SOILS OF THE KALBAR DISTRICT, SOUTH-EAST QUEENSLAND

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1. INTRODUCTION

This soil survey is the first of a series on the important agricultural areas of the Moreton region. Several soil maps and reports are currently available for the region and vary in scale from 1:63 360 to 1:2 000 000 (Isbell 1962, Isbell *et al.* 1967, Beckmann 1967, Paton 1971 and Hubble *et al.* 1972). These reports provide valuable regional soil information but more detailed soil surveys (1:25 000 or larger) are needed for the intensively cropped areas. A detailed knowledge of the types of soil occurring, their nutrient status and their physical properties is necessary to help overcome problems associated with intensive agriculture, particularly erosion, salinity and maintenance of fertility.

The Moreton region is also expected to be the main area of future urban expansion in Queensland. This may lead to situations of land use conflict on highly productive agricultural land. Maps and reports showing the best agricultural land may help to retain that land for agriculture.

It is estimated that agricultural and horticultural land covers an area of 176 400 ha in the Moreton region (Anonymous 1974). Assuming a survey progress of 5000 - 10000 ha per man year, 17.6 - 35 man years would be required to map this area at 1:25 000 (McDonald 1975). This may not allow for additional delays caused by the scattered location of some areas, and other responsibilities of the soil survey officer.

Reference or sample areas at 1:25 000 are less expensive, quicker to survey, and may give sufficient soil information at this stage. It is important that a reference area is appropriately located to include the major landscapes supporting intensive agriculture. A reference area will give a reliable indication of the major types of soil occurring, their geographical distribution and the extent of soil variability. This information is useful in the planning of field experiments and in understanding the soil complexity of the agricultural areas.

This survey is a reference area of 5 000 ha, centred at the township of Kalbar 64 km south-west of Brisbane (Fig. 1). The landscape consists of undulating open farmland, with a few timbered low hills and the Warrill Creek flats.

The area was chosen to include the major soil associations mapped by Paton (1971) in the Fassifern Valley, a major agricultural area in the Moreton region. Many irrigated crops are grown including soybeans, sorghum, potatoes, winter cereals, french beans, peas and carrots.

2. PHYSICAL ENVIRONMENT

2.1 Climate

Data presented here has been taken from the publications of Paton (1972), Thomas (1973) and Robinson and Mawson (1975).

The climate is subhumid and subtropical with an average annual rainfall of 800 mm. Rainfall has a marked seasonal distribution with 72% of rain falling from October to March and 54% falling from December to March.

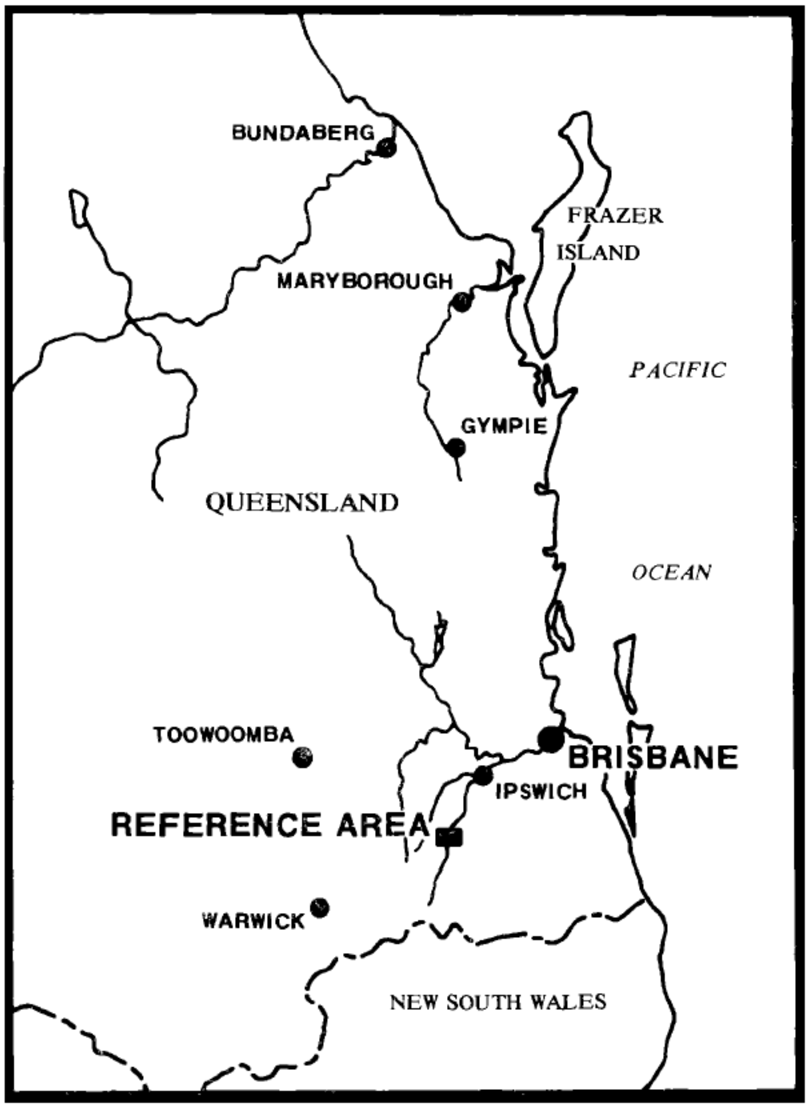


Figure 1. Locality plan

Mean monthly rainfall is compared with the monthly falls that can be expected with 20%, 50% and 80% probability (Fig. 2). As this illustrates, rainfall variability is high, particularly in summer. The average number of raindays a year is 81, with 51 occurring between October and March.

Rainfall is medium-high in intensity and falls average 10 - 11 mm/rainday. Thunderstorms play a major part in the rainfall pattern of the area. Due to high intensity rain, floods can occur fairly frequently in Warrill Creek, and high runoff rates cause severe erosion of the cultivated uplands, mostly in the summer months.

The area has a warm to hot summer (28 - 32°C maxima) and a cool winter (6 - 10°C minima). Average temperature data for Ipswich (46 km north of the area) are presented in Fig. 3.

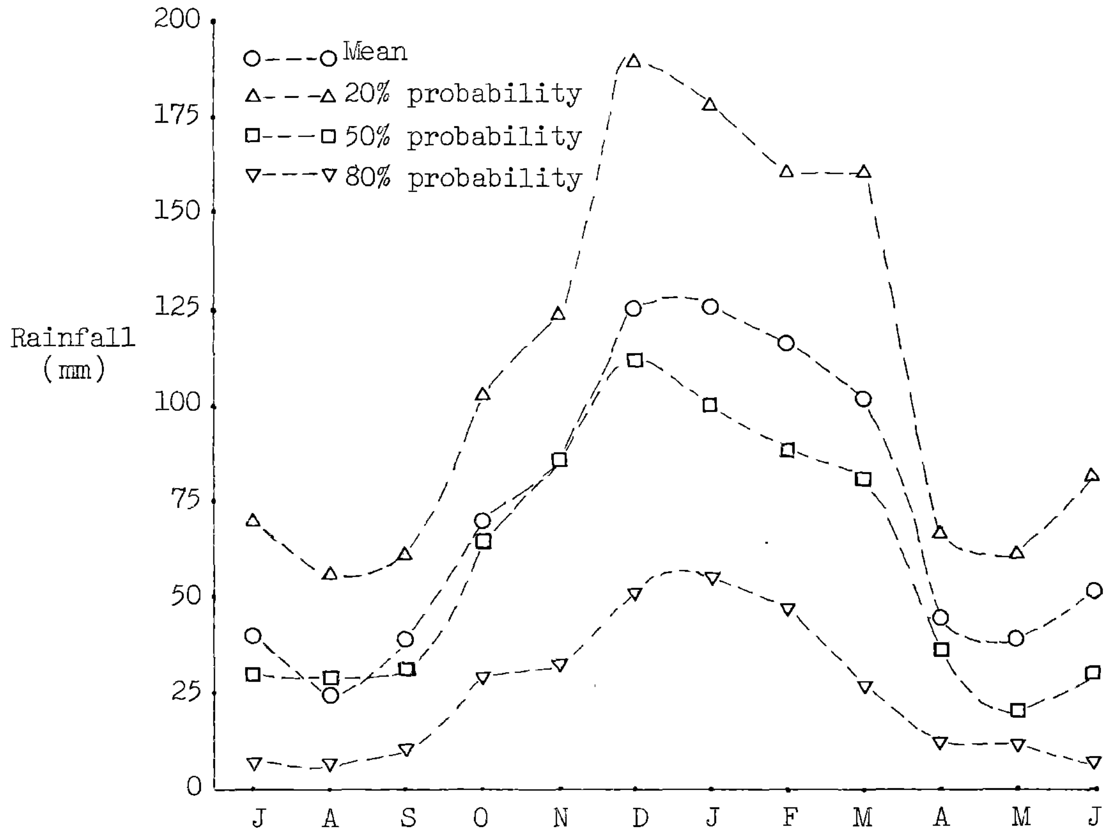


Figure 2. Mean monthly rainfall and probabilities.
(Boonah, 8 km SE of Kalbar)

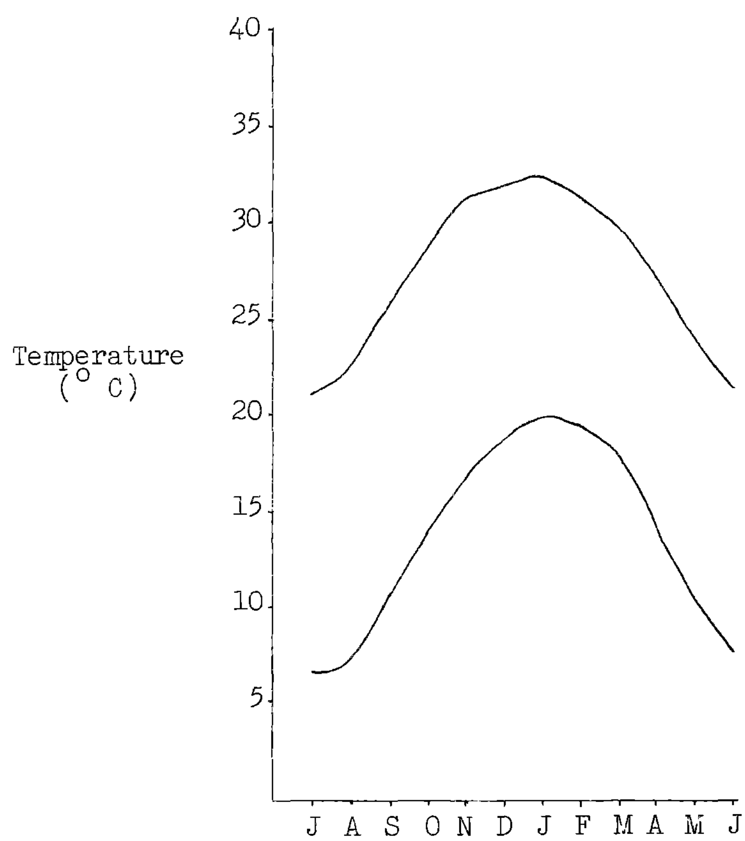


Figure 3. Mean monthly maximum and minimum temperatures

Frosts occur in the area during June - August depending on location, aspect, and altitude. In Table 1, screen temperatures <2°C are regarded as light frosts and readings <0°C indicate heavy frosts.

TABLE 1

Incidence of frost - Ipswich (days/month)

Frost	June	July	August
Light	1.6	2.2	2.1
Heavy	0.1	0.1	-

Minimum temperatures on the creek flats are lower than at Ipswich, and frosts more frequent. This affects planting dates and marketing prospects of frost sensitive crops such as potatoes.

Evaporation data are available from Moogerah Dam and are given below in Table 2.

TABLE 2

Evaporation rate (mm)

Month	Evaporation	Month	Evaporation
January	216	July	86
February	157	August	127
March	157	September	149
April	140	October	184
May	122	November	219
June	88	December	216
		Year	186

Source: Bureau of Meteorology

Prevailing winds during summer are south-easterly and during winter south-westerly. Wind damage to crops is not common.

2.2 Relief and Drainage

Three landforms can be easily distinguished in the area:

1. The flat low lying alluvial plains
2. The rolling topography of the undulating plains
3. The steep low hills with flat summits

A cross-sectional diagram of the three topographic forms is shown in Fig. 4. It is because these landforms are easily identified and also related to different soils, that soils are listed in the map legend and discussed in the text under landform headings. The relationship between topography and soil profile class is summarized in Table 4.

The alluvial plains occupy the Warrill Creek flood plain and the narrow creek flats. A subtle levee gently slopes away from the banks of Warrill Creek and Reynolds Creek.

The undulating plains have gently rolling smooth features with slopes rarely in excess of 10%. Relative heights of 120 to 170 m on crests and 90 to 110 m in troughs give a relief in the order of 50 m. The bedrock consists of gently dipping sandstones, mudstones and shales of the Walloon Coal Measures. These have been intruded by igneous rocks, which commonly form isolated peaks.

The low hills are formed on igneous rocks and rise to a maximum height of 150 - 210 m. Generally they have flat summits, upper slopes of 15 - 30% and lower slopes of 3 - 5%. On some slopes the smooth fall of the slopes is interrupted by platforms due to the outcrop of more resistant rocks.

Drainage is into Warrill Creek with flooding fairly common.

Small water seepage areas are increasing on some of the lower slopes of the undulating plains. The increase may be due to the extensive clearing and irrigation practices in the area.

Saline water also seeps to the surface in certain areas at the interface between the alluvial plains and undulating plains. In some drainage lines dams have become saline also. The presence of salinity probably depends on the salt content of sedimentary rocks upslope from the outbreak areas.

2.3 Geology

The geology of the area has been mapped and described by Stephens (1960) at 1:134 000 and by Cranfield and Schwarzbock (1971) at 1:250 000. Stephens refers to the area as "part of the region of greatest concentration of Tertiary intrusives in southern Queensland". Most rocks are highly weathered.

The undulating plains consist of the Jurassic Walloon Coal Measures and numerous Tertiary hypabyssal intrusions. The rock types range from andesite and trachyte to microsyenite, dolerite and teschenite. Gradations between trachyte and microsyenite and between microsyenite and dolerite are common.

The Walloon Coal Measures comprise brown to green mudstones, buff, cream or grey sandstones, with some siltstones, shales, thin coal seams and thin limestone beds. Most of the sandstones are lithic and many are calcareous, especially the compact, light grey types. Contact metamorphic effects are usually slight.

The Walloon rocks overlie the Lower Jurassic Marburg Formation and Triassic Ipswich Coal Measures, which do not out-crop in the survey area.

The low hills consist of Tertiary igenous rocks. Obum-Obum hill in the north-east of the area contains microsyenite and andesite or trachyte. The ridge in the north-west corner is microsyenite while the hills west of the Cunningham Highway - Kalbar turnoff are mostly andesite.

On the alluvial flats, unconsolidated materials of heavy texture show layering and numerous buried soils. On the Warrill Creek floodplain, bedrock occurs about 30 m below the surface.

2.4 Natural Vegetation

The vegetation of the alluvial flats and undulating plains has been extensively cleared. Some timber remains on the grazing country of the undulating plains and low hills.

On the alluvial flats, isolated broad-leaved and rough-barked apple trees (*Angophora subvelutina* and *A. floribunda*) and carbeen (*Eucalyptus tessellaris*) occupy the lighter textured, better drained soils, while blue gum (*Eucalyptus tereticornis*) and gum-topped box (*Eucalyptus moluccana*) occur on heavy textured, poorer drained soils. Along the narrow creeks and major water courses are found the river she-oak (*Casuarina cunninghamiana*), Moreton Bay chestnut (*Castanospermum australe*), red bottle brush (*Callistemon viminalis*), river tea tree (*Melaleuca bracteata*) and silky oak (*Grevillea robusta*).

Ground cover is variable and dominated by grasses, commonly kangaroo grass (*Themeda australis*), wire grasses (*Aristida* spp.), love grasses (*Eragrostis* spp.), pitted blue grass (*Bothriochloa decipiens*), blue grass (*Dicanthium sericeum*) and barb-wire grass (*Cymbopogon refractus*).

The uplands west of Warrill Creek and Obum-Obum hill are mostly ironbark open-forests with odd patches of brigalow softwood open to nearly closed-forest (scrub). The narrow-leaved ironbark (*Eucalyptus crebra*) or silver-leaved ironbark (*Eucalyptus melanophloia*) are usually dominant. Associated species are carbeen, blue gum, grey gum (*Eucalyptus propinqua*), pink bloodwood (*Eucalyptus intermedia*) and brush box (*Tristania conferta*).

There is no well-developed shrub layer although scattered shrubs of wattles (*Acacia* spp.), red ash (*Alphitonia excelsa*) grass tree (*Xanthorrhoea* spp.), and dense clumps of lantana (*Lantana camara*) may be present.

Ground cover is variable under the open forest and usually denser on the cleared native pastures. It consists mainly of grasses with kangaroo grass, barb-wire grass and bunch spear grass (*Heteropogon contortus*) prominent.

East of Warrill Creek, remnants of a brigalow-softwood scrub community lie scattered across the rolling topography. Pure stands of brigalow (*Acacia harpophylla*) prefer fine textured soils and pure stands of softwood scrub prefer medium textured, more stony soils.

Softwood scrub species include scrub wilga (*Geijera salicifolia*), crow's apple (*Owenia uenosa*), broad-leaved leopard wood (*Flindersia collina*), scrub bottle tree (*Brachychiton discolor*) and native cascarilla bark (*Croton insularis*). Vines are conspicuous, with native jasmines (*Jasminum* spp.), wonga wonga vine (*Pandorea pandorana*), *Parsonsia* spp., and lamb's tail or madeira vine (*Anredera cordifolia*) most common. There is a sparse or mid-dense shrub layer, usually 1 - 2 m high. Often present are currant bush (*Carissa ovata*), chain fruit (*Alyxia ruscifolia*), and scrub boonaree (*Heterodendrum diversifolium*). Ground cover is very sparse, consisting chiefly of a berry saltbush (*Rhagodia hastata*), wire grasses (*Aristida* spp.), wire weed (*Nyssanthes diffusa*) and rock or mulga fern (*Cheilanthes* spp.).

Additional information on vegetation for the area is outlined by Durrington (1973) in the Boonah Shire Handbook.

Some tree species or communities are often associated with a particular soil or certain soil conditions:

broad-leaved apple rough-barked apple carbeen	dark alluvial clay loam soils (Moogerah, Bromelton)
blue gums	dark alluvial clay soils (Warrill, Ugarapul, Fassifern)
brigalow	dark seasonally cracking clays on the undulating plains and associated creek flats (Kulgun, Kelly, McGrath, Warumkarie, Pennell, Warrill)
softwood scrub species	shallow gravelly clay loams/clays on undulating plains and low hills (Kalamba, Rangeview)
narrow-leaved ironbark	duplex soils of the undulating plains and low hills (Yellunga, Lance, Ortels, Watters)
silver-leaved ironbark carbeen	clay loam duplex soils and prairie soils of the undulating plains (Yellunga, Lance, Churchbank)
silver-leaved ironbark red bloodwood red ash	shallow red skeletal soils of the undulating plains and low hills of microsyenite (Frazer, Stibbes)

Further information on soil profile class - vegetation relationships is outlined in Table 4. Appendix 8 lists the common and scientific names of plant species found during the survey.

3. SOIL SURVEY METHOD

3.1 Soil Mapping

In soil survey, the soil variability of an area is summarised. The summary usually takes the form of a map and report describing the soil bodies that occur naturally in the landscape.

For this survey the soil bodies are called soil profile classes, which were defined by grouping profiles of similar morphology representative of soil bodies. The main properties used were texture profile, solum depth, subsoil colour and soil reaction trend (pH profile). The majority of these properties are strongly related to the agricultural suitability of the soil.

The taxonomic level (e.g. type, series, family) of soil profile classes is not specified as each class has its own unique range of properties.

Using 1:25 000 colour photos and a 1:10 000 orthophotomap, 5000 ha was mapped at 1:25 000. Mapping took place in three stages: the legend-making phase, the mapping phase, and map presentation.

3.1.1 Legend-making phase

The legend-making phase involved 149 ground observations located on traverse lines across the major photo-patterns, vegetation types and landforms. Traverses usually followed roads or farm tracks. At each site, soil profiles were described in detail to 150 cm, classified into great soil groups (Stace *et al.* 1968) and placed in the factual key (Northcote 1971). From the detailed descriptions a provisional legend of soil profile classes was developed.

3.1.2 Mapping phase

The accuracy of mapping and precision of definition of soil profile classes depends on map scale and density of ground observations. McDonald (1975) suggests for 1:25 000 maps, a density of 10 - 20 ha/ground observation with air photo interpretation or 3 - 6 ha/ground observation without air photo interpretation.

In the Kalbar area, many natural soil boundaries were not evident on the aerial photos. The surface expression of boundaries was probably destroyed by land clearing and cropping. Because air photo interpretation was useful to some degree, a density between the two extremes of 6 - 10 ha/ground observation is suggested as satisfactory for accurate mapping.

Soils were mapped by the free soil survey method (see Glossary), with soil boundaries drawn from air photo interpretation and field checking. During field checking, 193 soil profiles were described, mostly in brief, except for new soils which were described in detail. From this, a preliminary map and revised legend were produced.

The preliminary map was based on 342 ground observations, a density of 14.6 ha/ground observation. This density suggests that the preliminary map may not have the accuracy appropriate for a 1:25 000 map. To test the accuracy of this map, an additional 351 ground observations were inspected, located on a 300 x 500 m grid. At each site, the soil profile was briefly described and matched if possible to a soil from the map and legend.

The results were as follows:-

accurate	87%	-	59.5% dominant soils predicted by map
			27.5% minor soils predicted by map
inaccurate	13%	-	soils not predicted by map

Although the preliminary soils map can be regarded as satisfactory in soil prediction, map unit boundaries were frequently found to be out of position. Some map units had larger proportions of minor soils than predicted by the map; some minor soils were even found to be the dominant.

Using soil data from the grid sites, errors in soil definition or map boundary position were corrected, resulting in a final map and legend of 28 map units. The final map is thus based on 693 ground observations, a density of 7.2 ha/ground observation, which is within the guidelines suggested.

There were 25 soil profile classes and 3 degraded phases mapped and defined and 1 minor soil profile class described in the text but not mapped.

3.1.3 Map presentation

Soil profile classes were given names of local significance or the Paton (1971) subgroup name was used for soils that reasonably matched his descriptions.

Most of the reference area consists of simple map units, with one soil profile class occupying 70% or more of a map unit. These units are named after the dominant soil profile class. Compound map units however are more complex with two or more soil profile classes, each occupying less than 70% of the map unit area. These units are named after the two most common soil profile classes.

In the final legend (or reference), approximate great soil groups (Stace *et al.* 1968) are given and the commonly occurring principal profile forms (Northcote 1971) listed for each dominant soil profile class.

3.2 Soil Sampling and Analysis

To assess soil fertility, 0 - 10 cm surface soils were bulked and subsampled at each of the 300 x 500 m grid sites (see parametric maps for exact locations). For salinity every third profile along the east-west 300 m grid line was sampled to bedrock or a maximum depth of 150 cm.

19 profiles representative of the major soil profile classes were sampled for comprehensive soil analysis (see Appendix 4).

A summary of sampling procedures and soil analyses carried out is presented in Table 3.

Methods of soil analysis are described in Appendix 1 while interpretation of the values obtained is provided in Appendix 2.

TABLE 3

Summary of sampling procedure and soil analyses

Type of Sites	No. of Sites	Type of sample(s)	Analyses
300 x 500 m grid	351	Bulked 0 - 10 cm	pH, E.C., chloride, acid P, bicarb. P, repl. K, DTPA Fe, Mn, Cu, Zn.
900 x 500 m grid	117	Bulked 0 - 10 cm	A.D. moisture, particle size, exchangeable cations
900 x 500 m grid	117	Profile samples in 10 cm increments to bedrock or 150 cm	pH, E.C., chloride
representative profile site (marked on soil map)	19	Profile samples in 10 cm increments to bedrock or 150 cm	As in Appendix 4

3.3 Parametric Mapping

Using data from 351 surface soils collected on the 300 x 500 m grid, the variability of four important soil chemical properties is displayed on four single factor or parametric maps (enclosed). The properties mapped were bicarbonate-extractable phosphorus, replaceable potassium, DTPA-extractable copper and DTPA-extractable zinc. These properties were chosen because they each covered a wider range of values than the other chemical properties measured.

On each parametric map, the values of the particular property are printed at each site location. Clusters and areas of low, medium or high value sites are highlighted by hachuring. The ranges selected for low, medium or high levels are based on the interpretation of analytical data in Appendix 2.

Parametric maps are useful for assessing the variability of soil properties which are not strongly related to changes in the type of soil.

4. SOILS - MORPHOLOGY AND CLASSIFICATION

4.1 General

There are 25 soil profile classes and 3 phases of soil profile classes identified.

On the alluvial plains, the gentle levees close to the creeks are dominated by dark friable clay loams (Bromelton), while deep dark cracking clays (Warrill, Ugarapul, Muller) occur on the flood plain.

The upland undulating plains have several morphologically distinct soils. Dark, grey or brown cracking clays (Kulgun, Pennell) dominate east of the Warrill Creek floodplain and alkaline brown duplex soils (Yellunga) and prairie soils (Churchbank) dominate west of the flood plain.

The soils of the low hills vary according to parent material; shallow red gravelly soils (Frazer, Stibbes) have developed on micro-syenite and shallow hard cobbly loams (Rangeview) on andesite and trachyte. The hills of andesite west of the Cunningham Highway - Kalbar turnoff are dominated by red shallow gravelly acid duplex soils (Watters) on the midslopes.

Some soils occur on more than one landscape; Stibbes and Rangeview are found on both the undulating plains and low hills.

4.2 Morphology

Table 4 gives the major distinguishing features of soil profile class morphology. Detailed soil profile class descriptions are given in Appendix 3.

The morphology of profiles representative of major soils is described in detail in Appendix 4.

4.3 Map Units

In Table 4, the major characteristics of dominant soil profile classes, their associated physiography and predominant vegetation are indicated for each map unit.

The major and minor soil profile classes of map units are presented in Table 5.

Fig. 4 shows the relative position of map units across the landscape.

4.4 Soil Profile Classes

Although soil profile classes are primarily differentiated on soil profile characteristics, external features also influence differentiation to varying degrees.

Landform is usually associated with certain soil profile classes but in some cases, quite distinct soils occupy the same landform position e.g. Yellunga, a solodic, and Churchbank, a prairie soil. Similarly vegetation is not always a reliable guide for soil differentiation e.g. Rangeview was found under softwood vine scrub and also under narrow-leaved ironbark dominant open forest. Kulgun and Pennell both occur under brigalow-softwood scrub east of Warrill Creek but are found under eucalypt open forest west of Warrill Creek.

A notable feature of Kulgun is that under brigalow softwood scrub it has a clay loam to light clay non or weakly self-mulching surface. On cleared and cultivated land, Kulgun usually has a light-medium clay or heavier moderately self-mulching and distinctly cracking surface soil. Clearing of brigalow scrub since 1870 has led to almost complete removal of 10 - 15 cm of the very friable clay loam surface (Paton 1971). This was caused by the destruction of organic matter with tillage and loss of the top soil by erosion.

