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A Soil Survey of the Merbein Irrigation District, Victoria

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CONTENTS

SUMMARY

A soil survey of the Merbein Irrigation District, Victoria, comprising 8,200 acres of Mallee land, devoted chiefly to the production of dried vine fruits, has been completed. General conditions in the area are described, with special reference to climate, topography, and natural vegetation.

The soil map presented with this report shows the distribution of sixteen soil types over the settlement. Nine soil series are represented, five of which have been described elsewhere under the series names Murray, Berri, Barmera, Nookamka, and Coomealla. These soils cover the bulk of the area, the remainder being occupied by new types named Merbein loam, Benetook loam, Sandilong loam, and Karadoc sandy loam, together with four unnamed types. The series names indicate the relations between Merbein soils and those of the Berri-Cobdogla district in South Australia, the Coomealla area in New South Wales, and the Mildura settlement adjacent to Merbein in Victoria. The distinctive features of each type of soil are recorded.

Occurrences of the soil types show the usual relations between elevation and texture, the lighter types occupying the higher land, with sequences through intermediate types to the heavier soils at lower levels. The topographic conditions are such that relations of this kind connote complex soil type aggregations and considerable difficulty in avoiding development of excess soil water and salinity problems on the slopes. Principles of subsoil drainage are therefore discussed in detail, together with the relations of soil salinity to crop production, particularly with respect to vines. The district as a whole has a high average production, and it was concluded that satisfactory returns with vines may be obtained on all soil types under good management.

A laboratory examination of 88 soils has been carried out. All soils examined are alkaline, many are very alkaline, and most are highly calcareous. Detailed physical and chemical analyses are recorded, indicating that, in general character, Merbein soils conform to the normal features of the Mallee group of soils. Data on soluble salts obtained in the present survey and in former examinations of Merbein soils show that sulphate is of greater importance in this settlement than in most other Murray irrigation areas. Many of the subsoils contain appreciable amounts of soluble carbonate, indicating adverse conditions associated with hydrolysis of the sodium clay usually found in the deeper horizons. The influences on water movement within the soil of changes in texture and in the nature of the clay at certain depths, as well as the presence in some types of rubble lime or gypsum, are discussed in relation to development of excess soil water and provision of drainage.

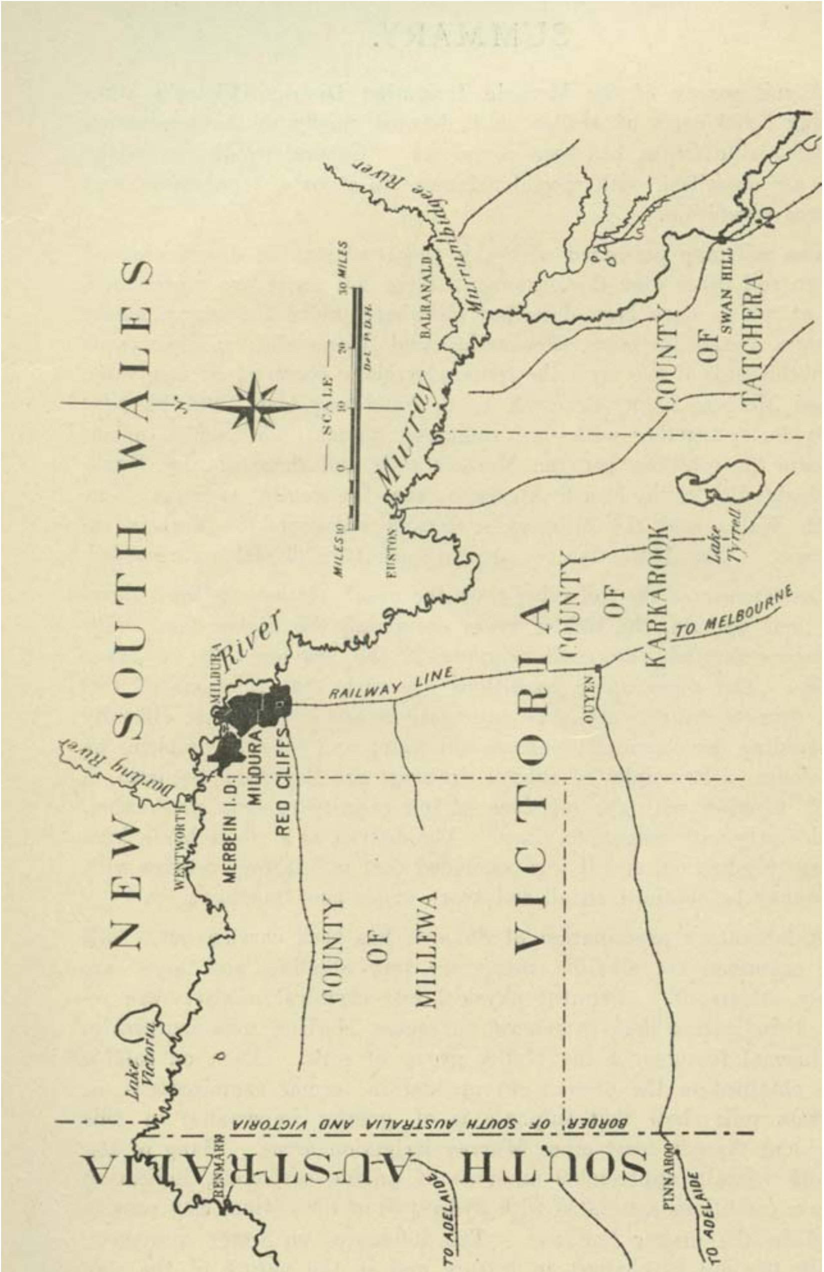

Fig. 1 – Locality plan, showing position of soil survey

A Soil Survey of the Merbein Irrigation District, Victoria.*

I. INTRODUCTION.

1. Development of Settlement.

The Merbein Irrigation District of approximately 7,700 acres lies in Mallee country in the far north-west of Victoria, adjoining the Murray River. Its proximity to the Mildura district and to other irrigation settlements in this part of the Murray Valley is shown in the locality plan (Fig. 1, opposite). The development of Merbein, formerly called White Cliffs, as an irrigation project was a natural outcome of the attainment of relatively stable conditions in the parent settlement of Mildura, but it was not until 1908 that plans for subdivision of the area were made. During 1909 the Victorian State Rivers and Water Supply Commission opened 5,000 acres for selection in 150 blocks, the original intention being to make dairying the chief activity. Within a few years, however, considerable plantings of vines and fruit trees as well as lucerne established the settlement after the example of Mildura.

Additions to the original area of the district were made between 1917 and 1921 to accommodate 147 soldier settlers, either along the eastern side of the settlement in the vicinity of Birdwoodton or in the western extension. By 1918, approximately 5,400 acres had been brought into bearing, vines predominating with 2,100 acres.

In its development, Merbein had many advantages which were not available to Mildura in its early stages. Many of the selectors at Merbein had already gained experience in the older settlement, railway facilities were ready before production began, and equipment for orchard and packing shed had been improved considerably. The district has enjoyed a relatively high average rate of production, and has shown steady progress to its present condition, in which it maintains about 430 settlers, the distribution of planting being as shown in Table 1.

TABLE 1.—AREAS OF CROPS IN THE MERBEIN SETTLEMENT.

Crop	Sultanas	Currants	Gordos	Other Vines	Citrus	Deciduous Fruits	Lucerne	Not in production	Total
Area in acres	4,563	1,446	339	361	563	28	53	354	7,697

The dominant position of vines in this area is shown by the table, 91 per cent of

* The soil survey was carried out by the Division of Soils, Council for Scientific and Industrial Research, and the Victorian Department of Agriculture. Field work was shared by Messrs. T. J. Marshall, P. D. Hooper, and J. K. Taylor, of the Division of Soils, and laboratory work was undertaken by the Victorian Agricultural Laboratory. The cartography is due to P. D. Hooper.

the planted area being devoted to this crop. In addition to depots for processing and packing of dried vine fruits, the district has a distillery at which most of the Doradillo crop is handled.

Irrigation water is supplied to the settlement by pumping from the Murray, most of the pumping equipment having been changed recently from steam to electric power. Water is available at 22s. per acre-foot, the water right being 2½ acre-feet per annum. The district is served by 54 miles of channel construction, most of which is lined, and 3 miles of drainage channel. Construction of a community subsoil drainage scheme, involving 58 miles of pipe reticulation, has just been completed, making the benefits of this type of drainage available to 7,660 acres and providing adequate drainage outfall for each holding.

2. Climatic Features.

Meteorological data for Merbein are given in Table 2. Rainfall, temperature, and humidity figures were supplied by the Commonwealth Meteorologist, while the remaining data have been calculated from records communicated by the Officer-in-Charge of the Commonwealth Research Station, Merbein.

The rainfall figures are very close to the averages over 46 years for Mildura, except for January when the Mildura result is only 0.65 inch. It is quite likely that, over a comparable period, Merbein average rainfall for January would approximate more closely to that of Mildura, heavy monsoonal falls in the past two years (4.37 inches in January, 1936, and 2.70 inches in January, 1937) having exercised a strong influence on the results for a month which is usually very dry, the mean for twelve years up to 1931 being only 0.38 inch. On the whole the distribution of rainfall favours vine-growing under irrigation apart from the occasional summer tropical storms, which may cause severe damage to fruit on vines or drying racks. For dry country conditions, the winter and spring rains are too unreliable to ensure profitable wheat-growing over a succession of seasons.

December to March is a period of sustained heat, with February the hottest month, while June and July include most of the colder, relatively calm, and frosty weather. Evaporation from a free water surface is of course related to temperature, humidity, and wind velocity. It is evident from the temperature, humidity, and evaporation, that conditions for fruit drying in April are definitely inferior to those obtaining in February and March, a change which is carried still further in May, when the considerable increase in average rainfall adds another adverse factor to the complications attendant upon late drying.

3. Native Vegetation and Topography.

Topographic conditions in the major part of the district are determined by the association of undulating formations with areas of more or less level country, while the western part of the settlement includes a small section of broken land, mainly above irrigation level. The undulating country includes sand ridge formations, which are not more than 30 feet high, and frequently only 15 to 20 feet with gentle slopes.

TABLE 2.—METEOROLOGICAL DATA FOR MERBEIN.

-	Monthly and Yearly Average													
	No. of Years	Jan.	Feb.	Mar.	Apl.	May	June	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
Rainfall (inches)..	18	0'80	0'74	0'74	0'55	1'07	1'11'	0'91	1'05	0'92	0'91	0/7	0'89	10'46
Mean Maximum Temp. (°F.)	17	87'7	89'1	83'9	74'4	66 • 8	59'5	39'7	62'4	68'9	75'5	82'8	86'6	74'8
Mean Minimum Temp. (°F.)	17	58'4	59'2	55'4	48'4	43'9	39'9	39 '1	40'4	43'7	48'1	52'7	67'3	48'9
Relative Humidity..	16	53	56	59	69	79	86	84	75	67	56	55	51	66
Wind Velocity (m.p.h.)	11	2'3	1'9	2'0	1'9	1'3	1'4	1'4I	2'0	2'4	2'6	2'2	2'1	2'0
Evaporation (inches)	11	9'59	7'35	6'35	3'91	2'66	1'77	1'85	2 55	3'81	5'13	7'53	8'54	61'04
Number of Frosts..	11	..	..	..	0'1	1'9I	5'6	6'7	4'4	2'1	0'3	..	..	..

With regard to natural cover, it may be said that the major part of the settlement lies on a mallee-sandalwood-belar association apart from the high rises and relatively heavy flats. As described in general terms at the time of the original subdivision, on a feature map made available by the State Rivers and Water Supply Commission, the native vegetation fell mainly into six classes

(a) Pine dominant with sandalwood and belar.*
(b) Pine, sandalwood, belar, needlewood, and cherry.
(c) Mallee, sandalwood, belar, and pine.
(d) Open mallee and bluebush, on country more or less lime-stoney.
(e) Bluebush with belar.
(f) Open grassy flats.

Although native vegetation does not follow soil types or topography at all closely in this area, certain relations are noted. The first group (a) above is found typically on the higher sandy rises mapped as Murray sand (descriptions of soil types quoted here are given on pp. 13-24). Apart from scattered trees, most of the pine is associated with this soil type. Hopbush is usually present with it and always re-establishes itself strongly with species of *Acacia* after the first clearing, unless cultivation is maintained.

Mallee is present at almost all levels but does not appear to reach dominance except on the soils with a rather dull brown to grey surface and with fair proportions of rubble lime. Dense mallee scrub bounds the settlement on the south-eastern corner and doubtless formerly extended over the area mapped as

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* Murray pine — *Callitris robusta;* sandalwood — Myoporum *platycarpum;* belar — *Casuarina lepidophloia;* Needlewood — *Hakea* spp.; Cherry — *Exocarpus cupressiformis mallee* — *Eucalyptus oleosa, E. dumosa,* and related species; hopbush — *Dodonaea attenuata;* bluebush — *Kochia* spp.; cabbage bush — Hetero*dendron oleifolium.*

Sandilong loam, a soil of the kind mentioned. Mallee with belar and sandalwood occurs on undulating country in the western half of the area, while the proportion of belar and sandalwood is greater in the eastern half. With reference to soil types, the latter relation is associated more specifically with the Barmera series and the former with the more extensive occurrences of the Coomealla series. A considerable sweep of country south of the township of Merbein is noted as "level and openly timbered with belar, mallee, and sandalwood."

