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Soils and Agricultural Suitability of the Childers Area, Queensland

P.R. WILSON
RESOURCE MANAGEMENT

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Summary

A land resource survey of 244 254 ha in the Childers area was aimed at providing information for improved sustainable farming systems and for regional planning, catchment management and property management planning. The report focuses on detailed descriptions of the physical and chemical attributes and the limitations of the soils for agricultural production. The report should be used in conjunction with the published soils and suitability map.

The very complex distribution of the 52 soils identified in the study can be attributed mainly to a complex geomorphic history. The relatively simple geology gives little indication to this complexity. Rapid soil changes over short distances and their associated attributes contributes to a general fragmentation of rural activities and infrastructure.

Water supply and associated infrastructure are the main limitations to agricultural development. At present, the bulk of the agricultural development is restricted to the Bundaberg Irrigation Area (BIA) with little room for further development on freehold land within the BIA. There is, however, considerable potential for development outside the BIA or on State Forest lands.

Another major limitation to sustainable agriculture is land degradation particularly waterlogging and salinity. Salinity has been aggravated by clearing of the native vegetation and irrigation of crops on recharge areas. On-farm and catchment management strategies need to be maintained or implemented to manage all degradation problems.

A Geographic Information System (GIS) provides rapid spatial presentation of site information, soil and land attributes limitations and sustainability for 26 different land uses. All of the information is beneficial in providing information for improved farming systems and land management. The report also provides a key for the rapid identification of soils in the area, a detailed description of the soils and an outline of the land suitability classification scheme.

The results of this study will be very useful to industry bodies, community groups, government departments, landholders and other land managers who have a commitment to managing the land and maintaining it in a productive and sustainable condition.

1. Introduction

The Childers study area comprises 244 254 hectares (Figure 1). It is a subtropical region with a mix of agricultural enterprises, mainly sugar cane, tree crops, small crops, grazing and forestry. Irrigation has facilitated the growth of horticultural crops, although much of the area is still dominated by sugar cane.

The Childers soil survey and land use study on the Childers 1:100 000 sheet began in 1989 to assess the suitability of those soils for a wide range of agricultural land uses. The survey was to incorporate information from numerous previous surveys in order to supply land resource information for the whole area in a uniform format. Previous land resource information was generally fragmented, done for a specific purpose or of insufficient detail to address today's land use and management issues.

The aims of the survey were to provide:

- information for improved sustainable farming systems
- information suitable for regional planning, catchment management, and property management planning
- information for improved irrigation management strategies
- information for the development of nature conservation strategies
- an evaluation of the land suitability for a wide range of land uses
- information on the current state of land use and land degradation

an inventory of the land resources of the Childers 1:100 000 map sheets (total area 244 254 ha)

- detailed description of the physical and chemical attributes, and the limitations of the soils and land for agricultural production.

This report focuses on the results of the survey, describing the soils, their distribution and their limitation for agricultural production and land degradation. This report should be used in conjunction with the published soils and suitability map. All survey information has been compiled onto a computer based Geographical Information System (GIS). The GIS allows flexibility in the presentation of all information, for example, maps, tables or overlays.

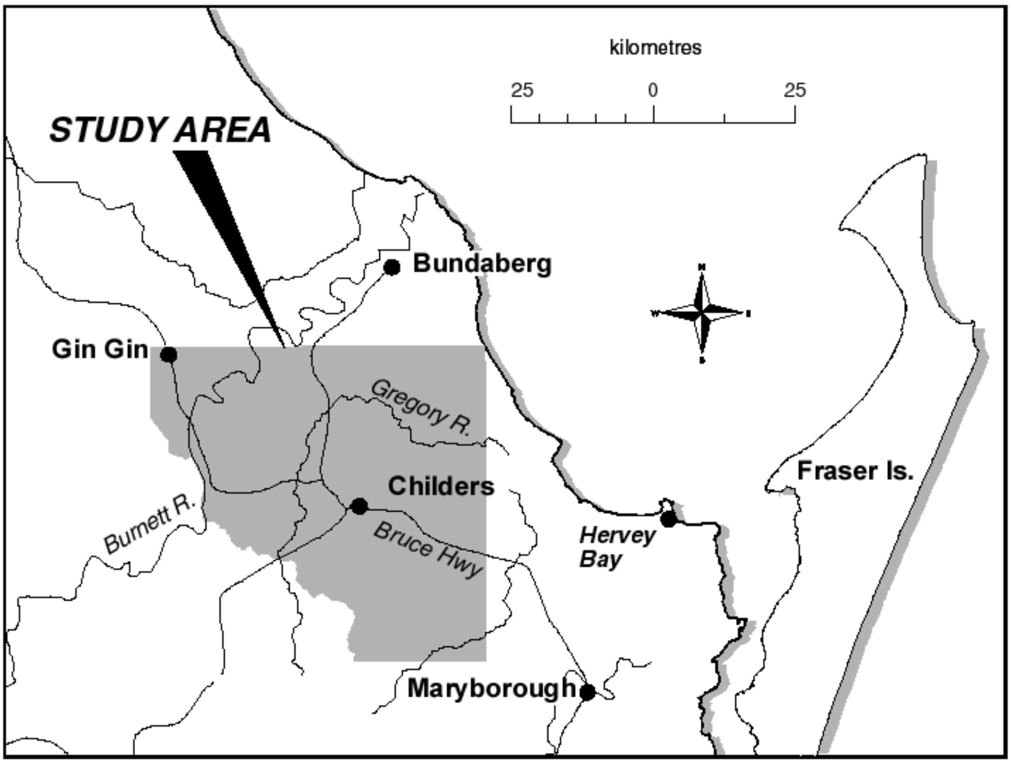


Figure 1. Locality map

2. Geology

The study area, while dominated by a relatively simple geological composition of sedimentary rocks has been influenced by plutonic activity in the Permean-Triassic (granite) and Tertiary Calcium activity (basalts). Topographically the area is level in the east becoming undulating in the west and southwest. The more deeply weathered geology occurs to the east and north east.

The mineral composition of the rocks or other parent material, the relative age of the soils, hydrology and landscape erosion are the main factors determining the attributes of the soils and their distribution within the study area. Appendices Ia to Ig show idealised relationships between geology, landform and soils. Detailed information on the geology is available from Ellis (1968).

Permean-Triassic sedimentary rocks

The Biggenden Beds and Brooweena formation comprise sandstone, siltstone, mudstone, slate, and conglomerate. The Biggenden Beds also comprise 20 to 30% volcanic rocks and minor limestone. The Brooweena Formation unconformably overlie the Biggenden Beds. A small area of Goodnight Beds west of Gin Gin has been included in this group.

These formations have similar rock types and have been extensively folded, and intruded by granite. Some metamorphose occur in the region of the intrusions. The Brooweena Formation has been downfaulted against the Biggenden Beds along the Electra Fault, south east of Wallaville.

As shown in Appendix 1c the sedimentary rocks have characteristically given rise to gravely, generally shallow, sodic texture contrast soils (*Brooweena*) with loamy to clay loam surface textures. The wide variation in colour of the clayey subsoil often reflects the thin, steeply dipping beds. Similar soils have formed on acid volcanic rocks in the Biggenden Beds and on slates of the Goodnight Beds.