On the Warrill Creek floodplain the surface texture of Warrill (a black earth) gradually becomes heavier the further away from the creek it occurs (light medium → heavy clay). Some of the cleared heavy clay soils may in fact be Fassifern (a wiesenboden) which have lost their gilgai characteristics, obvious mottling and fibrous surface through cultivation.

TABLE 4

Major distinguishing characteristics of map units

Map Unit	Dominant Soil Profile Class	Brief Description of Dominant* Soil Profile Class	Physiography	Predominant Vegetation
Mr	Moore	Dark friable clay loam to 30 cm over dark neutral to alkaline sand >150 cm deep	Slight rises in Warrill Ck. alluvial plain (0-1% slope)	Cleared
Mg	Moogerah	Dark friable loam to clay loam to 25-30 cm over dark or brown neutral massive clay loam to light clay subsoil >150 cm deep	Levee banks near Warrill Creek or on slight rises in alluvial plain (0-1% slope)	Cleared
Br	Bromelton	Dark friable clay loam to light clay to 45-90 cm over dark neutral to alkaline light to medium clay subsoil >150 cm deep	Gentle levee of Warrill and Reynolds Creeks; also along narrow local creek lines (0-2% slope)	Mostly cleared with remaining vegetation or regrowth of bottlebrush, blue gums, rough-barked apple, carbeen, broad-leaved apple, tea trees, silky oak.
Mu	Muller	Dark weakly self-mulching cracking clay with dark light clay to light-medium clay surface soil to 35-60 cm over dark or brown neutral medium to heavy clay subsoil over clay D-horizons to >150 cm deep	Gentle levee backslopes of Warrill and Reynolds Creeks (0-1% slope)	Cleared with a few blue gums remaining.
Wr	Warrill	Dark moderately self-mulching cracking clay with dark light-medium to medium clay surface soil to 15 cm over dark neutral to alkaline medium to heavy clay subsoil which may become grey or brown with depth (>150 cm deep)	Flood plain of Warrill Creek and local creek flats (0-1% slope)	Mostly cleared with remaining vegetation of blue gums and gum topped box on Warrill Creek flat. Brigalow or tea tree on some local creek flats
Wr-S	Warrill - saline phase	Salt crystals glitter on scalded surface. Massive powdery clay loam surface crust, which may crack into large hexagonal shapes. Mottling to 30-40 cm grading to a dark or grey clay subsoil	Interface between alluvial plain and Walloon uplands (0-2% slope)	Bare, except for clumps of Rhodes grass. Dead or stunted brigalow trees common or poor grass growth
Ug	Ugarapul	Dark moderately self-mulching cracking clay with light-medium or medium clay surface soil to 15 cm over dark grading to brown neutral light-medium to medium clay to 45-75 cm over mottled brown, friable, sandy loam to sandy clay D-horizon to >150 cm deep	Flood plain expanse of Warrill Creek usually in vicinity of microsyenite hills. (0-1% slope)	Mostly cleared with a few blue gums remaining
Fa	Fassifern	Dark fibrous mat surface to 2-10 cm occasionally with some weak self-mulching but large cracks evident. Mottled dark light to medium clay to 15-25 cm over dark to grey neutral to alkaline medium to heavy clay subsoils to >150 cm deep. Gilgai mound and depression have similar soil description	Strong gamma nuram gilgai and some linear gilgai. Depressions and swamps of the alluvial floodplain, often near interface with uplands. (0-2% slope)	Some cleared or blue gum open forest, sedges
St	Stibbes	Loose surface with weak crust, cobbly in patches. Red-brown very friable sandy loam to sandy clay loam to 15-20 cm over red brown neutral sandy clay loam to sandy clay subsoil to 25-60 cm	Upslope and midslope positions on igneous intrusions (2-13% slope) of microsyenite. Minor soil on low hills of microsyenite (15-18% slope)	Mostly cleared with remaining vegetation or regrowth of silver-leaved ironbark, red ash or narrow-leaved ironbark, red bloodwood
Ka	Kalamba	Grey friable gravelly light clay to 10-20 cm over brown gravelly acid clay subsoil to 40-50 cm	Upslope positions on andesitic intrusions and contact metamorphics (1-8% slope)	Cleared. Previously believed to be softwood vine scrub
Ch	Churchbank	Dark to brown, friable to firm clay loam to light-medium clay to 10-20 cm over red or brown neutral medium to heavy clay to 40-80 cm over sandy weathered rock	Upslope positions on igneous intrusions of microsyenite (4-13% slope)	Mostly cleared with remaining vegetation or regrowth of open forest, silver-leaved ironbark, carbeen, blue gum, narrow leaved-ironbark, crow's apple
Pu	Purdon	Dark friable to firm clay loam to light-medium clay to 15-30 cm over dark or brown alkaline, calcareous, light-medium to heavy clay to 90 to >150 cm deep	Upslope positions on Walloon sediments, probably calcareous (2-6% slope)	Mostly cleared with a remaining vegetation or regrowth of brigalow-softwood scrub, or carbeen
Wk	Warumkarie	Dark to grey self-mulching cracking clay with light-medium clay to heavy clay surface soil to 5-20 cm over medium to heavy clay alkaline calcareous subsoil which may become yellow-grey before it grades into weathered rock at 50-70 cm deep	All positions on calcareous Waloon sediments (2-12% slope) on undulating plains	Mostly cleared with remaining vegetation or regrowth of brigalow-softwood scrub
Pe	Pennell	Dark to brown self-mulching cracking clay with medium clay surface soil to 5-30 cm over brown to red-brown neutral medium to heavy clay to 30-60 cm over sandy weathered rock	Upper to lower slope positions on microsyenite and some Waloon sediments of the undulating plains (3-12% slope)	Mostly cleared with remaining vegetation or regrowth of brigalow-softwood scrub east of Warrill Creek; or carbeen, silver-leaved ironbark, narrow-leaved ironbark west of Warrill Creek
Ku	Kulgun	Dark to grey medium to strongly self-mulching cracking clay (often clay loam at virgin sites) with light-medium to heavy clay surface soil over grey neutral to alkaline, usually calcareous medium to heavy clay which may become yellow, mottled and calcareous at depth (90 to >150 cm deep)	Mid to lower slope positions on fine grained Waloon sediments, mudstone (3-1[illegible] slope)	Mostly cleared with remaining vegetation or regrowth of brigalow east of Warrill Creek; carbeen, silver-leaved ironbark, narrow-leaved ironbark west of Warrill Creek
Ke	Kelly	Dark to grey medium to strongly self-mulching cracking clay with light-medium to heavy clay surface soil over yellow alkaline calcareous subsoil which may become light-grey and mottled with depth (80-140 cm deep)	Mid to lower slope positions on fine grained sediments (3-8% slopes)	Mostly cleared with remaining vegetation or regrowth of brigalow
Mc	McGrath	Dark to brown medium to strongly self-mulching cracking clay with medium to heavy clay surface soil over red to brown neutral to alkaline, commonly calcareous, medium to heavy clay subsoils to 75 to >150 cm deep	Mid to lower slope positions on fine grained Walloon sediments (3-8% slope)	Cleared, probably brigalow-softwood scrub originally
Ro	Rosevale	Hardsetting duplex soil with dark to grey sandy loam to light sandy clay loam with a 5 cm thick bleached A_2 horizon to 12-30 cm abruptly overlying red to brown acid to neutral clay subsoil to 70-90 cm	Lower slope positions on Walloons (2-4% slope)	Mostly cleared with remaining vegetation of carbeen, narrow-leaved ironbark open forest

TABLE 4 (continued)

Map Unit	Dominant Soil Profile Class	Brief Description of Dominant* Soil Profile Class	Physiography	Predominant Vegetation
Di	Dieckmann	Loose or moderately hardsetting duplex soil with dark to grey fine sandy loam to loam with 5-10 cm thick sporadically or conspicuously bleached A_2 horizon to 20-40 cm clearly overlying manganiferous mottled yellow-grey to brown neutral clay subsoil to 70 to >150 cm deep	Lower slope positions on colluvium of low hills of igneous rock commonly microsyenite (4-10% slope)	Cleared or open forest of silver-leaved ironbark, carbeen
Wi	Wiss	Loose or weakly hardsetting duplex soil with red-brown to brown sandy loam to light sandy clay loam to 25-30 cm over red brown loamy sand to light sandy clay loam A_{12} or A_2 horizon, to 45-70 cm. The A_2 horizon clearly overlies a red-brown acid to neutral, ferromanganiferous sandy clay to light-medium clay to 100 to >150 cm deep	Mid to lower slope positions on low hills of microsyenite (5-20% slope)	Cleared or open forest of silver-leaved ironbark, carbeen, narrow-leaved ironbark, blue gum
La	Lance	Moderately hardsetting duplex soil with dark to brown clay loam to 8-20 cm over a brown clay loam A_2 horizon to 20-25 cm. The A_2 horizon clearly overlies a faintly mottled yellow-brown acid light-medium clay becomming heavy clay at depth (90 to >150 cm deep)	Upper to midslope positions on Walloons (3-12% slope)	Open forest of silver-leaved ironbark, narrow-leaved ironbark, blue gum, carbeen
Ye	Yellunga	Moderately hardsetting duplex soil with dark to grey clay loam to 8-15 cm over a thin bleached A_2 horizon to 10-20 cm. The A_2 horizon abruptly overlies a brown acid medium to heavy clay which at 50-70 cm becomes mottled brown to yellow-brown alkaline and calcareous (90 to >150 cm deep)	Mid to lower slope positions on the Waloons mostly west of Warrill Creek (2-10% slope)	Cleared grassland or open forest of narrow-leaved ironbark, silver-leaved ironbark, carbeen in pure or mixed stands
Ra	Rangeview	Dark cobbly loam to clay loam to 10-30 cm over a C horizon of grey or brown clay-loam to light clay containing abundant volcanic rocks and cobbles	Upslope and ridge positions on volcanic rocks, usually andesite to trachyte (2-7%); or on steep sideslopes (15-30%) of low hills	Brigalow-softwood scrub on ridges or layered open forest of narrow-leaved ironbark and red ash, red bloodwood, kurrajong, brush box on side slopes
Fr	Frazer	Dark to brown gravelly sandy loam or loam to 5-15 cm over a red-brown gravelly loam to clay loam to 15-30 cm over microsyenite	Mid to upper slope position of low hills of microsyenite (10-30% slope)	Open forest with silver-leaved ironbark, red bloodwood abundant, blue gum, rusty gum, narrow-leaved ironbark, carbeen, brush box
Or	Ortels	Loose or weakly hardsetting duplex soil with dark gravelly loam to clay loam to 13-20 cm over thin bleached A_2 horizon to 20-23 cm. A_2 horizon abruptly overlies grey neutral medium clay which at 45 cm becomes alkaline calcareous and may be brown. At 60 cm clay may become yellow-brown or a red-brown D horizon or a C horizon of weathered coal or mudstone may occur	Mid to lower slopes of low hills (5-20% slope); often on platforms of more resistant rock. Usually developed on fine grained sediments e.g. coal and mudstone	Open forest of narrow-leaved ironbark, carbeen, silver-leaved ironbark or less commonly brigalow scrub
Wt	Watters	Loose surfaced duplex soil with dark to brown gravelly loam to sandy clay loam to 5-10 cm over a gravelly bleached A_2 horizon to 15-17 cm. A_2 horizon abruptly overlies mottled red to red-brown acid clay to 30-45 cm grading to brown clay over rock at 60-70 cm	Mid to upper slope of low hills (10-30% slope) of andesite to trachyte	Layered open forest of narrow-leaved ironbark, red ash, occasional silver-leaved ironbark
	Horan**	Dark red commonly cobbly clay loam to 7-20 cm over red acid gravelly clay loam or light to light medium clay to 50-60 cm deep	Ridge tops and upper slopes of low hills of andesite and metamorphic rocks (5-15% slope)	Open forest of narrow-leaved ironbark, brush box, red bloodwood

* Detailed descriptions of soil profile classes are given in Appendix 3.

** **Horan is a minor soil profile class (<30%) of Fraser map unit**

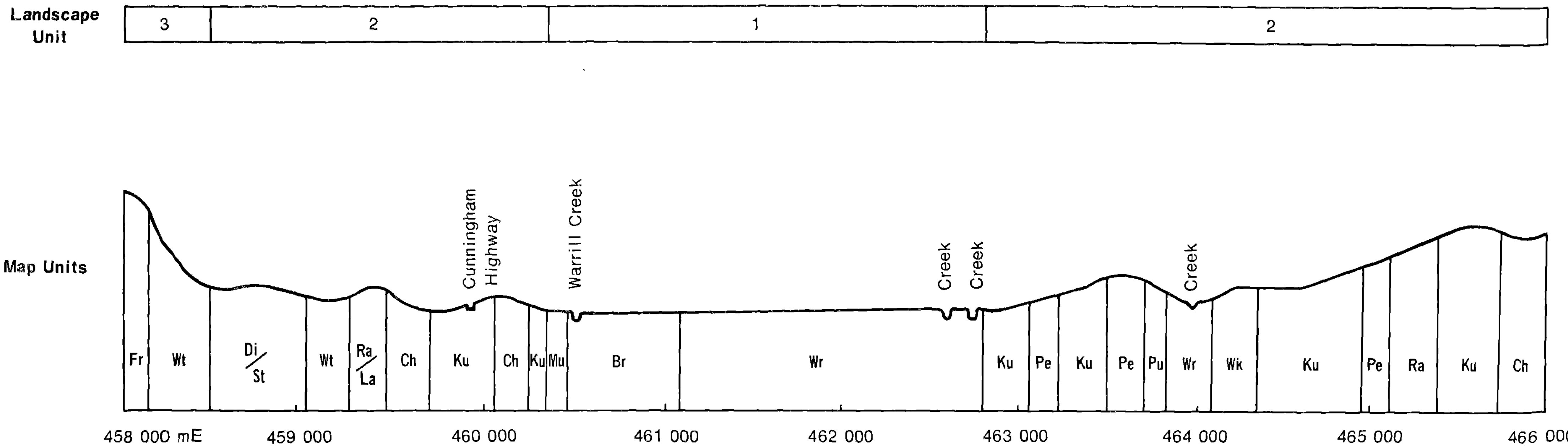
4.5 Soil Classification

Dominant soil profile classes were classified into great soil groups (Stace *et al.* 1968) and principal profile forms (Northcote 1971) on the soil map.

Where soil profile classes are described in detail (Appendix 3), all principal profile forms encountered are listed. In addition, soil horizons have been classified according to the Unified Soil Classification (FAO 1973) which is used to assess soil material for engineering purposes. The classification was decided by the amount of coarse material, soil texture and organic matter.

Reference soils which have laboratory analyses and detailed morphological descriptions (Appendix 4) are classified into principal profile forms, great soil groups and Soil Taxonomy subgroup (Soil Survey Staff 1975) in Appendix 5.

In general the black earths are Udic Chromusterts, the grey clays Udorthentic Chromusterts, the prairie soils Paralithic Vertic Haplustolls, and the solodics Typic Natrustalfs.



Landscape Units

1. Alluvial Plains
2. Undulating Plains
3. Low Hills

Cross-section along 6910 000 m N line.

Figure 4. Landscape – East-west Cross-section of Map Units and Landscape Units

TABLE 5

Map unit composition

Map Symbol	Dominant Soils	Minor Soils
Mg	Moogerah	Bromelton, Muller, Warrill
Mr	Moore	Bromelton, Ugarapul
Br	Bromelton	Warrill, Ugarapul, Muller
Wr	Warrill	Bromelton, Ugarapul, Muller
Fa	Fassifern	Warrill
Ug	Ugarapul	Warrill, Bromelton, Muller
Mu	Muller	Bromelton, Warrill, Ugarapul
St	Stibbes	Churchbank, Pennell, Kulgun, Rangeview
Ch	Churchbank	Yellunga, Pennell, Kulgun, Purdon
Ka	Kalamba	Pennell, Kulgun
Pu	Purdon	Pennell, Kulgun
Pe	Pennell	Churchbank, Purdon, Yellunga, Kulgun, Warumkarie, McGrath
Wk	Warumkarie	Churchbank, Purdon, Pennell, Kulgun
Ku	Kulgun	Pennell, McGrath, Warumkarie, Purdon, Churchbank, Kelly
Ke	Kelly	Kulgun, McGrath
Mc	McGrath	Kelly, Kulgun
Ye	Yellunga	Churchbank, Kulgun, Pennell, Stibbes, Rosevale, Purdon
La	Lance	Pennell, Churchbank, Yellunga, Rangeview
Wi	Wiss	Frazer, Stibbes
Ro	Rosevale	Churchbank
Di	Dieckmann	Rangeview, Wiss, Frazer, Churchbank
Ra	Rangeview	Pennell, Kulgun, Purdon, Warumkarie, Wiss, Frazer, Yellunga, Purdon, Ortels
Fr	Frazer	Dieckmann, Wiss, Rangeview, Watters, Churchbank, Stibbes, Horan
Wt	Watters	Frazer, Rangeview, Dieckmann, Purdon
Or	Ortels	Rangeview, Churchbank, Purdon, Watters, Lance

4.6 Soil Variability

Soils of the alluvial plains are generally less variable and more similar to each other than soils of the undulating plains and low hills. The soils under brigalow east of Warrill Creek are less variable than the soils under eucalypt open forest on the west side.

It is interesting to compare the 1:25 000 map units of this survey with the 1:63 360 map units of Paton (1971) over the same area. It should be kept in mind that the reference area only represents a 5000 ha portion of Paton's survey area of approximately 140 000 ha. Paton's observations outside the reference area includes soil variability not encountered in the reference area.

According to Paton : "The mapping unit employed is an association of soil subgroups within a particular landscape unit. In this report a subgroup includes soils of one great soil group developed on a particular parent material".

Soil variability of the two surveys can be visually compared from the maps and Table 6 shows how the map units are related.

In general the major map units of the 1:63 360 map had two dominant subgroups and none to three minor subgroups. Within the same 1:63 360 map unit areas, the 1:25 000 map was able to distinguish 6 - 8 simple map units, and indicate additional dominant and minor soils not described in the 1:63 360 map. This is understandable considering the greater density of ground observations (7.2 ha/ground observation) carried out in the 1:25 000 survey.

TABLE 6

Comparison of soil information obtained at 1:63 360 and 1:25 000 map scales

1:63 360 Map Unit	Soils Described or Mapped			
	1:63 360 Soil Subgroups (Dominants and Minors)		1:25 000 Soil Profile Classes (Dominants only)	
	Number	Names	Number	Names
Bromelton-Fassifern	3	Bromelton, Fassifern, Cyrus*	7	Moore, Moogerah, Bromelton, Muller, Warrill, Ugarapul, Fassifern
Kulgun-Churchbank	2	Kulgun, Churchbank	9	Stibbes, Kalamba, Churchbank, Purdon, Warumkarie, Pennell, Kulgun, Kelly, McGrath
Kengoon-Frazer	3	Kengoon, Frazer Waraperta	7	Frazer, Rangeview, Ortels, Watters, Dieckmann, Yellunga, Lance
Rosevale-Churchbank	2	Rosevale, Churchbank	6	Yellunga, Churchbank, Kulgun, Pennell, Rosevale, Lance
Peak-Churchbank	5	Churchbank, Peak, Warroolaba, Milora, Anthony	3	Pennell, Yellunga, Churchbank

* Cyrus is similar to Warrill

5. SOILS - CHEMICAL AND PHYSICAL PROPERTIES

5.1 General

Some information on chemical and physical properties is available in Paton (1971) for Churchbank, Bromelton, Kulgun and Rosevale.

In this report, a soil analysis program was undertaken for fertility assessment, evaluation of soil salinity and detailed characterisation of representative soil profiles. In section 3.2, a summary of the types of analyses, sampling procedures and sampling depths is provided in Table 3 (p. 9). Further information is available in Appendices 1 and 2.

Generally the reference area was found to have high fertility; surface soils are slightly acid (mean pH 6.7), have low salinity (mean E.C. 0.102 mS/cm), high phosphorus (mean bicarb. P 72 ppm), high potassium (mean repl. K 0.88 meq/100 g) and satisfactory calcium, magnesium and trace elements.

Apart from the land in or immediately surrounding the salt outbreak areas (map unit Wr-S), salinity is not a hazard. Elsewhere high salt levels (>1.0 mS cm^{-1} E.C.) can accumulate in the subsoil, but usually well below the effective root zone (>100 cm deep). However, in years of higher rainfall, rising watertables may create new salt outbreak areas or extend the existing ones.

For presentation and discussion of data, soil profile classes have been grouped on the basis of landform, vegetation and land use into three easily recognizable groups. They are: Soils of the alluvial plains; clay loam/clays of the undulating plains; duplex soils and shallow loams/clayloams of the uplands. Uplands refers to all landforms above the alluvial plains i.e. both undulating plains and low hills. Details are provided in table 7.

TABLE 7

Soil groups for soil analysis assessment

Soil Group	Associated Landform, Vegetation and Land Use	Soil Profile Classes
Soils of the alluvial plains	Cleared flat plain; a few isolated bluegums remain; intensively cropped.	Moogerah, Bromelton, Muller, Warrill, Ugarapul, Fassifern
Clay loam/clays of the undulating plains	Cleared undulating plains; remnants of brigalow scrub, vine scrub and occasionally open forest of silver-leaved ironbark and carbeen; majority is intensively cropped.	Kalamba, Churchbank, Purdon, Warumkarie, Pennell, Kulgun, Kelly, McGrath
Duplex soils and shallow loams/clay loams of the uplands	Cleared and timbered undulating plains and mostly timbered low hills, open forest dominated by ironbarks with small areas of scrub; mainly grazing rangeland.	Stibbes, Rosevale, Dieckmann, Wiss, Lance, Yellunga, Rangeview, Frazer, Ortels, Watters.

5.2 Soils of the alluvial plains

5.2.1 Fertility

Naturally high fertility and long term fertilizer use are probably responsible for the high plant nutrient levels indicated by the data in Table 8.

TABLE 8

Analysis of soils (bulked 0 - 10 cm) of the alluvial plains

		Moogerah	Bromelton	Muller	Warrill	Ugarapul	Fassifern	Warrill - saline phase	Interpretation*
		n_1 = 5 n_2 = 5	n_1 = 31 n_2 = 10	n_1 = 11 n_2 = 2	n_1 = 68 n_2 = 21	n_1 = 10 n_2 = 6	n_1 = 6 n_2 = 2	n_1 = 2	
pH	mean	7.0	6.6	6.6	6.9	6.8	6.1	7.4	
	range	6.7 - 7.6	5.6 - 8.3	6.0 - 7.1	6.1 - 7.4	6.4 - 7.1	5.9 - 6.6	6.7 - 8.1	
E.C.	mean	0.11	0.12	0.12	0.11	0.08	0.14	2.0	>0.6 high
mS cm^{-1}	range	0.03 - 0.29	0.04 - 0.65	0.05 - 0.28	0.05 - 1.1	0.05 - 0.14	0.07 - 0.29	1.2 - 2.8	<0.15 low
Acid P	mean	194	565	473	371	544	121	80	>45 high
ppm	range	120 - 490	115 - 980	23 - 820	28 - 930	120 - 820	11 - 200	41 - 120	
Bicarb P	mean	78	105	130	101	88	123	66	>30 high
ppm	range	52 - 100	45 - 330	35 - 220	20 - 260	23 - 125	35 - 230	31 - 100	
Repl. K	mean	1.4	0.96	1.2	0.90	0.69	0.79	0.6	>0.5 high
meq/100g	range	0.8 - 2.4	0.42 - 4.0	0.43 - 4.0	0.38 - 2.7	0.47 - 1.2	0.61 - 1.2	0.54 - 0.66	
Exch. Ca	mean	17	18	21	24	23	17		>2.0 adequate
meq/100g	range	14 - 20	13 - 24	18 - 23	18 - 35	18 - 28	16 - 18		
Exch. Mg	mean	11	11	12	16	15	16		>1.7 adequate
meq/100g	range	8 - 15	8 - 16	10 - 13	11 - 21	12 - 22	16 - 17		
Exch. Na	mean	0.60	0.22	0.35	0.57	0.42	0.46		
meq/100g	range	0.12 - 2.1	0.13 - 0.48	0.31 - 0.38	0.19 - 1.26	0.21 - 0.88	0.32 - 0.60		
Exch. K	mean	1.6	0.93	1.31	0.98	0.91	1.2		
meq/100g	range	0.64 - 2.3	0.43 - 1.66	1.15 - 1.48	0.44 - 2.63	0.48 - 2.02	1.0 - 1.4		
DTPA Fe	mean	69	76	130	89	61	289	82	>4.5 adequate
ppm	range	13 - 166	25 - 163	24 - 244	12 - 305	42 - 91	124 - 370	15 - 148	
DTPA Mn	mean	18	21	28	21	18	25	38	>1.0 adequate
ppm	range	8 - 42	9 - 74	7 - 140	8 - 70	9 - 34	16 - 40	30 - 45	
DTPA Cu	mean	1.5	1.4	1.7	2.0	1.5	3.8	3.0	>0.3 adequate
ppm	range	0.8 - 2.3	0.8 - 2.2	1.0 - 2.6	1.0 - 3.1	0.9 - 2.3	3.2 - 5.2	2.3 - 3.6	
DTPA Zn	mean	4.7	3.0	4.0	3.8	1.9	3.1	4.2	>1.0 adequate
ppm	range	1.2 - 10	1.0 - 7.8	1.4 - 11	0.8 - 59	0.7 - 3.8	1.8 - 3.9	2.8 - 5.6	
Clay	mean	19	28	42	48	38	51		
(%)	range	8 - 26	17 - 45	42 - 42	36 - 64	27 - 50	50 - 51		

NOTE - exchangeable cations are oven dry figures while the rest are air dry.

* More detailed interpretation of soil analyses is provided in Appendix 2.

n_1 = number of values used for calculations of analyses (except exchangeable cations)

n_2 = number of values used for calculations of exchangeable cation analyses

Most surface soils have high extractable phosphorus and potassium, and adequate exchangeable cations and trace elements.

Higher copper values (>3 ppm) are found in the lower lying wetter areas of the alluvial plain, where Fassifern and Warrill - saline phase occur.

Total nitrogen (0.11 - 0.23%) and organic carbon (1.4 - 2.7%) levels are generally fair for all soils except Fassifern, which is high (0.39% total N, 4.6% organic C) (from Appendix 4).

Total sulphur ranges from 0.018% to 0.032% in the surface 0 - 10 cm of soils other than Fassifern which had 0.50% (from Appendix 4). With these levels, sulphur deficiency is unlikely (Appendix 2).

Soil pH is usually slightly acid or neutral in the surface and becomes increasingly alkaline with depth. (See profiles in Appendix 4). Bromelton and some Warrill profiles become only slightly alkaline (pH 7.5 - 8.2) at 120 cm while Ugarapul, Fassifern, Muller and other Warrill profiles rise to pH 8.2 - 8.5 at 70 - 90 cm. The Warrill-saline phase profile is alkaline throughout and becomes extremely alkaline (pH >9.0) at 80 cm.