The greyer and flatter land toward the river in the north-west corner of the settlement originally carried malice, needlewood, and boree, and included a box swamp on the fringe. Although the soil types in this section are distinctive, there is no definite indication of differences in vegetation, except with regard to the boree, which probably was in the more favoured spots. The type of mallee growth also may have been significant under the somewhat wetter conditions in parts of this zone. Mallee-bluebush associations and bluebush-dominant patches are found mainly in the extreme south of the settlement. Belar by itself tends to follow the redder soils, notably the Nookamka series; as a rule, the heavier the soil, the denser and more scrubby the growth. The bigger trees are found rather on the Barmera series or on Nookamka sandy loam.

A number of open grassy flats, sometimes noted as having lime-stoney patches, occur in the south-western quarter, but these are not associated with any one soil type, although the flatter and lower occurrences may be on heavier types like Merbein loam or Nookamka loam or clay loam.

II. CLASSIFICATION AND DESCRIPTION OF SOILS.

1. Distribution and Extent of Soil Types.

The soils of the Merbein settlement are closely allied to those of the Berri-Cobdogla district in South Australia[*] and of the Coomealla Irrigation Area across the Murray River in New South Wales[†]. It was possible to fit the majority of the Merbein soils into the types already described, sometimes with slight modifications of the original definitions.

The distribution of the soils is shown in detail on the soil maps. From an irrigation point of view the soils are very variable, the gently rolling nature of the country, with alternating sandy rises and depressions, producing a complex aggregation of soil types. The sequence of lighter soils on the rises to heavier types at lower levels is attended by the development of water-logging and salinity problems under irrigation. The topographic conditions are such that it has not been possible always to map accurately the boundaries of soil types, and the map should not be interpreted rigidly in this respect. The division between the types is more frequently in the form of a narrow transitional zone rather than a definite line.

In all, sixteen types were mapped, included in nine soil series and four unnamed minor types. Five of the soil series have been previously described. The area surveyed covers 8,200 acres, and the extent of the individual types is as follows:-

	Acres.
Murray sand	835
Berri sandy loam	104
Barmera sand	186
Barmera sand (shallow phase)	164
Barmera sandy loam	782
Barmera sandy loam (shallow phase)	1,116
Nookamka sandy loam	766
Nookamka loam	500
Nookamka clay loam	190
Coomealla sandy loam	1,451
Coomealla loam	719
Merbein loam	314
Benetook loam	158
Sandilong loam	278
Karadoc sandy loam	225
Unnamed Type *A*	167
Unnamed Type *B*	150
Unnamed Type *C*	68
Unnamed Type *D*	26

[*] T. J. Marshall and P. D. Hooper, Coun. Sci. Ind. Res. (Aust.), Bull. 86, 1935.
[†] T. J. Marshall and A. Walkley, Coun. Sci. Ind. Res. (Aust.), Bull. 107, 1937.
[++] See folder at back

The Soil Map.

The soil map shows that the major types such as the Coomealla, Barmera, and Nookamka series are scattered generally over the settlement. The Murray sand lies mainly north-west, west, and south-west of the town of Merbein, with small fingers running in at intervals from the west boundary and increasing in extent in the south-west corner of the area. Benetook loam is in one area only, south of the town. Sandilong loam appears on the skirts of the settlement on the south-east fringe and on the west side, as continuations of dense mallee areas beyond the survey boundary. Merbein loam is confined to the central portion of the survey. The most strictly defined occurrences are of Karadoc sandy loam and Types *A, B, C, D*, all north of the railway line, the first three types being on comparatively low land falling away to the north-west corner of the settlement.

2. Key to Soil Types.

A key for systematic classification and preliminary identification of the soil types has been framed to serve as a guide in comparing them and as a means of interpreting the soil map.

A. Red-brown soils associated with sandy rises.

1. Surface soil—sand.
   - (a) Not underlain by clay within 6 feet.
     - (i) Texture not heavier than sandy loam, lime not more than light

       Murray sand.
   - (b) Underlain by sandy clay at 6 feet or less.
     - (i) Brown or red-brown clay loam or sandy clay at > 60", lime and rubble variable

       Barmera sand.
     - (ii) Brown or red-brown clay loam or sandy clay at 45"-60" lime and rubble variable

       Barmera sand (shallow phase).

2. Surface soil—sandy loam.
   - (a) Not underlain by clay within 6 feet.
     - (i) Texture not heavier than light sandy clay loam, lime and rubble variable

       Berri sandy loam.
   - (b) Underlain by clay at 6 feet or less.
     - (i) Brown or red-brown clay loam or sandy clay at > 60", lime and rubble variable.

       Barmera sandy loam.
     - (ii) Brown or red-brown clay loam or sandy clay at 45"-60", lime and rubble variable

       Barmera sandy loam (shallow phase).
     - (iii) Grey or grey-brown light clay (gypseous) at 36"

       Unnamed Type C.

B. Red-brown soils on gentle slopes.

1. Surface soil—sandy loam.
   - (a) Light profile
     - (i) Underlain by brown or red-brown clay at 36" Nookamka sandy loam.
     - (ii) Underlain by fine sandy clay at 48"

Unnamed Type A.

2. Surface soil—loam.
   - (a) Heavy profile.
     - (i) Underlain by brown or red-brown clay at 24"

Nookamka loam.

     - (ii) Underlain by brown or red-brown clay at 18" or less

Nookamka clay loam.

C. Brown soils on gentle slopes.

1. Surface soil—loam.
   - (a) Heavy profile underlain by brown clay.
     - (i) Brown clay at 24", lime light Merbein loam.
   - (b) Heavy profile underlain by grey-brown clay.
     - (i) Grey-brown clay (gypseous) at 48", lime light

Benetook loam.

2. Surface soil—sandy loam.
   - (a) Underlain by brown or red-brown clay.
     - (i) Brown clay at 48"

Coomealla sandy loam.

     - (ii) Brown clay at 36" (surface may be loam)

Coomealla loam.

   - (b) Underlain by grey-brown micaceous sandy clay.
     - (i) Sandy clay or lighter between 36"-72"

Karadoc sandy loam.

D. Grey and grey-brown soils.

1. Surface soil—loam.
     - (i) Underlain by mottled clay at 48", rubble and lime light to heavy

Sandilong loam.

     - (ii) Underlain by fine sandy clay at 48"

Unnamed Type B.

3. Descriptions of Soil Types.

The grouping in the key to soil types indicates a general alliance of heavy soils with the flatter ground and light soils with the steeper sloping sand rises. Absolute height is less distinctive than relative height in determining lightness of profile. The brown soils (usually rather dull brown), the grey soils, and the red brown soils of the Nookamka series lying in the depressions between sandy rises are the heaviest types. Some of the loose sandy rises are merely brown, and in some respects resemble the Winkie sand described from Berri, South Australia (Marshall and Hooper loc. cit., p. 18), but their vegetation of large pine and hopbush was considered distinctive.

(a) Murray sand.

Narrow parallel sand ridges trending more or less east and west occur over the western half of Merbein. The crests of the ridges have frequently a strip of deep sandy soil, often above present gravity irrigation level, and growing pine and hopbush in the virgin state. **In** earlier surveys of other irrigation areas, Murray sand has been confined to the high rises adjacent to the river valley, but these deep light soils of Merbein and their vegetation show only minor differences from typical Murray sand, and they have been mapped within the type.

The profile is light and sandy throughout, with little lime and rubble, as illustrated in Fig. 2.

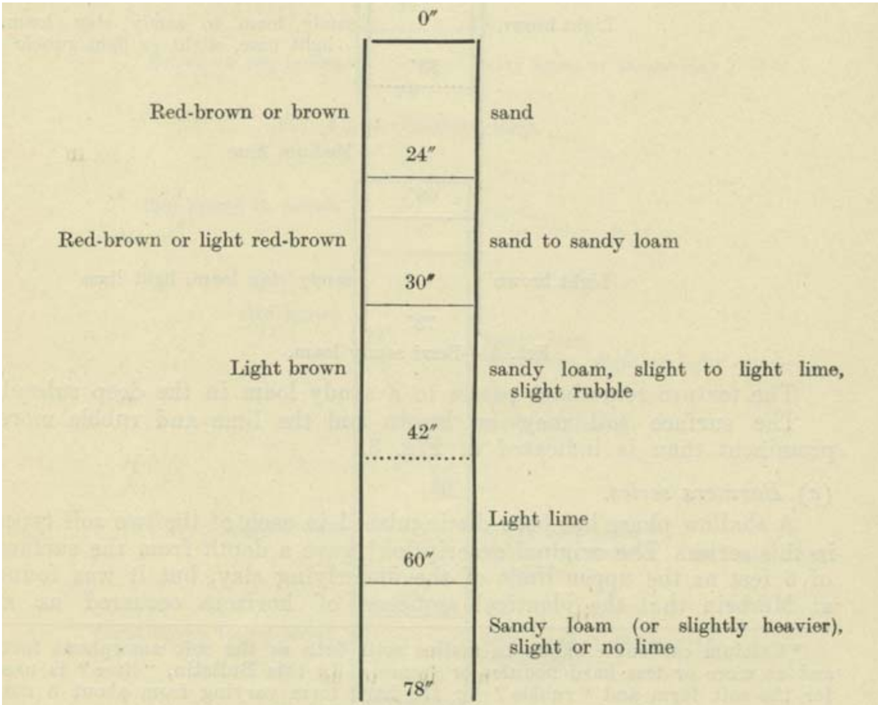

Fig. 2 – Murray sand

In some cases marked on the soil map as "Murray sand var." the .profile shows a sandy clay loam below 6 feet without meeting a clay layer within 9 feet. Rarely is lime present in more than small amounts.*

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* Calcium carbonate exists in mallee soils both as the soft amorphous form and as more or less hard nodules or stones. In this Bulletin, "lime" is used for the soft form and "rubble" for the hard form varying from about 5 mm. to 5 cm. in diameter. Larger rubble is

(b) Berri sandy loam.

This type is of minor importance at Merbein; it occurs on the tops of the lower sandy rises and immediately adjoins Murray sand in other cases. It also grew pine and hopbush in the virgin state. It has a more variable and higher lime content than Murray sand and is slightly heavier in profile.

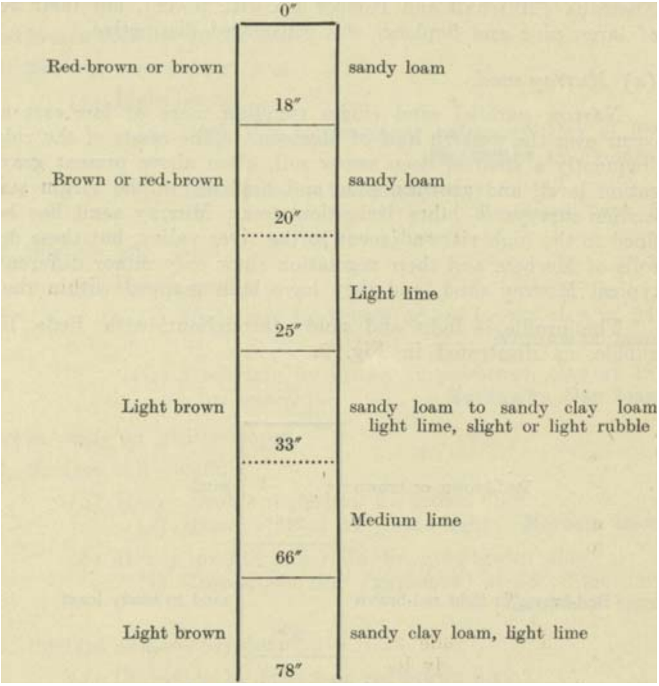

Fig. 3 – Berri sandy loam

The texture sometimes passes to a sandy loam in the deep subsoil. The surface soil may be brown and the lime and rubble more prominent than is indicated in Fig. 3.

(c) Barmera series.

A shallow phase has been distinguished in each of the two soil types in this series. The original description[†] gave a depth from the surface of 6 feet as the upper limit of the underlying clay, but it was found at Merbein that the identical sequence of horizons occurred as at Barmera, with the clay at 4 feet. It was decided that the normal type should have the clay at a greater depth than 5 feet and the shallow phase less than 5 feet with a minimum depth of approximately 45 inches. The typical occurrence is, on slopes from sandy rises or on low rises carrying sandalwood and some belar.

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described as "stone."

[†] Marshall and Hooper, Coun. Sci. Ind. Res. (Aust.), Bull. 86, 1935.