The intermediate to basic volcanic rocks (andesite, basalt, trachyte and basic metamorphosed volcanics) are of limited context (Appendix Ia) and mainly form shallow brown or red clayey soils (*Corfield*). Similar soils have also formed on metamorphosed sediments and basic volcanics of the Goodnight Beds. A red clayey soil (*Corfield limestone variant*) has formed on very minor lenses of recrystallised limestone (marble) south east of Wallaville.

Granites

Large areas of plutonic intrusives into the Permean-Triassic sedimentary rocks occur in the western part of the study area. Included in this general group are the Moolboolaman Granodiorite, Bloomfield Granite, undifferentiated granite, granodiorite and microdiorite.

Generally, the granites (Appendix Ib) give rise to sandy surfaced, sodic texture contrast soils (*Gigoon*) while the granodiorites give rise to red or brown texture contrast or gradational soils (*Booyal*) or occasionally, brown or dark clay soils (*Dawes*).

The undifferentiated microdiorite south of Childers has developed into a thin, loamy surfaced, sodic texture contrast soils (*Doongul*).

Jurassic - Tertiary sedimentary rocks

This group comprises predominantly sandstones, siltstones, mudstones, shales and conglomerate although the Graham's Creek Formation contains intermediate to acid volcanic flows and pyroclastics, tuffaceous sandstone and siltstone.

The oldest Myrtle Creek Sandstones unconformably overlies the granitic intrusives and older sedimentary rocks. The Myrtle Creek sandstones are overlain by the Tiaro Coal Measures, Graham's Creek Formation, Maryborough Formation and Burrum Coal Measures. All these formations generally dip gently to the east. The flat lying Tertiary Elliott Formation unconformably overlies all older formations and intrusives in the study area.

The Elliott Formation was deeply weathered (lateritized) and silicified (duricrusted) in the upper part while the older formations have been weathered to varying degrees. Recent erosion processes have dissected the deeply weathered sediments to expose other formations and generally creating an undulating landscape. The deeply weathered sediments have given rise to a diverse range of soils while the fresher or moderately weathered rocks give rise are restricted number of soils.

The dominant soil on all moderately weathered formation (Appendix Ic) is a thin loamy surfaced, strongly acidic (pH <5.5), grey, sodic texture contrast soil (*Kolan*). Of lesser extent is a minor gilgaied grey clay (*Duingal*) or a thin loamy surfaced, neutral (pH 6.5-8), yellow or brown, texture contrast soil (*Givelda*). A sandy surfaced sodic or non-sodic texture contrast soil (*Tirroan*) is restricted to the coarse sandstones of the Elliott Formation and Myrtle Creek Sandstone or where sand from the Elliott Formation has been deposited downslope overlying clay developed from other sedimentary formations. A minor grey clay (*Huxley*) has developed on andesite of the Graham's Creek Formation just north of Childers.

The deeply weathered sedimentary rocks give rise to a very diverse range of soils, particularly on the Elliott Formation. The undulating landscapes with fine grained sedimentary rocks (mudstones, shales, siltstones, fine sandstones) generally give rise to soils with loamy surfaces (Appendix Id). Soils with red (*Watalgan*) or yellow clay subsoils (*Kepnock, Woolmer*) generally occur on the upper slopes, while grey or brown sodic texture contrast soils (*Avondale, Woco*) always occur on lower slopes.

The level plains of the Elliott Formation have seasonally wet non-sodic soils (*Clayton)* or sodic soils with relatively deep loamy surfaces (*Kalah* and *Kolbore*). A soil with a loamy surface over a grey or brown, non-sodic clay subsoil (*Botherm*) developed on rhyolite is restricted to the Graham's Creek Formation. Extremely gravely soils (*Bungadoo, Takoko*) are restricted to the silicified upper part of the Maryborough Formation.

The coarse grained deeply weathered sedimentary rocks (sandstones) generally give rise to a wide variety of sandy surfaced soils (Appendix Ie). The variability in soil patterns reflects the deposition of the Elliott Formation from rapidly migrating streams, typical of alluvial fans (Robinson, personal communication). The erosion of the landscape to the currently gently undulating to undulating landscape has added to the complexity of soil patterns.

Soils vary from Podosols (*Kinkuna, Wallum, Theodolite*) to massive Kandosols (*Farnsfield, Quart, Mahogany*) to structured Dermosols (*Gooburrum, Isis, Meadowvale*) and sodic textured contrast soil (*Robur*).

Basalts

Tertiary basalts are confined to the Gin Gin Basalt and Berrembea Basalt and remnants of other basalts in the Gin Gin and Childers areas. The basalts give rise to a limited number of soils (Appendix Ia).

The Gin Gin basalt in the Gin Gin-Wallaville area has given rise mainly to dark cracking clay soils (*Maroondan*). The remaining Tertiary basalts overlie other formations and most have been deeply weathered (lateritised) in the Childers and Gin Gin area to form red clayey soil (*Childers*) and a mottled yellow clayey soil (*Doolbi*) on lower slopes. Minor areas of fresh basalt have developed into a shallow brown clayey soil (*Kowbi*). In the Gin Gin area, substantial areas of red clayey soils with fine quartz gravel (*Chin*) occur, indicating that the basalt derived soils have been influenced the underlying sandstones of the Elliott Formation.

Small areas of basalt flows in the Berrembea area has developed into extremely rocky brown clayey soils (*Berren*).

Alluvium

The alluvial plans, terraces and channel benches along the Burnett River constitute the largest area of alluviums with sediments derived from the wide diversity of rocks in the upper catchment.   The structural restriction of the Electra Fault has created relatively large areas of alluvium upstream of the fault.

The remaining alluvium are generally restricted to narrow plains along creeks which drain the local landscapes.

The older alluvial plains and terraces along the Burnett River (Appendix If) either have bleached grey or brown sodic texture contrast soils (*Auburn*) or bleached grey clays (*Walla*). The younger terraces and channel benches generally gave brown or black loamy to clayey soils (*Flagstone*) or sandy layered soils (*Burnett*).

The alluvium associated with the local creeks and rivers generally give rise to sodic texture contrast soils (*Peep*). Minor sandy soils (*Littabella*) are associated with levees along the Gregory, Isis and Elliott Rivers.

Beach ridges

Sand deposition by wave action during previous sea rises has developed beach ridges parallel to the current coastline from the Elliott River and south into the Woodgate area.

The higher ridges (Figure Ig) have several metres of white sand over coffee rock (*Coonarr*), while the swales have soils with coffee rock at less than one metre (*Woodgate*) and watertables at or near the surface for extended periods.

3. Soils

Background

Reconnaissance mapping in the study area include the Bundaberg Irrigation Area (van Wijk, undated), the Atlas of Australian Soils (Isbell *et al.* 1967), Isis District land use study (Isis Land Use Study Committee, 1971), Gin Gin land use study (Gin Gin Land Use Committee, 1972), Maryborough Elliott River land use study (Queensland Coastal Lowlands Land Use Committee, 1976), and an assessment of the ecosystems of the coastal lowlands (Coaldrake, 1961).

A study by Smith (1985) assessed the land suitability for a majority of the Isis Mill sugar cane growing area while Forster and Mcnish (1987) assessed the suitability of cane assigned areas at 1:10 000 scale as a prerequisite to the implementation of the Isis irrigation scheme. Information from both these studies were used extensively in the current study.

