	27.3	24.2	13.7	22.8	25.6	26.5
Silt	11.2	12.0	8.7	7.8	6.3	5.3	21.2	12.2	8.2	13.9	13.3	8.5	7.8	5.7	22.4	19.5	34.5
Clay	8.9	7.7	28.4	35.6	20.0	17.5	28.3	29.2	12.9	8.0	6.3	24.0	21.6	16.1	46.9	45.7	30.0
Moisture	0.7	0.5	2.0	3.7	2.1	1.5	2.5	3.0	0.9	0.4	0.2	1.9	2.2	0.6	2.6	4.1	2.6
Loss on acid treatment	0.7	1.3	0.4	1.0	0.8	0.6	2.1	0.9	1.2	0.5	0.3	1.0	0.4	0.8	0.6	0.8	2.6
Loss on ignition	2.4	1.3	3.0	3.7	2.2	2.0	3.3	2.8	3.3	1.2	0.7	2.1	2.1	2.7	5.9	4.0	3.0
Calcium carbonate	.01	.00	Tr.	.11	Tr.	.01	1.07	.03	.18	.02	.03	.03	.03	.02	.03	.02	.02
Specific conductivity	20	8	11	17	13	13	22	16	10	10	10	7	14	12	14	13	13
Chlorides (Cl)	.009	.005	.004	.003	.004	.006	.004	.004	.011	.004	.003	.002	.006	.005	.006	.001	.008
Nitrogen	.073								.113								
Organic carbon	.67								1.43								
C:N ratio	9.2								12.7								
Reaction (pH)	6.6	6.7	6.0	7.8	7.9	7.9	8.8	8.6	7.4	6.9	7.0	5.8	7.4	7.9	8.0	8.1	8.2

x Deep surface and gravelly profile.

SOIL TYPE	SHEPPARTON SANDY LOAM x								SHEPPARTON SANDY LOAM ø							
Soil No.	6276	6277	6278	6279	6280	6281	6282	6283	6646	6647	6648	6649	6650	6651	6652	6653
Depth (in.)	0-7	7-9	9-15	15-25	25-33	33-44	44-75	75-114	0-7	7-23	23-31	31-44	44-62	62-72	72-96	108-126
Texture	SL	SL	MC	MC	LC	SC	SCL	S+Gr.	SL	S	MCø	LC	FSC	FSCL	SL	MC
Gravel	3.2	5.9	-	-	4.4	5.9	8.4	40.6	1.4	1.6	1.2	0.6	-	-	-	-
Coarse sand	24.0	27.8	11.6	15.1	22.9	27.4	33.1	92.6	30.5	32.8	25.5	11.1	2.8	5.0	9.2	1.7
Fine sand	47.0	42.8	17.0	21.4	23.0	32.4	33.7	2.8	48.8	47.5	33.7	27.2	22.6	53.7	66.0	22.4
Silt	17.2	17.3	5.0	12.6	12.5	10.5	13.1	1.3	12.3	12.0	9.6	15.6	31.2	14.0	5.0	18.0
Clay	9.3	11.0	57.5	44.4	36.7	23.5	15.6	2.8	7.5	8.1	29.8	42.0	37.2	25.3	18.0	53.8
Moisture	1.0	0.5	6.1	4.9	3.7	2.1	1.1	0.2	0.6	0.0	1.7	4.1	3.9	2.0	1.6	3.9
Loss on acid treatment	0.8	0.2	1.3	1.2	1.2	4.8	0.7	0.3	0.4	0.5	0.8	0.9	2.1	1.0	1.0	1.3
L. on ignition	2.3	1.0	5.7	4.4	3.6	2.4	1.6	0.4	1.8	0.8	2.9	4.2	4.5	2.9	2.2	5.1
Cal. carbonate	.02	.01	.02	.01	Tr.	Tr.	.02	Tr.	.01	Tr.	.02	.07	.94	.14	.02	.03
Sp.conductivity	-	4	10	9	10	6	8	3	4	4	6	14	25	16	6	10
Chlorides (Cl)	.001	.001	.003	.002	.002	.001	.002	.001	.001	.001	.004	.006	.005	.010	.004	.007
Nitrogen	.071								.53							
Organic carbon	.86								.57							
C:N ratio	12.1								10.8							
Reaction (pH)	6.8	7.2	7.6	7.3	7.2	7.9	8.5	7.5	6.4	7.3	7.9	8.6	9.1	9.1	8.8	8.8

x Deep subsoil drift.
ø Deep surface and sand veins in subsoil.