(i) Barmera sand.—Average profiles of the type and shallow phase are shown in Figs. 4 *(a)* and 4 *(b).*

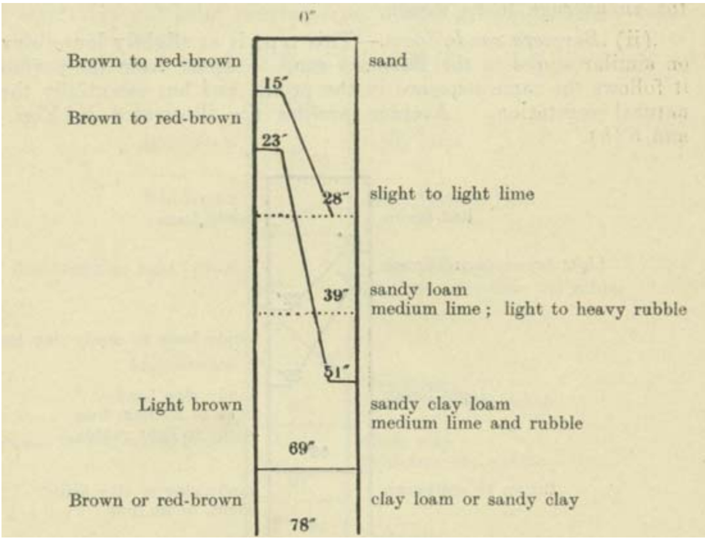

Fig. 4*(a)* – Barmera sand

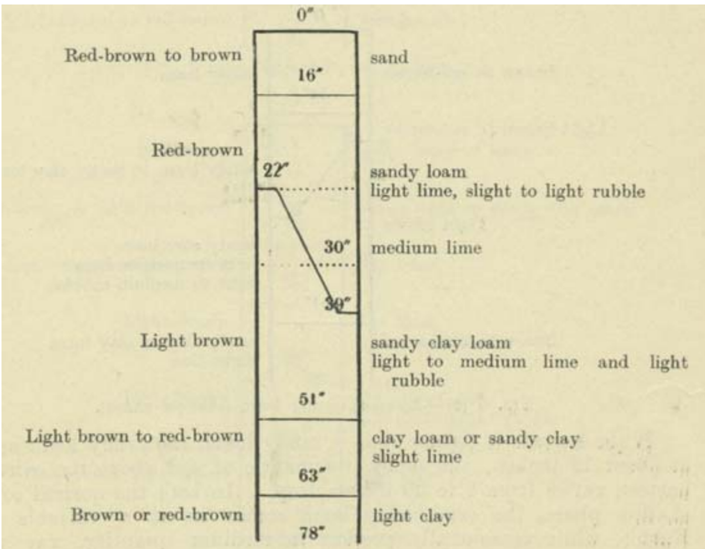

Fig. 4 *(b)* – Barmera sand (shallow phase)

The surface sand in the normal type varies from 12 to .45 inches deep, seldom approaching the shallow limit, while the sandy clay loam subsoil comes in between 21 and 60 inches. The lime and lime rubble are correspondingly variable. In the shallow phase, the surface sand varies from 6 to 33 inches deep, and the sandy clay loam appears at any depth between 18 and 50 inches. As shown on the profile sketches the depth to the sandy clay loam covers a very wide range, too irregular for an average to be struck.

(ii) Barmera sandy loam.—This type is at slightly lower elevations on similar slopes to the Barmera sand. Apart from the surface soil, it follows the same sequence in the profile and has essentially the same natural vegetation. Average profiles are illustrated in Figs. 5 (a) and 5 *(b).*

If the surface is lighter than a sandy loam, the sandy loam appears at about 12 inches; the sandy overmantle of soil above the calcareous horizon varies from 8 to 30 inches deep. In both the normal soil and shallow phase, the sandy clay loam comes in at a variable depth. Rubble, while occasionally present in medium quantity, was not a distinctive characteristic.

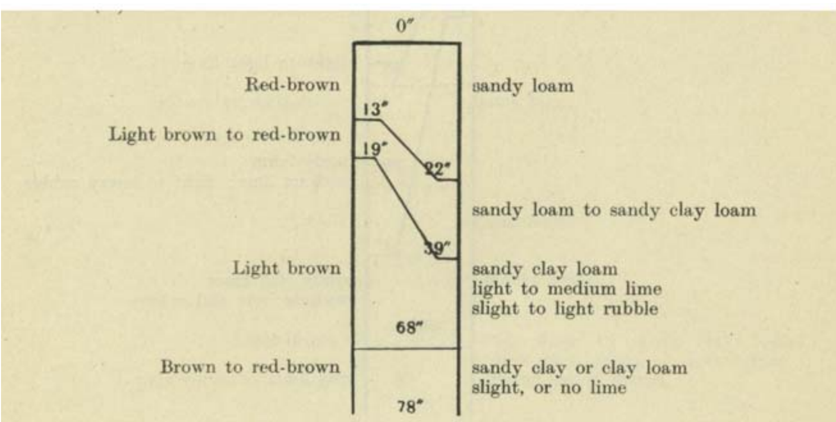

Fig. 5 *(a)* – Barmera sandy loam

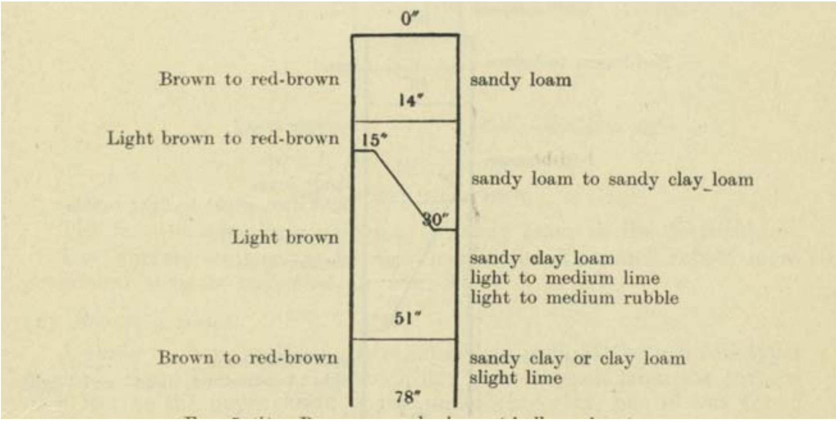

Fig. 5 *(b)* – Barmera sandy loam (shallow phase)

(d) Nookamka series.

The Nookamka sandy loam type was described in the Berri district, South Australia, and with Nookamka loam at Coomealla, New South Wales. At Merbein a third type, Nookamka clay loam, was added to include heavier, lower lying, but definitely red-brown soils. The red-brown surface down to 15 or 18 inches is very typical. All Nookamka types have a similar topographic position in the depression. The original vegetation was belar ranging from a close growing scrubby type to fine individual trees.

Average profiles are given in Figs. 6 (a), 6 *(b)*, and 6 *(c).*

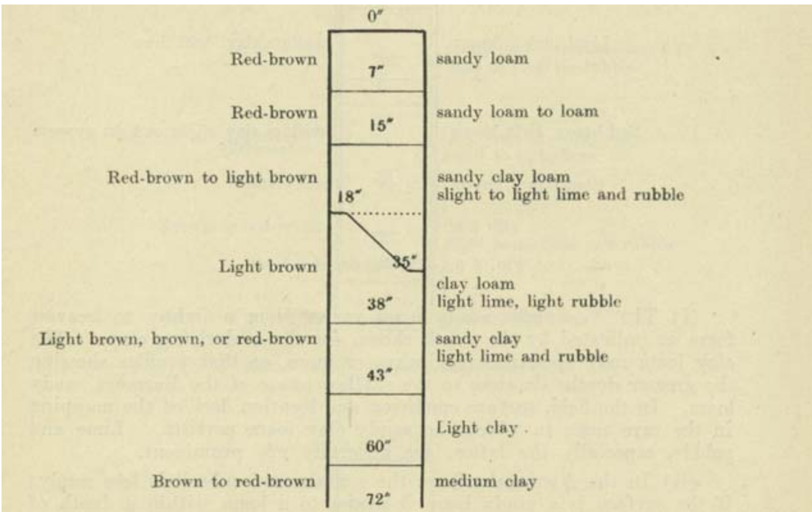

Fig. 6 *(a)* – Nookamka sandy loam

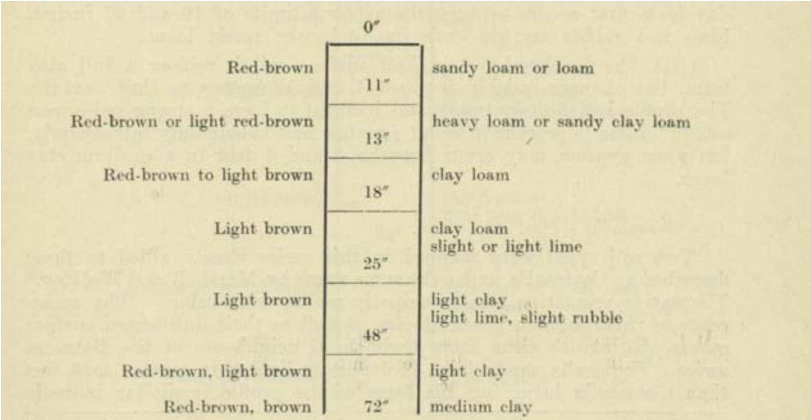

Fig. 6 *(b)* – Nookamka loam

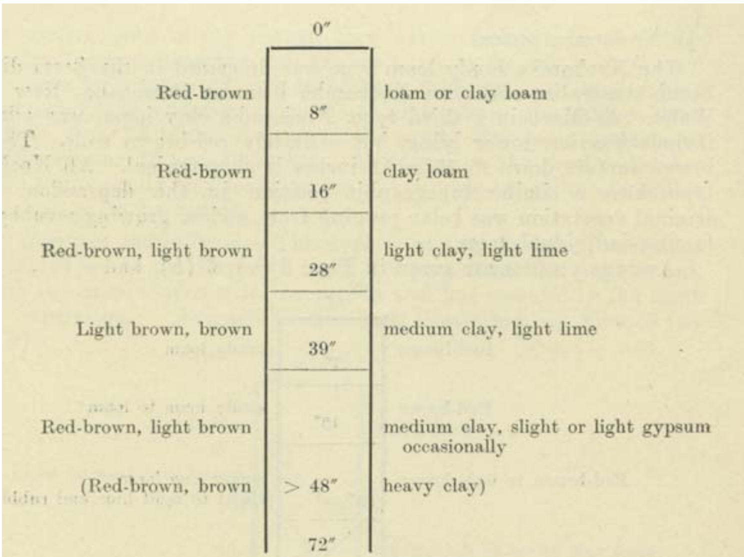

Fig. 6 *(c)* – Nookamka clay loam

(i) The ***Nookamka sandy loam*** varies from a lighter to heavier form as indicated by the depth shown for the underlying clay. The clay loam may appear at 40 inches or more, so that profiles showing the greater depths lie close to the shallow phase of the Barmera sandy loam. In the field, surface condition and location decided the mapping in the rare cases in which the sandy clay loam persists. Lime and rubble, especially the latter, are generally not prominent.

(ii) In the ***Nookamka loam*** the surface and subsoil is less sandy; if the surface is a sandy loam it passes to a loam within a depth of 6 inches. The surface soil varies from 6 to 20 inches deep, and the clay loam first occurs between the extreme limits of 10 and 27 inches. Lime and rubble are less than in Nookamka sandy loam.

(iii) The ***Nookamka clay loam*** surface soil is seldom a full clay loam, but changes quickly between 4 and 12 inches to that texture. The profile, is definitely heavy and inclined to have a strong red-brown colour. Lime is present in small amounts and rubble only infrequently, but some gypsum may occur between 3 and 4 feet in a medium clay layer.

(e) Coomealla series.

Two soil types were mapped in this series closely allied to those described at Coomealla under the same name by Marshall and Walkley.[*] The native vegetation was principally mallee with belar. The occurrence of these soils on gentle slopes, as well as their dull-brown surface colour, distinguish them from their usual neighbours of the Barmera series. Coomealla sandy loam is definitely lighter in texture to 3 feet than Coomealla loam, but the form of the profile is similar in both.

Although the red-brown colour of the deep subsoil clay was accepted as standard, it was not considered essential as long as the soil remained brown without grey effects.

(i) Coomealla sandy loam.—In certain parts of the area a light form of this type was mapped and distinguished by a note on the map. In these soils the sandy clay loam runs down to 48 or 54 inches followed by a sandy clay which may continue to 6 feet. In all forms of the type, rubble is present in considerable quantities; where it is heavy the surface colour is inclined to be brown to grey-brown, but it was decided to include these soils with the less calcareous variety.

(ii) Coomealla loam.—As a general rule the surface is a sandy loam followed by a loam at 6 inches. The depth to the sandy clay loam varies from 6 to 24 inches with, in the deeper cases, no great interval to the clay beneath.

(f) Merbein loam.

Merbein loam is a heavy version of Coomealla loam and rather dull-brown in surface colour. The deep subsoil may be red-brown, but is generally brown or even tending to grey-brown. The type lies on the relatively lowest levels mainly through the middle section of the settlement.

[*] Counc. Sci. Ind. Res. (Aust.), Bull. 107, 1937.