Other specific purpose studies include the Forestry Department pit identification sites in the Elliott State Forest (SF840), and the Coastal Burnett Land Management Manual (Glanville *et al,* 1991). Thompson *et al* (1994) investigated relict hardplans in a number of soils south of the Isis River. The western part of Childers study adjoins the Central Burnett Land Use Study (Kent, in preparation).

Mapping was done at medium to low intensity (1:100 000) by free survey (Reid, 1988). Soil landscape boundaries were checked with a concentration of ground observations and aerial photo interpretations. A total of 1370 sites were described and entered on computer file.

A total of 52 soils have been identified (Appendix III) in the Childers study area and their distribution is shown on the accompanying map. Classification of the soils is based on the Australian Soil Classification system developed by Isbell (1996). A key to the soils in Appendix I is designed to assist in the identification of soils at any point inspection and should be used in conjunction with the soils map.

A total of 104 analysed sites in the study area provides an extensive date set for the comments on soil chemistry. Analytical methods and nutrient ratings are based on Baker (1991).

It should be noted that the maps are published at 1:100 000 which equates to approximately one observation per 100 ha. A greater density of observations generally applying to developed areas or more productive land types. Reliability of the information declines at a larger (more detailed) scale.

Each area delineated on the map is called a “Unique Map Area” (UMA). Each UMA has been given a number and can be individually referred for the principal soil, geology, landform and specific soil attributes and limitations.

The mapping units on the map are associations and will contain a number of soils which may or may not occur in some predictable pattern. The assumption can never be made at any point inspection that the dominant soil will be encountered; there may often be some variability in one or more soil properties from what has been described as the soil type or soil profile class.

Another important note is that the boundary between two distinct soils may occur over metres or hundreds of metres. In all cases, the soils form a continuum with a gradual change from one soil to another.

All the soils under cultivation have been modified to some extent. The normal land preparation operations for sugar cane have resulted in ploughed surfaces 300–400 mm thick. That is sufficient in many soils to destroy all surface horizontation with the result that the ploughed layer is often a mixture of the original surface and subsurface horizons.

Podosols

Podosols are soils with B horizons dominated by the accumulation of compounds of organic matter, aluminium and/or iron.

Five podosols have been recognised — three occur on the deeply weathered sandstones of the Elliott Formation and two on the coastal beach ridges. The Woodgate soil is an unmapped soil occurring in association with the Coonarr soil. The Podosols represent a relatively minor group and occupy 10 691 ha or 4.4% of the study area.

Table 1. Major attributes, classification and areas for soils of the Podosols

Mapping Unit	**Major attributes of dominant soil**	**Australian Classification**	**Area (ha)**
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS			
Kinkuna	Black or grey sand surface over a conspicuously bleached A2 horizons (0.3 to 0.75m) over a brown or black orstein or coffee rock pan (0.45 to 1m) over grey sand.	Aquic Podosol Semiaquic Podosol	7891
Wallum	Black or grey sand surface over a conspicuously bleached A2 horizon (0.25 to 0.5m) over a brown sand B2 horizon (0.35 to 0.8m) over a bleached sand (0.65 to 1.1m) over an acid, mottled, massive, grey sandy clay loam to sandy clay.	Aquic Podosol/+ Redoxic Hydrosol	1293
Theodolite	Grey sand surface over a conspicuously bleached A2 horizon (0.25 to 0.5m) over a brown sand B2 horizon (0.35 to 0.65m) over a bleached sand (0.75 to 1.1m) over an acid, mottled, structured, grey sandy clay to sandy medium clay.	Aquic Podosol/ Redoxic Hydrosol	1305
BEACH RIDGES, DUNES AND COASTAL PLAINS			
Coonarr bleached	Black or grey sand surface over a conspicuously A2 horizon (3.5 to 4.5m) over a black coffee rock pan.	Aquic Podosols	202
+ Indicates that one soil overlies another soil.			

Landscape

The podosols on the deeply weathered sandstones of the Elliott Formation have formed on level plains or hill slopes up to 6% slope. The *Kinkuna*, *Wallum* and *Theodolite* soils generally occur randomly on level plains and can grade into each other. *Kinkuna* and *Wallum* soils also occur on lower slopes, generally downslope of other sandy surfaced soils.

The *Coonarr* and *Woodgate* podosols occur on beach ridges and swales respectively along the coast.

Vegetation

The *Kinkuna*, *Wallum* and *Theodolite* soils typically have wallum vegetation, usually *Banksia aemula* with an understory of heath. *Eucalyptus umbra* usually occurs as an emergent species and may be locally dominant. Tall turpentine (*Syncarpia glomulifera*) may also be locally dominant.

The *Coonarr* soils typically has isolated to sparse *Banksia aemula* with an understory of heath and spinifex (*Triodia marginata*) or occasionally *Callitris columellaris* with an understory of heath. The *Woodgate* soil in the swales has low dense heath.

Soil profile

All podosols have a sandy, black or grey surface over a conspicuously bleached A2 horizon over a sandy brown or black orstein or coffee rock layer. The *Kinkuna*, *Wallum* or *Theodolite* soils on the Elliott Formation typically have an orstein layer due to the accumulation of iron and organic matter at approximately 1 m. Below the orstein layer, a bleached sandy layer overlies massive mottled sands (*Wallum*) or massive sandy clay loams to sandy clays (*Wallum*) or structured sodic clays (*Theodolite*). Figure 2 shows the change in mean clay percentage for *Kinkuna* and *Theodolite* soils with depth.

The soils on the beach ridges have black coffee rock pans up to 4.5 m depth on the ridges (*Coonarr*) or <1 m in the swales (*Woodgate*). The *Woodgate* soil often has a black strongly acid sandy surface due to organic matter accumulation under wet conditions.