SOIL TYPE	SHEPPARTON SANDY LOAM ø						SHEPPARTON LOAM x							
Lab No.	6768	6769	6770	6771	6772	6773	9580	9581	9582	9583	9584	9585	9586	9587
Depth (in.)	0-5	5-8	8-20	20-28	28-49	49-84	0-5	5-7	7-18	18-23	23-31	31-37	37-54	54-78
Texture	SL	L	MCø	LC	FSC	HC	L	L	HC	LC	FSC	FSCL	ClFS	SiMC
Gravel	-	0.3	-	-	-	0.8	-	-	-	-	-	-	-	2.0
Coarse sand	4.5	3.9	2.5	1.3	0.9	4.2	4.7	4.5	3.1	19.7	3.0	1.5	1.5	0.4
Fine sand	59.6	54.8	37.1	38.3	41.6	24.6	58.6	58.6	33.1	36.8	35.4	62.2	66.3	13.3
Silt	19.1	20.1	14.5	15.8	18.2	16.1	19.6	21.6	12.9	9.9	16.2	12.3	11.1	44.7
Clay	11.9	19.1	42.2	39.7	33.8	48.6	13.2	13.7	45.2	29.7	41.3	21.5	18.8	36.6
Moisture	0.9	1.2	3.5	3.7	3.1	4.2	1.2	0.5	4.0	2.4	2.9	1.8	1.7	3.6
Loss on acid treatment	0.6	1.8	1.1	0.7	0.9	1.4	1.1	0.5	1.0	0.9	1.0	0.8	0.9	2.0
Loss on ignition	3.3	2.3	4.3	3.8	3.5	4.3	3.4	1.9	4.8	3.2	3.5	2.7	2.5	4.9
Calcium carbonate	.03	.02	.11	.01	.06	.19	.02	.00	.00	.01	.08	.16	.15	1.00
Specific conductivity	8	16	28	5	25	40	16	10	18	17	15	16	17	26
Chlorides (Cl)	.001	.004	.013	.023	.020	.040	.002	.004	.002	.004	.003	.005	.005	.005
Nitrogen	.076						.092							
Organic carbon	1.14						1.15							
C:N ratio	15.0						12.5							
Hydrochloric acid extract P_2O_5	.073		.022											
K_2O	.248		.631											
CaO	.199		.143											
MgO	.177		.500											
Reaction (pH)	7.3	6.3	6.8	8.3	8.8	8.9	7.2	7.5	7.7	8.4	8.6	8.9	8.7	8.6

x Light profile. N - Sal ø Sand veins in subsoil.

SOIL TYPE	SHEPPARTON LOAM							SHEPPARTON LOAM						
Lab. No.	9617	9618	9619	9620	9621	9622	9623	10073	10074	10075	10076	10077	10078	10079
Depth (in.)	0-4	4-7	7-24	24-30	30-38	38-60	60-78	0-6	6-10	11-20	20-32	32-40	40-60	66-84
Texture	L	L	HC	LC	FSC	FSCL	FSC	L	L	HC	MC	LC	FSC	MC
Gravel	-	0.2	-	1.0^x	0.5^x	Tr.^{x}	-	0.8	Tr.	-	-	1.9^x	1.6^x	1.6^x
Coarse sand	3.7	4.1	1.7	2.5	5.7	2.1	1.1	6.2	6.4	1.8	1.3	0.5	0.9	2.5
Fine sand	55.1	57.5	27.7	36.5	51.5	55.0	26.8	48.6	50.0	18.4	26.0	26.0	45.3	28.6
Silt	24.9	26.2	17.5	20.1	12.5	15.9	32.9	27.8	28.1	10.8	18.1	26.7	19.1	16.5
Clay	12.9	11.8	47.8	36.8	27.2	24.3	32.7	13.2	13.1	63.0	50.2	41.7	30.9	47.1
Moisture	1.2	0.6	4.6	3.8	2.8	2.7	2.9	0.9	0.6	5.7	4.8	4.4	3.3	4.7
Loss on acid treatment	0.6	0.7	0.6	1.0	0.6	0.6	2.1	1.1	0.4	1.0	0.7	1.7	0.6	1.1
Loss on ignition	3.6	1.8	5.2	4.0	2.9	2.7	3.8	3.7	1.5	6.4	4.8	4.5	3.0	4.5
Calcium carbonate	.01	.02	.02	.24	.16	.14	.55	.04	.02	.02	.02	.78	.22	.20
Specific conductivity	9	5	12	31	20	24	27	14	6	31	21	37	34	28
Chlorides (Cl)	.004	.001	.005	.012	.013	.009	.006	.009	.003	.007	.009	.017	.018	.018
Nitrogen	.092							.105						
Organic carbon	1.21							1.26						
C:N ratio	13.2							12.0						
Hydrochloric acid extract P_2O_5	.071		.043											
K_2O	.278		.765											
CaO	.193		.310											
MgO	.191		.427											
Reaction (pH)	6.8	7.0	7.0	8.5	8.9	9.2	9.2	6.8	7.5	7.0	7.7	8.8	9.0	8.8