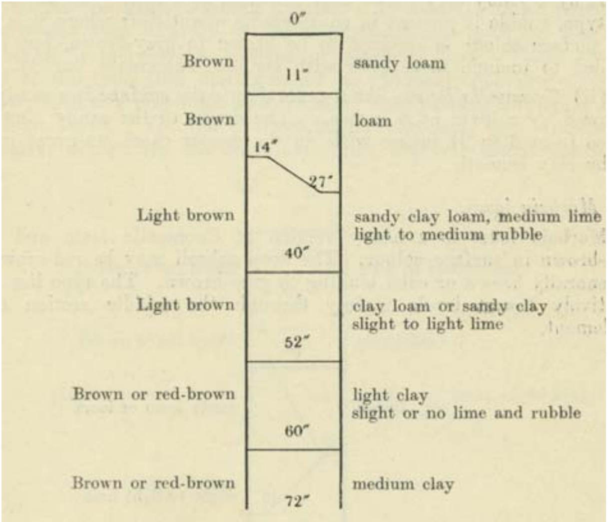

Fig. 7 *(a)* – Coomealla sandy loam

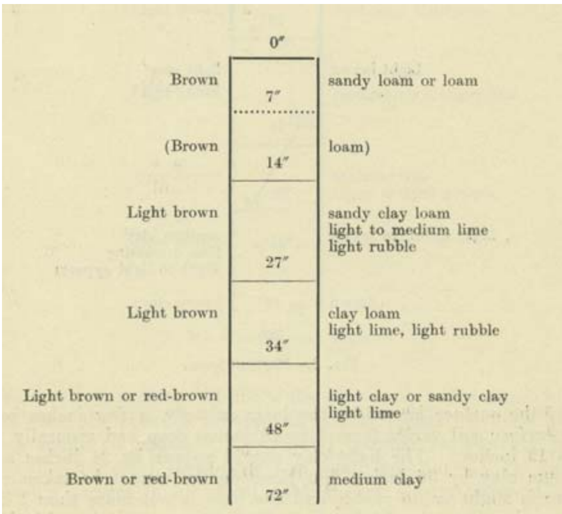

Fig. 7 *(b)* – Coomealla loam

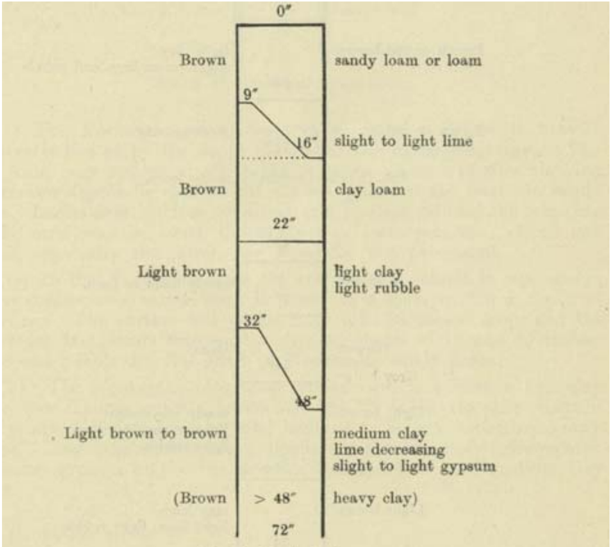

Fig. 8 – Merbein loam

If the surface be sandy, the loam is only a few inches beneath. The surface soil varies from 5 to 18 inches deep and generally is less than 12 inches. The light clay should appear by 24 inches and the medium clay by 36 inches, but these depths cannot be taken rigidly. There is slight or no rubble and the lime is not more than "light"; gypsum is present in the fourth foot but does not persist with depth.

(g) Benetook loam.

This type is more extensive in the adjacent Mildura district. The original vegetation was mallee and bluebush—at Merbein probably with more mallee—on gently sloping ground. It covers a small portion of the surveyed area entirely in the vicinity of the town on the south side, where it merges into patches of Merbein loam. There are two forms of the type (not distinguished as phases), one proceeding at shallow depth to a clay loam and the other first passing through a sandy clay loam layer. On the average profile sketched, this is shown by alternative depths for the clay loam with brackets round the lighter layer.

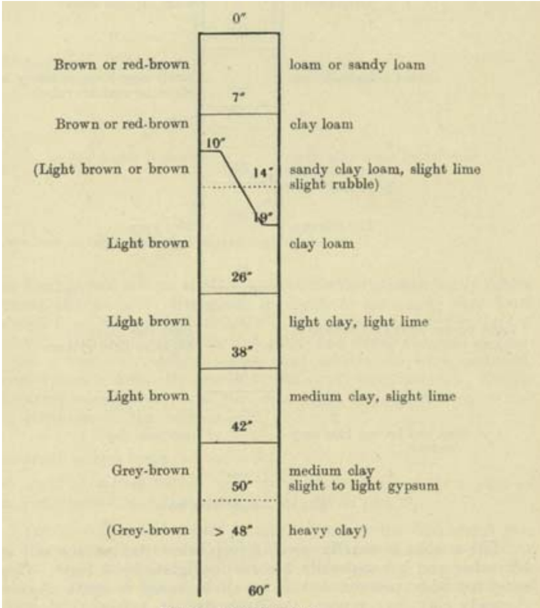

Fig. 9 – Benetook loam

The depth of surface soil above the clay loam varies from 3 to 19 inches, while the range is between 12 and 18 inches for those profiles showing sandy clay loam. The subsoil becomes increasingly heavy, and the lime decreases, being always of small importance. The gypsum is probably present in all cases, although not always observed in the field.

(h) Sandilong loam.

The Sandilong series appears also extensively at Mildura, differing in having a sandy loam surface and a greater depth td the clay, At Merbein the more southerly occurrences south of block 100 have also deep and light profiles with a loam surface soil. The features of the type are the grey-brown surface, the rubble in a. light subsoil, and the mottled-grey deep subsoil becoming increasingly heavy below 4 feet. An average profile is sketched in Fig. 10.

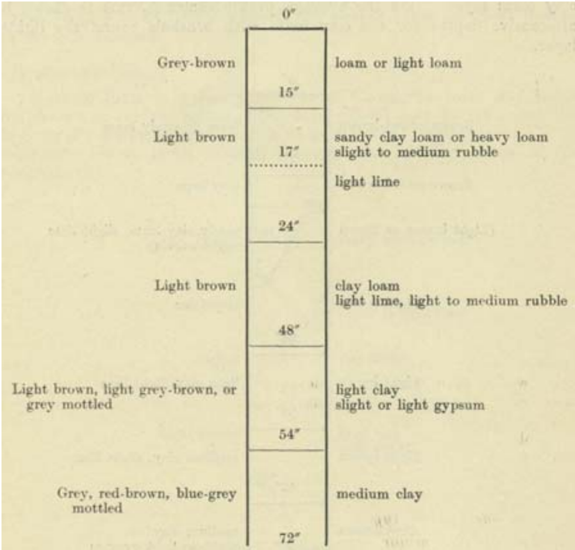

Fig. 10 – Sandilong loam

The rubble is usually present just below the surface soil at 12 to 18 inches and has generally become negligible by 3 feet. Gypsum is not invariably present, but in small amounts is quite characteristic. A sandy clay may replace the light clay at 4 feet.

(j) Karadoc sandy loam.

Several soils with a fine sandy deep subsoil (Karadoc sandy loam, Type A and Type B) are localized in the north-western corner of the Merbein settlement and almost entirely included within the 135-foot contour. The Karadoc sandy loam, which also occurs extensively at Mildura, lies mainly between the 115-foot and 135-foot contours, that is, on definitely low ground compared with the main part of the district.

Considerable variation exists in the profile which is shown as an average in Fig. 11.

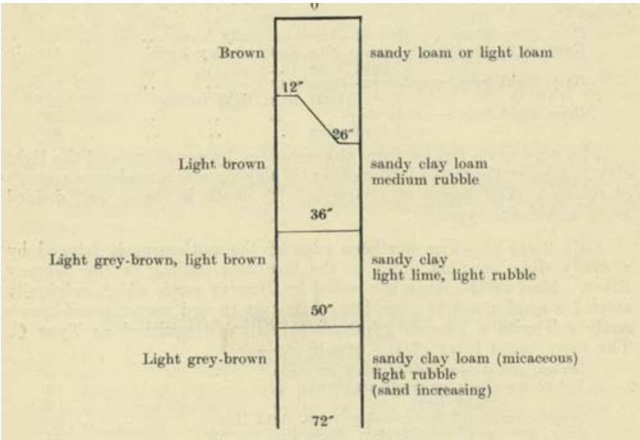

Fig. 11 – Karadoc sandy loam

Some borings had a loam surface and, particularly when heavy rubble was present, showed wide divergence in depth to the sandy clay loam layer, which itself was of considerable thickness before merging into a sandy clay. Usually, micaceous fine sand was dominant in the deep subsoil, but a few soils with a coarse sand substratum were included. The colour becomes definitely greyer in the sandy deep subsoil. Rubble content varied widely, and as a rule was high, sometimes even to the point of stoniness in the surface soil.

(k) Unnamed minor types.

Four soils of minor extent were mapped in the northern part of Merbein and denoted by letters as Types *A, B, C,* and *D.*

(i) Type A*.*—This soil occurs in small areas in the north-west portion and is best described as a modified Nookamka sandy loam containing moderate to high amounts of rubble and underlain by micaceous fine sandy clay at about 4 feet. Many of the occurrences were not penetrable with an auger at shallow depth.

Red-brown—sandy loam or loam	0"
Red-brown—loam	9”
Brown or red-brown—sandy clay loam, light or medium lime, medium to heavy stony rubble	16"
Light brown—sandy clay	33"
Light brown—fine sandy clay (micaceous)	44"-72"
(fine sandy clay loam sometimes	50")

In certain instances a red-brown clay loam to light clay may be a feature of the subsoil, passing on to the sandy clay.

***(ii) Type* B.**—Type *B* has a grey profile throughout, somewhat heavier in texture and less calcareous, but similar to the Karadoc sandy loam. Practically the whole area of this type falls below the 115-foot contour.

Grey, grey-brown (or brown)—loam or sandy loam ..	0"
Grey, light grey-brown—sandy clay loam or clay loam	11"
light lime ..	13"
Grey, light grey, grey-brown—light clay	14"
light lime, light rubble	21"
Grey, light brown—sandy clay	30"
sand increasing ..	48"

The type has a lighter form characterized by persistence of the light clay to greater depth than 30 inches; it may possess a moderate amount of rubble. The degree of sandiness with depth is not as well defined as in associated types.

***(iii) Type C**.*—The northern edge of the settlement is fringed by a sandy slope running down to the box flats leading to the Murray River. Most of the slope is covered by Murray sand, which originally carried a good stand of pine, but at its eastern end occurs a red-brown sandy soil with a greyish gypseous subsoil, distinguished as Type *C.* The more usual form of the profile is :-

Brown, red-brown—sandy loam or loam	0"
Red-brown—loam or sandy clay loam ..	12"
light lime	16"
Grey-brown, light brown—clay loam, light lime	20"
Grey, grey-brown—light clay, slight lime	33"
light to heavy gypsum ..	39"
Grey—medium clay ..	48".-72"

On the soil map a variant is shown with the words "underlain by sand"; the sandy layer is at a greater depth than 30 inches.

(iii) Type D.—On the same slope as Type *C* are several small patches of sandy soil underlain by a gritty sand in various stages of induration, as a rule not penetrable with an auger.

Red-brown—sand	0"
Red-brown—sandy loam ..	6"
Brown, light brown—sandy clay loam, light lime ..	12"
Sandstone or mottled gritty sand	30"

The surface sand may be as much as 30 inches deep.

Soil type variants.
Notes on local variations of the soil from the standard of the type mapped have been printed in a number of cases on the soil map. Some are self-explanatory, such as "surface stone," or "deep sandy surface," but others require explanation. On the western fringe of the settlement, as in blocks 120-120A and 114-115, occur some soils mapped either as Coomealla sandy loam or Merbein

loam but with a definitely grey deep subsoil at about 4 feet. It is, strictly, a point of distinction, but, owing to the minor areas involved, the soils were included with the type nearest in texture profile irrespective of colour. Merbein loam, in particular, included a number of odd borings with definitely grey colour in the deep subsoil. In blocks 94-95, Barmera sandy loam is underlain by a coarse gritty sand at 4 feet. This gritty layer (or sandstone, cf. Type *D)* occurs irregularly over mallee areas and was noted also in the spoil from a drainage shaft deeper than 6 feet in the south-west corner of the settlement.

Surface soil colours have been altered in some cases by waterlogging and surface salinity to appear greyer than normal. Growth of grasses, particularly couch grass which resists saline soil conditions, adds to the effect. The main soils concerned belong to the Barmera and Coomealla series. Greyness and a rubbly nature are also associated with spots formerly occupied by thick mallee clumps, and these may appear as a patchwork over an area. The soils in all cases have been made to conform to the type nearest in general profile characteristics.

Gypsum occurs in some of the types without being a characteristic feature, such as in the Nookamka and Coomealla series, in which case its presence has been indicated on the map. Such occurrences do not seem prejudicial to the productivity as compared with that of the average type.