5.2.2 *Salinity and exchangeable cations*

Soils of the alluvial plains have low salinity at the surface. Exceptions are Warrill-saline phase and areas adjacent to the uplands or along the narrow creeks, where the water table has risen.

On the alluvial plains of Warrill and Reynolds Creeks, the lighter textured well drained soils on the levee banks (Bromelton, Moogerah) have low salinity throughout the profile. The heavier textured less well drained soils in the middle of the floodplain (Muller, Warrill, Ugarapul) accumulate low salt levels (0.20 - 0.43 mS cm^{-1} E.C.) at 90 - 140 cm. Occasionally the salinity of Warrill soil continues increasing to 150 cm (0.64 mS cm^{-1} E.C.), the maximum depth sampled. Fassifern, the heaviest textured soil from the poorly drained back-swamp depressions, accumulates medium to high salinity (0.78 - 1.4 mS cm^{-1} E.C.) at 60 - 150 cm depth.

East of the watercourse draining into Kent's Lagoon, Warrill is found to have highly saline subsoils (0.9 - 2.9 mS cm^{-1} E.C.) at 70 - 120 cm depth. Near the salt outbreak areas adjacent to the uplands this high salinity is closer to the surface (50 - 70 cm depth). A feature of this area was the presence of brigalow prior to clearing, a common indicator of subsoil salinity.

Along the narrow creek lines surrounded by uplands of Walloon Coal Measures, Bromelton and Warrill reach high salt levels (>0.90 mS cm^{-1} E.C.) at 70 - 130 cm deep.

The Warrill-saline phase soils of the salt outbreak areas have very high surface salinity (2.8 - 10 mS cm^{-1} E.C.), which gradually decreases down the profile to a relatively constant level (0.9 - 1.2 mS cm^{-1} E.C.) at 90 - 150 cm. This may indicate a fairly permanent water table at 90 cm where a moist, greyish-olive (5Y 4/2) soil horizon is observed. In the wet season the water table rises, causing high salt levels to be concentrated by evaporation. Some parts of the salt outbreak areas are permanently under water.

The occurrence of high salinity depends on depth to the water-table. According to Talsma (1963), the salinity hazard of fine textured soils is markedly reduced where the water table occurs at 120 cm or deeper.

The relative proportions of exchangeable calcium and magnesium at different depths in the soil profiles, varies from one soil profile class to another. Bromelton, Ugarapul and Warrill have calcium dominant throughout while Warrill-saline phase has magnesium dominant throughout. Calcium is dominant to 150 cm in Muller when magnesium becomes dominant, whereas in Fassifern, calcium and magnesium are co-dominant to 120 cm where magnesium becomes dominant.

The exchangeable sodium percentage (ESP) is low for all surface soils (<3), except for Warrill-saline phase, while in the subsoil, the ESP varies between soil profile classes. Bromelton and Ugarapul have a low ESP down the profile but Muller, Fassifern and Warrill-saline phase are sodic (ESP >6) at 60 cm (Northcote and Skene 1972). By 150 cm Muller and Fassifern have an ESP of 12 while Warrill-saline phase has ESP values ranging from 27 in the surface to 35 at 150 cm. Warrill had variable ESP values with one profile having a low ESP throughout, while another was sodic by 60 cm.

5.2.3 Physical properties

The clay contents of soil profiles in Appendix 4 are compared in Fig. 5.

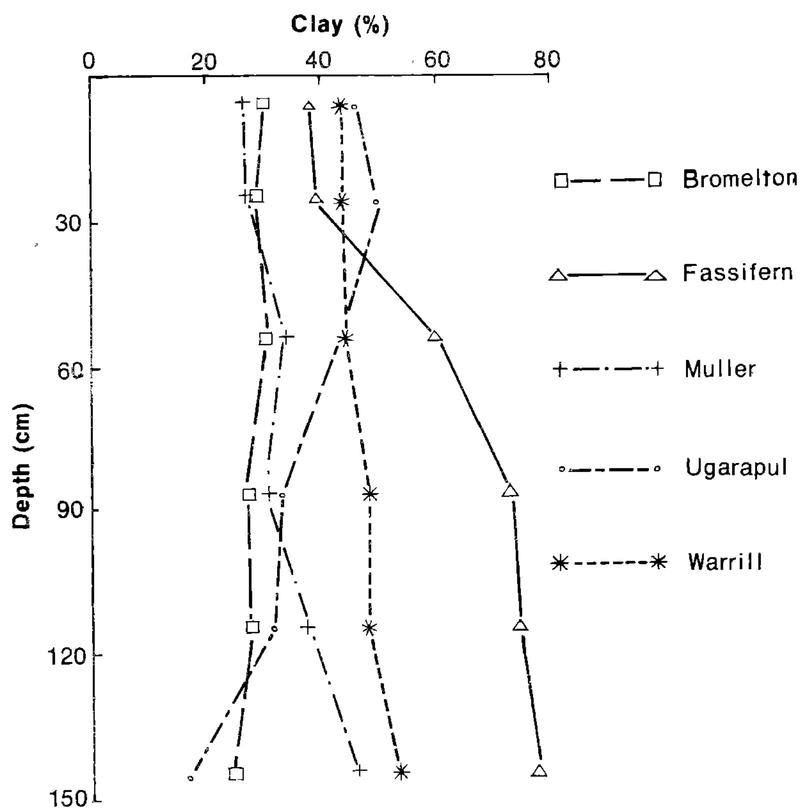


Figure 5. Soils of the Alluvial Plains – Clay (%).

Bromelton shows little change in clay content down the profile while Muller increases. Warrill increases slightly with depth compared to Ugarapul which decreases markedly. Fassifern clay contents become very high at depth (>70%).

There is a sequence in clay content away from the large creeks. The lighter textured soils occur on the levee banks close to the creek while the heavier textured soils are found in sequence some distance from the creek bank. e.g. Creek Bank → Bromelton (mean of 28% clay) → Muller (mean of 42% clay) or Ugarapul (mean of 38% clay) → Warrill (mean of 48% clay) → Fassifern (mean of 52% clay). Clay content values are from 0 - 10 cm samples in Table 8.

Available soil water capacity is estimated on a gravimetric basis as the difference between water held at $-^1/_3$ bar and -15 bar water potential (Table 9).

TABLE 9

Available soil water capacity for major soils of the alluvial plains (% Gravimetric)

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Bromelton (R2)	18	19	20	19
Muller (R11)	18	21	21	20
Warrill (R3)	19	20	20	23
Ugarapul (R9)	17	20	21	19
Fassifern (R12)	23	22	31	33

All soils show a relatively high available soil water capacity through the profile. Fassifern, which also has the highest subsoil clay content shows the greatest capacity to hold water in the subsoil.

Ratings of the tendency of clay and silt to disperse are presented in Table 10. Highly dispersed soils are likely to have poor drainage.

TABLE 10

Dispersion ratio for major soils of the alluvial plains

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Bromelton (R2)	0.43	0.38	0.36	0.37
Muller (R11)	0.54	0.51	0.64	0.66
Warrill (R3)	0.50	0.48	0.49	0.65
Ugarapul (R9)	0.66	0.66	0.59	0.57
Fassifern (R12)	0.62	0.74	0.83	0.88
Warrill-saline phase (R15)	0.68	0.72	0.86	0.89

The surface 0 - 10 cm of Ugarapul, Fassifern and Warrill-saline phase show a moderate tendency to disperse (ratio of 0.6 - 0.8) compared to the low dispersibility (ratio of <0.6) shown by Bromelton, Muller and Warrill (not saline phase). Muller and Warrill (not saline phase) have a moderate tendency to disperse at depth. Fassifern and Warrill-saline phase have subsoils with a high tendency to disperse (ratio of >0.8). The latter two soils are poorly drained and often waterlogged.

Soils of the alluvial plains have high clay activity ratios (see Glossary). Generally values are in the 0.7 to 1.3 range which suggests a high proportion of expanding lattice clay mineral in the clay fraction. An exception is the brown D-horizon of Ugarapul which has very high estimated clay activity (1.3 - 1.8). Ugarapul occurs in close vicinity to a large hill of microsyenite (Obum-Obum Hill) which also develops red to brown soils of high apparent clay activity. This suggests that the D-horizons of Ugarapul may be largely derived from microsyenite.

It was noticed that these soils have a high fine sand fraction. This fraction may be the cause of the high apparent clay activity in the form of partially weathered pseudomorph minerals. X-ray diffraction traces from the sand fraction showed a significant proportion of clay mineral (A. Koppi personal communication).

5.3 Clay loam/clays of the undulating plains

5.3.1 Fertility

Soils are generally fertile (Table 11) except for a few local areas (see attached parametric maps). Fertilizer additions have maintained high fertility levels despite nutrient depletion by erosion and cropping.

TABLE 11

Analysis of clay loam/clays (bulked 0 - 10 cm) of the uplands

		Kalamba	Churchbank	Purdon	Warumkarie	Pennell	Kulgun	Kelly	McGrath	Interpretation*	
		n_1 = 1	n_1 = 23 n_2 = 8	n_1 = 11 n_2 = 3	n_1 = 7 n_2 = 1	n_1 = 18 n_2 = 5	n_1 = 79 n_2 = 31	n_1 = 1	n_1 = 4 n_2 = 2		
pH	mean	6.0	6.4	6.4	7.4	6.8	7.2	7.2	7.6		
	range		5.7 - 7.2	6.1 - 6.6	6.2 - 8.5	5.6 - 7.9	5.8 - 8.5		7.2 - 8.4		
E.C.	mean	0.04	0.057	0.064	0.099	0.07	0.09	0.07	0.07	<0.15	low
mS cm^{-1}	range		0.02 - 0.15	0.03 - 0.12	0.04 - 0.14	0.03 - 0.21	0.03 - 0.43		0.03 - 0.12		
Acid P	mean	55	271	167	74	100	91	30	92	>45	high
ppm	range		6 - 999	24 - 999	19 - 120	9 - 430	8 - 550		48 - 120	<20	low
Bicarb P	mean	39	68	64	36	44	52	13	47	>30	high
ppm	range		10 - 160	11 - 100	12 - 100	9 - 100	10 - 195		32 - 55	<20	low
Repl. K	mean	0.45	0.94	1.0	0.66	0.79	0.84	0.42	0.58	>0.5	high
meq/100g	range		0.14 - 2.9	0.38 - 3.0	0.29 - 1.2	0.13 - 4.0	0.12 - 3.0		0.29 - 0.88	<0.2	low
Exch. Ca	mean		16	15	43	26	28		25	>2.0	adequate
meq/100g	range		10 - 20	12 - 21		17 - 32	13 - 41		19 - 32		
Exch. Mg	mean		7.1	6.5	9	15	13		17	>1.7	adequate
meq/100g	range		5.8 - 8.7	5.4 - 8.0		7.8 - 29	7 - 21		14 - 19		
Exch. Na	mean		0.18	0.12	0.21	0.29	0.43		0.51		
meq/100g	range		0.05 - 0.37	0.12 - 0.13		0.08 - 0.45	0.16 - 1.4		0.35 - 0.66		
Exch. K	mean		1.5	1.4	0.74	0.59	1.1		0.69		
meq/100g	range		0.31 - 2.7	0.74 - 2.6		0.27 - 0.89	.27 - 2.7		0.49 - 0.89		
DTPA Fe	mean	60	94	134	56	82	58	56	26	>4.5	adequate
ppm	range		9 - 223	47 - 240	14 - 182	3 - 410	2 - 238		2 - 48		
DTPA Mn	mean	54	48	40	25	30	24	19	15	>1.0	adequate
ppm	range		9 - 164	18 - 58	6 - 55	13 - 64	3 - 92		4 - 25		
DTPA Cu	mean	2.6	1.2	1.3	2.7	1.6	1.9	1.2	1.6	>0.3	adequate
ppm	range		0.6 - 2.2	0.8 - 2.0	1.2 - 5.4	0.6 - 2.9	0.8 - 3.2		1.1 - 1.9		
DTPA Zn	mean	2.2	4.4	7.0	2.3	3.1	2.4	0.8	1.4	>1.0	adequate
ppm	range		0.8 - 11	1.1 - 24	0.7 - 7.9	0.5 - 10	0.4 - 9.8		0.7 - 2.4	<0.5	deficient
Clay %	mean		34	32	62	50	53		53		
	range		23 - 47	28 - 39		37 - 65	35 - 63		52 - 54		

NOTE - exchangeable cations are oven dry figures while the rest are air dry.

* More detailed interpretation of soil analyses is provided in Appendix 2.

n_1 = number of values used for calculations of analyses (except exchangeable cations)

n_2 = number of values used for calculations of exchangeable cation analyses

Extractable phosphorus and potassium and trace elements are high, and exchangeable cations adequate.

As found by Paton (1971), surface organic matter levels are high (5.5% organic carbon) in undisturbed grey clay (Kulgun) under brigalow (site R19 in Appendix 4). However in a cultivated and eroded Kulgun profile the level is down to 2.0% organic carbon (Site R10). Similarly total nitrogen is high (0.35% total N) under brigalow but is lower under a cropping regime (0.22% total N).

Usually low to medium organic carbon (1.1 - 2.8%) and low to very fair total nitrogen levels (0.12 - 0.22%) are found under cultivation, but under pasture, Churchbank (site R16) has much higher organic matter (4.4% organic C) and total nitrogen (0.37%).

Total sulphur levels in Appendix 4 profiles indicate that deficiency is unlikely.

The friable non-cracking soils (Kalamba, Churchbank and Purdon) have a slightly acid surface compared with a neutral or weakly alkaline surface for the other soils (the cracking clays). The soils with calcareous subsoils (Purdon, Kulgun and McGrath) are strongly alkaline at depth while the other soils have neutral and non-calcareous subsoils (Appendix 4).

5.3.2 Salinity and exchangeable cations

The clay loam/clays of the undulating plains have low salinity at the surface (Table 11) but salinity in the subsoil varies with parent material and land use.

Soils developed from microsyenite (Churchbank, Pennell) have very low salt levels (<0.15 mS cm^{-1}) throughout the profile. In contrast, soils developed from the Walloon Coal Measures (Kulgun, McGrath, Purdon, Warumkarie) have higher (>0.15 mS cm^{-1} E.C.) and more variable salinity at depth.

Kulgun soils under brigalow scrub or native dryland pasture have high salt levels (0.87 - 1.1 mS cm^{-1} E.C.) peaking at 100 - 130 cm deep, the effective depth of wetting for the current climate. This is in keeping with the observation that clay soils under brigalow have moderate to high salt contents in the subsoil (Isbell 1962).

However, under irrigation the soils cleared of brigalow scrub (mainly Kulgun) have been leached of salts resulting in lower subsoil salinity (<0.45 mS cm^{-1} E.C.). These lower salt levels peak at 50 - 100 cm or occasionally continue increasing to 150 cm, but still to a low level (<0.45 mS cm^{-1} E.C.). Less commonly there are medium salt levels (0.46 - 0.90 mS cm^{-1} E.C.) peaking at 40 - 50 cm or at 100 - 110 cm. These variations may depend on several factors: the time since irrigation of crops commenced; differing irrigation management; or the original gilgai salinity pattern.

A very high salt level (>2.0 mS cm^{-1} E.C.) was found at 40 cm in one Kulgun profile taken from a 2% lower slope position. This was 100 m from a salt outbreak area on the edge of the alluvial plain.

A shallow and often saline water table is probably responsible for these high subsoil salt levels and saline wastelands. The rise in water table is initiated by increased lateral subsoil water movement down the slope following the clearing of native vegetation. Irrigation of the uplands raises the water table even higher and the additional leaching of soil salts by irrigation water increases the salinity of the ground water as well.

In Churchbank and Pennell, exchangeable calcium is dominant throughout the profile. Both soils are developed from microsyenite.

In soils developed from fine grained Walloon sediments e.g. Kulgun, calcium is dominant to 30 cm, and from 60 to 150 cm magnesium is dominant.

The irrigated and virgin Kulgun profiles have a similar cation balance, although calcium is lower and magnesium slightly higher under irrigation.

Churchbank and Pennell have low ESP's (<3) throughout their profiles. Kulgun is also low to 30 cm, but increases to 4 at 60 cm, up to 16 at 150 cm. This high subsoil sodicity does not appear to greatly influence irrigation suitability. Subsoil sodicity levels have not changed under irrigation.

5.3.3 Physical properties

Fig. 6 shows clay profiles of representative soils from Appendix 4. The surface soil of the cracking clays (Pennell and Kulgun) is high (50%) compared to the friable Churchbank surface soil (30%).

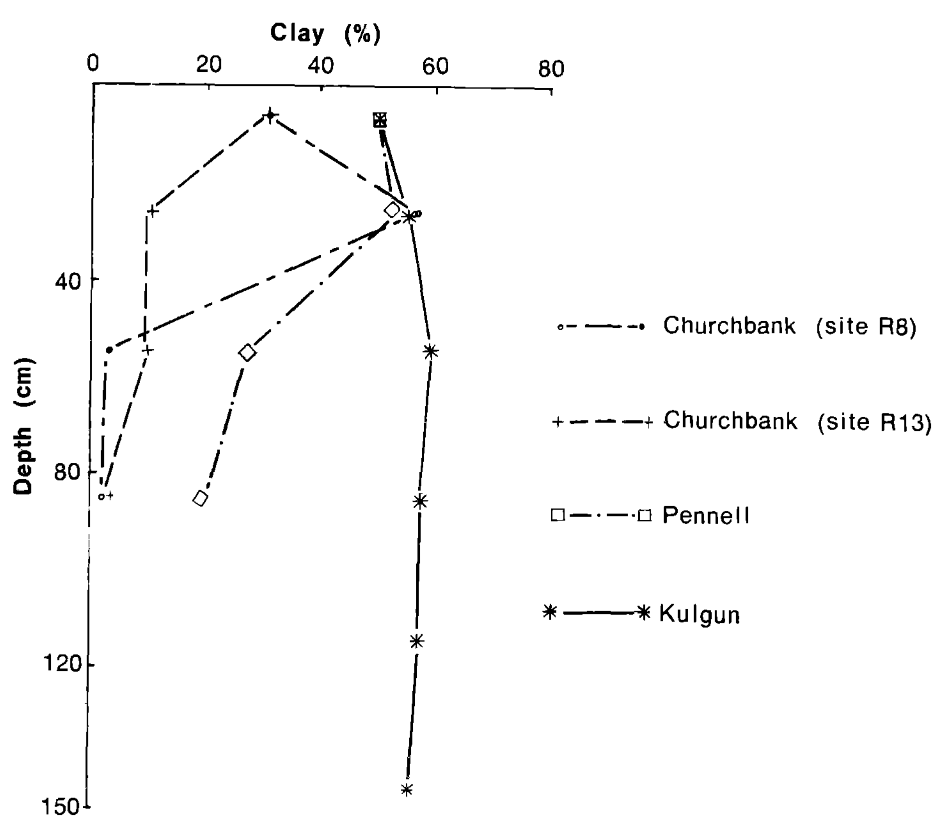


Figure 6. Clay Loam / Clays of the Undulating Plains – Clay (%).

The sharp drops in clay content down the profiles correspond to the horizons of weathered parent material. The shallow Churchbank profile (R8) has no high clay subsoil compared to the deeper Churchbank profile (R13) where clay substantially increases. The cracking clay, Kulgun has a fairly uniform clay profile, whereas Pennell gradually decreases in clay.

Data from Table 12 indicate that these soils hold relatively large amounts of available soil water in the top 30 cm. By 60 cm the shallow soils (Churchbank and Pennell) are into weathered parent material with low available water capacity while the deep Kulgun profile has a high estimated available water capacity. This means Kulgun does not need irrigating as frequently as Churchbank and Pennell, particularly for deeper rooting crops.

TABLE 12

Available soil water capacity for major clay loam/clays of the undulating plains (% Gravimetric)

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Churchbank (R13)	15	19	8	6
Pennell (R14)	16	18	13	6
Kulgun (R10)	17	19	20	23

Dispersion ratios from Table 13 indicate a low tendency to dispersion in the Churchbank and Pennell profiles but increasing dispersion down the Kulgun profile.

TABLE 13

Dispersion ratio for major clay loams/clays of the undulating plains

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Churchbank (R13)	0.41	0.41	0.36	0.41
Pennell (R14)	0.45	0.49	0.51	0.41
Kulgun (R10)	0.54	0.64	0.60	0.86

Clay loam/clays developed from microsyenite have high clay activity ratios (0.7 - 1.1). This increases to 2 to 4 in the transitional BC horizon to 20 to 40 in the C horizon. The high activities may be caused by the sand fraction composed of high activity pseudomorphs (possibly vermiculite) resulting from the partial weathering of augite, biotite and olivine.

Clays derived from the Walloon Coal Measures also have high clay activity ratios. Kulgun has a surface clay activity of 0.5 to 0.6, a subsoil of 0.6 to 0.7 and a C horizon of 0.9. This, and the expanding clay properties (cracking, self-mulching, gilgais) suggest that an expanding lattice clay mineral is the dominant clay mineral present.

5.4 Duplex soils and shallow loams/clay loams of the uplands

5.4.1 Fertility

Fertility is variable and commonly low (Table 14). Surface soils are slightly acid with variable phosphorus levels and generally good potassium status. Copper levels are lower than in the previous two soil groups with the red coloured soils on microsyenite, particularly Frazer, often marginal to deficient.

TABLE 14

Analysis of upland duplex soils and shallow loams/clayloams (bulked 0 - 10 cm)

		Stibbes	Rosevale	Dieckmann	Wiss	Lance	Yellunga	Ortels	Watters	Frazer	Rangeview	Interpretation*
		$n_1 = 5$ $n_2 = 2$	$n_1 = 2$	$n_1 = 1$	$n_1 = 6$ $n_2 = 2$	$n_1 = 1$	$n_1 = 20$ $n_2 = 9$	$n_1 = 4$	$n_1 = 4$	$n_1 = 17$ $n_2 = 3$	$n_1 = 8$ $n_2 = 3$	
pH	mean	6.5	6.4	5.9	6.5	6.2	6.1	5.9	6.1	6.5	6.3	
	range	6.1 - 6.7	6.2 - 6.5		5.9 - 6.8		5.5 - 6.6	5.8 - 6.3	5 8 - 6.6	5.9 - 6 9	5.6 - 6.8	
E.C. mS cm^{-1}	mean	0 09	0.03	0.03	0.04	0.05	0.06	0.06	0.06	0.06	0.11	>0.6 high
	range	0.04 - 0.22	0.03 - 0.03		0.03 - 0.05		0.03 - 0 17	0.04 - 0.08	0 04 - 0.08	0.02 - 0.09	0.06 - 0.13	<0 15 low
Acid P ppm	mean	98	30	5	117	13	79	14	90	167	103	>45 high
	range	10 - 120	6 - 53		103 - 120		5 - 999	5 - 33	8 - 250	13 - 950	11 - 130	<20 low
Bicarb P ppm	mean	77	27	17	94	14	35	13	46	50	84	>30 high
	range	18 - 100	6 - 48		69 - 100		9 - 180	6 - 22	13 - 92	10 - 155	30 - 100	<20 low
Repl. K meq/100g	mean	1.4	0.38	0.57	0.88	0.48	0.64	0.59	0 72	0.78	1.4	>0.5 high
	range	0.26 - 4.0	0.31 - 0.44		0.4 - 1.5	1	0.21 - 2.2	0.43 - 0.78	0.55 - 0.85	0.2 - 1 9	0.6 - 2.4	<0.2 low
Exch Ca meq/100g	mean	8.7			6.4		7.3			12	20	>2 0 adequate
	range	5 - 12			4.9 - 8.0		2.7 - 7.3			8 - 13	14 - 30	
Exch..Mg meq/100g	mean	2.9			2 3		5.3			3.2	6	>1.7 adequate
	range	2.7 - 3.1			1.5 - 3.0		3.3 - 6 6			2 4 - 3.9	4 - 8	
Exch. Na meq/100g	mean	0.05			0.10		0.32			0.06	0.11	
	range	0.05 - 0.05			0.08 - 0.12		0.10 - 0.44			0.05 - 0.08	0.08 - 0.13	
Exch. K meq/100g	mean	1.14			0.66		0.52			0.77	1.6	
	range	0.74 - 1.5			0.44 - 0.88		0.16 - 1.15			0.61 - 1.0	1.0 - 2.6	
DTPA Fe ppm	mean	98	75	152	88	104	167	177	93	69	109	>4.5 adequate
	range	62 - 198	72 - 78		49 - 205		52 - 360	82 - 260	68 - 114	30 - 136	32 - 196	
DTPA Mn ppm	mean	44	27	54	30	56	35	25	39	46	105	>1.0 adequate
	range	32 - 64	26 - 28		18 - 48		10 - 63	18 - 35	5 - 89	14 - 154	60 - 172	
DTPA Cu ppm	mean	1.0	0.6	0.30	0.6	0.6	1.2	0.6	0 43	0.5	1.1	>0.3 adequate
	range	0.1 - 2.3	0.4 - 0.8		0.4 - 1.0		0.5 - 3.3	0.4 - 0 8	0.3 - 0 6	0 2 - 0.8	0.1 - 2.6	
DTPA Zn ppm	mean	13	2.2	3.6	3.4	2.0	2.8	3.6	4.0	5.1	69	>1.0 adequate
	range	2 1 - 50	1.3 - 3.0		1.5 - 8.6		0.8 - 8 8	1.5 - 6.4	2.1 - 7.3	2.1 - 7 9	4.2 - 270	
Clay %	mean	15			6		28			10	20	
	range	11 - 19			5 - 7		18 - 41			5 - 19	11 - 30	

<u>NOTE</u> - exchangeable cations are oven dry figures while the rest are air dry.

* More detailed interpretation of soil analyses is provided in Appendix 2.

n_1 = number of values used for calculations of analyses (except exchangeable cations)

n_2 = number of values used for calculations of exchangeable cation analyses

Appendix 4 profiles indicate that the solodic Yellunga has fair organic carbon (2.5%) and total nitrogen (0.14%), compared to low organic carbon (0.7 - 1.6%) and total nitrogen (0.07 - 0.13%) for soils on microsyenite e.g. Frazer (a lithosol) and Stibbes (a red earth). In contrast, Rangeview, a dark lithosol developed on volcanics (andesite or trachyte), has 3.7% organic carbon and 0.75% total nitrogen.

Total sulphur levels (Appendix 4) indicate adequate amounts in these soils.

Soil pH becomes neutral down the profile for soils developed on microsyenite, but commonly becomes alkaline at depth for soils developed on the Walloon Coal Measures e.g. Yellunga.

5.4.2 Salinity and exchangeable cations

Apart from Yellunga, these soils are low in salt throughout the profile (<0.15 mS cm^{-1} E.C.). Yellunga usually has medium to high levels of salt (0.6 - 1.2 mS cm^{-1} E.C.) peaking at 70 - 90 cm depth, the effective depth of wetting. Occasionally salinity gradually increases with depth, peaking at 120 cm with 0.46 mS cm^{-1} E.C. Shallow variants of Yellunga (<70 cm deep) increase in salt down the profile but to lower maxima (0.29 - 0.36 mS cm^{-1} E.C.).