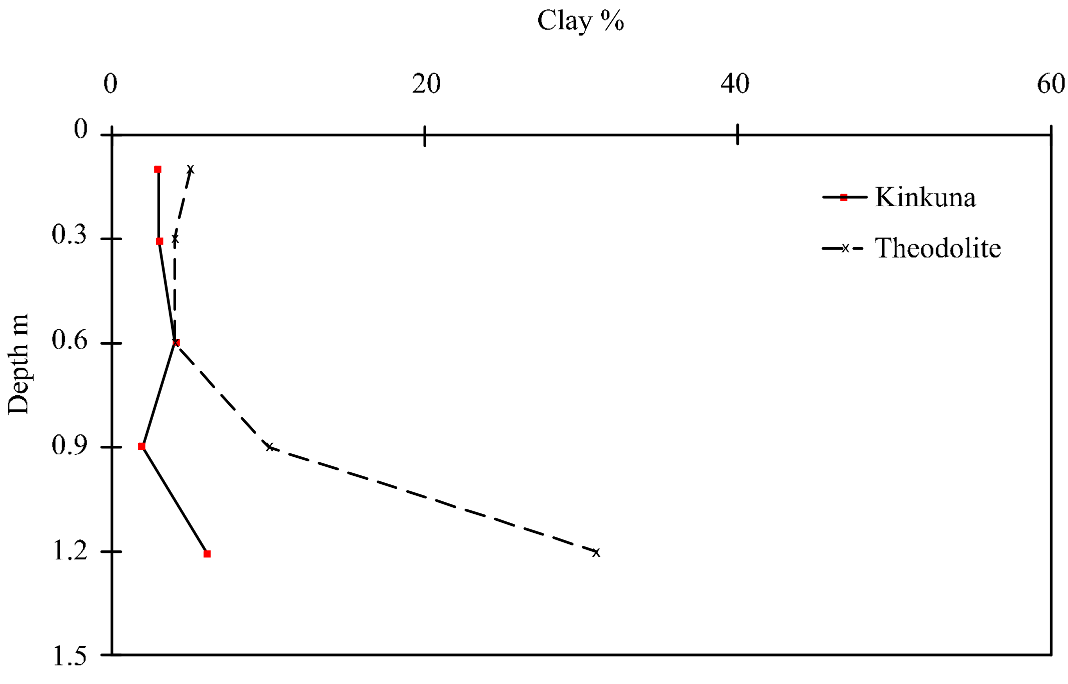


Figure 2. Mean clay content profiles for soils of the Podosols

Soil chemistry

Soil pH. All podosols have acid pH (pH <6) throughout the profile with surface field pH ranging from 3.5 to 6 and subsoil field pH ranging from 4.5 to 6. The strongly acid pH reflect the presence of organic acids in the surface organic matter and accumulation of organic complexes in the subsoil coffee and orstein horizons.

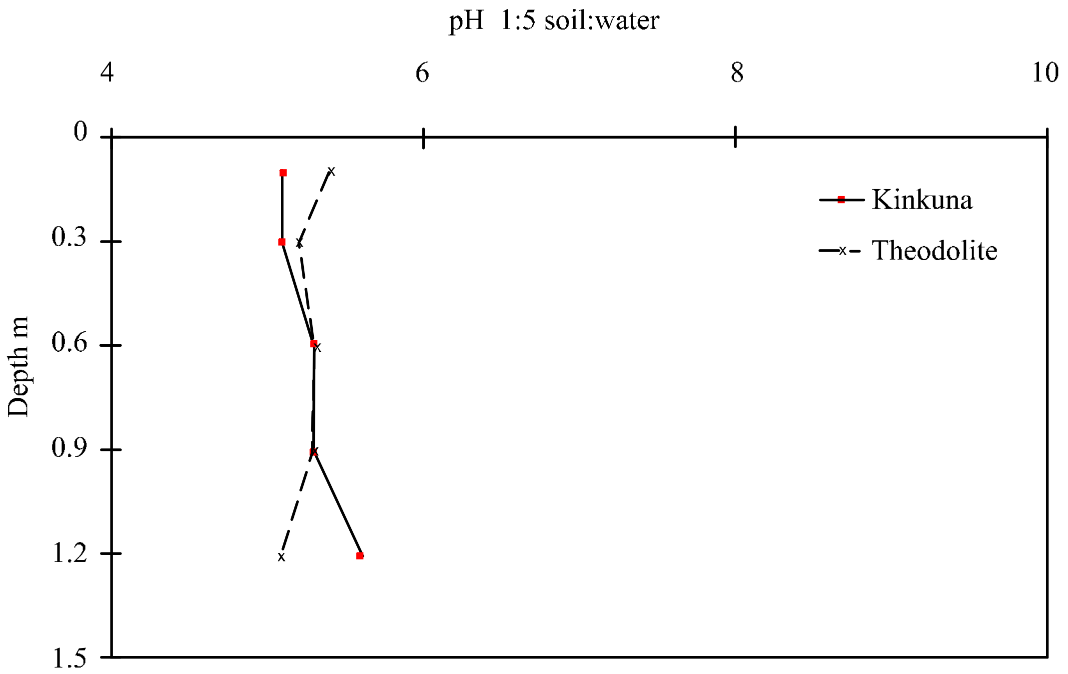


Figure 3. Mean pH (1:5) profile for soils of the Podosols

Salinity. All profiles have very low salt levels and sodicity, .. Effective Cation Exchange Capacity (ECEC) is extremely low (<1 meq /100g soil. Subsoils are sodic with higher ESP levels in the clay subsoil of the *Theodolite* soil.

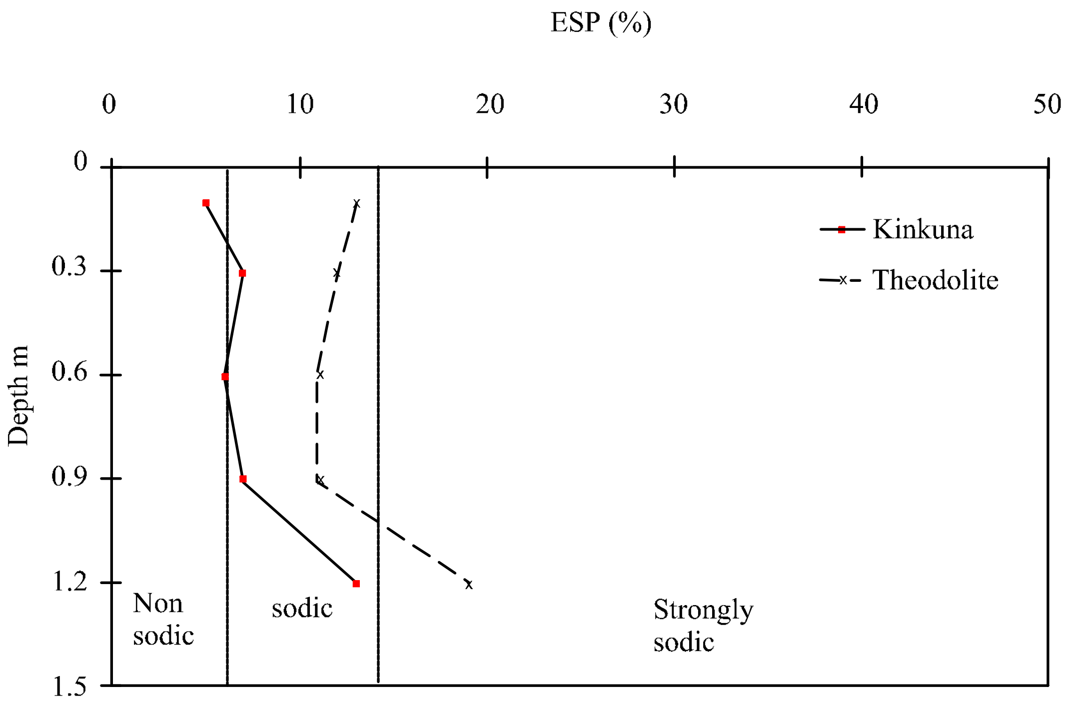


Figure 4. Mean ESP profiles for soils of the Podosols

Soil nutrients. All Podosols are low in all nutrients. Table 2 shows the mean levels of P, K, Ca, organic C, total N and extractable Zn. Calcium/magnesium ratios are variable with an average ratio of approximately one in the subsoil.