III. LABORATORY EXAMINATION OF SOILS.

1. Mechanical Analysis.

In mechanical composition the Merbein soils display the normal characteristics of the Mallee group of soils. Mechanical analyses by the International method, set out in the Appendix, show very low contents of silt fraction, the highest figure recorded being 8.3 per cent, except for horizons below 48 inches in the "grey mallee" soil, Sandilong loam, where results of approximately 12 per cent were obtained, and for Karadoc sandy loam. In the latter, all horizons examined gave silt contents greater than 10 per cent, the highest being 17.4 per cent. This type of soil therefore, as well as being sharply defined in its field occurrence, is well distinguished from other types in mechanical composition. The high silt content and high proportion of fine sand reflect the distinctive texture of the Karadoc soils noted in the field and associated with the occurrence of notable amounts of mica, particularly in the deeper horizons. Apart from the presence of mica in fine sand fractions of Karadoc sandy loam, both coarse and fine sands in the Merbein soils examined consist largely of quartz, in some cases with small proportions of ferruginous material. In nearly all cases, coarse sand content is less than fine sand, a typical ratio being 0.7.

The relations between the soil types at Merbein with respect to clay content are summarized in Table 3, which shows average clay percentages to a depth of 60 inches, calculated from the figures given in the Appendix.

The table illustrates the outstanding lightness of Murray sand and the gradation in texture among other types associated with sandy rises. As a group, these soils are well distinguished in average clay content from the heavier Nookamka series, which occur at lower levels between the rises. Among the brown soils, the heavy character is evident of the lowest level type, Merbein loam, while "grey mallee" soil is shown as having only moderate average clay content to a depth of 5 feet.

TABLE 3.--AVERAGE CLAY CONTENT TO 60" FOR MERBEIN SOILS.

-	Soil Type	Clay Percentage
Red-brown soils of the sandy rises	Murray sand *Berri sandy loam †Barmera sand Barmera sandy loam Barmera sandy loam, shallow phase	9.9 15.8 16.7 17.1 18.3
Red-brown soils of gentle slopes	Nookamka sandy loam Nookamka loam Nookamka clay loam	23.2 31.9 31.1
Brown soils of gentle slopes	Coomealla sandy loam Coomealla loam Merbein loam Karadoc sandy loam	17.3 22.6 35.2 19.0
"Grey mallee" soil	Sandilong loam	21.8

* From Conn. Sri. Ind. Res. (Aust.), Bull. 86, 1935.
† From Conn. Sci. Ind. Res. (Aust.), Bull. 107, 1937.

Merbein soils generally contain considerable quantities of calcium carbonate. The analyses tabulated in the Appendix show contents of "rubble and gravel" up to 35 per cent of the field sample, the bulk of this material consisting of limestone rubble, except where figures less than 2 per cent are given, when siliceous gravel may be relatively more important. Calcium carbonate in the fine earth ranges up to 38 per cent. In highly calcareous soils of this kind, it is evident that calcium carbonate must be considered in discussion of mechanical composition.

Fig. 12 illustrates the relations between sand fractions, silt, clay, and calcium carbonate for four of the chief Merbein soils. The minor role of silt and the dominance of fine over coarse sand are made clear, together with the more important features of variations in content of clay and lime with depth. The diagrams illustrate the tendency for maximum concentrations of lime to occur at depths of about 40 inches in the lighter soils and approximately 24 inches in the heavier types, this effect being related to the diminution of lime with increasing clay content in the deeper subsoils. The latter relation is shown by Fig. 12 in Nookamka loam below 30 inches, in Barmera sandy loam shallow phase below 48 inches, and to a lesser degree in Nookamka sandy loam and Coomealla sandy loam below 48 inches, the increase in clay' !content at the depths mentioned being relatively less pronounced in the second pair of soil types.

Similar effects may be noted in the results given in the Appendix for other soil types. Thus lime is very persistent with depth in Murray sand and Barmera sandy loam, which show but little variation in clay content to 72 inches. Only small proportions of lime are present in one profile of Coomealla loam below 42 inches and in Sandilong loam below 48 inches, an increase in clay content occurring at the depths stated. In another Coomealla loam profile, while diminution in 'lime content is coincident with increase in clay at 42 inches, the relatively high amount of 21.5 per cent calcium carbonate persists in the medium clay at 42-60 inches. A similar feature is noted in Merbein loam, where lime remains to the extent of 16.2 per cent, in medium clay at 27-45 inches. The profile of Sandilong loam examined is notable for its high lime content, the sub-surface horizon having 35.2 per cent rubble lime in the field sample, associated with 24.4 per cent of lime in the fine earth, while the underlying horizon has 37.7 per cent of lime in the latter form. Karadoc sandy loam is outstanding for persistence of rubble throughout the profile, figures ranging from 8.3 to 26.3 per cent of the field samples being obtained to a depth of 60 inches.

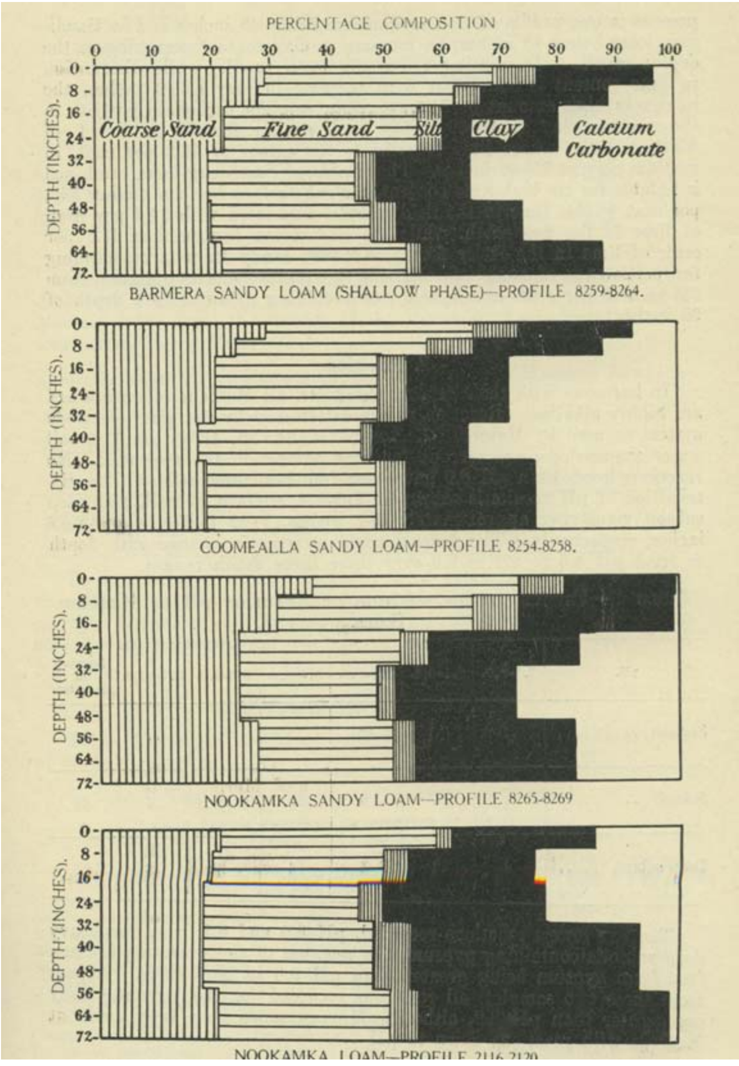

FIG. 12.—Showing physical constitution of soil at different depths in four representative Merbein profiles. The diagrams are based on recalculations to a total of 100 per cent. for the five constituents shown.

2. Reaction.

In harmony with their general character, all Merbein soils examined are highly alkaline. Reaction values determined by the glass electrode system as used by Heintze *(J. Agric. Sci.* 24: 28, 1934), on 1:5 soil water suspensions, are set out for each sample in the appendix. No reactions lower than pH 8.0 have been found in these soils. The distribution of pH results is shown in Table 4, surface, subsoil, and deep subsoil signifying approximately 0-7 inches, 7-42 inches, and 42-72 inches, respectively. The general trend in reaction change with depth is from pH 8.6 to 9.2 to 9.6 over these three depth ranges.

TABLE 4.—FREQUENCY DISTRIBUTION OF REACTION pH IN MERBEIN

pH.	7.7-8.0.	84-8.4.	8. 5-8.8.	8.9-9.2.	9.3-9.6.	9.7-10 .0	Number of Samples.
Surface	. .	6	10	2	..	..	18
Subsoil	..	..	6	23	16	4	49
Deep subsoil	1	1	4	4	3	8	21

The two lowest reactions recorded, pH 8.0 and 8.1, were for heavy deep subsoils containing gypsum, the reaction of the overlying horizon free from gypsum being greater than pH 9.0 in both cases. Apart from these two samples, all reactions recorded for the present survey are greater than pH 8.2, although Murray sands have been noted at Merbein with reactions down to pH 7.1.

3. Nitrogen.

On the whole the Merbein soils conform to the general principle of increase in content of total nitrogen with increase in clay content, as shown by Table 5 for surface samples. Individual results are set out in the Appendix.

TABLE 5.-TOTAL NITROGEN IN MERBEIN SOILS.

-----	Number of Samples.	Average Nitrogen Percentage.
Sands	2	0.031
Sandy loams	9	0.054
Loams	6	0.065
Clay loams	1	0.067

The distribution of total nitrogen for the samples listed in the Appendix, together with a number of other analyses of surface soils of Merbein taken from the records of the Victorian Agricultural Laboratory, is shown in Table 6.

TABLE 6.-FREQUENCY DISTRIBUTION OF NITROGEN IN MERBEIN SURFACE SOILS.

Number of Samples.	Nitrogen Percentage							
	0.02-0.03	0.03-0.04	0.04-0.05	0.05-0.06	0.06-0.07	0.07-0.08	0.08-0.09	0.09-0.10
35	3	9	8	8	4	2	0	1

Total nitrogen content shows the usual decrease with depth below the surface soil; for 10 profiles for which figures are available, mean nitrogen in surface soil (to approximately 12 inches deep, is 0.039 per cent, while corresponding subsoils to depths of 3 feet average 0.023 per cent.

4. Hydrochloric Acid Extracts.

Table 7 presents results of analyses of hydrochloric acid extracts of surface samples.

TABLE 7.-CREMICAL ANALYSIS OF SOILS.

(The figures represent per 0.09-0.10 of air-dry soil.)

Soil Type.	Sample Number.	Depth (Inch).	Phosphoric Acid P_2O_5 Percentage.	Potash K_2O Percentage	Lime CaO Percentage	Magnesia MgO Percentage
Murray sand	8225	0-9	0.06	0.28	0.70	0.31
Barmera sandy loam	2108	0-7	0.05	0.68	1.32	0.33
Barmera sandy loam (shallow phase)	2112	0-9	0.05	0.83	0.75	0.42
Barmera sandy loam (shallow phase)	8259	0-6	0.07	0.56	2.28	0.60
Coomealla sandy loam	8250	0-7	0.13	0.60	8.64	0.72
Nookamka sandy loam	8265	0-7	0.13	0.58	0.60	0.47
Coomealla loam	8239	0-7	0.09	0.62	3.26	0.74
Nookamka loam	2116	0-8	0.12	0.60	7.05	0.62
Sandilong loam	2121	0-7	6.14	0.60	8.53	0.25
Nookamka clay loam	8270	0-5	0.10	0.63	3.06	0.64

Potash is present in considerable quantity in most cases except the very light type, Murray sand. Lime and magnesia are usually at relatively high concentration, but show wide variations, particularly in lime, due to the presence of varying amounts of calcium and magnesium carbonates. These results are typical of Mallee soils, but the presence in several of the samples examined of 0.1 percent or more of phosphoric acid as P_2O_5 is rather unusual for soils of this kind, suggesting that phosphatic fertilizer applications have not been neglected in the handling of the soils concerned. Distribution data for 27 analyses of surface Merbein soils for which records are available are given in Table 8.

TABLE 8.—FREQUENCY DISTRIBUTION OF PHOSPHORIC ACID, POTASH, MAGNESIA, AND LIME IN 27 MERBEIN SOILS.

(The figures show the numbers of soils falling in *each composition range.)*
As percentages of air dry soil.

	0.02-0.04	**0.04-0.06**	**0.06-0.08**	**0.08-0.10**	**0.10-0.12**	**0.12-0.14**
Phosphoric acid (P_2O_5)	6	5	6	5	2	3
	0.2-0.4	0.4-0.6	0.6-0.8	0.8-1.0	-------	---------
Potash (K_2O)	8	13	3	3	..	..
Magnesia (MgO)	10	10	6	1	..	..
	0-0.5	0.5-1.0	1.0-5.0	5.0-10.0	10.0-15.0	---------
Lime (CaO)	4	4	11	7	1	..

Phosphoric acid in most cases lies between 0.02 and 0.10 per cent, and there is a very even scatter over this range. All except one of the samples above this range are taken from Table 7. Potash and magnesia, in the majority of the soils, lie between 0.2 and 0.6 per cent, the magnesia values being evenly distributed, while potash shows a well-defined median value at 0.5 per cent. The range of lime content is shown to be very wide.