Exchangeable cation data was available for Stibbes, Wiss, Yellunga, Frazer and Rangeview. Exchangeable calcium and magnesium levels are lower in these soils compared to the other groups and calcium usually dominates the exchange complex of the surface soils (Table 14).

Calcium is the dominant exchangeable cation on the surface of soils developed from microsyenite and andesite. (Frazer, Stibbes and Rangeview). Magnesium is usually less than half the calcium value and ESP's are low.

For a soil developed on Walloon sediments (Yellunga), magnesium is the strongly dominant cation. Calcium is about a fifth of the magnesium value. Yellunga has a low surface ESP, but a higher subsoil ESP of 7 at 20 cm increasing to a maximum of 22 by 80 cm.

5.4.3 Physical properties

Particle size distribution depends mainly on soil parent material. Soils developed on sediments of the Walloon Coal Measures (Yellunga), and Tertiary andesite (Rangeview) have higher clay contents than soils developed on microsyenite (Frazer, Wiss and Stibbes) (Fig. 7). Soils from microsyenite also have a high fine sand component (>45%) (Appendix 4).

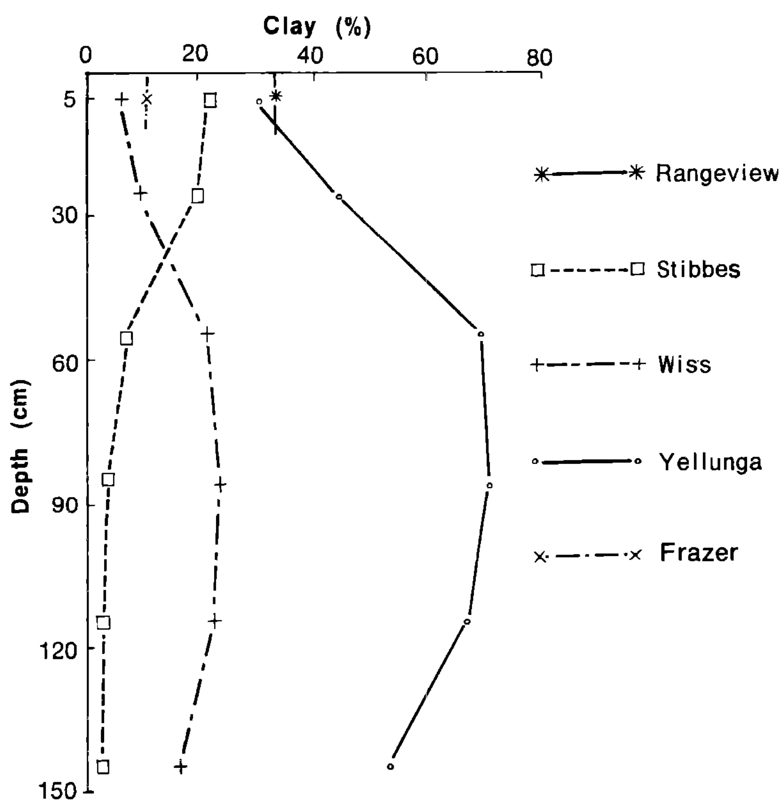


Figure 7. Duplex Soils and Shallow Clay Loam / Clays of the Uplands – Clay (%).

From Table 15, available soil water capacity is seen to be lower for the lighter textured soils (Stibbes and Wiss) and higher for the more clayey soils (Yellunga and Rangeview).

TABLE 15

Available soil water capacity for major duplex soils and shallow loams/clay loams of the uplands (% gravimetric)

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Stibbes (R5)	15	13	11	9
Wiss (R6)	10	10	13	15
Yellunga (R18)	19	11	20	16
Rangeview (R4)	18			
Frazer (R1)	11			

The dispersion ratios of Table 16 indicate a moderate to strong tendency of the Yellunga clay subsoil to disperse. However for soils with textures coarser than clay loam (Wiss and Stibbes), high ratios may reflect the weakness of bonding strength of the plentiful fine sand fraction rather than undesirable dispersion of the smaller amounts of silt and clay present.

TABLE 16

Dispersion ratio for major duplex soils and shallow loams/clay loams of the uplands

Soil	Depth			
	0 - 10 cm	20 - 30 cm	50 - 60 cm	80 - 90 cm
Stibbes (R5)	0.49	0.56	0.69	0.53
Wiss (R6)	0.45	0.71	0.59	0.55
Yellunga (R18)	0.44	0.29	0.78	0.91
Rangeview (R4)	0.14			
Frazer (R1)	0.11			

Sandy soils developed from microsyenite (Stibbes, Wiss) on the uplands have high apparent clay activity ratios (0.7 - 1.5). This is similar to the microsyenite derived clay loam/clays (Pennell, Churchbank) and is due to high activity sand.

Rangeview has a lower clay activity (0.5), indicating that several clay minerals are present.

Yellunga has a surface clay activity of 0.5 which increases down the profile to 0.7. A higher montmorillonite component is probably responsible for this increase.

5.5 Comparison of Three Intensively Cropped Soils

There are three major soils intensively cropped and irrigated in the area: Bromelton and Warrill on the alluvial plains, and Kulgun of the undulating plains.

Data from previous sections of this Chapter show that the fertility of these soils is similar. All three soils have fair or very fair nitrogen, high phosphorus and potassium and adequate iron, manganese, copper and zinc (Tables 8, 11 and 14). In addition, available soil water capacity is about 20% gravimetric moisture through out the profile for all three soils (Tables 9, 12 and 15).

Although all the soils have low dispersion ratios in the surface soil, they have different dispersion at depth (Tables 10, 12 and 16). Bromelton has very low dispersion throughout the profile compared to moderate dispersion in the Warrill subsoil and high dispersion in the Kulgun subsoil.

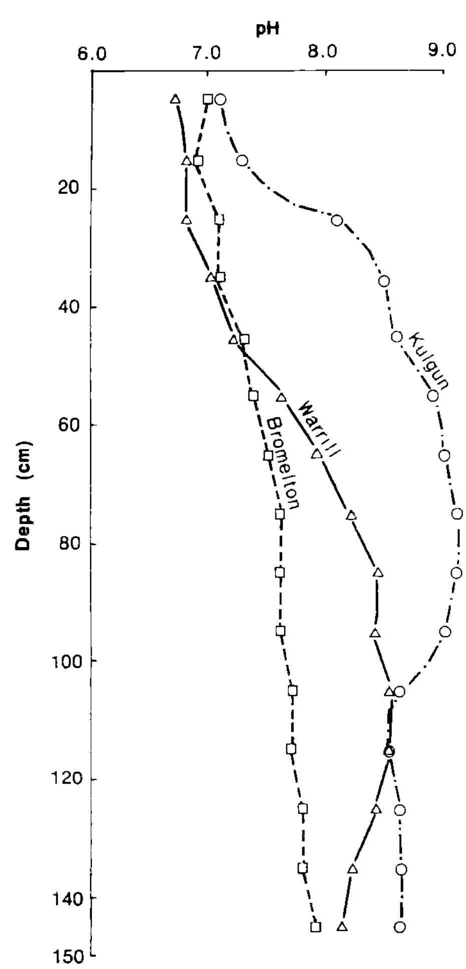


Fig. 8. Soil pH Profiles of Bromelton, Warrill and Kulgun

To further investigate the differences between soils, profiles under irrigation were compared in Figs. 8, 9, 10 and 11. In Figure 8, all soils have a neutral pH at the surface which becomes more alkaline at depth. Bromelton's pH increases slightly to be pH 7.8 at 150 cm while Warrill gradually increases to a pH peak of 8.5 at 100 - 120 cm before decreasing to pH 8.1 at 150 cm. Kulgun increases in pH rapidly down the profile and peaks at pH 9.1 at 70 - 90 cm before decreasing to pH 8.6 at 110 - 150 cm.

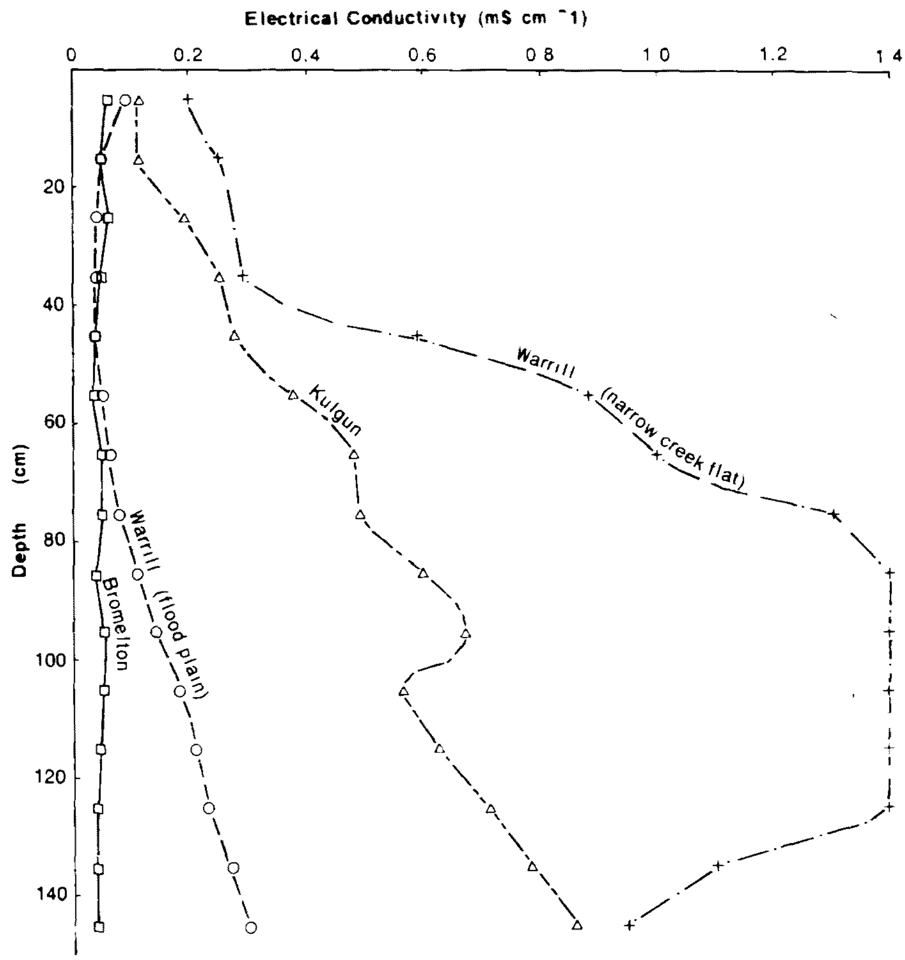


Figure 9. Electrical Conductivity (1.5) Profiles of Bromelton, Warrill and Kulgun.

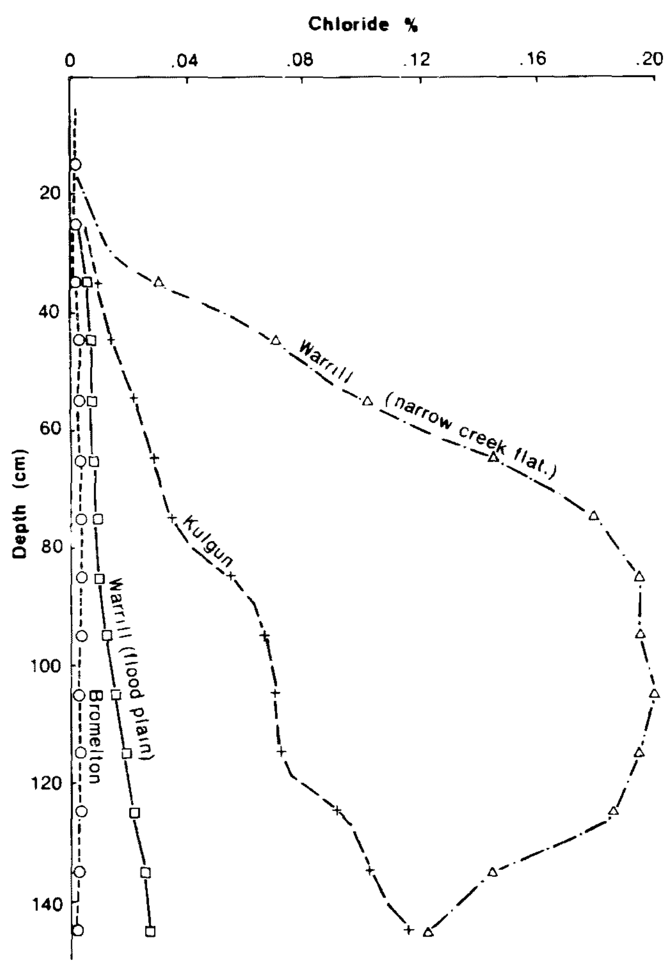


Figure 10. Chloride (%) Profiles of Bromelton, Warrill and Kulgun.

Salinity is compared in Figs. 9 and 10 and all soils are low at the surface. Bromelton has very low salinity throughout the profile while Warrill on the floodplain increases slightly. However Kulgun and Warrill on the narrow creek flat increase in salinity at depth. Kulgun salinity gradually increases down the profile with a maximum at 150 cm of 0.8 mS cm^{-1} or 0.11% chloride, whereas Warrill on the narrow creek flats peaks at 80 - 110 cm with 1.4 mS cm^{-1} or 0.19% chloride and declines to 0.95 mS cm^{-1} or 0.12% chloride at 150 cm. The narrow creek flats are not extensive and are of lesser importance than the wide flood plain of Warrill Creek.

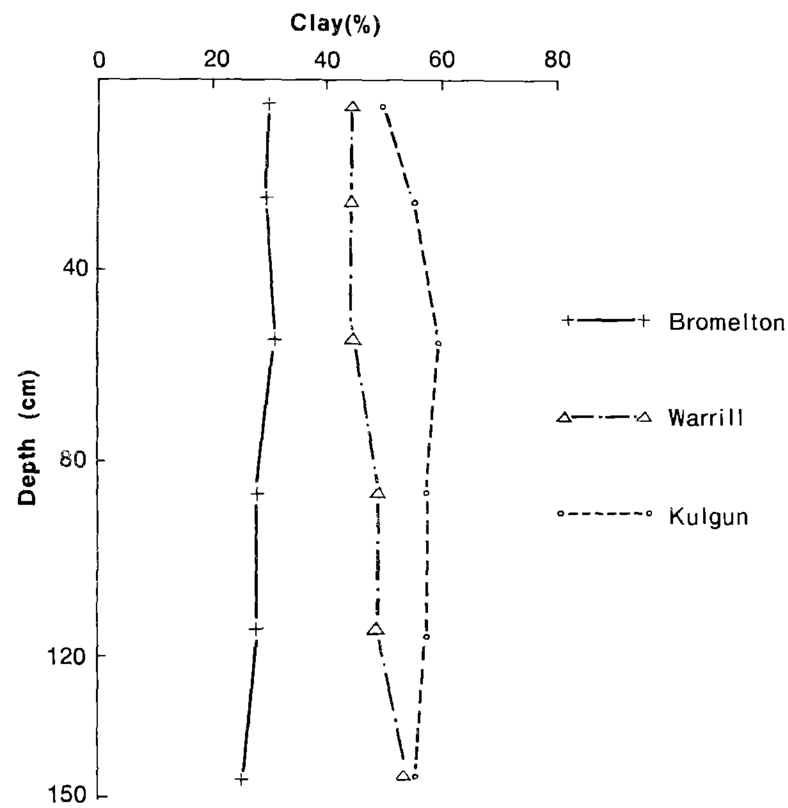


Figure 11. Clay (%) Profiles of Bromelton, Warrill and Kulgun.

In Figure 11, differences in clay content between soils are quite marked. Bromelton has a clay content of about 30% throughout the profile while Warrill gradually increases from 44% at the surface to 53% at 150 cm. Kulgun is even more clayey, with 50% clay at the surface increasing to 60% at 60 - 150 cm.

Several properties point to Bromelton as a superior agricultural soil to Warrill and Kulgun. The near neutral pH, the low salinity and dispersion ratio and lower clay content throughout the profile all indicate that Bromelton is freely draining. Because the surface drains quicker and is less sticky, cultivation and other management activities are possible, much sooner after rain or irrigation.

5.6 Parametric Maps

The distributions of bicarbonate extractable phosphorus, replaceable potassium and DTPA extractable copper and zinc are presented as parametric maps (enclosed). These four estimates of essential plant nutrients were chosen because they varied considerably across the area.

Parametric maps are useful for indicating the variability of soil properties not strongly related to changes in the type of soil. Differences in these properties may be explained by other factors such as changes in geology, farm management or the close proximity of buildings or yards.

5.6.1 Bicarbonate extractable phosphorus

From the bicarbonate extractable phosphorus map it is seen that the Warrill Creek floodplain and the uplands to the east are rich in phosphorus where cropping takes place. There are isolated pockets of low phosphorus, usually on the hills and where there is no cultivation. Different management appears to be responsible for some boundaries between medium and high phosphorus levels.

On the uplands west of the floodplain, phosphorus is variable but often low. Many areas on Yellunga, a solodic, and Frazer, a lithosol, are surprisingly high in phosphorus.

5.6.2 Replaceable potassium

Replaceable potassium is generally high on the parametric map. Pennell and Churchbank commonly show low or medium potassium levels, and these soils are largely derived from microsyenite. In the northern section of the reference area, large areas of Yellunga have medium levels.

5.6.3 DTPA extractable copper

In the DTPA extractable copper map, most cultivated land appears to have high copper. A medium but still satisfactory level of copper occurs on an area of Bromelton soil on the alluvial plain. This is difficult to explain but appears to follow property boundaries. Medium copper levels also occur on areas of Stibbes and Churchbank south-east of Kalbar.

Generally high copper levels are evident on the soils derived from alluvia and Jurassic Walloon Coal Measures. However soils developed from Tertiary microsyenite and trachyte usually have medium copper levels. A small area of low copper occurs on these latter soils on the low hills west of the Kalbar turnoff of the Cunningham Highway.

5.6.4 DTPA extractable zinc

The DTPA extractable zinc map indicates levels approximately the reverse of those of copper. Soils developed from Tertiary microsyenite, trachyte and andesite are generally very high in zinc. The remaining soils have satisfactory zinc and low levels were only recorded at one point in the north-east corner of the reference area.

It was also noticeable that where sample sites were located close to buildings or yards, zinc levels are usually very high. This may be the result of the presence of galvanised iron material at some time.

6. LAND USE

6.1 Present Land Use

Large areas of the alluvial plain and the undulating plains east of Warrill Creek are irrigated. Moogerah Dam supplies permanent water of good quality which flows into Reynolds Creek, Warrill Creek and diversion channels. Water for the uplands is pumped up to 5 km inland and held in storage dams. On the alluvial plain, underground water of variable quality is also used. Generally, bores close to the major creeks have good quality water while further away from the creeks, bore water is often of low quality (Queensland Water Resources Commission). In some areas well away from the creeks, it appears that the bore water is gradually becoming more saline. Bean crops in recent years have suffered salt damage for the first time (I. Romano - pers. comm.).

Carrots, peas, french beans, soybeans, lucerne and potatoes are the most popular irrigated crops. Other crops include sorghum, barley, wheat, oats, canary seed, maize, sunflower and pumpkins. Improved pastures are also irrigated on the occasional dairy farm in the area.

West of the Warrill Creek alluvial plain, small areas of soybeans, sorghum and sunflower are dryland cropped over the summer wet season. High yields are often obtained on the first crop after clearing, which takes advantage of the initial fertility. However yields decline with continued cropping if rain is inadequate and fertilizers not used. Because rainfall is unreliable, the economics of using fertilizer is questionable.

With dryland cropping, preference has been given to the cracking clay soils (Kulgun, Pennell), probably because of their better water storage. Because they have high wilting points however, these soils require substantial falls of rain for crops to respond.

Minor areas of duplex soils (Yellunga and Lance) and prairie soils (Churchbank) are also dryland cropped and these soils respond better to light rains. Yellunga is less suitable for cropping because of its poor internal drainage and lower fertility.

Some dryland cropped areas have been abandoned, and erosion often appears to have been severe.

Most of the undulating plains west of the alluvial plain and nearly all the timbered low hills are under native pasture grazed by cattle.

6.2 Land Capability Classification

Map units and their various limitations are listed in Table 17. Details of limitation subclasses are given in Appendix 6 and on land classes in Appendix 7.

The limitation subclasses in Appendix 6 refer only to the limitations of the dominant soil of the map unit. The limiting criteria for minor soils are not specified except in their effect on soil variability (subclasses pd_3 and pd_4).

TABLE 17

Provisional land capability classification of map units

Map Unit	Limitation Sub-class	Land Class
Soils of the Alluvial Plains		
Moore	pc2, e2, f2	2
Moogerah	pc2, e2, f2	2
Bromelton	pc2, e2, f2	2
Bromelton - eroded phase	pc2, e4, f2	4
Muller	e2, f2	2
Muller - eroded phase	e4, f2	4
Warrill	k2, sa2-3, e2, f2	2
Warrill - saline phase	k2, sa5, w4, e2, f2	5
Ugarapul	k2, e2, f2	2
Fassifern	k3, sa2-3, g3, w4, f2	4
Soils of the Undulating Plains		
Stibbes	pc2, pd3, d3, e3	3
Kalamba	d3, t3, e3	3
Churchbank	d3, t3, pc2, e3	3
Purdon	t3, e3, pc2	3
Warumkarie	d3, k2, t3, r3, e3	3
Pennell	d3-d4, k2, t3-4, r3, e3-4	3
Kulgun	k2, sa2-3, t2-3, r2-3, g2, e3	3
Kelly	k2, t2-3, r2-3, e3, w3	3
McGrath	k2, t2-3, r2-3, e3	3
Rosevale	d2, pb3-4, pc3, t2-3, e3-4	3
Dieckmann	d1-2, pb3-4, pc3, pd4, sa2-3, t2-4, e3-4	3 - 4
Wiss	pc2-3, pd4, t3-4, e3-4	4
Lance	pb2-3, pc3, pd4, t2-4, e3-4	4
Yellunga	d1-2, pb4, pc3, sa2-3, t3-4, e3-4	4
Soils of the Low Hills		
Rangeview	d4-5, t4-5, r5, e4	5
Frazer	d4-5, t4-5, r5, e4	5
Ortels	d2, pb3, pc3, pd4, t3-4, r4-5, e4	5
Watters	d2, pb3, pc3, t4-5 r4-5, e4	5

6.3 Climatic Factors in Land Use

Flooding of the Warrill Creek - Reynolds Creek floodplain can destroy standing crops and severely erode large areas.

On the upland undulating plains (2-12% slopes), intense summer rain causes considerable erosion, particularly when the ground is bare and erosion control measures inadequate.

When very hot periods (>35°C) in summer follow heavy rain, flood or irrigation, some crops, particularly lucerne become very distressed and may even die. Waterlogging, which reduces root aeration and encourages root disease is combined with high temperatures. High temperatures result in speedier respiration and transpiration and the wet soil may scald plant roots. According to Cameron (1973) it is widely accepted that the basic cause of damage is the deficiency of oxygen in the root zone. This leads to the production of a toxin probably ethanol which concentrates in the upper parts of the plant.

The distribution of frost over the area affects planting dates for susceptible crops. On the uplands where frosts are less of a threat, spring potatoes are planted as early as June and pumpkins, watermelons and rockmelons in July.

6.4 Soil Suitability

In Table 18, soils with similar agronomic qualities and limitations have been placed in agronomic groups. In grouping soils, workability, depth, water intake and retention, drainage, stoniness, topography and salinity were considered.

TABLE 18

Distinguishing characteristics, major limitations and crop suitability of agronomic soil groups

Agronomic Group	Distinguishing Characteristics of Agronomic Importance	Major Limitations		Crop Suitability
		Physical	Chemical	
ALLUVIAL PLAINS				
Bromelton, Moore Muller, Moogerah	Dark friable surface	Flooding. Erosion. Surface crusting	No major problems	All crops currently irrigated in the area
Bromelton-eroded phase, Muller-eroded phase	Deep erosion channels through Bromelton and Muller soils	Flooding. Erosion. Microrelief	No major problems	Native or improved pasture
Warrill, Ugarapul	Dark self-mulching cracking clay surface, sticky when wet	Flooding. Erosion. Workability. Drainage	No major problems	All crops currently irrigated in the area
Warrill-saline phase	Mostly bare surface; salt crystals glitter on surface; mottled dark upper 40 cm of clay	Flooding. Erosion. Waterlogging	High salinity	None or low density grazing
Fassifern	Mottled dark clay surface; gilgai microrelief, sticky when wet	Flooding. Erosion. Microrelief. Waterlogging	No major problems	Native or improved pastures
UNDULATING PLAINS				
Stibbes	Shallow soils with red very friable sandy surface	Low water retention. Shallow. Erosion	Variable fertility	All crops currently irrigated in the area
Kalamba, Churchbank	Shallow soils with friable clay loam/clay surface	Shallow. Erosion	No major problems	All crops currently irrigated in the area
Purdon	Deep soil with dark friable clay loam/clay surface	Erosion. Stoniness in patches	No major problems	All crops currently irrigated in the area
Warumkarie, Pennell, Kulgun, McGrath, Kelly	Self-mulching cracking clay surface, sticky when wet	Erosion. Workability. Soil variability in stoniness and seepages	Variable salinity. Variable fertility	All crops currently irrigated in the area
Rosevale, Dieckmann	Duplex soils with sandy loam to loam to 30 cm over clay	Erosion. Low plant available water and impeded internal drainage	Low to medium general fertility	Improved or native pastures
Wiss	Duplex soils with sandy loam to 45-70 cm over red clay	Erosion. Low plant available water	No major problems	All crops currently irrigated in the area
Lance, Yellunga	Duplex soils with clay loam to 10-25 cm over clay	Erosion. Surface crusting. Slow water entry, and impeded internal drainage	Low to medium general fertility	Improved or native pastures. Occasional dryland or irrigated cropping
LOW HILLS				
Rangeview, Frazer	Shallow gravelly soils	Erosion. Slope hazard. Stoniness. Gravel. Shallow	No major problems	Native pastures. Rangeland
Ortels, Watters	Shallow gravelly duplex soils	Erosion. Slope hazard. Stoniness. Gravel. Shallow. Impeded internal drainage	Low to medium general fertility	Native pastures. Rangeland

On the alluvial plains, Warrill-saline phase, Bromelton-eroded phase, Muller-eroded phase and Fassifern are only suitable for dryland pasture. The other soils of the alluvial plain are suited to irrigation although the more clayey soils (Warrill, Ugarapul) are more difficult to manage in wet weather.

Soils on the undulating plains east of the floodplain are irrigated for all current crops. The friable clayloam/clays (e.g. Churchbank) are slightly easier to manage in wet weather than the self-mulching cracking clays (e.g. Kulgun).

West of the floodplain, the clay loam duplex soils (Yellunga and Lance) are hardsetting, have slow infiltration rates and slow internal drainage. They are therefore not as suitable for irrigation but are better suited to permanent pastures or occasional dryland cropping.

With slopes of 2-12%, all the undulating plain soils risk severe erosion.