Table 2. Mean profile soil nutrients for soils of the Podosols

	Depth (meq)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Kinkuna	0-0.1	0.08 (L)	0.45 (VL)	6 (VL)	4 (VL)	2.2 (VL)	0.05 (VL)	0.3 (L)
	0.2-0.3	0.03 (L)	0.2 (VL					
	0.5-0.6	0.03 (L)	0.2 (VL)					
	0.8-0.9	0.02 (L)	0.2 (VL)					
	1.1-1.2	0.04 (L)						
Theodolite	0-0.1	0.03 (L)	0.06 (VL)	--	--	0.66 (L)	0.03(VL)	--
	0.2-0.3	0.04 (L)	0.04 (VL)					
	0.5-0.6	0.01 (L)	0.04 (VL)					
	0.8-0.9	0.03 (L)	0.05 (VL)					
	1.1-1.2		0.04 (VL)					

(VL) Very Low (L) Low (M) Medium (H) High (VH) Very High

Plant Available Water Capacity (PAWC). The model developed by Littleboy from the model of Shaw and Yule (1978) was used to estimate PAWC. The model uses -1500kPa moisture to estimate the amount of water in the soil profile for plant growth. Effective rooting depth was taken to be 0.9 m or the depth to rock, hardpans, high salt levels or where a rapid rise in profile EC indicates the depth of regular wetting if <0.9 m.

All Podosols have an estimated mean PAWC of <50 mm and a predicted rooting depth of >1m. Coffee rock or orstein pans are generally thin and discontinuous and not expected to restrict rooting depth. However, due to the low nutrient levels in all Podosols, particularly calcium, root growth and therefore water extraction in the subsoil would be minimal.

Vertosols

Vertosols are clay soils with swell shrink properties that exhibit strong cracking when dry, and at depth have slickensides and/or lenticular structure.

Six Vertosols have been mapped (Table 3), including a brown or black clay on granodiorite (*Dawes*), a black clay on Gin Gin basalt (*Maroondan*), a grey clay on andesite (*Huxley*), a grey clay on moderately fresh sedimentary rocks (*Doongul*), a grey clay on alluvial plains along the Burnett River (*Walla*), and a grey clay on alluvial plains draining basalt areas (*Weithew*).

They are a relatively minor group of soils, occupying 7071ha or 2.9% of the study area.

Table 3. Major attributes, classification and areas for soils of the Vertosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON GRANITES			
Dawes	Black light medium clay to medium clay surface over a neutral to alkaline, brown or black medium clay to heavy clay (0.45 to 0.8m) over weathered granodiorite.	Brown Vertosol Black Vertosol Black Dermosol	388

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON BASALTS			
Maroondan	Black light medium clay to heavy clay surface over a neutral to alkaline, black or occasionally brown medium clay to heavy clay (0.3 to 0.7m) over weathered basalt.	Black Vertosol	3698
Huxley	Black light medium clay to heavy clay surface over an acid to neutral, mottled, grey medium clay to heavy clay (0.5+m) over weathered andesite or basalt.	Grey Vertosol Brown Vertosol	392
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Duingal	Black light clay to light medium clay surface over a sporadically bleached A2 horizon (0.05 to 0.15m) over an acid, mottled, grey or brown medium clay to heavy clay (1+m) over weathered rock.	Grey Vertosol Brown Vertosol	589
ALLUVIAL PLAINS OF THE BURNETT RIVER			
Walla	Grey or black light clay to medium clay surface over an acid to alkaline, mottled, grey medium clay to heavy clay.	Grey Vertosol	1800
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
Weithew	Black light clay to light medium clay surface over an acid to alkaline, black or occasionally grey medium clay (0.25 to 0.5m) over a acid to alkaline, mottled, grey medium clay to heavy clay.	Black Vertosol Grey Vertosol	204

Landscape

The vertosols on granodiorites, basalt and sedimentary rocks occur on hillslopes of gently undulating to undulating rises with slopes less than 8%. Soils are generally shallower on upper slopes. The soils formed on alluvium are predominantly level alluvial plains.

Vegetation

The brown and black vertosols on granodiorite and basalt have minor remnants of silver leaved ironbark (*E. melanophloia*), and bloodwood (*E. erythrophloia*). The grey clay (*Doongul*) on sedimentary rocks has pockets of tall gum topped box (*E. moluccana*). The other soils are totally cleared.

Soil profile

All vertosols have clay textures (>35% clay) throughout the profile. The soils have a black structured clay surface, except *Walla*, which has a black or grey surface. The *Duingal* and *Walla* soils frequently have a shallow sporadically bleached A2 horizon which disappears under cultivation. Sub-soil horizons all have medium to heavy clay textures with moderate to strong, fine lenticular structure, particularly in the lower subsoil.

Colours in the subsoils range from black in the shallow to moderately deep (<0.6m) *Maroondan* soil to brown or black in the *Dawes* soil to brown or grey in *Huxley*, *Duingal*, *Walla* and *Weithew* soils, with colour generally becoming paler at depth. The *Maroondan grey variant* has a black subsoil overlying a grey clay at depth (generally >0.5m) frequently with lime nodules.

Soil chemistry

Field pH for the *Maroondan*, *Weithew* and *Dawes* soils generally range from 6 to 7.5 in the surface and 7 to 9 in the deeper subsoils. Lime nodules are associated with the alkaline pH (pH >8).

The remaining Vertosols (*Duingal*, *Huxley* and *Walla*) are generally more acid with surface pH generally 5.5 to 6.5 and subsoil pH predominantly 5.5 to 7. The *Duingal* clay is consistently more acid with subsoil pH frequently as low as 4.5. The *Walla* subsoil is extremely variable with pH ranging from 5 to 9, possibly reflecting variation in the deposition of alluvial material. Lime modules are associated with high pH.

Salinity and sodicity. The *Maroondan* soil has low salt and low sodicity to 0.6m. Field observations suggest that the other Vertosols are sodic at depth. Strongly alkaline soil pH (>8.5) is associated with strongly sodic soils. High salt levels would also be expected, especially in the *Walla* and *Duingal* clays.

Cation Exchange Capacity. The CEC of 60 meq/100g throughout the shallow *Maroondan* soil corresponds to the heavy clay texture dominated by montmorillonite type clays.

Soil nutrients. The clays would be expected to have variable nutrient status, generally corresponding to the lithology and geomorphology. The *Maroondan* soil has moderate to high levels of nutrients throughout the shallow profile. The high Ca levels in the Maroondon soil correspond to calcium/magnesium ratios to an average 1.2 at the surface and at 0.2 - 0.3m.

Table 4. Mean profile soil nutrients for soils of the Vertosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Maroondan	0-0.1	0.58 (M)	30 (H)	44 (H)	30 (M)	2.6 (M)	0.23 (M)	3.1(M)
	0.2-0.3	0.22 (M)	31 (H)					

Plant Available Water Capacity (PAWC). The predicted rooting depths and PAWC for each of the Vertosols are shown in Table 5. The variation in PAWC in the *Maroondan* and *Dawes* soils depends on the depth to rock while PAWC in all other Vertosols depends on the depth to the strongly sodic, saline subsoil.