Variations of these constituents with depth may be judged from the averages for ten profiles in Table 9, in which surface soils representing depths of about 12 inches are compared with subsoils down to approximately 3 feet. These figures have been calculated from records of the Victorian Agricultural Laboratory.

TABLE 9.—CHANGES IN PHOSPHORIC ACID, POTASH, LIME AND MAGNESIA WITH DEPTH IN MERBEIN SOILS (MEAN OF TEN PROFILES).

—	**Soil.**	**Subsoil.**
	(per cent.)	(per cent.)
Phosphoric Acid (P_2O_5)	0.050	0.041
Potash (K_2O)	0.482	0.553
Lime (CaO)	3.750	8.500
Magnesia (MgO)	0.491	0.843

Changes of this kind with depth are quite typical of Mallee soils, involving slight decrease in phosphate content, some increase in potash and considerable increase in magnesia and more particularly in lime. The latter changes are dependent chiefly upon the greater content of calcium and magnesium carbonates at depth.

5. Soluble Salts.

Analyses of soluble salt extracts of representative Merbein soils, determined on 1:5 extracts, are given in Table 10, while figures for chloride content and for total soluble salts estimated by the conductivity method are listed in the Appendix for all samples.

TABLE 10.—ANALYSIS OF SOLUBLE SALTS.

(Expressed as parts per 100,000 of air-dry soil.)

Soil Type.	Sample Number	Depth (Inch).	Total Soluble Salts	Cl.	SO_4	HCO_3	CO_3	Ca	Mg.
Murray sand	8225	0-9	55	2	3	19	Nil	..	..
Barmera sandy loam (shallow phase)	2112	0-9	244	69	74	41	Nil		
Barmera sandy loam (shallow phase)	8235	14-36	130	4	9	61	5	9	2
Coomealla sandy loam	8255	7-12	260	66	47	39	Nil	..	..
Karadoc sandy loam	8286	8-21	70	2	5	40	Nil	..	..
Merbein loam	8277	13-27	165	18	47	36	Nil	..	..
Coomealla loam	8244	0-7	505	60	240	18	Nil	..	..
Sandilong loam	2121	0-7	95	27	6	42	Nil	13	8

The latter show variations from 0.06 per cent to 0.51 per cent in total soluble salts and from 0.002 to 0.101 in chloride, expressed as chlorine. The majority of the samples shows only moderate amounts of salts, but several of the profiles exhibit a tendency towards concentration of salts at the surface, as in the Barmera sandy loam (shallow phase) profile 2112-2115, both profiles of Coomealla sandy loam, Nookamka sandy loam, Merbein loam, and the Coomealla loam profile 8244-8249. The extent of this effect is of course dependent to a considerable degree on the time at which the particular profile was sampled in relation to the previous irrigation.

Table 10 indicates that sulphates are of considerable importance in certain cases, for example, in the Coomealla loam sample 8244. Surface incrustations of salt from this district often contain notable proportions of sodium sulphate. Chloride is usually dominant among the soluble salts of the Murray irrigation areas, except where total concentration of soluble salts is relatively low, in which cases bicarbonate assumes greater magnitude. It is therefore important to examine the extent to which the presence of sulphates may set Merbein soils apart in this respect. Analyses of 97 soluble salt extracts of soils from this district are available, including those listed in Table 10, most of the samples having been taken from areas in which the possibility of salt damage to crops was suspected.

TABLE 11.—AVERAGE SOLUBLE SALT CONTENT OF MERBEIN SOILS AT DIFFERENT CHLORIDE LEVELS.

Group.	Average Soluble Salt Content Percentage				
	Number of Samples.	Total Soluble Salts.	Chloride (Cl).	Sulphate (SO_4).	Bicarbonate (RCN.
Chloride (as Cl), less than 0.05 per cent.	28	0.183	0.020	0.039	0.072
Chloride (Cl), 0.05-0.10 per cent.	26	0.391	0.075	0.102	0.069
Chloride (Cl), greater than 0.10 per cent.	43	1.018	0.354	0.220	0.062

The table shows that, on the average, sulphate dominates chloride in actual quantity in soils containing less than 0.1 per cent chloride and approaches chloride content even in the more saline soils. Bicarbonate shows very little variation on the average. Considering all results up to 0.10 per cent chloride, an average of 0.047 per cent for chloride as chlorine compares with 0.069 per cent for sulphate radicle and 0.283 per cent for total soluble salts. The latter relations show that chloride expressed as sodium chloride represents only 27 per cent of the total soluble salts in moderately saline soils. Compared with most other Murray irrigation areas, this is a particularly low proportion. On this account, chloride results, as indications of total soil salinity, must be interpreted rather differently at Merbein than elsewhere, the deleterious effect of salt concentration on crops in this district being due in most cases to association of notable proportions of sulphate with chloride.

With regard to the presence of soluble carbonate in these soils, their highly alkaline nature suggests that this constituent is likely to be of common occurrence. Of the 97 samples concerned in Table 11, 38 contain soluble carbonate, the average amount present in these cases being 0.013 per cent, while the maximum figure is 0.042 per cent. Most of the samples in question were subsoils, the presence of soluble carbonate indicating relatively unfavorable conditions involving hydrolysis of sodium clay.

6. Replaceable Bases.

Table 12 lists details of replaceable base determinations (by the Hissink procedure) and other data for nineteen Merbein soils. These results are of normal character for irrigated Mallee soils. In surface samples calcium constitutes about 65 per cent of the replaceable bases and magnesium about 22 per cent, while sodium is only about 4 per cent of the total. In the upper subsoils, magnesium and calcium are the chief replaceable bases, and sodium increases in relative importance as compared with surface soils. The deeper subsoils usually show dominance of sodium and magnesium. Typical examples of these deeper samples are the Nookamka sandy loam subsoil 8268 and the lower horizons of the Sandilong loam profile.

TABLE 12.-REPLACEABLE BASES IN SOILS.

Soil Type	Sample Number	Depth (inch)	pH	Percentage		Total base mgm. Equivalents per 100 g soil	Percentage of total bases			
				Total soluble salts	Clay		Ca	Mg	Na	K
Murray sand	8229	0-12	8.5	0.12	9.0	9.8	66	20	4	10
	8232	45-75	9.5	0.09	13.2	8.3	30	36	14	20
Barmera sandy loam	2111	39-72	9.7	0.11	16.5	7.4	30	35	25	10
Barmera sandy loam (shallow phase)	2115	48-78	9.8	0.15	21.5	10.4	26	24	40	10
	8236	36-48	9.9	0.12	17.7	12.0	24	40	22	14
	8263	48-3	9.7	0.14	21.2	13.1	29	38	20	13
Coomealla sandy loam	8257	33-52	9.2	0.15	15.7	8.7	32	33	20	15
	8258	52-72	9.6	0.19	22.6	15.7	25	36	30	9
Nookamka sandy loam	8268	30-52	9.5	0.17	20.2	15.0	18	31	40	11
Coomealla loam	8239	0-7	8.6	0.08	16.7	16.6	62	23	6	9
	8242	30-42	9.1	0.06	17.7	11.7	48	35	10	7
	8243	42-60	8.9	0.08	31.0	22.1	44	41	9	6
Nookamka loam	2119	30-54	8.8	0.20	38.9	22.6	34	36	26	4
Sandilong loam	2121	0-7	8.4	0.10	16.5	13.3	67	21	3	9
	2122	7-15	8.7	0.17	17.2	10.3	25	45	17	13
	2123	15-33	9.1	0.15	16.6	9.2	15	45	25	15
	2124	33-48	9.2	0.15	22.8	12.8	32	39	22	7
	2125	51-66	9.1	0.20	38.7	21.7	17	39	38	6
	2126	66-84	8.6	0.24	47.5	27.1	24	32	39	5

The latter is of interest in that replaceable base data for the whole profile are presented, and the profile came from an area which had been badly damaged by salt and had improved markedly following drainage. Replaceable bases show a fairly normal trend with depth in this profile, except that replaceable calcium drops very sharply with the change from surface to sub-surface soil, although 24.4 per cent of calcium carbonate occurs in the sub-surface horizon. The analysis for sample 2125, at depth 51"-66" in this profile, illustrates the type of subsoil, high in replaceable sodium and magnesium and with clay content approaching 40 per cent and calcium carbonate only 2.6 per cent, which inhibits penetration of water. This induces development of waterlogging and salt problems and necessitates provision of drainage at this point in the profile. Sharp changes in clay content and nature of the clay, reflected in the analyses for samples 2124 and 2125, are common causes of excess water development in the soil under irrigation.

Analyses showing more favorable base status than usual in Mallee subsoils are those for the Coomealla loam profile samples 8242 and 8243 representing subsoil at depth 30"-60". In these cases, replaceable sodium does not exceed 10 per cent of the total bases whereas, at comparable depths in most other cases, the corresponding figure is greater than 20 per cent and reaches 40 per cent in two instances. Replaceable potash ranges between 4 and 20 per cent of the total bases. Expressed as potash, $K_{9}0$, the figures vary between 0.036 and 0.080 per cent and, insofar as replaceable potash may be considered an index to availability of potash to the plant, values of this kind suggest that Merbein soils in general contain adequate amounts of this nutrient.

IV. RELATION OF SOIL TYPES TO CROP, IRRIGATION AND DRAINAGE, AND SALINITY.

1. Crop and Soil Types.

The installation of a complete drainage system for the settlement may make considerable changes in the capacity of Merbein soils for crop production. This applies particularly to citrus, which so far has been grown with general success only on Murray sand and Berri sandy loam on the highest levels. The Barmera series has suffered to some extent from excess water and salinity, even when it caps the sandy rises or is unaffected by irrigation higher on a slope. Nevertheless, with subsoil drainage, this type should yield profitable returns in citrus in the situations mentioned, but less surely when it occupies lower slopes below Murray sand.

For the remainder of the crops only vines need be considered. All types of soils encountered grow vines profitably unless injured by treatment. All do best on the lighter rather than on the heavier soils, and probably the Gordo is less vigorous on the heavier types than the sultana or currant. No satisfactory conclusion could be drawn from the survey on the superiority of one soil type over another for sultanas, currants, Gordos, or other grapes. It is evident that high yields may be obtained with sultanas and currants on all types under good management. Average yields of dried fruits for the Merbein district over the period 1933-1937 have been calculated from data supplied by the Government Statist, Victoria, and are shown in Table 13.

TABLE 13.—AVERAGE YIELDS OF DRIED VINE FRUITS FOR MERBEIN, 1932-1937.

Year.	**1933.**	**1934.**	**1935.**	**1936.**	**1937.**
Yield cwt./acre	35.8	30.9	32.9	26.8	33.1

The marked drop in average yield in 1936 is attributable largely to the partial failure of the currant crop in that year. Of the dried fruit production over the period stated, sultanas average 70 per cent and currants 23 per cent, the remainder being largely lexias with a small proportion of muscatels.

With reference to soil tilth and the use of soil amendments, while no direct evidence is available concerning the effect of these factors on crop yield at Merbein, there is no doubt that applications of gypsum exert a beneficial effect on the heavier soils such as the Nookamka series, Benetook loam, and Merbein loam. Applications of lime have been made for this purpose on some holdings in recent years, but the general character and analysis of these soils indicate that gypsum is preferable. Burying of vine cuttings with the object of opening the upper horizons is a practice which has been adopted to a considerable extent in this district.

2. Irrigation and Drainage.

With the exception of four soil types, Merbein loam, Benetook loam, Nookamka clay loam, and Nookamka loam, the soils of the Merbein district are all liable to overwatering to some extent, with the consequent possibility of waterlogging and salt damage. This is being vigorously combated on many blocks by the installation of tile drains linking with the community drainage system, and in a less degree by reduction in the amount of applied water. It has been shown that, if the drains be spaced at a certain minimum interval, dependent on the absorptive capacity of the soil and the depth of the drain lines, the excess subsoil water can be withdrawn and to a limited extent salt removed.* It is reasonably certain that a layer of sandy clay loam or highly calcareous clay loam or sandy clay presents no real bar to the vertical penetration of irrigation water. The depth of unrestricted penetration is governed by the presence in the subsoil of a clay layer, decreasingly calcareous with depth. Taking the average type descriptions as standard, the depth to this significant layer, suitable for the laying of drains, is given in Table 14 for the various soil types. The depths are minimum, and the soils are in approximate order of decreasing rates of water absorption.

TABLE 14.—DEPTH OF CLAY SUBSTRATUM AND WATER ABSORBING RATES OF MERBEIN SOILS.