x Limestone rubble.

SOIL TYPE	ORRVALE SANDY LOAM x								ORRVALE LOAM								
Lab. No.	6295	6296	6297	6298	6299	6300	6301	6302	6583	6584	6585	6586	6587	6588	6589	6590	6591
Depth (in.)	0-8	8-14	14-26	26-34	34-42	42-59	59-72	72-96	0-6	6-10	10-29	29-39	39-60	60-84	84-100	100-108	108-132
Texture	LS	S	MC x	LC	SC	SCL	LC	LC	L	L	MC	LC	SCL	SCL	ClGr	LC	MC
Gravel	1.0	3.1	-	-	1.5	3.0	-	-	4.5 ≮	16.7 ≮	4.8	12.3 Ø	8.4	19.0	61.0	6.1	0.3
Coarse sand	30.9	32.0	20.3	29.0	34.2	46.5	8.4	5.9	14.3	18.0	9.5	17.7	19.9	25.6	49.0	3.9	3.3
Fine sand	49.4	52.2	22.6	29.1	33.2	28.8	28.9	33.0	43.4	40.5	26.5	38.2	47.9	40.6	21.7	14.0	10.8
Silt	9.2	9.8	4.4	3.8	5.4	3.6	21.6	20.5	20.2	24.1	14.1	11.0	13.5	11.5	6.5	37.9	26.5
Clay	7.6	5.7	48.9	34.8	24.5	18.8	36.4	35.5	17.8	16.3	46.4	29.9	17.5	18.3	18.1	37.2	52.9
Moisture	1.0	0.4	3.8	2.9	2.1	1.7	3.3	3.5	1.2	0.8	3.2	3.0	1.6	2.8	1.1	3.8	4.7
Loss on acid treatment	0.7	0.8	1.1	1.4	1.5	0.6	1.9	2.5	0.9	0.5	0.5	1.2	0.5	0.7	3.7	2.3	1.1
Loss on ignition	2.4	0.9	5.0	4.3	2.7	2.1	3.0	3.1	3.4	2.2	4.6	3.2	2.2	2.9	2.2	3.9	6.3
Calcium carbonate	.04	.05	Tr.	.03	.31	.12	.14	.06	.02	.01	Tr.	.11	.01	Tr.	.01	Tr.	Tr.
Specific conductivity	8	4	9	10	14	11	20	19	8	8	15	26	15	25	21	50	39
Chlorides (Cl)	.004	.002	.003	.004	.004	.003	.009	.003	.002	.002	.007	.006	.010	.025	.020	.049	.046
Nitrogen	.078								.073								
Organic carbon	.92								.89								
C:N ratio	11.8								12.2								
Reaction (pH)	7.9	7.9	7.4	8.4	8.8	9.0	9.0	8.7	6.8	6.5	6.0	8.5	8.8	8.5	8.5	7.7	7.3

x Sandy deep surface and sand veins in subsoil. ≮ Buckshot.

Ø Including slight limestone rubble.