Table 5. Estimated PAWC (mm) and rooting depth (m) for soils of the Vertosols

Soil	Rooting Depth (m)	PAWC (mm)
Dawes	0.6 - 0.8	105 - 130
Maroondon	0.3 - 0.8	60 - 130
Huxley	0.4 - 0.6	75 - 105
Doongul	0.4 - 0.6	75 - 105
Walla	0.4 - 0.9	75 - 120
Weithew	0.6 - 0.9	100 - 125

Hydrosols

Hydrosols are soils in which the greater part of the profile is saturated for at least several months in most years. The soils may or may not experience reducing conditions for all or part of the period of saturation, and 'gley' colours and ochrous mottles may or may not be present (Podosols and Vertosols are excluded).

Saturation by a watertable may not necessarily be caused by low soil permeability. Site drainage is particularly important. In artificially drained soils, drainage has merely lowered the watertable. The appraisal of Hydrosols is based on site drainage, topographic position, climate and soil profile attributes such as colour, mottles, segregations, permeability. This information was used in conjunction with rudimentary watertable measurements conducted on a range of soils and landscapes in the Childers area to determine soil wetness. It should be recognised that soil colours, mottles and segretations can be relict and may not be indicative of a saturated condition.

Seven dominant Hydrosols have been recognised (Table 6) with a diverse range of soil profile attributes.

Minor Hydrosols may be associated with other soil orders such as the Sodosols (*Turpin, Avondale, Peep*) and Dermosols (*Drinan*) and conversely, other soil orders such as Kandasols, Dermosols and Sodosols may be associated with the dominant Hydrosols. These associated soil orders usually reflect slight changes in site drainage due to topographic position.

Landscape

The hydrosols in the study area occur on level plains, drainage depressions and lower slopes of hillslopes. High watertables are usually associated with an impermeable layer at depth, lack of incised drainage and outfall, or seepage due to changes in the local hydrology from clearing and irrigation.

Vegetation

All the Hydrosols, except *Drinan*, support extensive areas of native vegetation. Tea trees (*Melaleuca quinquenervia, M. viridiflora, M. nodosa*) are conspicuous tree species usually mixed with scattered eucalyptus species (*Eucalyptus umbra, E. hallii, E. trachphloia, E. intermedia*).

Melaleuca quinquenervia is usually restricted to the wetter drainage lines, drainage depressions and seepage areas whereas *M viridiflora* usually occurs scattered over the plains. *Melaleuca nodosa* is a low shrub commonly occurring on saline areas.

Table 6. Major attributes, classification and areas for soils of the Hydrosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS.			
Winfield	Grey sand to loamy sand surface over a conspicuously bleached A2 horizon (0.3 to 0.85m) over an acid, mottled, massive, grey loamy sand to sandy loam.	Redoxic Hydrosol	102

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
Mahogany	Grey or black sand to sandy loam surface over a conspicuously bleached A2 horizon (0.35 to 0.8m) over an acid, mottled, massive, grey sandy clay loam to sandy clay.	Redoxic Hydrosol Grey Kandosol	4606
Alloway	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.5 to 0.8m) over an acid, mottled, non-sodic, grey light clay to medium clay.	Redoxic Hydrosol	6676
Robur	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.5 to 0.9m) over an acid, mottled, sodic, grey sandy clay to heavy clay.	Redoxic Hydrosol Grey Sodosol	12202
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Clayton	Grey fine sandy loam to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.3 to 0.6m) over an acid to neutral, mottled, non-sodic, grey light clay to medium clay.	Redoxic Hydrosol	2119
Kalah	Grey fine sandy loam to loam fine sandy surface over a conspicuously bleached A2 horizon (0.35 to 0.7m) over an acid to neutral, mottled, sodic, grey medium clay.	Redoxic Hydrosol	6096
Kolbore	Grey loamy sand to loam fine sandy surface over a conspicuously bleached A2 horizon (0.3 to 0.8m) over an acid to alkaline, mottled, sodic, grey sandy clay to medium clay (0.5 to 1.2m) over a very hard, brittle, mottled duripan.	Salic Hydrosol	14471

Soil profile

Subdivision of the seven dominant Hydrosols is based on surface and subsoil texture, structure and sodicity. All have grey massive surfaces overlying a conspicuously bleached A2 horizon. Generally, the depth to the bottom of the bleached A2 horizon decreases as texture increases.

Winfield, *Mahogany, Alloway* and *Robur* soils have sandy surface textures (loamy sand to sandy loam) while *Clayton*, *Kalah* and *Kolbore* have loamy surface textures (loam fine sandy to clay loam).

Subsoils range from massive sands (*Winfield*) to massive sandy clay loam and sandy clays (*Mahogany*) to non-sodic structured clays (*Alloway, Clayton*) to sodic structured clays (*Robur, Kalah*). The *Kolbore* soil is similar to the *Kalah* soil but has a very hard brittle pan (duripan) at depth, usually <1 m.

All soils frequently have ferromanganiferous nodules in the profile indicating fluctuating watertables.

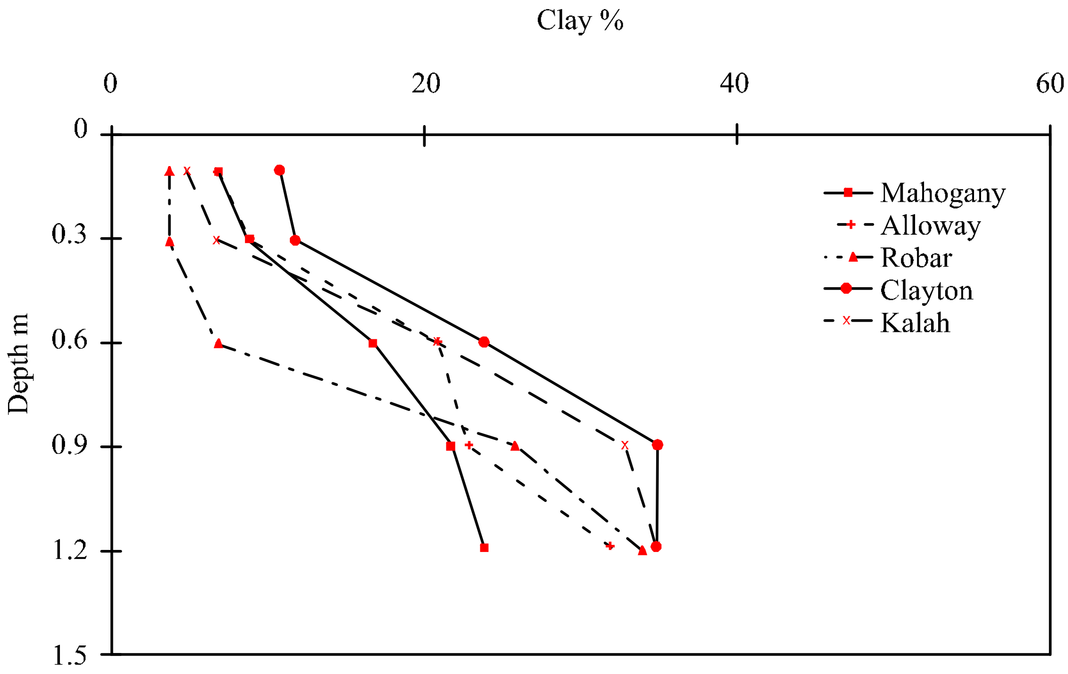


Figure 5. Mean clay content profiles for soils of the Hydrosols

Soil chemistry

Soil pH. Most Hydrosols are typically acid throughout the profiles. The texture contrast hydrosols (*Robur, Kalah and Kolbore*) are more variable and may have neutral to alkaline pH (pH 7-8) in the subsoil. The *Kolbore* soil may occasionally have strongly alkaline pH (pH 8.5-9) subsoils. The neutral to alkaline pH in these soils is always associated with very low exchangeable calcium and elevated exchangeable sodium.