Soil Type.	Phase or Variant.	Rate of Water Absorption	Average Depth of Clay Layer for Drainage Lines.
Murray sand	..	Very high	No clay within 6 feet
Berri sandy loam	..	Very high	No clay within 6 feet
Barmera sand	..	Very high	69 inches
Barmera sand	Shallow phase	Very high	51-72 inches
Barmera sandy loam	..	Very high	68 inches
Barmera sandy loam	Shallow phase	Very high	51-72 inches
Karadoc sandy loam	..	Moderate to high	Variable—no estimate
Coomealla sandy loam	..	Moderate to high	52-60 inches
Coomealla sandy loam	Light variant	Moderate to high	66 inches
Coomealla loam	..	Moderate	48 inches
Sandilong loam	..	Moderate	48-54 inches
Nookamka sandy loam	..	Moderate	45-60 inches
Nookamka sandy loam	Light variant	Moderate	60 inches
Nookamka loam	..	Slow to moderate	Not generally requiring
Nookamka clay loam	..	Slow	drainage. If necessary
Merbein loam	..	Slow	drain at about 4 feet or
Benetook loam	..	Slow ..	below gypseous layer

The table is designed to give an approximate picture of the irrigation and drainage character of the soils in a comparative way. Alternative figures in the fourth column indicate the probable extremes of depth at which drainage lines would be laid for satisfactory results. Six feet represents the maximum depth for economic drainage under average conditions, and in all but two types a suitable bottom can be obtained within that depth.

The irrigation problem is connected also with the topographic position of the

* Experimental studies on these points are proceeding at the Commonwealth Research Station, Merbein, Victoria.

more permeable soils. Murray sand has been mapped along the crests of the ridges and constitutes a source of danger to soils in the adjacent valleys, such as Barmera sandy loam or, lower still, Nookamka sandy loam or soils of the Coomealla series. There is doubtless, beneath the sand ridges, some clay bottom on which water can accumulate and slowly drift down the slopes. The movement of water in this formation, however, is not clearly understood, and the constancy of water table levels on the rises requires explanation. The Berri and Barmera series are in turn equally dangerous in causing heavy water absorption. The division between the soil types forms the line of danger where sandy rises are concerned, and in many cases trouble has shown up in Barmera sandy loam just above Nookamka or Coomealla types.

Another feature affecting water movement is the rubbly condition of the profile, well exemplified in some soils of the Coomealla series and in Sandilong loam and Karadoc sandy loam. Occurrences of gypsum in the clay zone also have a definite effect on free water relations within the soil, and if such are present it is advisable if possible to drain at the lower limit of the gypsum layer.

With regard to the effectiveness of drainage under Merbein conditions, evidence is available from about 1922 concerning the results of local drainage projects involving disposal of drainage waters into shafts sunk to drifts. Expedients such as this have, of course, been superseded recently by the construction of the community drainage scheme. One local scheme for which data is available involved several blocks in the Birdwoodton area, on which damage to vines became very severe in 1923. Considerable additions were made, with generally satisfactory results, to the limited subsoil drainage provided up to that time. The effect on yield of dried fruit from five representative blocks is shown in Table 15, in which yields are expressed as index figures calculated from the mean yields for the five blocks for each year, adjusted for seasonal variation by reference to the average yields for the county. The latter were calculated from data made available by the Victorian Government Statist, while the Closer Settlement Commission supplied yield data for the particular blocks concerned.

TABLE 15.—AVERAGE YIELD INDEX FOR FIVE MERBEIN DRIED FRUIT BLOCKS BEFORE AND AFTER DRAINAGE.

1922	1923	1924	1925	1926	1927	1928	1929	1930	1931	1932
28	57	45	56	74	74	67	85	100	94	96

The condition of the vines showed that drainage did not become generally effective until 1926-1927, and the table indicates considerable improvement in production after that date, an average of the figures for 1922-1926 being 52 compared with 86 for the period 1927- 1932. The main soil type affected on these blocks was the "grey mallee" soil Sandilong loam, and the extent to which salinity had developed may be judged from the average figure, namely 0.113 per cent., for sodium chloride content to a depth of 4 feet in fifteen bores distributed over the five blocks in 1924.

Results such as these suggest that considerable improvement in the area is reasonably certain following the completion of the comprehensive subsoil drainage scheme, which will provide drainage outfall at minimum depth of 4' 6" for each block. In the past, shallow drains, though temporarily beneficial, have not proved fully successful over long periods. Drainage at adequate depth has been proved a practical remedy for excess water problems associated with the irrigation of Merbein soils, and further investigation will determine the optimum depth and distance apart on average soil formations, the principles of drainage being based on considerations such as those set out in Table 14.

3. Soil Salinity.

The topography and arrangement of soil types at Merbein are such that the development of waterlogging in some areas was inevitable under irrigation. Where this has occurred, toxic salinity of the soil in the root zone has supervened almost invariably. The soils more particularly disposed to this state are those associated with the flatter mallee areas and the dull brown soils containing moderate amounts of rubble and soft lime. The down-slope edges of Barmera sandy loam, Coomealla types in general, and Sandilong loam, are cases in point.

During the survey, eight profiles from virgin land were examined for chloride content. While two samples from virgin grey rubbly mallee soil were extremely salty, those from sand-hill formations above present irrigation level followed the usual progressive increase in salinity with depth. Expressed as parts of sodium chloride per 100,000 of soil, the order of salt content in these latter profiles was as follows:- 1st foot, 20; 2nd foot, 60; 3rd to 6th foot, 150. As these figures are similar to those recorded for virgin soils in certain other irrigation settlements along the Murray, they may be taken to represent the type of salt distribution which prevailed in Merbein soils prior to irrigation.

Examples of two different types of salt re-distribution following development of excess soil water under irrigation at Merbein may be mentioned. The two profiles were sampled at the same period, details being available from the records of the Victorian Agricultural Laboratory. In the first case, which shows concentration of salt in the surface soil, sodium chloride content of the upper 6 inches of soil was 857 parts per 100,000 compared with 16 parts in the subsoil 6"-48". In the second case, showing concentration of salt in the deeper horizons, the corresponding figures were 49 and 230. Salt concentrations of this order are, of course, sufficient to cause toxic effects in horticultural crops. Of 40 profiles represented by the two quoted as types, 28 showed figures for sodium chloride in the surface 6" greater than 100 parts per 100,000 of soil, while 19 were above this concentration for the zone 6"-48". These results were obtained before subsoil drainage had been applied to any notable extent at Merbein.

During the present investigation, a large number of samples were taken for estimation of chloride at various depths in the soil. The work was done during the irrigation season and because of the probability of leaching of salt from the surface soil by irrigation water, the salt content of the 12"-24" depth was taken as representative of the salt status of the root zone. Most of the information relates condition of vines with soil salinity represented in this way. For citrus, the number of samples available is inadequate to define the relation between salinity and crop condition for the Merbein district, but probably 50 parts of sodium chloride per 100,000 of soil is an extreme figure for safety of citrus under local conditions. For vines, a total of 322 samples from the second foot of soil are tabulated below according to sodium chloride content and vine condition. These samples were taken where the water table was high, or where salt was showing on the soil surface or its presence suspected.

TABLE 16.—DISTRIBUTION OF SODIUM CHLORIDE CONTENT OF SOILS IN RELATION TO VINE GROWTH.

Condition of vines	Sodium Chloride – Parts per 100,000 of Soil													Total Samples
	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	90-100	101-150	151-200	>200	
Poor or dead	..	2	6	6	7	2	7	9	6	5	7	2	3	62
Patchy	..	4	2	12	7	9	4	3	3	..	3	1	..	48
Fair	4	15	17	21	17	7	7	1	1	3	..	..	..	93
Very fair	8	36	30	19	11	4	3	..	..	..	..	..	..	111
Good	..	4	3	1	..	..	..	..	..	..	..	..	..	8

Table 16 demonstrates, as expected, a downward trend in salt content of soil from the poor to the good vines. Among vines designated patchy, localization of salt affects a proportion of the plants, which vary in vigour from poor to very fair within a short radius. In view of the well-known variability of salt concentration in soil, variations in vine vigour at different times during the season, and the use of salt content of a particular depth of soil as an index to salinity of the root zone, closer relations than the general trend shown by the table can hardly be expected. Consideration of the whole table, however, and of the fact that there were indications that the poor or dead vines had declined because of the presence of salt, leads to the suggestion that contents of sodium chloride greater than 60 parts per 100,000 of soil are indicative of dangerous conditions for vines in Merbein soils in general. As the table shows, a decline due to salinity is possible in a proportion of the soils at even lower figures. Compared with certain other districts, the level of soil salinity, as indicated by chloride, at which injury to vines may become manifest, is therefore rather low at Merbein. Probably, a major factor in this connexion is the relation of chloride to total soluble salts in the soils and particularly to soluble sulphates. As has been shown in the section on laboratory examination of these soils, sulphate is of considerable importance among the soluble salts at Merbein. For a series of 28 soils, an average of 33 parts per 100,000 for chloride as sodium chloride compares with 53 parts for sulphate as sodium sulphate, while an extreme case shows 33 parts of sodium chloride and 251 of sodium sulphate. While no direct evidence concerning the toxicity of sulphates for vines under Merbein conditions has been obtained in the present work, there is no doubt, from the known properties of this type of soluble salt that its presence in notable quantities in the soils of this area must denote a considerable intensification, above that attributable to chloride alone, of deleterious effect due to salt concentration.

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APPENDIX.
MECHANICAL ANALYSES AND OTHER DATA FOR MERBEIN SOILS.

All figures are shown as percentages of fine earth, except those for reaction, depth, and "rubble and gravel," the latter being percentages of the field samples. As indications of field texture, **S** signifies sand; **SL,** sandy loam; **SCL,** sandy clay loam; **FSCL,** fine sandy clay loam; **L,** loam; **FSC,** fine sandy clay; **LC,** light clay; **MC,** medium clay; HC, heavy clay.

TABLE I. MECHANICAL ANALYSES AND OTHER DATA FOR MURRAY SAND PROFILES.

Lab. No.	**8225**	**8226**	**8227**	**8228**	**8229**	**8230**	**8231**	**8232**
Depth (inch)	0-9	9-27	27-42	42-66	0-12	12-26	26-45	45-72
Texture	S	S	S	S	S	SL	SL-SCL	SL-SCL
Rubble and Gravel	..	1.1	1.1	..	0.6	1.2	1.2	11.3
Coarse Sand	38.8	35.3	31.5	34.3	38.3	30.7	24.6	20.4
Fine Sand	49.9	47.5	49.0	50.3	46.6	41.4	35.6	29.7
Silt	1.7	1.2	1.1	2.2	2.4	4.5	3.6	1.4
Clay	5.9	6.8	5.9	5.9	9.0	13.7	16.8	13.2
Moisture	1.1	1.3	0.9	0.8	1.5	2.0	1.9	1.4
Loss on Acid Treatment	1.5	7.3	6.0	6.2	1.1	7.5	18.0	34.0
Loss on Ignition	2.0	4.4	5.7	3.6	2.3	5.2	9.8	16.6
Calcium Carbonate	0.7	6.0	9.4	5.4	0.3	6.0	16.6	32.4
Total Soluble Salts	0.06	0.06	0.06	0.06	0.12	0.10	0.10	0.09
Chlorides (as Cl)	0.002	0.004	0.002	0.003	0.022	0.005	0.005	0.005
Nitrogen	0.039	..	..	..	0.022	..	..	..
Reaction (pH value)	8.9	8.9	9.0	9.1	8.5	9.5	9.5	9.5

Table II.—Mechanical Analyses and Other Data for Barmera Sandy Loam Profiles.