SOIL TYPE	ORRVALE LOAM																	
Lab No.	6565	6566	6567	6568	6569	6570	6571	6572	6573	6574	6575	6576	6577	6578	6579	6580	6581	6582
Depth (in.)	0-5	5-8	8-23	23 -31	31 -42	42 -55	55 -70	70 -82	82 -108	108 -138	138 -162	162 -180	180 -234	234 -276	276 -312	312 -324	330 -354	354-
Texture	L	L	MC	MC	FSC	ClS	LC	SC	MC	HC	HC	FSC	FSCL	FSC	LC	FSC	ClS	CS
Gravel	3.5≠	-	0.6	-	-	19.8	-	1.3	Tr.	0.7^x								
Coarse sand	17.1	18.2	8.7	9.3	26.8	56.6	2.8	24.2	15.6	4.2								
Fine sand	44.5	47.3	25.6	34.1	37.5	22.7	28.2	29.6	21.4	23.3								
Silt	21.7	22.1	12.9	12.8	14.2	5.8	29.0	13.2	17.0	20.0								
Clay	14.6	11.0	48.4	37.6	19.2	13.5	36.7	30.2	41.7	47.7								
Moisture	0.8	0.4	3.2	3.4	1.7	0.6	3.0	2.0	4.0	3.7								
Loss on acid treatment	1.7	0.4	1.0	0.9	0.8	0.4	1.1	0.8	0.9	2.0								
Loss on ignition	3.7	1.7	4.9	3.9	2.7	1.5	4.1	2.4	4.1	4.7								
Calcium carbonate	.02	.01	.02	.02	.09	.00	.06	.05	.13	.97								
Sp. conductivity	7	5	10	16	23	9	18	11	19	35	16	11	15	16	14	14	7	8
Chlorides (Cl)	.004	.002	.004	.008	.008	.006	.012	.006	.010	.007	.017	.014	.017	.019	.018	.015	.010	.008
Nitrogen	.091																	
Organic carbon	1.20																	
C:N ratio	13.2																	
Hydrochloric acid extract P_2O_5	.093		.027															
K_2O	.285		.909															
CaO	.213		.209															
MgO	152		.484															
Reaction (pH)	6.9	7.2	6.2	7.6	8.5	8.3	8.7	9.0	9.0	9.3	8.7	8.9	8.2	5.7	5.6	5.7	6.6	8.1

x Limestone rubble. ≠ Buckshot.

SOIL TYPE	ORRVALE LOAM ≁									
Lab. No.	6313	6314	6315	6316	6317	6318	6319	6320	6321	6322
Depth (in.)	0-7	7-29	29 -36	36 -50	50 -61	61 -72	72 -81	81 -90	90 -98	98- 150
Texture	CL	HC	LC	FSC	FSCL	FSC	C1S	FSCL	LC	MC
Gravel	-	-	-	1.1[x]	-	-	0.6	-	-	-
Coarse sand	4.1	2.4	2.4	2.8	2.9	1.7	29.0	1.5	10.8	8.8
Fine sand	53.2	35.3	38.8	45.5	57.5	52.2	42.2	62.9	28.9	20.1
Silt	19.5	16.3	20.4	15.5	10.2	12.9	4.9	10.0	26.0	25.5
Clay	19.5	42.2	35.2	33.6	27.8	29.2	18.6	21.1	30.4	40.2
Moisture	1.6	3.4	3.0	2.5	1.9	2.3	1.4	1.1	2.7	3.2
Loss on acid treatment	0.7	1.3	1.2	1.1	0.6	2.7	2.4	1.6	0.8	1.7
Loss on ignition	3.8	4.1	3.4	3.4	2.9	3.0	4.9	3.3	3.2	3.3
Calcium carbonate	Tr.	.01	.00	.33	.18	.10	.00	.01	.19	.15
Sp. conductivity	8	18	29	25	19	16	7	8	25	24
Chlorides (Cl)	.005	.016	.024	.011	.008	.006	.003	.003	.020	.006
Nitrogen	.098									
Organic carbon	1.12									
C:N ratio	11.4									
Reaction (pH)	6.6	7.3	8.7	9.0	9.1	9.0	8.9	9.1	8.9	9.2