The rugged terrain, shallow depth and stony surface of the low hills mean the soils are unsuitable for anything other than pasture or undisturbed forest.

6.4.1 Soil Variability

Variation in surface texture can seriously affect the crop suitability of Warrill soil on the alluvial plain. The light-medium to medium clay surface variants are easier to cultivate and better drained than the heavy clay surface variants. The heavy clay soils are thus more restricted in choice of crop or pasture and more difficult to manage.

Variability in internal drainage of the dark cracking clay soil (Kulgun) on the undulating plains may be responsible for the seepage areas that occur on mid and lower slopes. Temporary waterlogging can cause nitrogen loss as gaseous nitrogen (denitrification), root rots, and prevent agricultural machinery from covering the paddocks uniformly after rain.

6.4.2 Erosion

Erosion channels up to a metre deep are found on the alluvial floodplain and are mapped as eroded phases of Bromelton and Muller. It is best to leave these channels grassed to hinder any further erosion during floods.

Elsewhere on the floodplain, flooding causes shallow topsoil erosion or silt deposition to varying depths. The uneven surfaces which result often require levelling. The upland areas under cultivation are susceptible to severe sheet, rill and gully erosion. With slopes of 2 to 12% being spray irrigated, intense rainfall particularly at planting time or following an irrigation can result in devastating erosion.

The cracking clay soils and sandy duplex soils are probably most susceptible to erosion. The surface aggregates of cracking clay soils slake on wetting and sheet erosion results. Sandy surfaces are very vulnerable to the destructive action of raindrops and have low wet aggregate stability.

The least erodible soils have clay loam surfaces with reasonably stable aggregates which do not readily slake or disperse on wetting. However, cultivation destroys much of the organic matter responsible for aggregate stability and on these slopes (2-12%), all soils are vulnerable if the surface is bare. Shallow soils on the undulating plains (Churchbank and Pennell) risk becoming too shallow and infertile to crop if erosion continues to speedily remove the soil. Some areas have already been abandoned to permanent pasture.

The suggestion of contour banks and contour planting to control erosion however may not find easy acceptance amongst landholders. This is probably because irrigation is carried out in small regular paddocks shaped to suit row crops and travelling irrigators.

6.4.3 Salinity

Almost bare, highly saline areas (Warrill-saline phase) occur intermittently where the alluvial plains meet the uplands or on the narrow alluvial flats surrounded by uplands.

Some dams in gullies immediately above the outbreak area are also saline and occasionally saline springs appear on midslopes during wet periods.

This suggests that the salt may come from the soils (usually Kulgun) and rocks (Walloon Coal Measures) of the local uplands.

Clearing and irrigation have both encouraged the downward lateral movement of water and dissolved salts. As a result, water tables have risen in outbreak areas to the point where salts have concentrated by evaporation.

6.4.4 Flooding

Flooding destroys standing crops, causes erosion and siltation, and levelling is often needed afterwards. Eroded areas have lower fertility and are harder to cultivate while surface crusting of silted areas inhibits seedling emergence.

However, higher yields are usually recorded for crops grown following silt deposition, probably from increased fertility. In addition, silt is often less sticky and easier to manage in wet weather.

6.4.5 Soil Workability and Trafficability

The cultivated dark self-mulching clay soils of the alluvial plain (Warrill, Ugarapul) and the undulating plains (mainly Kulgun and Pennell) have a narrow moisture range suitable for cultivation. Thus after rain soils with a clayey surface and slow drainage are untrafficable for several days and management plans may be held up. This is particularly so on the more slowly drained alluvial plain.

Impermeable layers and clods are often formed when moist soils are compacted by agricultural machinery. Compaction is likely where processing crops are harvested on specific dates regardless of soil moisture conditions.

Compaction layers reduce internal drainage and soils may need deep ploughing, deep ripping and gypsum.

Cloddiness is more common on soils with light to light-medium clay surfaces and these are usually non or weakly self-mulching and marginally cracking e.g. Muller.

Soils with clods have several disadvantages -

- they need more cultivating to form a fine seedbed
- germination is often reduced
- clods form a physical barrier to seedlings
- potato harvesters dig up clods and more labour is needed for sorting

6.4.6 Stoniness

Stones in many local areas of the irrigated upland soils (Kulgun, Pennell, McGrath, Kelly, Warumkarie) have been removed over the years. The ridges and low hills are steep and often too stoney to cultivate, particularly the gravelly loams (Rangeview, Frazer) and gravelly duplex soils (Ortels and Watters).

6.4.7 Topography

The mostly flat (<1%) alluvial plain soils are suitable for irrigation except for the lower lying gilgaied Fassifern soil. Erosion depressions and siltation deposits after flooding may need to be levelled.

The 2-12% slopes of the undulating plains tolerate spray irrigation and erosion control measures are needed for long term soil stability.

The low hills with slopes 10-30% are too steep for cultivation without severe erosion loss and should be left as pasture, preferably timbered. A few small flatter areas that occur on the summits and lower slopes could be cultivated occasionally without too much danger.

6.4.8 Drainage

As mentioned earlier, wet seepage areas occur after heavy rain on the irrigated uplands, particularly on the Kulgun soil. Variation in internal drainage of the soils is probably responsible.

Groundwaters have risen in certain drainage lines and in local areas at the junction of uplands and the alluvial plains.

There appears to be no permanent water table in the uplands but ground water occurs in the alluvial aquifers 15 m under the Warrill Creek flood plain.

6.4.9 Soil Depth

The soils of the low hills are generally too shallow for cultivation. However the shallow soils of the undulating plains (Kalamba, Churchbank, Pennell and Stibbes) are cultivated quite successfully unless severe erosion has occurred.

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9. GLOSSARY

Available soil water capacity: The amount of water (on a weight, volume or depth basis), between the moisture content of field capacity and permanent wilting point.

It is commonly approximated in the laboratory by determining the difference between the equilibrium moisture contents at suctions of $^1/_{10}$ bar (core or clod) or $^1/_3$ bar (sieved material <2 mm), and 15 bar (Beckmann *et al.* 1976).

Clay activity ratio: CEC/clay content (m. equiv./g of clay). It is a measure of the activity of the clay fraction (assuming that only clay particles contribute to CEC). From the values obtained, one may infer whether one has 2:1 or 1:1 clays dominant or mixtures of the two. Where organic matter makes a significant contribution to measured CEC, a corrected CEC can be calculated (Coughlan 1969).

Cracking clays: Refer to those shrinkable clay soils which develop and exhibit during a dry season or period cracks as wide, or wider than, 6 mm and which penetrate at least 30 cm into the solum (Northcote 1971).

Duplex soils: Soils which have strongly contrasting horizons with a lighter textured surface soil (clay loam or lighter) over a heavier textured (more clayey) subsoil. A more complete definition is provided by Northcote (1971).

Exchangeable sodium percentage (ESP): The percentage of the cation exchange capacity occupied by the sodium cation.

Free soil survey:	A method of soil survey involving regular ground observations on each side of soil boundaries which have surface expression in secondary features such as micro- and macro-relief, vegetation and crop response. A modification of free soil survey (this survey) involves initial ground observations on a regular or irregular basis, sufficient to adequately characterize the mapping units and their internal variability. Boundaries are then checked by the free surveying method. (McDonald 1975).
Ground observation:	Refers to observations on auger hole borings, pits, or cuttings as distinct from surface observations (Bie and Beckett 1970).
Levee:	A linear rise in alluvial terrain, comprising a part of the floodplain, formed by water action beyond the banks of a river in flood. Relief is ultra low and the outer slope very gentle.
Map unit:	An area or group of areas coherent enough to be represented to scale on a map, which can be adequately described in a simple statement in terms of its main soil profile classes (Beckett and Webster 1971).
Soil association:	A group of defined and named taxonomic soil units, regularly geographically associated in a defined proportional pattern (Soil Survey Staff 1951).
Soil profile class:	A group or class of soil profiles, not necessarily contiguous, grouped on their similarity of morphological characteristics (Beckett 1971; Beckett and Burrough 1971; Beckett and Webster 1971; Burrough *et al.* 1971). As mapped they are representative of bodies of soil with similar parent materials, topography, vegetative structure and generally vegetation composition.
Uplands:	Area of low hills and undulating plains above the alluvial plain.

APPENDIX 1

Soil Analytical Methods

Sample Preparation

Samples were dried in a forced air draught at 40°C and ground to less than 2 mm. Soil tests were carried out on the <2 mm soil except where indicated.

Electrical Conductivity

A 1:5 soil deionized water suspension was shaken for one hour and the electrical conductivity (E.C.) measured at 25°C.

pH

The soil water suspension used for determination of electrical conductivity was used for pH. pH was determined with glass and calomel electrodes and a Townson Specific Ion/pH meter.

Chloride

After electrical conductivity and pH were determined the same soil water suspension was used to measure chlorides. The specific ion chloride electrode was used according to Haydon, Williams and Ahern (1974).

Organic Carbon

The wet combustion method of Walkley and Black (1934) was used on finely ground soil (<80 mesh).

Results were obtained using the colorimetric method of Sims and Haby (1971). Results are reported as per cent carbon (Walkley and Black values).

Total Nitrogen

The sample was finely ground and a selenium catalyst used in the Kjeldahl method. An Auto Analyser system was used for estimation of ammonium in the digests.

Extractable Phosphorus

Acid extractable phosphorus was determined by the method of Kerr and von Stieglitz (1938) by extracting with 0.01 N H_2SO_4 for 16 hours. An auto analyser system was used to read the extracts using the Murphy and Riley (1962) colour development method.

Bicarbonate extractable phosphorus (Colwell 1963) was extracted with 0.5 M sodium bicarbonate pH 8.5 and shaken for 16 hours. The extracts were read by auto analyser using similar system to the acid extractable phosphorus.

Total Phosphorus, Potassium and Sulphur

About 3 g of soil sample were finely ground in a 'Shatterbox' mill and pressed into a pellet as described by Norrish and Hutton (1964). The pellet was then exposed to a beam of X-rays in a Philips 1410 vacuum X-ray spectrograph. Simple linear calibration was used to obtain percentage phosphorus, potassium and sulphur from fluorescent intensities.

Exchangeable Cations

A method similar to that reported in 'Methods for Analysis Of Irrigated Soils', Loveday (1974) was used.

Prewashing was done with 60% ethanol. Exchangeable cations were removed with 1 N NH_4Cl at pH 8.5 in 60% ethanol. Adsorbed ammonium was removed with 1 N sodium sulphate.

Ammonium N and Cl were determined on an auto analyser using colorimetric methods. The difference was reported as the C.E.C.

Particle Size Distribution

Particle size distribution was determined using a modification of the hydrometer method of Day (1956).

Dispersion Ratio

Soil dispersibility is estimated by the ratio of readily dispersible silt plus clay to the silt plus clay determined by particle size analysis. 30 g of soil in 1 litre of deionized water was shaken end over end for 1 hour and silt and clay determined as for particle size.

Moisture Characteristics

The gravimetric water content of soils was measured on ground samples equilibrated on ceramic pressure plates at two potentials, $-^1/_3$ bar and -15 bar after the method of McIntyre (1974).

Results are reported as g/100 g O.D. soil and recorded as % moisture. Available water is calculated as the difference between the gravimetric water contents at $-^1/_3$ and -15 bar.

Iron, Manganese, Copper and Zinc

Micronutrients were extracted by the DTPA method of Lindsay and Norvell (1969). Concentrations in the extract were determined by atomic absorption spectrophotometry.

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APPENDIX 2

Interpretation of Soil Analytical Results

Interpretations given are general guidelines only.

Extractable Phosphorus

	N/100 H_2SO_4 extraction ppm	M/2 $NaHCO_3$ extraction ppm
Very low	<10	<11
Low	10 - 20	11 - 20
Fair	21 - 35	21 - 30
Very Fair	36 - 45	31 - 40
High	46 - 100	>40
Very High	>100	

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries.

Total Nitrogen (Kjeldahl)

	%
Very low	<0.05
Low	0.05 - 0.09
Fair	0.10 - 0.14
Very Fair	0.15 - 0.24
High	0.25 - 0.49
Very High	>0.50

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries.

Soluble Salts (1:5 soil, water suspension)

	Chloride %	Elect. Conductivity $mS\ cm^{-1}$
Very low	<.010	<0.15
Low	.011 - .030	0.16 - 0.45
Medium	.031 - .060	0.46 - 0.90
High	.061 - 0.20	0.91 - 2.0
Very High	>0.2	>2.0

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries.

Replaceable Potassium (0.05N HCl extraction)

	meq./100 g
Very low	<0.15
Low	0.15 - 0.20
Fair	0.21 - 0.30
Very Fair	0.31 - 0.50
High	>0.50

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries.

pH (1:5 soil, water suspension)

extremely acid	<4.5	mildly alkaline	7.4 - 7.8
very strongly acid	4.5 - 5.0	moderately alkaline	7.9 - 8.4
strongly acid	5.1 - 5.5	strongly alkaline	8.5 - 9.0
medium acid	5.6 - 6.0	very strongly alkaline	>9.0
slightly acid	6.1 - 6.5		
neutral	6.6 - 7.3		

Sulphur

Soils containing <0.01% total sulphur were commonly found to show fertilizer responses on a range of Queensland soils.

Source: Andrew, Crack and Rayment (1974).

Organic Carbon (Walkley and Black values)

	%
Very low	<0.59
Low	0.59 - 1.75
Medium	1.76 - 2.9
High	3.0 - 5.8
Very High	>5.8

Many Australian soils have been recorded in the 1.2 to 2.3 range.

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries.

Calcium and Magnesium

Calcium	<2 meq/100 g	low
	>2 meq/100 g	adequate
Magnesium	<1.7 meq/100 g	low
	>1.7 meq/100 g	adequate

Source: ACF - Austral soil test interpretation charts (1973).

Copper, Zinc, Manganese and Iron

Critical levels of DTPA - extractable micronutrients for sensitive crops

Nutrient	Deficient	Marginal	Adequate
		- ppm extracted from soils -	
Zn	<0.5	0.5 - 1.0	>1.0
Fe	<2.5	2.5 - 4.5	>4.5
Mn	<1.0		>1.0
Cu	<0.2	0.2 - 0.3	>0.3

Source: Viets and Lindsay (1973)

A rough guide when suspecting toxicity would be:-

Mn	>500 ppm
Zn	>15 ppm
Cu	>15 ppm

Manganese toxicity may be complicated by soil pH, and induced zinc and iron deficiency.

Available Water (water held between $-^1/_3$ bar and -15 bar water potentials)

%	
<5	very low
5.1 - 8.0	low
8.1 - 12	medium
12.1 - 15	high
>15	v. high

Dispersion Ratio

<0.6	low dispersion
0.6 - 0.8	moderate dispersion
>0.8	high dispersion

Source: Agricultural Chemistry Branch, Queensland Department of Primary Industries

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APPENDIX 3

Detailed Morphological Descriptions of Soil Profile Classes

Notes:

General: Soil profile classes are presented in the same order as in the map reference (legend).

Soil Profile Morphology:

(i) Modal soil profile descriptions refer to the most commonly observed profile morphology. Variations outside the modal range occur less frequently.

(ii) Gilgai:

incipient	=	<5 cm vertical interval
weak	=	5 - 10 cm vertical interval
moderate	=	10 - 30 cm vertical interval
strong	=	>30 cm vertical interval

(iii) Self-mulch:

weak	=	<1 cm of poorly developed self-mulch
moderate	=	1 - 2 cm of discrete aggregates breaking to granular peds
strong	=	>2 cm of discrete aggregates breaking to granular peds

(iv) The soil profile diagram indicates upper and lower depth limits of each horizon.

(v) Horizon Nomenclature : As per McDonald (1977)

(vi) Colour : Moist colours were recorded using the Revised Standard Soil Colour Chart (Oyama and Takehara 1967).

(vii) Bleach : An horizon which is "bleached when dry" is an A_2 horizon that is white or almost so. It has been defined (Northcote 1971) as having the following Munsell notations for a dry soil:-

(a) for all hues, value 7 with chroma 4 or less or value 8 or higher with chroma 4 or less, and

(b) where both the A_1 and the B horizons have hues of 5YR or redder then the value of 6 with a chroma of 4 or less is allowable.

(viii) Texture : As defined in Northcote (1971)

(ix) Structure : As per Soil Survey Manual (Soil Survey Staff 1951). Lenticular size categories defined as for prismatic.

(x) Consistence and horizon boundaries : as per Soil Survey Manual (Soil Survey Staff 1951).

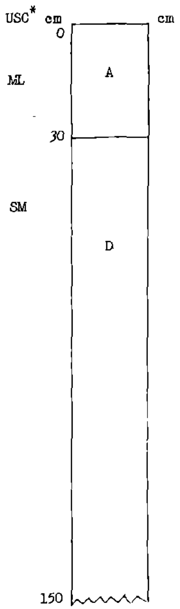
SOIL PROFILE CLASS: **MOORE**

PRINCIPAL PROFILE FORMS: Um 1.44

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: cultivated; cloddy; friable



A-horizon: dark (10YR 3/2); clay loam; weak fine crumb to massive; friable; acid (pH 6.0). Clear to -

D-horizon: dark (10YR 3/2); loamy sand; massive; loose; neutral becoming alkaline at depth (pH 7.0 - 8.5).

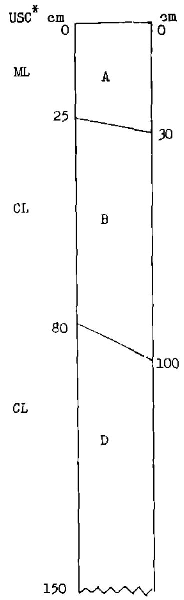
SOIL PROFILE CLASS: **MOOGERAH**

PRINCIPAL PROFILE FORMS: Gn 2.42, Gn 2.02, Gn 2.03

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface Condition: loose



A-horizon: dark (10YR 3/2); loam to clay loam; weak fine subangular blocky; very friable to friable; acid (pH 6.0 - 6.7). Gradual to -

B-horizon: dark or brown (7.5YR 3/2 - 3/3); clay loam to light clay; massive; friable; neutral (pH 7.0 - 7.8). Gradual to -

D-horizon: grey-brown or brown (7.5YR 4/2 - 4/3); light clay; massive; friable; neutral (pH 7.0 - 7.5).

(b) Variations outside the above range include:

A-horizon: sandy loam; brown (7.5YR 3/3)

B-horizon: red-brown or dark red brown; fine sandy clay loam; sandy clay loam; fine sandy clay ; manganese concretions

D-horizon: light-medium to medium clay; moderate to strong medium blocky; very firm; lime present; alkaline (pH 8.2)

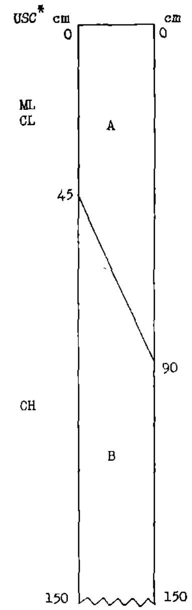
SOIL PROFILE CLASS: **BROMELTON**

PRINCIPAL PROFILE FORMS: Uf 6.32, Gn 3.42, Uf 6.31

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: cultivated; cloddy; friable



A-horizon: dark (10YR 3/1, 3/2, 4/2); clay loam to light-clay; weak fine to medium crumb or massive; friable; acid to neutral (pH 6.0 - 7.0). Gradual or diffuse to -

B-horizon: dark (10YR 3/1, 2/2, 3/2) faintly mottled at depth; light clay to medium clay; strong coarse blocky or lenticular, very firm to extremely firm; neutral to alkaline (pH 7.0 - 8.5); small amounts of manganese; traces of lime below 90 cm.

(b) Variations outside the above range include:

A-horizon: light-medium clay; recent alluvial deposits of fine sandy loam;silty clay loam to 12 cm over clay

B-horizon: brown (7.5YR 3/3-4/3); moderate medium blocky

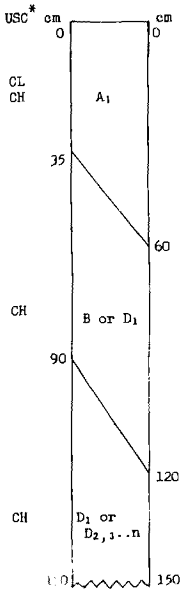
* Unified Soil Classification (FAO, 1973)

SOIL PROFILE CLASS: **MULLER**

PRINCIPAL PROFILE FORMS: Ug 5.15, Uf 6.31, Ug 5.17, Uf 6.32

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: seasonally cracking and weakly self-mulching

A₁-horizon: dark (10YR 3/2, 2/2); light-clay to light-medium clay; moderate medium subangular blocky; firm to very firm; acid to neutral (pH 6.0 - 7.0). Gradual to -

B-horizon: dark (10YR 3/2); medium to heavy clay; strong coarse blocky or lenticular; very firm to extremely firm; neutral to weakly alkaline (pH 7.0 - 8.2). or

D₁-horizon: brown (7.5YR 4/3); light-medium clay; moderate medium blocky; firm; alkaline (pH 8.0 - 8.5). Clear to -

D₂,₃ ...n horizon: brown (7.5YR 4/3) or dark (10YR 2/2, 3/2) light-medium to heavy clay; strong lenticular or weak subangular blocky; neutral to alkaline (pH 7.0 - 8.5); occasionally traces of lime

(b) Variations outside the above range include:

Surface condition: not seasonally cracking

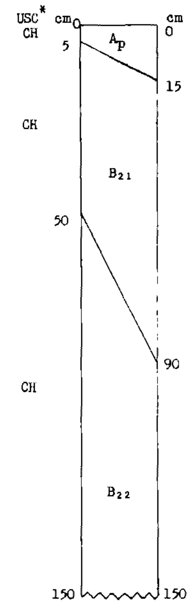
B-horizon: light clay; grey (10YR-2.5Y 4/1-2, 10YR 5/2); faint mottling; lower depth of 150 cm; medium blocky

SOIL PROFILE CLASS: **WARRILL**

PRINCIPAL PROFILE FORMS: Ug 5.16, Ug 5.15, Ug 5.1 , Ug 5.24

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: seasonally cracking and moderately self mulching

Ap-horizon: dark (10YR 2/1, 3/1, 2/2, 3/2); light-medium to medium clay; strong medium granular to sub angular blocky or cloddy; very firm to extremely firm; acid to neutral (pH 6.0 - 7.0). Clear or gradual to -

B₂₁-horizon: dark (10YR 2/1, 3/1, 2/2, 3/2); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; neutral to alkaline (pH 7.5 - 8.5). Gradual or diffuse to -

B₂₂-horizon: commonly mottled, dark (10YR 2/1, 3/2), brown (7.5YR 4/3, 4/4) or grey (10YR 4/2, 5/2, 5/3); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; alkaline (pH 8.0 - 9.0); commonly small amounts of lime; commonly manganese nodules

(b) Variations outside the above range include:

Ap-horizon: heavy clay; lime present; silty clay; silty clay loam surface veneer; light clay.

B₂₁-horizon: grey (10YR 4/1, 4/2); brown (7.5YR 4/3, 4/4); faintly mottled; traces of lime; may continue to 150 cm; manganiferous gravel, light-medium clay.

B₂₂-horizon: light-medium clay; ferruginous gravel; manganiferous gravel.

* Unified Soil Classification (FAO, 1973)

SOIL PROFILE CLASS: **WARRILL - SALINE PHASE**

SOIL PROFILE MORPHOLOGY

Surface condition: periodically submerged; on drying salt crystals glitter on the surface; a massive powdery clay loam surface crust is present on scalded bare areas; crust may crack into large hexagonal shapes.

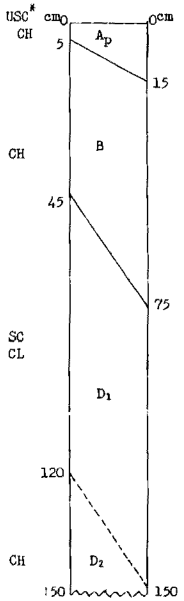
Profile: mottling may occur in the upper 30 - 40 cm grading into a dark (10YR 3/1) or grey (10YR 4/1, 4/2, 5Y 4/2) subsoil.

SOIL PROFILE CLASS: **UGARAPUL**

PRINCIPAL PROFILE FORMS: Ug 5.15, Ug 5.17

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: seasonally cracking and moderately self-mulching

A_p-horizon: dark (10YR 3/1, 3/2); light-medium to medium clay; strong fine to medium sub angular blocky; firm to very firm; acid to neutral (pH 6.2 - 7.0) Clear or gradual to -

B-horizon: dark (10YR 3/1, 3/2) grading to brown (10YR 3/3, 4/3) with depth; light-medium to medium clay; strong coarse blocky or lenticular; very firm to extremely firm; neutral (pH 6.7 - 8.0) Clear or gradual to -

D_1-horizon: mottled brown (10YR 3/3, 4/3, 7.5YR 4/3); sandy clay loam to sandy clay; massive; friable to firm; neutral to weakly alkaline (pH 7.0 - 8.2); manganese nodules present

(b) Variations outside the above range include:

A_p-horizon: heavy clay

B-horizon: heavy clay; lower depth 120 cm; alkaline (pH 8.5); lime present; mottles at depth

D_1-horizon: mottled grey (10YR 4/2); light-medium clay; lime present

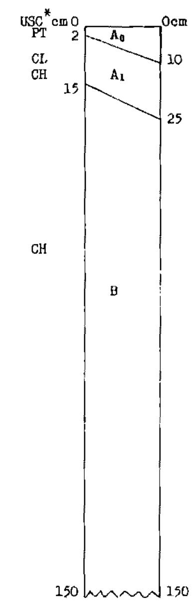
D_2-horizon present: mottled grey (10YR 4/2) medium clay

SOIL PROFILE CLASS: **FASSIFERN**

PRINCIPAL PROFILE FORMS: Ug 5.24, Ug 5.16

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Microrelief: strong gamma nuram gilgai and some linear gilgai; occurs in depressions and swamps

Surface condition: seasonally cracking; dark fibrous litter; some weak self mulching where only 2-3 cm of fibrous surface.