—	Barmera Sandy Loam.				Barmera Sandy Loam (Shallow Phase).			
Lab. No.	2108	2109	2110	2111	2112	2113	2114	2115
Depth (inch)	0–7	7–20	20–39	39–72	0–9	9–17	17–48	48–78
Texture	SL	SL–SCL	SCL	SCL	SL	SL	SCL	SC
Rubble and Gravel	—	—	0.1	3.4	—	—	1.9	8.1
Coarse Sand	31·9	31·3	25·4	21·6	32·8	28·3	25·4	22·5
Fine Sand	43·9	39·4	33·5	24·7	39·3	36·4	26·7	23·4
Silt	3·8	3·1	3·2	·9	4·3	5·5	3·2	2·9
Clay	16·1	18·3	17·2	16·5	20·6	23·6	18·4	21·5
Moisture	1·4	1·3	2·0	1·4	1·1	2·7	1·7	2·4
Loss on Acid Treatment	3·2	7·8	20·4	36·2	2·3	5·7	25·5	28·4
Loss on Ignition	3·6	5·2	10·5	17·0	3·3	4·6	12·9	14·5
Calcium Carbonate	2·0	6·1	19·2	34·9	1·0	4·0	22·7	26·7
Total Soluble Salts	0·12	0·11	0·09	0·11	0·24	0·16	0·15	0·15
Chlorides (as Cl)	0·018	0·019	0·010	0·013	0·074	0·027	0·026	0·018
Nitrogen	0·066	..	..	..	0·048	..	..	..
Reaction (pH value)	8·4	8·7	9·1	9·7	8·4	9·3	9·7	9·8

—	Barmera Sandy Loam (Shallow Phase).											
Lab. No.	8233	8234	8235	8236	8237	8238	8259	8260	8261	8262	8263	8264
Depth (inch)	0–6	6–14	14–36	36–48	48–57	57–72	0–6	6–13	13–30	30–48	48–63	63–72
Texture	S	SL–S	SL–SCL	SCL	LC	LC–MC	SL–L	L	SCL	SCL	SC	MC
Rubble and Gravel	0.4	0.6	0.6	2.6	0.9	1.3	2.2	1.6	6.5	2.7	2.9	1.9
Coarse Sand	28·6	25·4	25·4	19·2	18·4	21·3	27·3	27·2	21·4	18·8	18·7	20·7
Fine Sand	52·1	53·1	39·9	31·8	33·0	38·1	38·1	32·5	31·7	24·7	26·5	31·1
Silt	4·7	3·8	2·9	1·5	3·5	4·5	7·0	5·4	4·3	3·7	3·7	3·7
Clay	11·4	12·5	13·2	17·7	24·2	30·3	19·5	21·2	19·1	15·3	21·2	28·9
Moisture	1·3	2·0	1·9	2·0	1·9	2·8	2·8	2·4	2·4	1·8	2·7	3·2
Loss on Acid Treatment	2·2	3·2	14·6	28·4	20·1	2·9	4·7	12·6	20·9	36·1	27·5	14·2
Loss on Ignition	3·0	3·4	8·1	14·3	11·2	3·9	5·6	8·2	11·6	18·0	14·1	8·6
Calcium Carbonate	0·8	2·3	13·4	26·5	18·8	1·3	3·3	11·2	20·0	34·8	25·3	11·7
Total Soluble Salts	0·06	0·09	0·13	0·12	0·16	0·18	0·06	0·06	0·07	0·10	0·14	0·16
Chlorides (as Cl)	0·008	0·010	0·004	0·006	0·008	0·009	0·003	0·002	0·005	0·009	0·007	0·008
Nitrogen	0·045	..	..	..	..	..	0·056	..	..	..	..	..
Reaction (pH value)	8·6	9·0	9·6	9·9	9·8	9·7	8·7	8·7	9·2	9·6	9·7	9·9

TABLE III.—MECHANICAL ANALYSES AND OTHER DATA FOR PROFILES OF THE NOOKAMKA SERIES.

	Nookamka Sandy Loam.					Nookamka Loam.					Nookamka Clay Loam.				
Lab. No.	**8265**	**8266**	**8267**	**8268**	**8269**	**2116**	**2117**	**2118**	**2119**	**2120**	**8270**	**8271**	**8272**	**8273**	**8274**
Depth (inch)	0–7	7–17	17–30	30–52	52–72	0–8	8–18	18–30	30–54	54–80	0–5	5–15	15–30	30–48	48–72
Texture	L–SL	L	CL	LC	MC	L	CL	LC	MC	HC	CL	LC–CL	SC–MC	MC	HC
Rubble and Gravel ..	1.8	1.8	3.4	4.7	1.7	0.8	0.4	0.3	0.2	—	2.7	4.9	4.3	2.8	2.4
Coarse Sand	34·7	28·7	23·4	22·7	26·0	18·2	17·1	15·8	16·6	18·3	26·0	26·9	25·6	23·9	19·1
Fine Sand	34·2	33·3	26·5	22·7	24·0	36·1	28·2	25·6	28·5	28·1	30·6	26·5	25·8	25·4	25·8
Silt	7·0	7·1	4·4	2·8	2·8	3·2	4·0	4·4	6·0	4·6	8·3	5·9	5·3	5·4	5·1
Clay	18·8	26·3	25·3	20·2	27·9	23·9	21·5	27·1	38·9	41·8	24·4	28·6	30·0	32·7	35·1
Moisture	2·7	4·4	3·0	2·2	2·5	1·6	2·9	3·3	4·7	3·6	3·9	3·0	3·3	3·3	5·4
Loss on Acid Treatment	1·9	1·9	18·7	29·6	18·6	17·4	27·8	25·2	7·1	3·8	6·9	9·9	11·2	10·7	11·3
Loss on Ignition ..	4·3	4·0	10·7	14·6	10·4	10·3	10·0	12·9	6·4	4·6	7·0	7·0	7·9	7·6	6·0
Calcium Carbonate ..	0·2	0·3	16·8	26·5	17·5	15·3	25·1	22·9	7·1	1·8	5·0	7·6	9·6	8·2	5·0
Total Soluble Salts ..	0·20	0·12	0·14	0·17	0·18	0·08	0·09	0·18	0·20	0·21	0·07	0·11	0·18	0·21	*
Chlorides (as Cl) ..	0·041	0·012	0·013	0·015	0·011	0·020	0·016	0·025	0·028	0·031	0·002	0·002	0·011	0·011	0·017
Nitrogen	0·050	..	..	..	..	0·073	..	..	..	..	0·067	..	..	..	..
Reaction (pH value) ..	8·3	8·7	9·5	9·5	9·9	8·5	9·2	8·9	8·8	8·7	8·8	9·4	9·7	9·4	8·0

* Contains gypsum.

TABLE IV.—MECHANICAL ANALYSES AND OTHER DATA FOR PROFILES OF THE COOMEALLA SERIES.

	Coomealla Sandy Loam.								
Lab. No.	8250	8251	8252	8253	8254	8255	8256	8257	8258
Depth (inch)	0–7	7–17	17–48	48–70	0–7	7–12	12–33	33–52	52–72
Texture	SL	SL–SCL	SCL	LC–MC	SL	SL–SCL	SCL	SCL	MC
Rubble and Gravel	1.1	4.6	0.3	—	2.4	2.2	19.5	19.1	7.8
Coarse Sand	24·1	19·8	14·7	13·9	27·6	21·8	18·8	16·2	17·4
Fine Sand	35·8	34·4	29·6	28·1	38·3	35·5	28·1	27·6	29·0
Silt	4·4	4·8	3·6	4·3	5·3	6·8	5·0	1·8	4·3
Clay	13·8	14·4	15·8	24·4	16·5	20·0	16·9	15·7	22·6
Moisture	2·1	1·7	1·8	2·5	2·0	2·5	2·0	1·9	2·4
Loss on Acid Treatment	18·3	25·5	35·5	28·6	9·5	14·5	30·9	37·1	25·6
Loss on Ignition	10·3	12·8	17·0	14·2	7·1	9·1	15·6	18·2	13·5
Calcium Carbonate	16·6	22·8	34·3	25·6	7·5	12·6	29·0	35·1	23·3
Total Soluble Salts	0·34	0·13	0·14	0·25	0·34	0·26	0·15	0·15	0·19
Chlorides (as Cl)	0·055	0·011	0·007	0·018	0·101	0·067	0·015	0·019	0·032
Nitrogen	0·056	..	..	..	0·067	..	..	..	..
Reaction (pH value)	8·7	9·5	9·7	8·8	8·6	9·2	9·8	9·2	9·6

	Coomealla Loam.										
Lab. No.	8239	8240	8241	8242	8243	8244	8245	8246	8247	8248	8249
Depth (inch)	0–7	7–14	14–30	30–42	42–60	0–7	7–14	14–30	30–42	42–50	50–72
Texture	SL	SCL	SCL–CL	SC–LC	MC	SL–L	SL–SCL	SCL	SC	LC	HC
Rubble and Gravel	2.1	2.3	3.2	3.8	2.4	1.6	3.1	3.4	0.7	0.7	0.6
Coarse Sand	21·2	19·9	19·2	14·7	13·9	27·2	19·3	16·7	16·7	17·9	20·8
Fine Sand	38·2	34·5	29·7	27·7	24·6	40·6	34·7	27·6	26·5	32·1	27·8
Silt	6·4	5·5	4·3	4·4	5·7	4·6	4·1	3·8	4·8	6·8	6·8
Clay	16·7	19·9	16·1	17·7	31·0	14·7	16·4	16·5	22·4	33·3	40·9
Moisture	2·4	2·4	1·6	2·0	3·6	2·1	2·1	1·7	2·1	3·4	4·1
Loss on Acid Treatment	14·7	19·0	28·6	34·0	21·4	10·8	23·8	35·4	28·5	8·3	1·4
Loss on Ignition	9·6	10·7	14·5	16·6	12·8	6·7	12·4	16·9	14·2	6·3	4·3
Calcium Carbonate	13·1	17·0	27·4	31·0	21·5	8·3	22·4	31·0	26·6	6·6	0·3
Total Soluble Salts	0·08	0·06	0·06	0·06	0·08	0·51	0·16	0·16	0·17	0·21	0·22
Chlorides (as Cl)	0·007	0·003	0·003	0·004	0·004	0·065	0·021	0·015	0·016	0·014	0·017
Nitrogen	0·056	..	..	..	..	0·039	..	..	..	..	..
Reaction (pH value)	8·6	9·0	9·1	9·1	8·9	8·4	9·0	9·6	9·6	9·7	9·1

TABLE V.—MECHANICAL ANALYSES AND OTHER DATA FOR MERBEIN LOAM AND KARADOC SANDY LOAM PROFILES.

	Merbein Loam.				Karadoc Sandy Loam.				
Lab. No.	8275	8276	8277	8278	8285	8286	8287	8288	8289
Depth (inch)	0–6	6–13	13–27	27–45	0–8	8–21	21–33	33–45	45–60
Texture	L	L–CL	CL	MC	L	SCL	SC	FSC	FSCL
Rubble and Gravel	0.9	0.9	0.7	0.4	8.3	26.3	24.1	21.6	10.0
Coarse Sand	22·7	18·0	11·9	9·7	21·0	15·9	10·5	6·6	4·4
Fine Sand	36·7	30·9	23·7	23·7	44·7	35·2	29·6	40·0	53·6
Silt	9·7	9·0	5·7	6·8	13·1	10·2	11·7	15·5	17·4
Clay	24·5	33·9	33·3	38·2	14·7	17·7	18·9	22·7	19·6
Moisture	2·9	4·2	3·5	4·5	2·0	2·0	1·9	2·0	2·2
Loss on Acid Treatment ..	3·6	4·8	23·5	18·2	9·4	19·6	29·0	15·0	3·8
Loss on Ignition	4·9	6·1	13·6	11·7	5·5	11·5	15·6	9·6	4·9
Calcium Carbonate	0·9	2·9	21·6	16·2	2·9	17·4	28·2	13·9	2·9
Total Soluble Salts	0·24	0·12	0·17	0·19	0·08	0·07	0·07	0·07	0·07
Chlorides (as Cl)	0·045	0·013	0·020	0·014	0·007	0·003	0·004	0·006	0·006
Nitrogen	0·073	..	..	..	0·056	..	..	..	..
Reaction (pH value)	8·3	8·8	9·0	9·2	9·1	9·2	9·3	9·2	9·2

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Table VI.—Mechanical Analyses and Other Data for Profiles of Sandilong Loam and Minor Types.

	Sandilong Loam.						Type B.				Type C.					
Lab. No.	2121	2122	2123	2124	2125	2123	8290	8291	8292	8293	8279	8280	8281	8282	8283	8284
Depth (inch)	0–7	7–15	15–33	33–48	51–66	66–84	0–7	7–11	11–16	16–42	0–5	5–14	14–27	27–42	42–54	54–72
Texture	L	SL–SCL	SCL–CL	CL–LC	MC	HC	SL	CL	CL	SC–SCL	L	SCL	CL	LC	MC	HC
Rubble and Gravel	1.7	35.2	8.5	1.1	0.2	0.2	1.9	1.6	3.6	1.2	3.7	0.9	—	—	0.6	0.5
Coarse Sand	25·9	17·3	13·1	13·8	13·6	8·7	..	..	..	..	18·2	14·7	..	..	..	..
Fine Sand	36·0	34·6	24·5	25·7	30·5	26·9	..	..	..	..	45·7	41·1	..	..	..	..
Silt	4·9	2·5	4·2	6·8	11·7	12·2	..	..	..	..	5·5	3·9	..	..	..	..
Clay	16·5	17·2	16·6	22·8	38·7	47·5	..	..	..	..	13·1	12·8	..	..	..	..
Moisture	2·1	1·3	1·8	2·7	3·7	3·8	..	..	..	..	1·7	1·8	..	..	..	..
Loss on Acid Treatment	15·3	27·8	41·8	30·2	4·0	3·0	..	..	..	..	15·1	26·8	..	..	..	..
Loss on Ignition	9·8	13·5	19·5	14·8	4·7	4·8	..	..	..	..	8·9	13·1	..	..	..	..
Calcium Carbonate	12·6	24·4	37·7	27·9	2·6	1·1	..	..	..	12·9	13·4	24·4	..	12·6	..	..
Total Soluble Salts	0·10	0·17	0·15	0·15	0·20	0·24	0·12	0·10	0·12	0·15	0·07	0·06	0·06	0·07	*	0·19
Chlorides (as Cl)	0·030	0·042	0·030	0·024	0·022	0·020	0·025	0·010	0·010	0·011	0·003	0·002	0·002	0·002	0·004	0·004
Nitrogen	0·100	..	..	..	..	..	0·039	..	..	..	0·050	..	..	..	..	..
Reaction (pH value)	8·4	8·7	9·1	9·2	9·1	8·6	8·5	8·8	8·9	9·4	8·8	9·0	9·2	9·1	8·1	8·5

* Contains gypsum, 5·1 per cent. of fine earth.