SOIL TYPE	ORRVALE LOAM ≁							
Lab. No.	6638	6639	6640	6641	6642	6643	6644	6645
Depth (in.)	0-6	6-8	8-29	29 -38	38 -58	58 -68	68 -100	100 -114
Texture	L	L	MC	LC	FSC	FSCL	FSCL	MC
Gravel	0.6	0.3	-	-	1.8	-	-	-
Coarse sand	8.0	8.2	3.1	1.9	1.2	0.8	0.5	7.2
Fine sand	58.1	59.3	30.5	43.8	51.9	62.4	67.8	30.9
Silt	20.1	23.1	13.5	16.9	15.2	13.0	12.3	21.0
Clay	11.5	9.8	48.4	34.4	29.3	22.4	18.3	38.2
Moisture	0.8	0.2	3.9	3.2	2.4	1.7	1.5	3.2
Loss on acid treatment	0.3	0.1	1.1	0.8	0.8	0.6	0.7	0.5
Loss on ignition	2.8	0.8	5.2	3.4	2.9	2.5	2.1	3.7
Calcium carbonate	.01	Tr.	.01	.01	.07	.01	.02	Tr.
Sp. conductivity	6	3	12	17	19	9	7	9
Chlorides (Cl)	.001	.001	.004	.010	.010	.005	.006	.003
Nitrogen	.082							
Organic carbon	1.12							
C:N ratio	13.7							
Reaction (pH)	6.3	6.2	5.1	7.9	8.7	8.6	8.4	8.6

x Including limestone rubble.
≁ Greyer profile.

SOIL TYPE	LEMNOS SANDY LOAM								LEMNOS SANDY LOAM[≠]					LEMNOS LOAM				
Lab. No.	10080			to				10087	6290	6291	6292	6293	6294	9612	9613	9614	9615	9616
Depth (in.)	0-6	6-12	12-18	18-24	24-34	34-60	60-75	75-96	0-7	9-19	19-28	28-45	45-72	0-6	7-20	20-29	29-40	40-72
Texture	SL	SL	MC	MC	LC	LC	SC	LC	SL	MC[≠]	MC	LC	MC	L	HC	MC	LC	MC
Gravel	1.2	1.6	-	-	-	0.5[x]	3.2	-	0.6	Tr.	0.6	-	-	-	-	Tr.[x]	-	Tr.[x]
Coarse sand	30.3	31.6	15.4	16.7	20.4	10.3	26.1	22.8	37.6	27.5	22.4	6.7	3.0	2.9	0.9	0.8	3.4	0.8
Fine sand	45.7	46.6	23.5	26.8	31.1	20.2	40.4	30.0	40.2	20.7	20.3	29.2	23.7	54.9	30.4	45.1	34.2	9.2
Silt	13.6	12.4	5.8	6.5	10.3	27.9	8.9	5.1	11.6	10.6	16.4	16.9	15.2	21.4	11.1	12.2	23.6	20.3
Clay	7.5	8.3	48.4	43.3	34.0	35.2	22.4	38.3	7.3	37.4	36.3	42.2	53.2	14.9	52.7	38.0	34.9	61.8
Moisture	0.4	0.2	4.7	4.6	3.3	3.6	1.6	3.5	0.8	3.3	3.5	4.0	3.6	1.4	4.8	3.4	3.4	5.8
Loss on acid treatment	0.5	0.4	0.9	0.6	0.8	3.6	0.9	1.2	0.6	1.1	2.0	2.0	1.1	0.7	0.9	1.0	1.3	2.2
Loss on ignition	2.8	1.0	5.0	4.1	3.4	5.2	2.1	3.9	2.3	3.7	3.6	4.0	4.9	3.5	5.3	3.7	3.4	5.6
Calcium carbonate	.00	.00	.01	.02	.02	2.61	.12	.07	Tr.	Tr.	.65	.42	.23	.02	.03	.01	.02	.62
Sp. conductivity	6	3	8	6	8	18	15	17	7	9	28	27	37	9	28	34	50	82
Chlorides (Cl)	.003	.005	.004	.003	.005	.006	.005	.007	.003	.003	.008	.010	.027	.002	.010	.025	.059	.094
Nitrogen	.062								.068					.088				
Organic carbon	.69								0.98					1.17				
C:N ratio	11.1								14.4					13.3				
Hydrochloric acid extract P_2O_5									.043									
K_2O									.163									
CaO									.100									
MgO									.102									
Reaction (pH)	6.6	6.7	6.5	6.9	7.5	8.6	8.7	8.4	6.3	7.4	9.0	9.0	8.9	6.1	5.6	7.6	8.5	8.7

x Limestone rubble. ≠ Sand veins in subsoil.