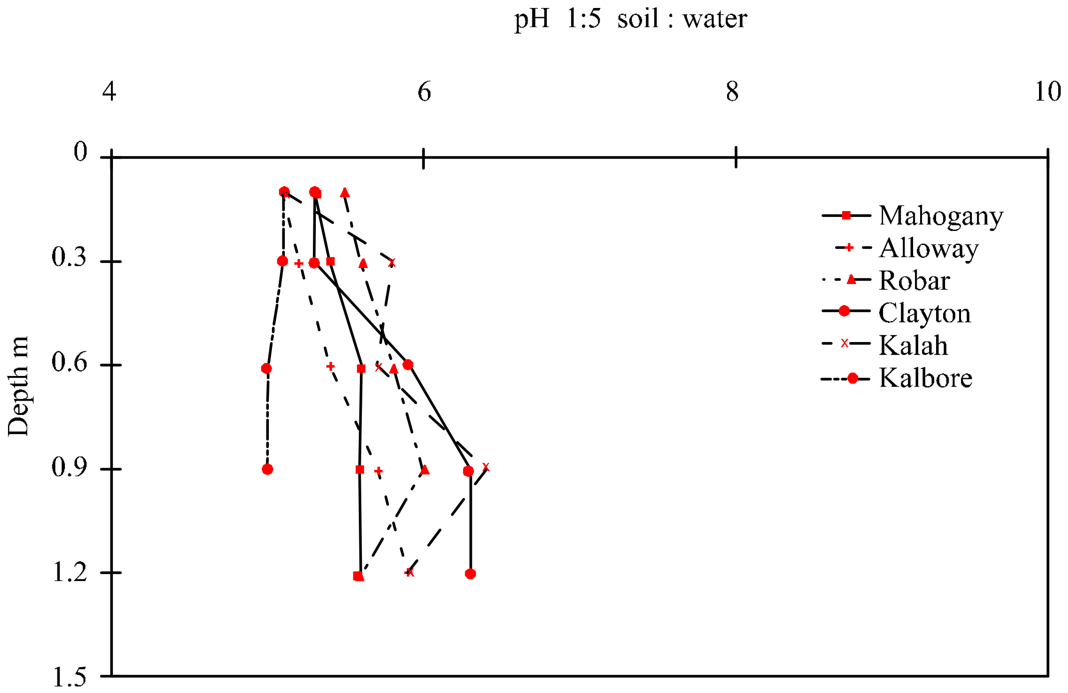


Figure 6. Mean pH (1:5) profiles for soils of the Hydrosols

Salinity. The Hydrosols developed on sandstones (*Mahogany, Alloway, Robur*) and the non-sodic Hydrosol developed on fine sedimentary rocks (*Clayton*) typically have very low salt levels below the surface.

However, these soils can develop surface salting due to the long term evaporation of water from the shallow seasonal watertable.
The impermeable *Kalah* and *Kolbore* soils frequently have moderate to high salt levels at depth and on the surface. The *Kolbore* soil with the impermeable duripan at depth are particularly prone to salting.

Salt levels are strongly correlated with sodicity levels in the profile which influences permeability and therefore, the ability to leach salts from the profiles.

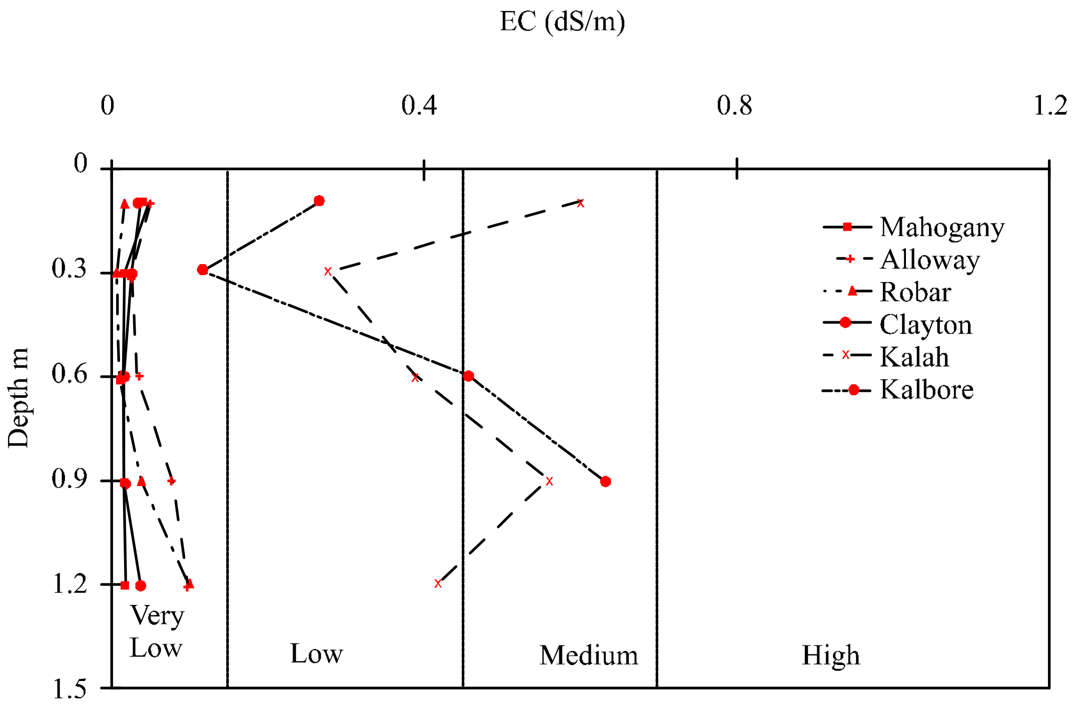


Figure 7. Mean EC (1:5) profiles for soils of the Hydrosols

Sodicity. ESP of the Hydrosols generally reflects lithology. The *Mahogany*, *Alloway* and *Robur* soils developed on sandstones have deep sandy A horizons with corresponding lower ESP deeper in the profile compared to the other Hydrosols developed on fine grained sedimentary rocks.

The abrupt change in ESP of the *Robur* and *Kalah* soils reflects the abrupt change from the A to B horizons. The higher ESP levels correspond to higher EC levels.