A_0-horizon: dark fibrous litter. Clear to -

A_1-horizon: dark (10YR 3/2) with rusty root mottles; light to medium clay; strong fine to medium subangular blocky; very firm to extremely firm; acid (pH 6.0 - 6.5). Gradual to -

B-horizon: dark (10YR 3/2) to grey (10YR 4/1, 4/2, 5/2); medium to heavy clay; strong coarse blocky or lenticular; slightly acid to neutral (pH 6.5 - 7.5) in the upper B becoming alkaline (pH 8.0 - 8.5) at depth (60 cm in mound, 90-120 cm in depression). Lime present below 90 cm

(b) Variations outside the above range include:

B-horizon: pH 8.0 - 8.5 in the upper B; lime present in the upper B; brown mottles

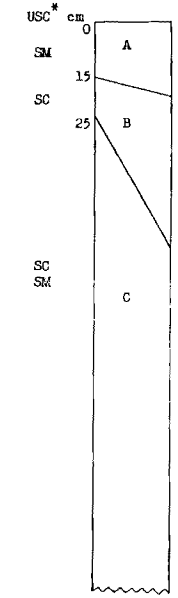
Microrelief: alpha nuram gilgai

SOIL PROFILE CLASS: **STIBBES**

PRINCIPAL PROFILE FORMS: Um 5.51, Gn 2.12

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: loose with weak surface crust; cobbly in patches

A-horizon: red-brown (5YR 3-4/4); sandy loam to sandy clay loam; massive; very friable; acid (pH 5.9 - 6.2). Gradual to -

B-horizon: red-brown (5YR 4/4-4/6); sandy clay loam to sandy clay; massive; very friable to friable; acid to neutral (pH 6.5 - 7.7). Clear to -

C-horizon: yellow-brown (7.5YR 4/6-5/8); sandy clay loam with fissures of clay; volcanic rock; some manganese segregations; loose; massive; neutral to slightly alkaline (pH 7.0 - 8.0); becoming sand with depth

(b) Variations outside the above range include:

B-horizon: light-medium clay (sandy)

* Unified Soil Classification (FAO, 1973)

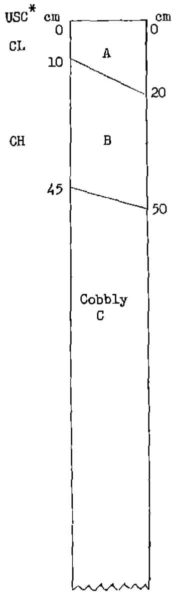
SOIL PROFILE CLASS: **KALAMBA**

PRINCIPAL PROFILE FORMS: Uf 6.31

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose, usually gravelly; cloddy where cultivated



A-horizon: grey to yellow-grey (10YR 4/2-5/3); light clay; weak to moderate fine and medium subangular blocky; friable; medium amounts of gravel; neutral (pH 7.5). Clear to -

B-horizon: brown (7.5YR 4/3); medium clay; strong coarse blocky; very firm; medium amounts of gravel; acid (pH 5.5 - 6.0)

C-horizon: mottled dark grey (5Y 3/2-4/2) mudstone

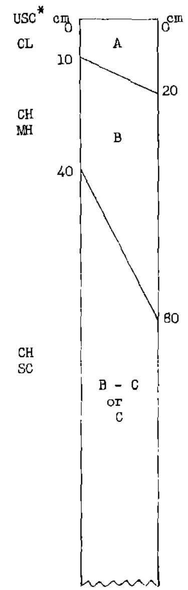
SOIL PROFILE CLASS: **CHURCHBANK**

PRINCIPAL PROFILE FORMS: Uf 6.31, Uf 6.32, Um 5.51, Gn 3.22, Ug 5.32

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose; cloddy where cultivated; cobbly in patches; occasionally weakly self-mulching



A-horizon: dark to brown (7.5YR-10YR 2/2, 3/1, 3/2, 7.5YR 3/3, 4/3); clay loam to light-medium clay; moderate to strong fine subangular blocky; friable to firm; acid (pH 6.0 - 6.5). Abrupt or clear to -

B-horizon: brown to red-brown (10YR 4/4, 7.5YR 3/3-4, 4/4, 5YR 3/3-4, 4/3-6); light-medium to heavy clay; strong medium to coarse blocky; very firm to extremely firm; neutral (pH 7.0); traces of manganese. Diffuse to -

B-C horizon: mottled yellow (7.5YR 5/6); medium clay; strong coarse blocky; extremely firm; neutral (pH 7.5); traces of manganese; traces of weathered rock fragments. Diffuse to -

C-horizon: brown to yellow-brown (7.5YR 4/4-6, 5/6, 10YR 4/3); loamy sand to sandy clay loam; massive; very friable to friable; slightly alkaline (pH 7.5 - 8.0); concentrations of manganese; weathered volcanic rock

(b) Variations outside the above range include:

A-horizon: abundant volcanic gravel and cobbles; medium clay; 5 cm thick.

B-horizon: mottled; dark (10YR 3/1-2); clay loam to light clay; weak to moderate medium subangular blocky; friable; slightly alkaline (pH 8.0); abundant volcanic gravel and cobbles.

C-horizon: dark (10YR 2/1); calcareous

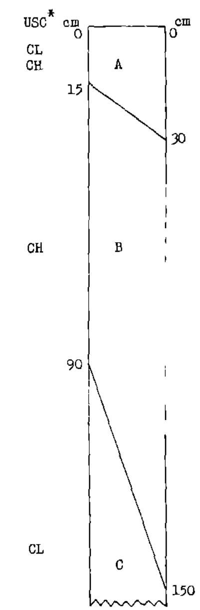
SOIL PROFILE CLASS: **PURDON**

PRINCIPAL PROFILE FORMS: Uf 6.31, Dd 3.13, Db 3.13, Uf 6.32, Dy 5.[illegible]

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose; cloddy where cultivated



A-horizon: dark (10YR 2/1, 3/1, 3/2); clay loam to light medium clay; moderate fine subangular blocky to strong coarse granular; friable to firm; occasionally gravelly; acid to neutral (pH 6.0 - 7.5). Clear or abrupt to -

B-horizon: dark (10YR 3/2) to brown (7.5YR [illegible], 10YR 4/3) becoming yellow-brown (10YR 5-6, [illegible]) or brown (7.5YR 4/6) with depth; light-medium to heavy clay; moderate medium subangular blocky to strong coarse blocky; trace to moderate amounts of lime. alkaline (pH 8.0 - 9.0). Gradual to -

C-horizon: yellow (10YR 5/3-4) or mottled grey (5Y 8/2); clay loam; massive; friable; lime present alkaline (pH 8.5 - 9.0)

(b) Variations outside the above range include:

A-horizon: sandy clay loam; 0-5 cm thick

B-horizon: mottled yellow-brown (10YR 5/4); ferruginous gravel, soft manganese gravel; lower depth of 60 cm.

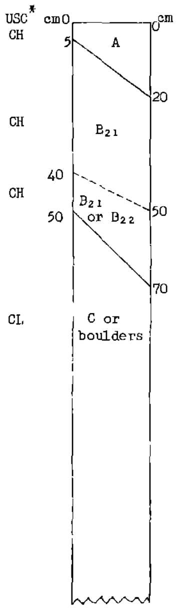
* Unified Soil Classification (FAO, 1973)

SOIL PROFILE CLASS: **WARUMKARIE**

PRINCIPAL PROFILE FORMS: Ug 5.22, Ug 5.14, Ug 5.12, Gn 3.42

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: medium self-mulching; seasonally cracking; occasionally cobbly

A-horizon: dark to grey (10YR 2/1, 2/2, 3/1, 4/2); light-medium to heavy clay; strong fine granular to strong medium blocky; very firm to extremely firm; slightly acid to neutral (pH 6.4 - 7.5). Clear or diffuse to -

B_{21}-horizon: dark to grey (10YR 3/1, 3/2, 4/1, 4/2, 5/3); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; neutral to slightly alkaline; (pH 7.5 - 8.0); trace to small amounts of lime. Gradual to -

B_{22}-horizon: yellow-grey (10YR 5/2, 5/3, 5/4); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; medium to strongly alkaline (pH 8.2 - 8.8); trace to moderate amounts of lime; Gradual or diffuse to -

C-horizon: yellow (10YR 6/4, 6/6, 7/6), clay loam to light-clay; massive; loose to friable, alkaline (pH 8.0 - 8.8); small to moderate amounts of lime.

(b) Variations outside the above range include:

A-horizon: clay-loam to light clay; friable to firm; alkaline (pH 8.5); small amounts of lime; trace amounts of volcanic gravel; ferruginous gravel

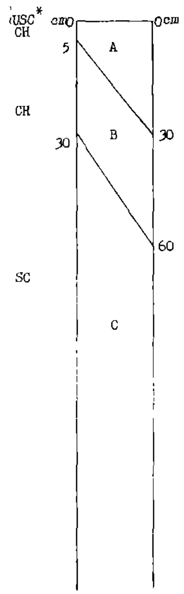
C-horizon: brown (10YR 4/3); sandy-loam to sandy clay loam; ferruginous gravel

SOIL PROFILE CLASS: **PENNELL**

PRINCIPAL PROFILE FORMS: Ug 5.32, Ug 5.13, Ug 5.22, Ug 5.31, Ug 5.12, Ug 5.37, Uf 6.31,

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: weakly to medium self-mulching; seasonally cracking; occasionally cobbly

A-horizon: dark to brown (10YR 3/2 - 7.5YR 4/3); medium clay; moderate fine granular to strong medium subangular blocky; very firm to extremely firm; acid to neutral (pH 6.0 - 7.0); Clear or gradual to -

B-horizon: brown to red brown (7.5YR 3/3-4/4, 5YR 4/4-5/6); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; neutral (pH 6.5 - 7.5). Gradual or diffuse to -

C-horizon: yellow to yellow-brown (10YR 4/4-6/4, 7.5YR 5/6, 6/6); sandy clay loam to sand; massive; friable to loose; commonly cobbly; commonly calcareous; neutral to slightly alkaline (pH 7.0 - 8.0).

(b) Variations outside the above range include:

A-horizon: red-brown (5YR 4/4); light clay; heavy clay; moderate fine crumb; friable; volcanic gravel

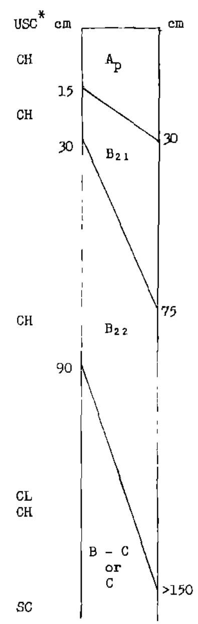
B-horizon: grey-brown (10YR 4/1-2, 5/3, 7.5YR 4/2); yellow-brown (7.5YR 5/6, 6/4, 6/6); alkaline (pH 8.5); traces of lime; volcanic gravel

SOIL PROFILE CLASS: **KULGUN**

PRINCIPAL PROFILE FORMS: Ug 5.14, Ug 5.15, Ug 5.16, Ug 5.22, Ug 5.24, Ug 5.35, Gn 3.93

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: medium to strongly self-mulching; seasonally cracking; cobbly in patches

A_p-horizon: dark to grey (10YR-7.5YR 3/1, 3/2, 4/1, 4/2); light-medium to heavy clay; strong medium granular to strong fine blocky; very firm to extremely firm; acid to neutral (pH 6.2 - 7.5); occasionally cobbly. Clear or gradual to -

B_{21}-horizon: dark to grey (7.5YR-10YR 3/1, 3/2, 4/1, 4/2, 5/2); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; trace to abundant amounts of lime at various depths; traces of manganese or iron concretions; commonly fragments of weathered rock; neutral to alkaline (pH 7.0 - 8.0). Clear to diffuse to -

B_{22}-horizon: grey to yellow (2.5Y 4/1, 10YR 5/3, 5/4, 6/3, 7/3) which may become mottled and yellower (10YR 6/4, 6/6, 7/6, 7/8) with depth, medium to heavy clay; strong coarse lenticular; extremely firm; moderate to abundant amounts of lime; traces of manganese and iron concretions; commonly fragments of weathered rock; strongly alkaline (pH 8.5 - 9.0) occasionally becoming neutral (pH 7.0 - 8.0) at depth. Gradual to -

B-C horizon: yellow-brown (10YR 6/3, 6/6) or grey (10YR 4/1, 4/1); light clay to light-medium clay; massive to weak subangular blocky; friable to firm; alkaline (pH 8.2 - 9.0); lime and weathered rock fragments common. OR

C-horizon: brown (10YR 4/4) or commonly mottled yellow (7.5YR-10YR 6/4, 6/6, 5Y 5/4); sand to sandy clay loam; massive; very friable to firm; commonly containing lime; abundant weathered rock; strongly alkaline (pH 8.5 - 9.0)

(b) Variations outside the above range include:

A-horizon: clay loam on virgin land; dark brown (10YR 3/3); slightly alkaline (pH 8.0)

B_{21}-horizon: mottled; brown (7.5YR-10YR 3/3, 4/3); red (2.5YR-5YR 4/6, 4/8); yellow (7.5YR 5/6-5/8); lime absent; lower depth greater than 150 cm

B_{22}-horizon: absent; acid (pH 6.5) at depth; brown

C-horizon: light clay

This soil often intergrades to the shallower Warumkarie soil type.

* Unified Soil Classification (FAO, 1973)

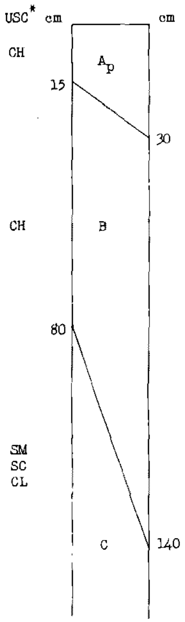
SOIL PROFILE CLASS: **KELLY**

PRINCIPAL PROFILE FORMS: Ug 5.23, Ug 5.32

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: medium to strongly self mulching; seasonally cracking



A_p-horizon: dark (10YR 3/2) or grey (10YR 4/2) or brown (10YR 4/3); light-medium clay to heavy clay, strong medium granular to strong medium subangular blocky; extremely firm; occasionally moderate amounts of lime; neutral to alkaline (pH 7.0 - 8.5). Gradual to -

B-horizon: yellow (10YR 5/4, 6/3) which may become light-grey (10YR 7/2) and mottled with depth; medium to heavy clay; strong coarse blocky or lenticular; extremely firm; moderate to large amounts of lime, strongly alkaline (pH 8.5 - 9.0). Clear to -

C-horizon: yellow-brown (10YR 6/4); sandy loam to light clay; massive; acid (pH 6.0) or alkaline (pH 8.2) sometimes calcareous.

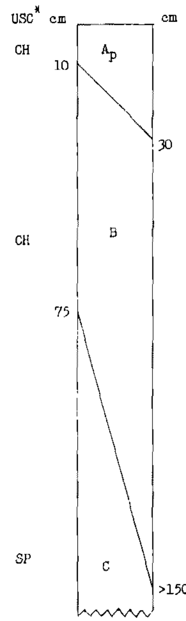
SOIL PROFILE CLASS: **McGRATH**

PRINCIPAL PROFILE FORMS: Ug 5.34, Ug 5.37, Ug 5.15

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: medium to strongly self mulching; seasonally cracking



A_p-horizon: dark (10YR 3/2, 4/2) to brown (10YR 3/3); medium to heavy clay; strong medium granular to strong medium subangular blocky; extremely firm; small amounts of lime; acid to neutral (pH 6.0 - 7.0). Clear or gradual to -

B-horizon: red (5YR-2.5YR 4/6, 4/8) to brown (7.5YR 4/4, 4/6); medium to heavy clay; strong coarse blocky or lenticular; extremely firm; commonly small amounts of lime; neutral to alkaline (pH 7.5 - 9.0). Gradual to -

C-horizon: yellow-brown (7.5YR 6/6); sand; massive; very friable; commonly calcareous

(b) Variations outside the above range include·

B-horizon: dark (10YR 3/2) B_{21}-horizon over brown B_{22}-horizon

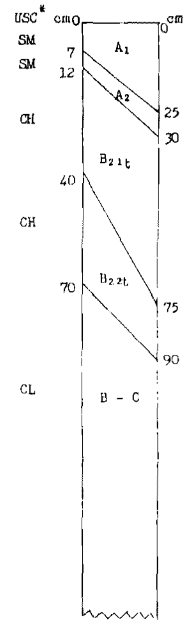
SOIL PROFILE CLASS: **ROSEVALE**

PRINCIPAL PROFILE FORMS: Dr 2.41, Db 1.42

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: hardsetting



A_1-horizon: dark to grey (10YR 3/2-4/2); sandy loam to light sandy clay loam; weak medium crumb; very friable to friable; slightly acid (pH 6.0 - 6.5). Clear to -

A_2-horizon: yellow-brown (10YR 5/3, 6/3); bleached when dry; sandy loam; massive; very friable; slightly acid (pH 6.5); Abrupt to -

B_{21t}-horizon: red (5YR-2.5YR 4/6-4/8); to brown (7.5YR 4/4, 4/6) medium clay; strong medium blocky; very firm; slightly acid to neutral (pH 5.8 - 7.0). Clear to -

B_{22t}-horizon: yellow-brown (7.5YR 5/6-5/8); medium clay; strong medium blocky; very firm; acid to neutral (pH 6.0 - 7.0); low to medium amounts of concretionary manganese. Clear to -

B-C horizon: yellow (10YR 5/4-6/6); clay, massive, firm; slightly acid (pH 6.0)

* Unified Soil Classification (FAO, 1973)

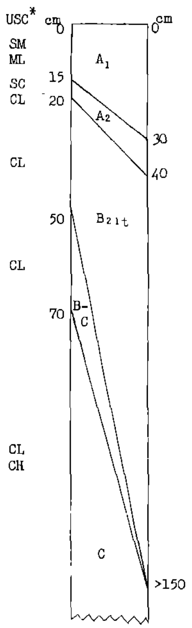
SOIL PROFILE CLASS: **DIECKMANN**

PRINCIPAL PROFILE FORMS: Dy 5.42, Db 4.42, Dy 4.32, Dy 4.22, Db 2.12

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose or moderately hardsetting



<u>A_1-horizon:</u> dark (10YR 3/2) to grey (10YR 4/2); fine sandy loam to loam; weak fine and medium crumb to massive; very friable to friable; slightly acid (pH 6.0 - 6.5). Clear or diffuse to -

<u>A_2-horizon:</u> grey (10YR 4/2), sporadically bleached when dry or yellow-grey (10YR 5/3), commonly bleached when dry; sandy clay loam to clay loam; massive; loose to friable; slightly acid (pH 6.0 - 6.5); small to large amounts of concretionary manganese. Clear to -

<u>B_{21t}-horizon.</u> mottled yellow-grey to brown (10YR 4/2, 4/3, 4/4, 5/3, 5/4); medium clay; strong medium blocky; very firm to extremely firm; slightly acid to neutral (pH 6.0 - 7.5); small to medium amounts of soft or concretionary manganese. Clear or diffuse to -

<u>B-C horizon:</u> yellow brown (7.5YR 5/6) to brown (7.5YR 4/4); sandy clay to medium clay; moderate to weak blocky to massive; firm to very firm, neutral (pH 6.7 - 7.0). Clear to -

<u>C-horizon:</u> yellow brown (7.5YR 5/6), gritty clay.

(b) Variations outside the above range include:

A_1-horizon: sandy loam;

A_2-horizon: sandy loam; no concretionary manganese; lower depth of 50 cm; absent

B-horizon: concretionary lime at >100 cm

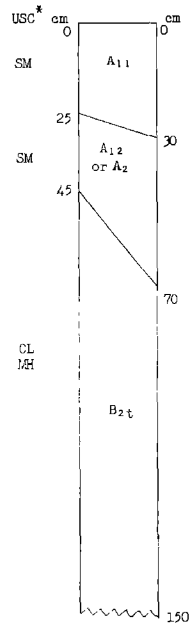
SOIL PROFILE CLASS: **WISS**

PRINCIPAL PROFILE FORMS: Dr 4.52, Dr 2.51, Gn 2.14, Gn 2.11

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose or weakly hardsetting



<u>A_{11}-horizon:</u> red-brown to brown (5YR 3/3-4, 4/4, 7.5YR 4/4); sandy-loam to light sandy clay loam; massive to weak medium crumb; loose to very friable; acid to neutral (pH 6.0 - 7.0). Clear to -

<u>A_{12} or A_2-horizon.</u> red-brown (5YR 3/4-6, 4/6-8); loamy sand to light sandy clay loam; massive; loose to very friable; acid to neutral (pH 6.0 - 7.0); small to medium amounts of concretionary manganese. Clear or gradual to -

<u>B_{2t}-horizon:</u> red-brown (5YR 4/6-4/8); sandy clay to light-medium clay; weak to moderate medium blocky; firm, acid to neutral (pH 6.2 - 7.8); small to medium amounts of ferromanganiferous gravel.

(b) Variations outside the above range include:

A_2-horizon: not evident; sandy clay loam at lower depth

B-horizon: upper depth limit of 30 cm

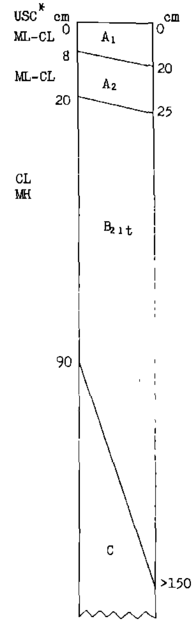
SOIL PROFILE CLASS: **LANCE**

PRINCIPAL PROFILE FORMS: Dy 2.21, Dy 2.42, Db 1.21, Dy 3.41

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: hardsetting



<u>A_1-horizon:</u> dark to brown (7.5YR 3/2-3); clay-loam; weak to moderate medium crumb; friable; medium acid (pH 5.5 - 6.0). Clear to -

<u>A_2-horizon:</u> brown (7.5YR 3/4); clay-loam; weak crumb; friable, medium acid (pH 5.5 - 6.0) Clear to:

<u>B_{21t}-horizon:</u> yellow-brown (7.5YR 4-5/6); faintly mottled; light-medium clay; moderate medium blocky; very firm; medium acid (pH 6.0 - 6.5); becoming heavy clay at depth. Clear to -

<u>C-horizon:</u> weathered mudstone or sandstone

(b) Variations outside the above range include:

Surface condition: cobbly

A_1-horizon: grey (10YR 4/2); light sandy clay loam

A_2-horizon: yellow-grey (10YR 5/3), bleached when dry; medium to large amounts of ferromanganiferous concretions; gravel; lower depth of 12 cm; lower depth of 30 cm

B-horizon: strongly mottled grey (10YR 4/2); red-brown (2.5YR 4/6); sandy clay; low to medium amounts of ferromanganiferous concretions; large amounts of gravel; to 40 cm over C-horizon; neutral in upper B (pH 7.0)

* Unified Soil Classification (FAO, 1973)

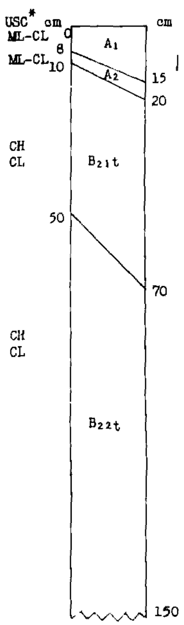
SOIL PROFILE CLASS: **YELLUNGA**

PRINCIPAL PROFILE FORMS: Db 1.43, Db 2.43, Db 1.33, Db 1.12, Db 2.33, Dr 2.33

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: hardsetting



A_1-horizon: dark to grey (10YR 2/1, 3/2, 4/2); clay-loam; weak sub-angular blocky to moderate medium crumb; friable; medium to slightly acid (pH 5.5 - 6.0). Clear to -

A_2-horizon: grey to yellow grey (10YR 5/2, 5/3), bleached when dry, commonly sporadic; clay loam; weak sub-angular blocky to massive; very friable; medium acid (pH 5.5 - 6.0). Clear or abrupt to -

B_{21t}-horizon: brown (7.5YR 4/3, 4/4, 10YR 3/3, 4/3), medium to heavy clay, strong coarse angular blocky or columnar; very firm or extremely firm; slightly acid (pH 6.0 - 6.5); trace amounts of manganese concretions. Diffuse to -

B_{22t}-horizon: mottled brown to yellow-brown (10YR 4/4, 5/4, 6/4), medium to heavy clay, strong coarse blocky, extremely firm; alkaline (pH 8.2 - 9.0); trace to medium amounts of concretionary lime.