SOIL TYPE	LEMNOS LOAM															
Lab. No.	6611	6612	6613	6614	6615	6616	6617	6618	6619	6620	6621	6622	6623	6624	6625	6626
Depth (in.)	0-7	8-28	28-39	39-51	61-72	72-84	84 -100	104 -126	126 -138	138 -180	180 -198	198 -210	210 -252	252 -288	288 -330	330 -348
Texture	L	MC	LC	LMC	LMC	FSC	MC	FSC	LC	MC	LC	FSC	LC	SC	SCL	MC
Gravel				1.1												
Coarse sand	13.4	6.7	12.9	10.3	8.8											
Fine sand	42.3	17.5	34.1	27.3	34.2											
Silt	27.6	14.9	17.1	13.0	16.4											
Clay	13.0	56.6	32.9	45.3	36.3											
Moisture	0.8	4.2	1.9	3.3	2.1											
Loss on acid treatment	1.2	1.1	2.1	0.8	2.2											
Loss on ignition	3.2	5.9	3.3	4.6	4.5											
Cal. carbonate	.01	.06	.08	.03	.03											
Sp. conductivity	6	8	17	15	18	15	14	12	14	14	13	13	11	13	11	19
Chlorides (Cl)	.001	.003	.005	.005	.005	.007	.010	.012	.011	.014	.013	.011	.014	.014	.015	.024
Nitrogen	.084	.031	.025	.033												
Organic carbon	1.11	.22	.10	.06												
C:N ratio	13.2	7.1	4.0	1.8												
Hydrochloric acid extract P_2O_5	.068	.031	.021	.026												
K_2O	.258	.993	.644	.743												
CaO	.262	.533	.235	.242												
MgO	.206	.475	.379	.630												
Reaction (pH)	7.3	7.8	8.2	8.3	8.2	8.5	8.7	8.8	8.8	8.7	8.7	8.4	8.9	8.8	8.8	8.4

SOIL TYPE	GOULBURN LOAM					GOULBURN LOAM /			GOULBURN CLAY LOAM					
Lab. No.	6271	6272	6273	6274	6275	6774	6775	6776	10088	10089	10090	10091	10092	10093
Depth (in.)	0-7	7-18	18-30	30-50	50-78	0-7	8-23	23-34	0-8	8-21	21-34	34-44	44-66	66-90
Texture	L	MC	MC	MC	MC	L	MC /	LC	CL	HC	MC	LC	MC	MC
Gravel	-	-	-	1.2 x	2.6 x	2.6	1.0	1.1	-	-	-	-	-	-
Coarse sand	6.0	2.7	2.0	1.5	4.5	19.6	15.0	22.0	5.7	3.1	3.0	10.0	8.0	7.4
Fine sand	51.9	29.2	28.0	29.3	26.0	45.5	26.7	24.9	38.4	24.5	23.4	24.7	21.2	25.0
Silt	22.6	18.9	23.3	24.3	22.1	16.1	12.5	13.4	27.8	18.9	23.3	20.7	17.0	21.1
Clay	15.1	45.8	41.4	38.7	41.9	14.5	40.7	34.9	25.7	47.9	45.9	41.1	49.2	42.2
Moisture	1.4	3.0	4.5	3.9	4.8	1.2	3.0	3.1	2.3	3.8	4.2	4.2	4.0	4.5
Loss on acid treatment	1.1	1.2	1.8	1.3	1.5	0.5	1.4	2.7	1.1	1.3	1.2	0.5	1.4	0.9
Loss on ignition	3.6	5.1	4.5	4.0	4.2	3.3	4.3	3.5	4.6	5.3	4.7	4.1	4.8	5.0
Calcium carbonate	.01	.01	.13	.16	.15	.01	.01	.02	.03	.05	.03	.07	.05	.22
Specific conductivity	8	12	39	42	31	5	11	17	15	16	26	52	35	39
Chlorides (Cl)	.004	.006	.007	.008	.014	.006	.009	.017	.011	.002	.006	.022	.034	.033
Nitrogen	.088					.085			.091					
Organic carbon	1.13					1.06			1.15					
C:N ratio	12.8					12.5			12.6					
Hydrochloric acid extract P_2O_5									.136	.029				
K_2O									.541	.929				
CaO									.368	.236				
MgO									.277	.499				
Reaction (pH)	7.1	8.0	8.0	8.4	8.6	6.8	6.7	8.6	7.3	7.5	8.1	8.4	8.5	8.7

x Limestone rubble. / Sand veins in subsoil.