(b) Variations outside the above range include:

A_1-horizon: rounded quartz gravel; weathered sandstone gravel;

A_2-horizon: absent; brown (7.5YR 4/3); red-brown (5YR 5/6) but not bleached when dry;

B_{21t}-horizon: dark or yellow; neutral (pH 7.0); mottled; red-brown (5YR 4/4)

B_{22t}-horizon: absent; calcareous sandy C-horizon present; slightly alkaline (pH 7.9); lime absent

C-horizon: weathered mudstone or sandstone; upper depth of 45-90 cm

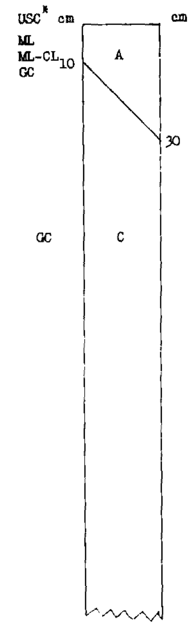
SOIL PROFILE CLASS: **RANGEVIEW**

PRINCIPAL PROFILE FORMS: Um 6.21, Um 6.22, Gn 2.81, Um 4.11

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: very cobbly; loose



A-horizon: dark (10YR-7.5YR 2/2, 2/3, 3/2); loam to clay loam; moderate fine to medium granular or crumb; friable; large amounts of volcanic gravel. Diffuse to -

C-horizon: grey (10YR 4/2) or brown (7.5YR 3/3, 4/4); clay loam to light clay; abundant volcanic cobbles

(b) Variations outside the above range include:

C-horizon: red-brown (5YR 4/4)

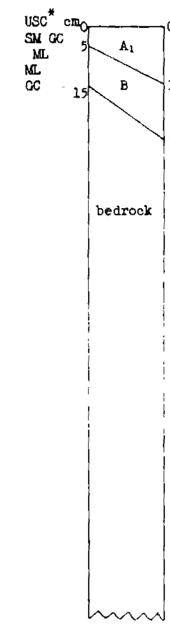
SOIL PROFILE CLASS **FRAZER**

PRINCIPAL PROFILE FORMS: Gn 2.11, Gn 2.12, Um 4.1, Um 4.21, Uc 6.14, Uc 1.44

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile

Surface condition: loose; commonly very cobbly; considerable areas of exposed rock



A_1-horizon: dark (10YR 3/2, 7.5YR 3/2, 2/2, 2/3); to brown (7.5YR-5YR 3/3); sandy-loam to loam; moderate fine crumb to moderate medium granular; friable; acid (pH 5.6 -6.5); small to abundant amounts of volcanic gravel. Diffuse or gradual to -

B-horizon: red-brown (5YR 3/3, 3/4, 3/6, 4/4, 7.5YR 3/3); loam to clay loam; massive; friable; small to abundant volcanic gravel; acid to neutral (5.6 - 7.0). Clear to -

Bedrock: microsyenite

(b) Variations outside the above range include:

A_1-horizon: clay loam; weak very fine crumb; dark-red (2.5YR 2/2)

B-horizon: lower depth 45 cm

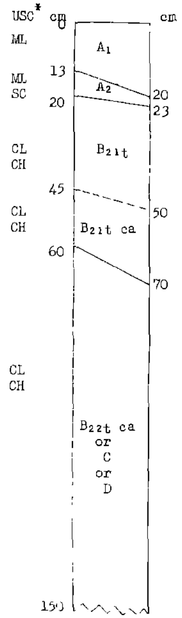
* Unified Soil Classification (FAO, 1973)

SOIL PROFILE CLASS: **ORTELS**

PRINCIPAL PROFILE FORMS: Dy 4.43, Dy 3.13, Db 1.23, Dd 1.13

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition. loose or weakly hardsetting; very cobbly and gravelly

A_1-horizon: dark (10YR 2/2); loam to clay loam; weak medium granular; friable; acid (pH 5.8 - 6.2); volcanic gravel, Clear to -

A_2-horizon: grey (10YR 5/2); conspicuously or sporadically bleached when dry; loam to sandy clay loam, weak fine crumb; friable; acid (pH 6.5); volcanic gravel. Abrupt to -

B_{21t}-horizon: grey (10YR 5/2) or brown (10YR 3/3); medium clay; strong coarse blocky, extremely firm; neutral (pH 7.0). Diffuse to -

B_{21t} ca-horizon: as for B_{21t} or brown (7.5YR 4/4), with trace to small amounts of lime; alkaline (pH 8.2 - 9.0). Diffuse to -

B_{22t} ca-horizon: yellow-brown (10YR 6/3, 6/4), medium to heavy clay; strong medium blocky or massive, extremely firm; trace to small amounts of lime, alkaline (pH 9.0)

C-horizon: weathered black coal or yellow grey mudstone commonly containing lime

D-horizon: red-brown (5YR 5/6); medium clay, strong medium blocky; extremely firm; alkaline (pH 8.8)

(b) Variations outside the above range include:

A_2-horizon: absent

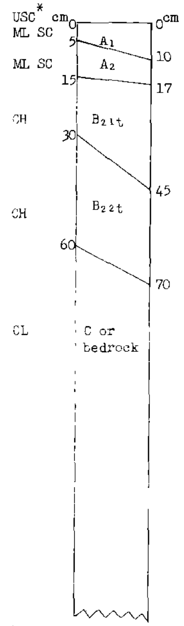
B_{21}-horizon: dark (10YR 3/2)

SOIL PROFILE CLASS: **WATTERS**

PRINCIPAL PROFILE FORMS Dr 2.41, Dr 3.41

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: gravelly, cobbly or stony; hardsetting

A_1-horizon: dark to brown (10YR 3/2, 7.5YR 3/3); loam to sandy clay loam; weak fine crumb to moderate fine granular; friable; acid (pH 6.0 - 6.5); commonly some volcanic gravel present. Clear to -

A_2-horizon: grey (10YR 5/2, 5/3), bleached when dry; loam to sandy clay loam; massive; friable; acid (pH 6.0 - 6.5); commonly abundant volcanic gravel present. Abrupt to -

B_{21t}-horizon: red to red-brown (2.5YR 3/4, 5YR 3/4) commonly mottled; medium to heavy clay; strong coarse blocky; extremely firm; acid (pH 4.5 - 6.5). Diffuse to -

B_{22t}-horizon. brown (7.5YR 4/3, 4/4), medium to heavy clay, strong coarse blocky, extremely firm; acid (pH 4 5 - 6.0). Diffuse to -

C-horizon: yellow-brown (10YR 6/4); sandy clay; massive, friable, weathered sandstone rock; acid (pH 6.0)

OR

Bedrock of volcanic material

(b) Variations outside the above range include:

A_1-horizon: fine sandy loam; lower depth of 20 cm

A_2-horizon. brown (7.5YR 3/3); fine sandy loam; 20-30 cm depth range

B_{21}t-horizon: brown (7.5YR 4/6); abundant weathered rock fragments

B_{22}t-horizon. absent

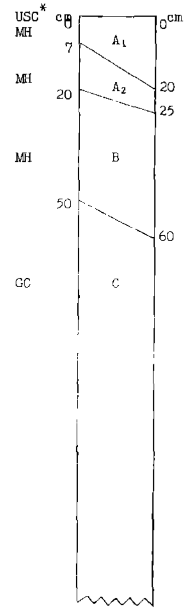
C-horizon: starts at 45 cm

SOIL PROFILE CLASS: **HORAN**

PRINCIPAL PROFILE FORMS: Gn 2.14, Gn 4.11, Dr 2.11, Gn 4.14

SOIL PROFILE MORPHOLOGY

(a) Modal Soil Profile



Surface condition: loose; commonly very cobbly

A_1-horizon: dark red (5YR 2/3); clay loam; moderate fine crumb; friable; acid (pH 6.0 - 6.2). Clear to -

A_2-horizon: (commonly absent but when present) red (2.5YR 3/4); clay loam; massive, friable, acid (pH 5.8). Gradual to -

B-horizon: red (10R 3-4/6); light to light medium clay; massive or strong medium subangular blocky; friable to firm, acid to neutral (pH 5.8 - 7 5) commonly very gravelly. Gradual to -

C-horizon. andesitic rocks

* Unified Soil Classification (FAO, 1973)

APPENDIX 4

Morphological and Analytical Data of Soil Profiles

Notes:

General: Soil profiles representative of the major soil profile classes are presented in the same order as in the map reference.

Profile Morphology: As per notes (ii) and (iii) and (v) to (x) for Appendix 3.

Laboratory Data: Apart from pH, all chemical data is recorded on an oven dry basis.

Soil Profile Class: **BROMELTON**
Great Soil Group: Prairie soil
Parent Material: Alluvium
Topography: Nearly level alluvial flood plain
Vegetation: Cleared

Site No: R2
Location: 60 m [illegible] of Reynold's Creek, 0.7 km south of Muller's Road
Australian Map Grid Reference: Zone SF 56 460230 E 6908240 N
Air Photo Reference Southern Moreton District Flood 1974 Run 29 Ph 4918 91 mmE [illegible] mmN
Principal Profile Form: Uf 6.32

Profile Morphology: Surface. cultivated, cloddy

Horizon	Depth	
A_1	0 - 50 cm	Brownish-black (10YR 3/2); light clay; moderate medium subangular blocky; friable. Gradual to -
B_{21}	50 - 140 cm	Dark-brown (7.5YR 3/3); light clay, moderate medium blocky, friable. Gradual to -
B_{22}	140 -150$^+$ cm	Brown (7.5YR 4/3); light clay (sandy); moderate medium blocky, friable.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14108	0-10	7.0	0.06	0.002	0.43	5	43	23	30	32	19	9.2	0.68	0.3	.152	1.76	.018	3.4	32	14
14110	20-30	7.1	0.06	0.002	0.38	7	44	22	28	30	19	9.2	0.39	0.4	.145	1.76	.016	3.4	34	15
14113	50-60	7.4	0.04	0.003	0.36	8	41	22	31	30	19	8.8	0.42	0.5	140	1.75	.012	3.3	35	15
14116	80-90	7.6	0.04	0.004	0.37	11	44	18	27	28	16	7.2	0.40	0.6	.143	1.82	.012	2.6	32	13
14119	110-120	7.7	0.05	0.003		12	44	15	28	26	16	7.5	0.41	0.65	.134	1.74	.010	2.8		
14122	140-150	7.9	0.04	0.002		18	40	15	25	25	16	6.6	0.39	0.5	.119	1.70	.009	2.7		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14108	0-10	1.4	0.11	>120	100	0.62	24	19	1.?	0.8	
14109	10-20	1.3	0.09	>120	91	0.47					

Soil Profile Class: **MULLER**
Great Soil Group: Black earth - chernozem integrade
Parent Material: Alluvium
Topography: Nearly level alluvial flood plain
Vegetation: Cleared

Site No: R11
Location: 400 m north-west of Fassifern homestead
Australian Map Grid Reference: Zone SF56 459920E 6907280 N
Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4918 77 mmE 102 mmN
Principal Profile Form: Uf 6.32

Profile Morphology: Surface: occasional surface cracks and weakly self-mulching

Horizon	Depth	
A_1	0 - 70 cm	Brownish-black (7.5YR 3/1); light clay, moderate fine subangular blocky; friable to firm. Gradual to -
B_1	70-100 cm	Brownish-black (7.5YR 3/2); light clay; moderate medium blocky; friable to firm. Gradual to -
B_{21fm}	100-130 cm	Greyish-yellow-brown (10YR 4/2); light clay; moderate medium blocky, very firm; small amounts of soft manganese. Gradual to -
B_{22ca}	130-150$^+$ cm	Greyish-yellow-brown (10YR 4/2); medium clay, strong coarse lenticular; extremely firm, trace amounts of concretionary lime.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D. O.C32					
14215	0-10	6.8	0.13	0.004	0.54	5	38	38	26	37	20	13	0.71	0.3	.159	1.74	0.32	4.4	37	19
14217	20-30	7.2	0.05	0.003	0.51	1	38	41	27	40	22	15	0.28	0.68	.136	1.65	.018	5.3	40	19
14220	50-60	7.5	0.07	0.005	0.64	1	33	37	34	41	21	17	0.40	1.5	.126	1.64	.012	5.3	41	20
14223	80-90	8.1	0.08	0.006	0.66	1	41	33	31	40	20	18	0.39	2.5	.149	1.64	.010	5.2	40	20
14226	110-120	8.4	0.15	0.013		3	26	41	37	40	17	19	0.39	4.0	.100	1.74	.007	5.2		
14229	140-150	9.0	0.21	0.013		4	19	33	46	48	18	24	0.37	5.8	.066	1.42	.074	5.7		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14215	0-10	2.29	0.20	125	86	0.63	85	33	1.78	3.0	
14216	10-20	2.00	0.14	124	40	0.31					

Soil Profile Class: **WARRILL**
Great Soil Group: Black earth
Parent Material: Alluvium
Topography: 1% slope of alluvial flood plain
Vegetation: Cleared and cultivated

Site No: R3
Location: 10 m west of Kent's Lagoon Road, 2.6 km north of intersection with Kalbar Connection Road
Australian Map Grid Reference: Zone SF56 462340E 6912080N
Air Photo Reference: South Moreton District Flood 1974 Run 28 Ph 4618 145 mmE 188 mmN
Principal Profile Form: Ug 5.16

Profile Morphology: Surface: moderately cracking when dry; moderately self-mulching

Horizon	Depth	
A_p	0-15 cm	Brownish-black (10YR 3/2); light-medium clay, strong fine angular blocky; very firm. Gradual to -
B_{21}	15-30 cm	Brownish-black (10YR 3/2), 10% distinct fine brown mottle; light-medium clay; strong angular blocky; very firm. Clear to -
B_{22}	30-70 cm	Brownish-black (10YR 3/1); light-medium clay; strong lenticular; very firm. Clear to -
B_{23}	70-140 cm	Brownish-grey (10YR 4/1); medium clay; strong lenticular, extremely firm. Gradual to -
B_{24}	140-150$^+$	Greyish-yellow-brown (10YR 4/2); medium clay; strong lenticular; extremely firm.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14123	0-10	6.9	0.05	0.002	0.50	2	20	34	44	36	20	9.1	0.93	0.26	.192	1.81	.023	4.2	38	19
14125	20-30	6.9	0.07	0.002	0.48	2	20	34	44	37	21	9.3	0.71	0.3	.190	1.81	.021	3.8	40	20
14128	50-60	6.8	0.09	0.003	0.49	1	17	38	45	41	22	10	0.65	0.5	.195	1.72	.021	4.3	42	22
14131	80-90	7.2	0.05	0.002	0.65	6	14	31	48	43	22	13	0.51	0.8	.176	1.71	.010	5.4	46	23
14134	110-120	7.5	0.06	0.002		3	18	31	48	40	23	14	0.46	1.2	.136	1.74	.008	4.3		
14137	140-150	7.8	0.06	0.002		2	21	22	53	43	25	16	0.47	1.5	.132	1.54	.008	4.6		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14123	0-10	1.9	0.16	>120	>100	0.80	40	18	2.2	2.2	
14124	10-20	2.0	0.17	>120	>100	0.73					

Soil Profile Class: **WARRILL**

Great Soil Group: Black earth

Parent Material: Alluvium

Topography: Nearly level alluvial flood plain

Vegetation: Partially cleared bluegum (*Eucalyptus tereticornis*) open forest

Site No: R17

Location: 40 m east of Cunningham Highway, 0.7 km south of intersection with Kalbar Connection Road.

Australian Map Grid Reference: Zone SF56 459710E 6909630N

Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4917 151 mmE 209 mmN

Principal Profile Form: Ug 5.17

Profile Morphology: Surface: moderately cracking; hardsetting.

Horizon	Depth	
A_1	0-17 cm	Brownish-black (7.5YR 3/2); light clay; moderate fine blocky; hard. Clear to -
$2A_1$	17-64 cm	Brownish-black (7.5YR 3/1); medium clay; strong fine blocky; hard. Gradual to -
$2B_{21}$	64-90 cm	Brownish-black (7.5YR 3/1); medium clay; strong coarse blocky; very hard. Diffuse to -
$2B_{22}$	90-150 cm	Brownish-black (7.5YR 3/1); medium clay; strong coarse lenticular; very hard. Clear to -
$2B_{23ca}$	150-160$^+$ cm	Brownish-black (7.5YR 3/1); medium clay; strong coarse lenticular; very hard; small amounts of concretionary lime.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
8140	0-10	6.7	0.09	0.004	0.47	3	15	52	32	37	21	15	2.1	.21	.176	1.57	.038	4.9	44	25
8142	20-30	6.8	0.04	0.002	0.46	1	13	46	40	42	26	18	0.60	0.41	.194	1.51	.029	5.5	45	26
8145	50-60	7.6	0.05	0.002	0.50	1	16	40	43	44	29	21	0.35	1.9	.191	1.42	.019	4.1	47	25
8148	80-90	8.4	0.11	0.009	0.61	1	13	39	46	45	27	21	0.45	3.0	.168	1.54	.012	4.3	46	24
8151	110-120	8.5	0.22	0.020	0.62	1	12	37	47	46	28	24	0.67	3.9	.157	1.49	.010	3.8	50	25
8154	140-150	8.6	0.31	0.028	0.62	1	12	33	52	54	30	27	0.50	4.6	.167	1.25	.010	4.1	55	28

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
8140	0-10	2.7	0.23	125	-	1.9	132	22	3	2.9	
8141	10-20	2.5	0.20	125	-	0.92					

Soil Profile Class: **WARRILL – Saline Phase**

Great Soil Group: Solonchak

Parent Material: Alluvium

Topography: Nearly flat alluvial plain - adjacent to uplands.

Vegetation: Bare

Site No: R15

Location: 100 m south of Kalbar Connection Road, 1.1 km from Kalbar

Australian Map Grid Reference: Zone SF56 462360E 6909870N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4619 46 mmE 70 mmN

Principal Profile Form: Ug 5.5

Profile Morphology: Surface: scalded depression with large cracks when dry.

Horizon	Depth	
A_1	0-3 cm	Brownish-black (10YR 3/1); clay loam; weak fine crumb; slightly hard. Clear to -
$2B_{21}$	3-40 cm	Dark-greyish-yellow (2.5Y 4/2), 30% distinct dark mottle; light-medium clay; strong lenticular; extremely hard. Diffuse to -
$2B_{22}$	40-60 cm	Greyish-yellow-brown (10YR 4/2), 30% distinct dark mottle; medium clay; strong lenticular; extremely hard. Diffuse to -
$2B_{23ca}$	60-90 cm	Greyish-yellow-brown (10YR 4/2), 10% faint grey mottle; medium clay; strong lenticular; very hard; small amounts of concretionary lime. Diffuse to -
$2B_{24ca}$	90-150$^+$ cm	Greyish-olive (5Y 4/2), 10% faint brown mottle; medium clay; strong lenticular; very firm; small amounts of concretionary lime.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14264	0-3	7.8	10	1.68	0.68	4	34	32	36	32	12	17	0.48	8.7	.115	1.14	.153	4.5	36	19
14265	3-10	8.1	7.0	1.34	0.66	2	22	31	51	43	13	21	0.51	13	.103	1.02	.584	5.1	41	22
14267	20-30	8.2	3.0	0.892	0.72	1	26	31	50	41	12	19	0.45	14	.101	1.08	.418	5.4	40	21
14270	50-60	8.6	2.0	0.337	0.86	<1	27	30	51	41	10	17	0.42	14	.081	1.10	.253	4.9	39	20
14273	80-90	9.2	1.2	0.165	0.89	1	31	27	48	40	9.3	17	0.35	14	.080	1.09	.291	5.0	41	20
14276	110-120	9.2	0.11	0.139		2	30	28	48	37	9.0	19	0.35	13	.068	1.06	.029	6.7		
14279	140-150	9.1	1.0	0.125		3	30	28	49	37	8.8	19	0.34	13	.071	1.02	.031	6.8		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14264	0-3	1.5	0.14	125	104	1.09	16.7	12.5	2.1	4.1	
14265	3-10	1.2	0.14	126	105	0.38					
14266	10-20	1.4	0.14								

Soil Profile Class: **UGARAPUL**

Great Soil Group: Black earth

Parent Material: Alluvium

Topography: Nearly level alluvial flood plain

Vegetation: Cleared

Site No: R9

Location: 10 m west of Kent's Lagoon Road, 3.1 km north of intersection with Kalbar connection Road.

Australian Map Grid Reference: Zone SF56 462550E 6912660N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4618 151 mmE 207 mmN

Principal Profile Form: Ug 5.17

Profile Morphology: Surface: moderately cracking when dry, moderately self-mulching.

Horizon	Depth	
A_p	0-20 cm	Brownish-black (7.5YR 3/1); medium clay; strong fine granular; very hard. Diffuse to -
B	20-45 cm	Brownish-black (7.5YR 3/2); medium clay; strong blocky; very hard. Clear to -
D_1	45-100 cm	Brown (7.5YR 4/3); clay loam to light clay; moderate fine subangular blocky; hard. Diffuse to -
D_2	100-140 cm	Brown (7.5YR 4/3); sandy clay loam; massive; slightly hard; trace amounts of soft lime. Diffuse to -
D_3	140-150 cm	Brown (7.5YR 4/3), 10% fine faint yellow mottle; sandy clay loam; massive; slightly hard.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14185	0-10	6.7	0.06	0.001	0.66	2	20	31	46	27	21	10	0.82	0.4	.189	1.74	.023	4.1	37	20
14187	20-30	6.7	0.06	0.002	0.66	2	18	28	50	38	21	12	0.61	0.5	.180	1.64	.022	4.7	44	24
14190	50-60	7.7	0.07	0.003	0.59	1	32	23	43	42	26	15	0.34	0.89	.119	1.39	.013	4.7	45	24
14193	80-90	8.1	0.08	0.002	0.57	<1	42	27	33	42	25	14	0.33	0.95	.144	1.50	.008	5.5	40	21
14196	110-120	8.2	0.05	0.001		4	48	22	28	39	24	14	0.40	0.95	.146	1.51	.007	5.7		
14199	140-150	8.2	0.05	0.001		8	47	27	20	37	22	11	0.49	0.99	.166	1.59	.006	4.5		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14185	0-10	1.9	0.15	125	104	0.68	45	17	.01	1.9	
14186	10-20	1.9	0.15	125	104	0.65					

Soil Profile Class: **FASSIFERN**

Great Soil Group: Wiesenboden

Parent Material: Alluvium

Topography: Back-swamp depression of alluvial flood plain; nuram alpha gilgai with 50 cm vertical interval and 4 m wavelength.

Vegetation: Open-forest of bluegum (*E. tereticornis*)

Site No: R12

Location: 0.9 km north-west of Fassifern homestead

Australian Map Grid Reference: Zone SF56 459480E 6907410N

Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4918 57 mmE 110 mmN

Principal Profile Form: Ug 5.24

Profile Morphology: Shelf Surface: strongly cracking in dry periods.

Horizon	Depth	
A_0	0-2 cm	Dark fibrous litter.
A_1	2-20 cm	Brownish-grey (10YR 4/1), 20% fine distinct yellow mottle; light clay; moderate fine granular; firm. Clear to -
B_{21}	20-60 cm	Brownish-grey (10YR 4/1), 5% medium faint yellow mottle; medium clay; strong lenticular; very firm. Diffuse to -
B_{22}	60-140 cm	Brownish-grey (10YR 4/1); heavy clay; strong lenticular; extremely firm. Clear to -
B_{23ca}	140-150$^+$ cm	Brownish-grey (10YR 4/1); heavy clay; strong lenticular; extremely firm; trace amounts of concretionary lime.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14230	0-10	5.7	0.20	0.003	0.62	11	7	42	38	48	13	13	1.2	0.5	.151	1.53	.507	5.0	53	30
14232	20-30	7.1	0.06	0.002	0.74	2	14	47	39	37	16	16	0.89	1.1	.166	1.70	.104	5.7	45	23
14235	50-60	7.8	0.16	0.011	0.83	1	10	34	60	51	22	22	0.5	3.6	.088	1.14	.081	6.6	62	31
14238	80-90	8.3	0.33	0.035	0.88	1	4	25	69	59	27	27	0.49	6.4	.036	0.83	.052	7.2	67	34
14241	110-120	8.5	0.68	0.084		1	4	26	71	60	26	28	0.49	7.4	.036	0.82	.043	7.3		
14244	140-150	8.5	0.98	0.102		1	3	23	74	64	26	30	0.57	8.0	.038	0.81	.002	8.1		

Lab. No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14230	0-10	4.52	0.37	77.8	105	.79	378	24.1	3.5	8.0	
14231	10-20	2.09	0.14	102.7	105	.78					

Soil Profile Class: **STIBBES**

Great Soil Group: Red earth

Parent Material: Microsyenite

Topography: 10% convex upper mid slope of undulating plains

Vegetation: Cleared

Site No: R5

Location: 5 m north of Stibbes Road, 1 km east of George Street

Australian Map Grid Reference: Zone SF56 463600E 6808020N

Air Photo Reference: Southern Moreton District Flood Run 29 Ph 4920 59 mmE 133 mmN

Principal Profile Form: Um 5.51

Profile Morphology: Surface: hardsetting

Horizon	Depth	
A_p	0-20 cm	Reddish-brown (5YR 4/6); sandy clay loam; weak medium subangular blocky; slightly hard. Gradual to -
AC	20-30 cm	Brown (7.5YR 4/6); sandy clay loam; massive; soft. Gradual to -
C_1	30-60 cm	Brown (7.5YR 4/6); sandy loam; massive; soft. Diffuse to -
C_2	60-150$^+$ cm	Brown (7.5YR 4/6); gritty sand; massive; loose.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14140	0-10	7.0	0.03	0.001	0.49	22	46	12	22	27	19	4.1	0.47	0.1	.325	1.87	.012	3.5	27	12
14142	20-30	7.1	0.02	0.001	0.56	18	51	13	20	32	22	4.8	0.18	0.1	.347	1.68	.009	3.3	25	12
14145	50-60	7.6	0.02	0.001	0.69	31	50	12	7	29	23	6.5	0.05	0.1	.440	1.59	.004	3.0	20	9
14148	80-90	7.8	0.02	0.001	0.53	46	41	7	4	27	19	7.1	0.05	0.1	.507	1.42	.002	2.8	18	9
14151	110-120	7.8	0.02	0.001		61	30	3	3	26	17	7.3	0.07	0.1	.522	1.53	.002	2.8		
14154	140-150	7.9	0.02	0.001		61	31	3	3	26	17	7.5	0.24	0.1	.512	1.65	.002	2.7		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14140	0-10	0.72	0.11	124	103	0.39	13	11	0.6	2.3	
14141	10-20	0.57	0.08	124	103	0.27					

Soil Profile Class: **CHURCHBANK**

Great Soil Group: Prairie soil

Parent Material: Microsyenite

Topography: 13% planar upper midslope of undulating plains

Vegetation: Cleared

Site No: R8

Location: 100 m east of eastern end of Davies Street

Australian Map Grid Reference: Zone SF56 463290E 6908660N

Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4920 46 mmE 160 mmN

Principal Profile Form: Uf 6.31

Profile Morphology: Surface condition: loose.

Horizon	Depth	
A_p (mixed A and B)	0-22 cm	Dark-reddish-brown (5YR 3/3); light clay; moderate medium crumb; friable. Clear to -
BC	22-30 cm	Reddish-brown (5YR 4/6); sandy clay loam; massive; very friable. Diffuse to -
C_1	30-60 cm	Reddish-brown (5YR 4/6); light sandy clay loam; massive; very friable. Diffuse to -
C_2	60-90$^+$ cm	Brown (7.5YR 4/6); coarse sand; massive; loose.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14176	0-10	6.5	0.06	0.002	0.36	15	42	7	31	39	16	7.1	0.94	0.6	.417	1.45	.032	4.0	29	16
14178	20-30	7.4	0.05	0.002	0.34	52	30	8	10	32	23	5.1	0.12	1.3	.414	1.34	.015	5.0	21	12
14181	50-60	7.1	0.14	0.014	0.58	40	41	9	10	32	26	6.2	0.09	0.78	.401	1.31	.009	4.0	20	11
14184	80-90	7.3	0.05	0.005	0.42	53	38	5	2	31	21	6.6	0.04	0.2	.467	1.34	.003	3.6	12	7

Lab. No.	Depth cm	Org. C O.D. %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14176	0-10	1.6	2.0	124	104	0.82	56	22	1.0	1.9	
14177	10-20	1.4	1.9	124	103	0.31					

Soil Profile Class: **CHURCHBANK**
Great Soil Group: Prairie soil
Parent Material: Microsyenite
Topography: 12% convex mid-lower slope of undulating plains
Vegetation: Cleared

Site No: R13
Location: 100 m north of Kalbar connection road, 300 m east of Cunningham Highway
Australian Map Grid Reference: Zone SF56 460360E 6910220N
Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4617 140 mmE 91 mmN
Principal Profile Form: Uf 6.31

Profile Morphology: Surface: hardsetting.

Horizon	Depth	
A_1	0-20 cm	Brownish-black (7.5YR 3/1); light clay; moderate fine crumb; slightly hard (dry). Gradual to -
B_{2t}	20-30 cm	Brown (7.5YR 4/3); medium clay; strong fine blocky; very hard (dry). Gradual to -
B_3	30-40 cm	Brown (7.5YR 4/3); 10% dark mottle; light-medium clay; strong fine blocky; very hard (dry). Gradual to -
C_1	40-70 cm	Brown (7.5YR 4/4); sandy loam; massive. Gradual to -
C_2	70-90$^+$ cm	Dull brown (7.5YR 4/4); loamy sand; massive (weathered microsyenite).

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14245	0-10	6.4	0.07	0.004	0.41	16	32	24	31	31	15	4.7	0.38	0.2	.152	0.92	.408	3.5	31	16
14247	20-30	6.9	0.05	0.002	0.41	9	20	19	56	40	26	5.8	0.15	0.48	.090	0.40	.230	6.3	43	24
14250	50-60	7.8	0.03	0.004	0.36	43	41	16	3	31	24	4.8	0.03	0.47	.249	0.87	.034	3.9	16	8
14253	80-90	8.1	0.06	0.006	0.41	64	30	12	2	29	24	4.6	0.03	0.47	.199	0.75	.007	3.9	12	6

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14245	0-10	2.9	0.19	124	90	0.39	142	45	1.6	2.2	
14246	10-20	1.9	0.15	125	57	0.15					

Soil Profile Class: **CHURCHBANK**
Great Soil Group: Prairie soil
Parent Material: Microsyenite
Topography: 8% convex upper slope of undulating plains
Vegetation: Cleared

Site No: R16
Location: 20 m north of Old Kalbar Road, 0.85 km east of Stibbes Road intersection
Australian Map Grid Reference: Zone SF56 465190E 6907890N
Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4920 27 mmE 123 mmN
Principal Profile Form: Uf 6.32

Profile Morphology: Surface: slightly hard.

Horizon	Depth	
A	0-20 cm	Brownish-black (7.5YR 3/2); light clay; strong fine crumb; hard (dry). Gradual to -
B	20-30 cm	Brownish-black (7.5YR 3/2); light-medium clay; strong medium blocky; very hard (dry). Clear to -
BC	30-40 cm	Dull-brown (7.5YR 5/4); sandy clay loam; massive; slightly hard. Diffuse to -
C	40-60$^+$ cm	Yellowish-brown (10YR 5/6); sandy loam; massive; soft (dry) (weathered microsyenite).

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14280	0-10	6.4	0.12	0.004	0.21	16	22	24	40	52	27	11	2.6	0.32	.142	0.77	.082	4.6	41	26
14282	20-30	6.9	0.07	0.003	0.27	10	28	20	44	53	35	10	0.66	0.21	.060	0.48	.034	4.8	36	22
14285	50-60	7.6	0.03	0.001	0.50	31	42	22	7	48	37	10	0.42	0.26	.092	0.38	.006	4.6	23	12

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14280	0-10	4.2	0.36	125	79	2.0	164	48	3.1	6.0	
14281	10-20	2.7	0.29	14	32	1.2					

Soil Profile Class: **PENNELL**
Great Soil Group: Brown clay
Parent Material: Microsyenite and Walloon Coal Measures sediments
Topography: 8% upper slope of undulating plains
Vegetation: Cleared

Site No: R7
Location: 50 m east of Old Kalbar Road, 0.5 km from Edward Street intersection
Australian Map Grid Reference: Zone SF56 464500E 6908580N
Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4920 97 mmE 157 mmN
Principal Profile Form: Ug 5.32

Profile Morphology: Surface: moderately cracking when dry; weakly self-mulching

Horizon	Depth	
A_p	0-20 cm	Dark-brown (7.5YR 3/3); light-medium clay; strong fine subangular blocky; very hard. Clear to -
BC	20-30 cm	Yellowish-brown (10YR 5/6); sandy clay loam; massive; soft. Clear to -
C	30-60$^+$ cm	Yellowish-brown (10YR 5/6); sand; massive; loose.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14170	0-10	6.9	0.04	0.001	0.47	15	35	11	36	22	25	13	0.20	0.63	.073	0.50	.020	5.6	33	19
14172	20-30	7.5	0.03	0.001	0.44	27	46	16	10	43	30	13	0.02	0.58	.111	0.55	.006	4.8	22	12
14175	50-60	7.6	0.02	0.001	0.38	58	33	8	1	41	28	15	0.01	0.26	.116	0.45	.002	4.1	16	9

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14170	0-10	1.2	0.12	126	29	0.10	19	15	1.6	.63	
14171	10-20	0.98	0.12	126	19	0.04					

Soil Profile Class: **PENNELL**

Great Soil Group: Brown clay

Parent Material: Mixed origin - volcanic rocks and Walloon Coal Measures

Topography: 2% upper convex slope of undulating plain

Vegetation: Cleared

Site No: R14

Location: 400 m east of George Street, 600 m north of Watters Road intersection

Australian Map Grid Reference: Zone SF56 463040E 6907760N

Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4920 35 mmE 121 mmN

Principal Profile Form: Ug 5.37

Profile Morphology: Surface: recently cultivated and strongly self-mulching; small to moderate amounts of gravel.

Horizon	Depth	
A_p	0-30 cm	Dull-reddish-brown (5YR 4/4); medium clay; strong medium granular; very hard; small amounts of quartz gravel. Clear to -
B_2	30-50 cm	Bright-reddish-brown (5YR 5/6); medium clay; strong blocky; very hard. Gradual to -
B_3	50-70 cm	Bright-reddish-brown (5YR 5/6); light clay; massive; slightly hard. Gradual to -
C	70-100 cm	Dull-brown (7.5YR 5/4); light sandy clay loam; massive; soft.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14254	0-10	6.4	0.16	0.008	0.45	16	14	22	50	40	28	6.6	0.48	0.74	.090	0.40	.268	4.0	36	20
14256	20-30	6.4	0.15	0.006	0.49	14	14	22	53	41	27	6.1	0.41	0.58	.086	0.38	.291	6.0	39	21
14259	50-60	7.4	0.10	0.004	0.51	27	26	22	27	41	38	5.6	0.20	0.37	.033	0.26	.058	6.4	29	16
14262	80-90	7.5	0.09	0.003	0.41	33	26	24	19	38	36	6.1	0.19	0.21	.075	0.25	.055	6.3	20	14

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14254	0-10	1.4	0.19	78	41	0.42	57	93	3.9	2.1	
14255	10-20	1.3	0.16	38	43	0.39					

Soil Profile Class: **KULGUN**

Great Soil Group: Grey clay

Parent Material: Sediment of Jurassic Walloon Coal Measures

Topography: 3% convex mid to upper slope of undulating plains

Vegetation: Cleared and cultivated

Site No: R10

Location: 10 m west of George Street, 40 m south of intersection with Warumkarie Road

Australian Map Grid Reference: Zone SF56 462510E 6907000N

Air Photo Reference: Southern Moreton District Flood 1974 Run 29 Ph 4918 188 mmE 90 mmN

Principal Profile Form: Ug 5.24

Profile Morphology: Surface: strongly cracking when dry; moderate self-mulching

Horizon	Depth	
A_p	0-20 cm	Greyish-brown (7.5YR 4/2); medium clay; strong medium granular; extremely firm. Clear to -
B_{21}	20-50 cm	Greyish-yellow-brown (10YR 5/3); medium heavy clay; strong lenticular; extremely firm. Gradual to -
B_{22ca}	50-100 cm	Dull-yellowish-brown (10YR 5/4); medium heavy clay; strong lenticular; very firm; small amounts of concretionary lime.
B_{23}	$100-150^+$ cm	Dull-yellow-orange (10YR 6/4); medium heavy clay; strong lenticular; very firm.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14200	0-10	7.1	0.11	0.002	0.54	8	14	30	50	34	22	14	1.1	0.6	.076	1.22	.031	4.1	40	23
14202	20-30	8.1	0.20	0.006	0.64	8	13	26	55	42	23	17	0.50	1.9	.045	1.10	.025	6.0	43	24
14205	50-60	8.9	0.40	0.023	0.60	7	11	26	59	40	16	21	0.42	6.2	.035	1.24	.024	5.4	45	25
14208	80-90	9.1	0.62	0.057	0.86	7	11	29	57	38	12	19	0.40	7.4	.038	1.44	.022	4.7	45	22
14211	110-120	8.5	0.65	0.075		4	12	31	57	38	10	22	0.41	8.7	.043	1.73	.018	5.0		
14214	140-150	8.1	0.90	0.123		2	13	34	55	38	9.2	21	0.40	8.9	.055	1.83	.016	5.2		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14200	0-10	1.9	0.21	77	47	0.83	54	29	4.4	2.2	
14201	10-20	2.0	0.20	57	38	0.72					

Soil Profile Class: **KULGUN**

Great Soil Group: Chernozem - grey clay integrade

Parent Material: Mudstone of Walloon Coal Measures

Topography: 7% midslope of undulating plains

Vegetation: Open-forest of brigalow (*Acacia harpophylla*)

Site No: R19

Location: 20 m south of Kulgun-Roadvale Road, 0.7 km west of intersection with Obum-Obum Road

Australian Map Grid Reference: Zone SF56 464980E 6910660N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4619 149 mmE 102 mmN

Principal Profile Form: Gn 3.93

Profile Morphology: Surface: hardsetting, occasional cracks in dry periods

Horizon	Depth	
A_1	0-20 cm	Brownish-black (10YR 3/2); clay loam; strong medium subangular blocky; hard. Gradual to -
B_{21}	20-60 cm	Dark-greyish-yellow (2.5Y 5/2); medium clay; strong coarse lenticular; extremely hard; small amounts of volcanic gravel. Clear to -
B_{22ca}	60-83 cm	Yellowish-grey (2.5Y 5/3); medium clay; strong coarse lenticular; extremely hard; small amounts of concretionary lime. Gradual to -
B_{23}	83-118 cm	Dull-yellow (2.5Y 6/4); light-medium clay; strong fine blocky; very hard; trace amounts of concretionary lime. Abrupt to -
C_1	118-124 cm	Dull-yellow-orange (10YR 7/2), 10% prominent dark mottle; light-medium clay; strong fine blocky; hard. Abrupt to -
C_2	$124-150^+$ cm	Dull-yellow (2.5Y 6/4); light clay (weathered mudstone).

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
15021	0-10	6.3	0.23	0.008	0.19	9	22	21	45	45	22	6.2	2.4	0.31	.157	1.28	.105	4.7	37	15
15023	20-30	7.3	0.07	0.002	0.41	11	23	17	49	30	17	9.0	1.2	1.1	.051	1.18	.027	3.8	30	16
15026	50-60	8.4	0.48	0.037	0.77	6	14	7	69	44	19	20	.35	7.0	.022	1.14	.027	5.3	40	21
15029	80-90	9.3	0.97	0.072	0.77	8	7	16	66	35	14	17	.38	7.7	.044	1.74	.025	4.0	37	19
15032	110-120	9.4	0.99	0.085		1	9	17	69	43	15	21	.41		.024	1.37	.019	5.1		
15035	140-150	8.6	0.83	0.082	0.61	1	22	37	41	36	10	16	.31	8.4	.034	1.87	.012	4.0	31	17

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Extr. P ppm	Bicarb	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
15021	0-10	5.5	0.34	261	104	1.6					
15022	10-20	3.3	0.30	177	104	1.1					

Soil Profile Class: **WISS**

Great Soil Group: Red podzolic soil

Parent Material: Microsyenite

Topography: 7% mid-lower slope of low hills

Vegetation: Cleared

Site No: R6

Location: On southern slope of Obum-Obum hill, 1km north-west of Obum Obum Rd., Kulgun-Roadvale Rd., intersection

Australian Map Grid Reference: Zone SF56 464920E 6911380N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4916 156 mmE 136 mmN

Principal Profile Form: Dr 4.12

Profile Morphology: Surface: loose

Horizon	Depth	
A_{11}	0-20 cm	Dark-reddish-brown (5YR 3/4); fine sandy loam; weak fine crumb; soft. Clear to -
A_{12}	20-50 cm	Dark-reddish-brown (5YR 3/6); fine sandy loam; massive; soft. Clear to -
B_{2t}	50-120 cm	Dark-reddish-brown (5YR 3/6); sandy clay; moderate blocky; slightly hard; small amounts of irregular volcanic gravel.
BC	120-150$^+$ cm	Dark-reddish-brown (5YR 3/6); sandy clay loam; massive; soft; small amounts of irregular volcanic gravel.

'Laboratory Data:

'Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14155	0-10	6.5	0.07	0.002	0.45	27	56	12	6	8	3.5	0.8	1.1	0.05	.118	3.69	.014	0.79	15	5
14157	20-30	7.2	0.03	0.001	0.71	28	55	6	10	7	3.8	0.8	0.7	0.1	.122	3.62	.006	1.0	15	5
14160	50-60	7.1	0.03	0.002	0.59	22	48	8	22	19	13	3.3	0.35	0.15	.232	3.11	.006	2.2	26	13
14163	80-90	7.3	0.06	0.004	0.55	20	48	8	24	24	16	4.4	0.43	0.21	.262	2.85	.004	2.6	29	14
14166	110-120	7.4	0.05	0.002		12	54	8	23	25	16	5.1	0.44	0.26	.230	3.00	.003	3.1		
14169	140-150	7.6	0.03	0.001		31	47	3	16		16	4.8	0.38	0.26	.180	2.99	.002	3.0		

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14155	0-10	1.2	0.07	122	102	0.89	48	29	0.5	2.3	
14156	10-20	0.5	0.04	122	89	0.81					

Soil Profile Class: **YELLUNGA**

Great Soil Group: Solodic

Parent Material: Mudstone of Walloon Coal Measures

Topography: 5% mid-lower slope of low hill

Vegetation: Cleared - native pasture

Site No: R18

Location: 200 m west of Cunningham Highway, 0.9 km north of Kelly's Road intersection (southern end)

Australian Map Grid Reference: Zone SF56 460730E 6912960N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4617 160 mmE 213 mmN

Principal Profile Form: Dr 3.43

Profile Morphology: Surface: hardsetting

Horizon	Depth	
A_1	0-8 cm	Brownish-black (10YR 3/2); clay loam; moderate fine subangular blocky; slightly hard (dry). Gradual to -
A_2	8-16 cm	Greyish-yellow-brown (10YR 5/2), bleached when dry; clay loam; moderate coarse subangular blocky; hard; small amounts of ironstone. Abrupt to -
B_{21t}	16-38 cm	Reddish-brown (5YR 4/8), 25% fine faint brown mottle; medium clay; strong coarse blocky; very hard; small amounts of ironstone. Gradual to -
B_{22t}	38-60 cm	Brown (7.5YR 4/3); medium clay; strong very coarse blocky; extremely hard; small amounts of volcanic gravel; trace amounts of manganese nodules. Gradual to -
B_{23t}	60-102 cm	Dull-reddish-brown (5YR 4/4); medium clay; strong coarse blocky; extremely hard; small amounts of ironstone gravel. Gradual to -
B_{24tca}	102-132 cm	Brown (7.5YR 3/2); medium clay; strong medium blocky; extremely hard; small amounts of ironstone gravel; trace amounts of concretionary lime. Gradual to -
C	132-150 cm	Dull-yellow-orange (10YR 6/4); medium clay; strong medium blocky; very hard; weathered mudstone.

'Laboratory Data:

'Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
15005	0-10	6.0	0.07	0.004	0.44	9	33	28	31	18	3.5	4.6	0.57	0.26	.044	0.48	.027	3.2	30	11
15007	16-20	6.5	0.10	0.010	0.75	11	26	19	45	22	4.5	11	0.17	1.5	.029	0.55	.007	2.8	26	15
15010	40-50	7.6	0.51	0.062	0.78	2	15	12	69	33	6.8	20	0.15	5.4	.016	0.69	.010	4.4	42	22
15013	70-80	8.5	0.82	0.114	0.91	3	14	9	71	36	7.3	24	0.18	7.9	.016	0.69	.008	4.6	39	23
15016	100-110	9.2	0.94	0.108		3	15	12	67	36	7.8	23	0.23	7.8	.015	0.71	.004	3.9		
15019	130-140	8.8	0.60	0.079		1	23	14	59	37	7.7	24	0.22	7.8	.025	1.03	.002	4.1	40	20
15020	140-150	8.9	0.53	0.070	0.85	1	26	17	53	39	7.5	24	0.22	7.8	.033	1.14	.002	4.1	36	19

Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
15005	0-10	2.5	0.14	9	14	0.46					
15006	10-16	1.1	0.06	2	3	0.14					

Soil Profile Class: **RANGEVIEW**

Great Soil Group: Lithosol

Parent Material: Andesite

Topography: 5% upper mid slope of undulating plain

Vegetation: Cleared. Formerly softwood scrub of brigalow (*Acacia harpophylla*)

Site No: R4

Location: 15 m north of Edward Street, 0.6 km east of Kalbar

Australian Map Grid Reference: Zone 56F 464350E 6909170N

Air Photo Reference: South Moreton District Flood 1974 Run 29 Ph 4920 92 mmE 183 mmN

Principal Profile Form: Um 4.11

Profile Morphology: Surface: loose.

Horizon	Depth	
A_1	0-10 cm	Brownish-black (10YR 3/2); clay loam; moderate fine subangular blocky; very friable. Diffuse to -
A_2	10-20 cm	Greyish-yellow-brown (10YR 4/2); clay loam; weak fine crumb; very friable; moderate amounts of subangular andesite gravel
C	20$^+$ cm	Abundant andesite gravel.

'Laboratory Data:

'Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S. Particle Size % O.D.	F.S.	Si	C	C.E.C. Exch. Cations m.equiv/100g	Ca^{++}	Mg^{++}	K^+	Na^+	P % O.D.	K	S	Moisture % A.D.	1/3 bar	15 bar
14138	0-10	6.6	0.15	0.004	0.14	20	25	21	33	30	14	6.1	2.5	0.41	.193	1.19	.065	4.2	38	20

'Lab. No.	Depth cm	Org. C O.D. %	Tot. N	Acid Bicarb Extr. P ppm		Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
14138	0-10	3.7	0.75	>120	>100	2.0	173	33	1.4	11	
14139	10-20	3.3	0.49	>120	>100	1.2					

Soil Profile Class: **FRAZER**

Great Soil Group: Lithosol

Parent Material: Microsyenite

Topography: 12% planar mid-lower slope of low hills

Vegetation: Grassland. Formerly open forest of silver-leaved ironbark (*Eucalyptus melanophloia*).

Site No: R1

Location: On south-west slope of Obum-Obum hill, 1.5 km east of Kent's Lagoon (south end)

Australian Map Grid Reference: Zone SF56 464160E 6912010N

Air Photo Reference: Southern Moreton District Flood 1974 Run 28 Ph 4619 119 mmE 161 mmN

Principal Profile Form: Uc 6.12

Profile Morphology:

Horizon	Depth	
A_1	0-20 cm	Dark-reddish-brown (2.5YR 3/2); sandy loam; weak fine crumb; soft; moderate amounts of angular microsyenite gravel. Diffuse to -
C	20^+ cm	Microsyenite gravel.

Laboratory Data:

Lab. No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	K^+	Na^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m.equiv/100g					% O.D.					
14106	0-10	6.4	0.06	0.002	0.11	24	54	8	12	18	6.6	3.3	1.7	0.05	.215	3.43	.035	2.0	19	8

Lab. No.	Depth cm	Org. C O.D. %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
14106	0-10	1.6	0.13	>120	>100	1.4	85	24	0.6	4.1	
14107	10-20	0.96	0.07	>120	>100	1.4					

APPENDIX 5

Classification of Soil Profile Classes Sampled for Analysis

Soil Profile Class	Site No.	Principal Profile Form (Northcote 1971)	Great Soil Group (Stace *et al.* 1968)	Soil Taxonomy Subgroup (Soil Survey Staff 1975)
Bromelton	R2	Uf 6.31	Prairie soil	Pachic Haplustoll
Muller	R11	Uf 6.32	Black earth - Chernozem intergrade	Pachic Haplustoll
Warrill	R3	Ug 5.16	Black earth	Udic Chromustert
Warrill	R17	Ug 5.17	Black earth	Udic Chromustert
Warrill - saline phase	R15	Ug 5.5	Solonchak	Udorthentic Chromustert
Ugarapul	R9	Ug 5.17	Black earth	Udic Chromustert
Fassifern	R12	Ug 5.24	Wiesenboden	Entic Pelludert
Stibbes	R5	Um 5.51	Red earth	Ustic Ustochrept
Churchbank	R8	Uf 6.31	Prairie soil	Udic Haplustoll
Churchbank	R13	Uf 6.31	Prairie soil	Argiustoll
Churchbank	R16	Uf 6.32	Prairie soil	Paralithic Vertic Haplustoll
Pennell	R7	Ug 5.32	Brown clay	Udertic Haplustoll
Pennell	R14	Ug 5.37	Brown clay	Udorthentic Chromustert
Kulgun	R10	Ug 5.24	Grey clay	Udorthentic Chromustert
Kulgun	R19	Gn 3.93	Chernozem - Grey clay intergrade	Udorthentic Chromustert
Wiss	R6	Dr 4.12	Red podzolic soil	Udic Haplustalf
Yellunga	R18	Dr 3.43	Solodic	Typic Natrustalf
Rangeview	R4	Um 4.11	Lithosol	Lithic Ustorthent
Frazer	R1	Uc 6.12	Lithosol	Lithic Haplustoll

APPENDIX 6

Provisional Land Capability Classification for Kalbar Area

Limiting Factor	Degree of Limitation	Capability Class (If sole limiting factor)	Sub-Class Symbol
Effective soil depth.	>100 cm	1	d1
	60 - 100 cm	2	d2
	45 - 60 cm	3	d3
	25 - 45 cm	4	d4
	<25 cm	5	d5
Soil physical factors affecting plant growth and management	1. B horizon or sub-soil depth. Depth to B horizon with dry extremely hard consistence		
	20 - 45 cm	2	pb3
	<20 cm	3	pb4
	2. Surface crust. Surface soils likely to set hard if overworked.	2	pc2
	Surface soils set hard	3	pc3
	3. Distribution of soil profile classes. Soil distribution is such that 2 or more different soil profile classes occur within a 150 m traverse. Soil profile classes are different such that markedly different inputs are required:		
	For specific crops	3	pd3
	For any crop	4	pd4
	4. Soil workability. Surface soils with narrow moisture range for working.		
	Slight restriction	2	k2
	Moderate restriction	3	k3
	Severe restriction	4	k4
Soil salinity or sodicity	Electrical conductivity of 1:5 extract at 25°C is greater than 1 mS cm^{-1} at:		
	30 - 90 cm	3	sa3
	<30 cm	4	sa4
	>2 mS cm^{-1} at <30 cm	5	sa5
	Exchangeable sodium percentage greater than 15		
	40 - 90 cm	2	so2
	20 - 40 cm	3	so3
	<20	4	so4

Limiting Factor	Degree of Limitation	Capability Class (If sole limiting factor)	Sub-Class Symbol
Topography	Slopes 0.1 - 2%	1	t1
	2 - 5	2	t2
	5 - 8	3	t3
	8 - 12	4	t4
	>12	5	t5
Rockiness and stoniness	Tillage restricted - some picking necessary.	3	r3
	Tillage difficult - stone picking necessary.	4	r4
	Tillage impossible.	5	r5
Microrelief	Vertical interval of gilgai		
	<25 cm	2	g2
	25 - 60 cm	3	g3
	>60 cm	4	g4
Wetness	Requires accurate levelling and storm drains.	3	w3
	Requires permanent drainage.	4	w4
Susceptibility to water erosion	To reduce erosion to an acceptable level, require:		
	Simple practices	2	e2
	Intensive practices	3	e3
	Pasture phase	4	e4
Susceptibility to flooding	No flooding		-
	Occasional flooding		f2

APPENDIX 7

Land Classes

The following are modified versions of land classes as defined by the United States Bureau of Reclamation (1951).

CLASS 1 - ARABLE

Lands that are highly suitable for irrigation farming, being capable of producing sustained and relatively high yields of a wide range of climatically adapted crops at reasonable cost. They are smooth lying with gentle slopes. The soils are deep and of medium to fairly fine texture with mellow, open structure allowing easy penetration of roots, air and water and having free drainage yet good available moisture capacity. These soils are free from harmful accumulations of soluble salts or can be readily reclaimed. Both soil and topographic conditions are such that no specific farm drainage requirements are anticipated, minimum erosion will result from irrigation and land development can be accomplished at relatively low cost.

CLASS 2 - ARABLE

Lands of moderate suitability for irrigation, being lower than Class 1 in productive capacity. They are not so desirable nor of such high value as lands of Class 1 because of certain correctible or non-correctible limitations. They may have a lower available moisture capacity as indicated by coarse texture or limited soil depth; they may be only slowly permeable to water because of clay layers in the subsoil; or they also may be moderately saline which may limit productivity or involve moderate costs of leaching. Topographic limitations include uneven surface requiring moderate costs for levelling, short slopes requiring shorter length of runs, or steeper slopes necessitating special care and greater costs to irrigate and prevent erosion. Farm drainage may be required at a moderate cost or loose rocks or woody vegetation may have to be removed from the surface. Any one of the limitations may be sufficient to reduce the lands from Class 1 to Class 2 but frequently a combination of two or more of them is operating.

CLASS 3 - ARABLE

Lands that are suitable for irrigation development but are of restricted suitability because of greater deficiencies in the soil, topographic, or drainage characteristics than described for Class 2 lands. They may have good topography, but because inferior soils have restricted adaptability, require larger amounts of irrigation water or special irrigation practices and demand greater fertilization or more intensive soil improvement practices. They may have uneven topography, moderate to high concentration of salts or restricted drainage, susceptible to correction but only at relatively high costs. Generally, greater risk may be involved in farming Class 3 lands than better classes of land, but under proper management they are expected to have adequate payment capacity.

CLASS 4 - LIMITED ARABLE OR SPECIAL USE

Lands that have an excessive, specific deficiency or deficiencies susceptible to correction at high cost; or they may have one or more excessive, non-correctible deficiencies thereby limiting their utility to pasture, orchard or other relatively permanent crops. The deficiency may be inadequate drainage, excessive salt content requiring extensive leaching, unfavourable position allowing periodic flooding or making water distribution and removal very difficult, rough topography, excessive quantities of loose rock on the surface or in the plough zone. On these lands special economic and agronomic and/or engineering studies are required to show they are capable of sustained production and capable of supporting a farm family and meeting water changes if operated in units of adequate size or in association with better lands.

CLASS 5 - NON-ARABLE

Lands in this class are non-arable under existing conditions. They have specific soil deficiencies such as being excessively steep, shallow, rocky, rough or badly eroded or have very high salinity.

APPENDIX 8

Vegetation - Common and Scientific Names

Common Name	Scientific Name
Trees	
Blue gum	*Eucalyptus tereticornis*
Brigalow	*Acacia harpophylla*
Broad-leaved apple	*Angophera subvelutina*
Broad-leaved leopard wood	*Flindersia collina*
Brush box	*Tristania conferta*
Carbeen or Moreton Bay ash	*Eucalyptus tesselaris*
Crow's apple	*Owenia uenosa*
Grey gum	*Eucalyptus propinqua*
Gum-topped box	*Eucalyptus mollucana*
Moreton Bay chestnut	*Castanospermum australe*
Narrow-leaved ironbark	*Eucalyptus crebra*
Native cascarilla bark	*Croton insularis*
Pink bloodwood	*Eucalyptus intermedia*
Red bottle brush	*Callistemon viminalis*
River she-oak	*Casuarina cunninghamiana*
River tea tree	*Melaleuca bracteata*
Rough-barked apple	*Angophera floribunda*
Scrub bottle tree	*Brachychiton discolor*
Scrub wilga	*Geijera salicifolia*
Silky oak	*Grevillea robusta*
Silver-leaved ironbark	*Eucalyptus melanophloia*
Shrubs	
Chain fruit	*Alyxia ruscifolia*
Currant bush	*Carissa ovata*
Grass trees	*Xanthorrhoea spp.*
Lantana	*Lantana camara*
Red ash	*Alphitonia excelsa*
Scrub boonaree	*Heterodendrum diversifolium*
Wattles	*Acacia spp.*
Vines	
Lamb's tails or madeira vine	*Anredera cordifolia*
Native jasmines	*Jasminum spp.*
Wonga wonga vine	*Pandorea pandorana*

Grasses

Barb-wire grass	*Cymbopogon refractus*
Blue grass	*Dicanthium sericeum*
Bunch spear grass	*Heteropogon contortus*
Kangaroo grass	*Themeda australis*
Love grasses	*Eragrostis spp.*
Pitted bluegrass	*Bothriochloa decipiens*
Wire grasses	*Aristida spp.*

Other Ground Cover Species

Rock fern or mulga fern	*Cheilanthes spp.*
Salt bush	*Rhagodia hastata*
Wire weed	*Nyssanthes diffusa*

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