SOIL TYPE	CONGUPNA LOAM						CONGUPNA CLAY LOAM										
Lab. No.	9600	9601	9602	9603	9604	9605	6627	6628	6629	6630	6631	6632	6633	6634	6635	6636	6637
Depth (in.)	0-6	6-11	11 -33	33 -51	51 -72	72 -84	0-6	6-10	10 -39	39 -84	84 -108	108 -132	132 -150	156 -180	180 -222	222 -336	336 -354
Texture	L	FSCL	HC	HC	MC	LC	CL	FSCL	HC	MC	MC	MC	MC	S	ClCS	HC	MCLC
Buckshot	12.6	12.3	-	-	-	1.2[/]	6.3	8.6	-	Tr.	5.1[x]						
Coarse sand	7.9	8.8	1.9	2.1	0.9		14.9	15.7	8.4	4.6	1.9						
Fine sand	42.8	43.7	19.6	31.1	32.3		35.9	39.0	26.1	27.0	28.5						
Silt	27.3	26.3	22.0	19.5	25.6		23.4	28.5	20.4	20.4	22.2						
Clay	16.7	19.7	51.7	42.1	36.9		18.5	14.7	39.8	43.5	39.9						
Moisture	1.3	1.2	3.9	3.7	3.5		1.4	0.9	3.2	4.0	4.2						
Loss on acid treatment	0.9	0.6	1.5	2.4	1.7		2.0	0.6	1.2	1.1	3.0						
Loss on ignition	3.6	2.7	5.3	4.7	3.9		4.8	2.0	3.9	3.9	4.9						
Calcium carbonate	.02	.01	.16	1.17	.38	.52	.79	.01	.02	.06	2.16						
Specific conductivity	13	9	26	45	45	51	14	4	7	15	26	11	13	8	6	20	32
Chlorides (Cl)	.004	.003	.008	.023	.033	.043	.002	.001	.002	.001	.004	.013	.013	.009	.010	.025	.037
Nitrogen	.093						.113										
Organic carbon	.97						1.68										
C:N ratio	10.4						14.9										
Reaction (pH)	6.5	6.4	8.4	9.1	9.0	9.0	8.1	7.8	7.9	8.5	9.1	8.7	8.9	8.8	8.5	7.5	5.4

x Limestone rubble.
/ Gravel.

SOIL TYPE	CONGUPNA CLAY LOAM													CONGUPNA CLAY			
Lab. No.	6598	6599	6600	6601	6602	6603	6604	6605	6606	6607	6608	6609	6610	6309	6310	6311	6312
Depth (in.)	0-8	10 -34	34 -50	50 -90	90 -102	108 -138	138- 162	162 -222	222 -270	270 -288	288 -300	300 -324	324 -366	0-5	5-29	29 -63	63 -90
Texture	CL	HC	HC	MC	LC(s)	MC(s)	ClS	HC	MC	HC	MC	LC	FSC	LC	HC	HC	MC
Buckshot	15.8	Tr.	13.2[x]	1.4[x]										-	-	0.9[x]	0.3[x]
Coarse sand	15.8	2.4	1.5	6.1										4.5	1.2	0.9	1.2
Fine sand	30.6	20.2	13.4	19.0										28.9	10.6	13.2	18.3
Silt	26.5	25.8	33.2	27.6										27.3	20.6	25.6	27.5
Clay	22.5	47.3	45.3	40.7										34.6	60.2	53.9	47.9
Moisture	2.0	3.5	3.7	3.7										2.6	4.5	4.4	4.1
Loss on acid treatment	1.3	1.3	2.6	1.7										0.9	3.4	2.9	1.9
Loss on ignition	5.0	4.8	4.5	3.5										5.4	6.7	5.3	4.5
Calcium carbonate	.06	.02	4.36	.25										Tr.	1.60	1.50	.25
Specific conductivity	8	21	58	33	18	12	9	25	26	39	40	38	48	15	58	104	87
Chlorides (Cl)	.006	.015	.037	.033	.013	.013	.010	.020	.034	.045	.051	.050	.062	.002	.066	.040	.091
Nitrogen	.104													.088			
Organic carbon	1.31													1.34			
C:N ratio	12.6													15.2			
Hydrochloric acid extract P_2O_5	.128	.025															
K_2O	.457	.848															
CaO	.326	.193															
MgO	.407	.751															
Reaction (pH)	7.0	8.0	8.7	8.8	8.7	8.6	8.0	5.2	5.1	4.9	5.0	5.0	4.9	6.5	8.6	8.7	8.7

x Limestone rubble.