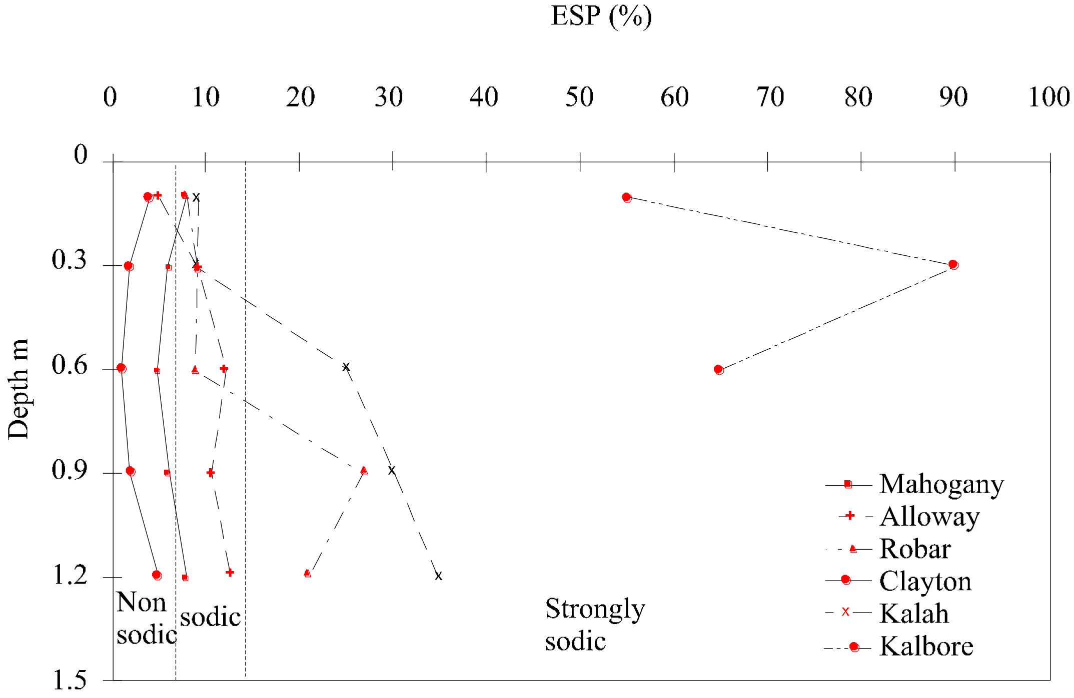


Figure 8. Mean ESP profiles for soils of the Hydrosols

Cation Exchange Capacity. Mean effective cation exchange capacity (ECEC) (Figure 9) is very low throughout the profile with slightly high surface values reflecting organic matter, and higher values at depth corresponding to clay content.

Soil nutrients. All Hydrosols developed on deeply weathered sedimentary rocks are low to very low in all nutrients reflecting the highly leached environment. Table 7 shows the mean nutrient levels for the Hydrosols. Calcium/Magnesium ratios (figure 10) indicate a surface accumulation of Ca in the organic matter and a strong dominance of Mq at depth, corresponding to the soil nutrients for highly weathered profiles.

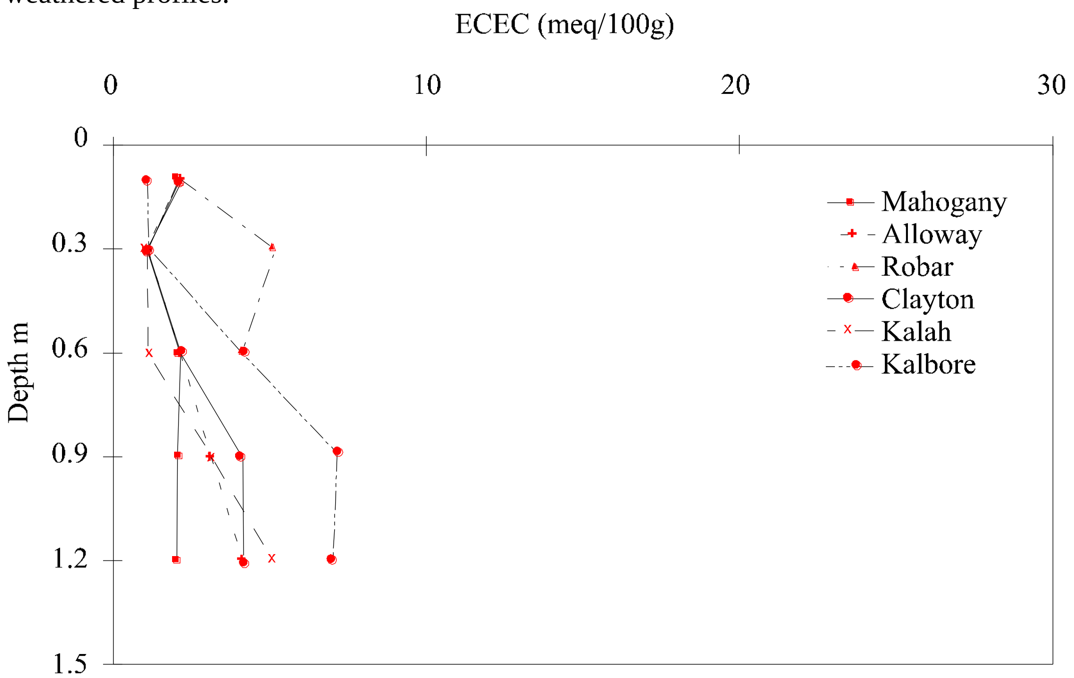


Figure 9. Mean effective cation exchange capacity (ECEC) profiles for soils of the Hydrosols

Table 7. Mean profile soil nutrients for soils of the Hydrosols

	Depth (M)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Mahogany	0-0.1	0.1 (L)	0.63 (L)	5 (VL) 112* (VH)	3 (VH) 48*(H)	1.55(M)	0.07 (L)	0.26 (L)
	0.2-0.3	0.04 (L)	0.14 (VL)					
	0.5-0.6	0.04 (L)	0.27 (VL)					
	0.8-0.9	0.03 (L)	0.32 (VL)					
	1.1-1.2	0.02 (L)	0.36 (VL)					
Alloway	0-0.1	0.11 (L)	0.4 (VL)	<5 (VL) >40* (H)	- >40 *(H)	0.9 (L)	0.04 (VL)	0.3 (L)
	0.2-0.3	0.04 (L)	0.18 (VL)					
	0.5-0.6	0.03 (L)	0.25 (VL)					
	0.8-0.9	0.03 (L)	0.34 (VL)					
	1.1-1.2	0.02 (L)	0.26 (VL)					
Robur	0.0.1	0.04 (L)	0.47 (VL)	-	2 (VL)	0.79 (L)	0.03(VL)	0.2(L)
	0.2-0.3	0.02 (L)	0.12 (VL)					
	0.5-0.6	0.02 (L)	0.1 (VL)					
	0.8-0.9	0.04 (L)	0.12 (VL)					
	1.1-1.2	0.04 (L)	0.09 (VL)					
Clayton	0-0.1	0.11 (L)	0.56(L)	-97*(H)	3 (VL) 80*(H)	1.2(L)	0.05(VL)	0.2(L)
	0.2-0.3	0.07 (L)	0.2(VL)					
	0.5-0.6	0.02 (L)	0.9(L)					
	0.8-0.9	0.02 (L)	1.1 (L)					
	1.1-0.2	0.02 (L)	0.7 (L)					
Kalah	0-0.1	0.19 (L)	0.5 (L)	4(VL)	4(VL)	1.1(L)	0.05(VL)	0.2(L)
	0.2-0.3	0.03 (L)	0.17 (VL)					
	0.5-0.6	0.06 (L)	0.23 (VL)					
	0.8-0.9	0.06 (L)	0.16 (VL)					
	1.1-0.2	0.07 (L)	0.09 (VL)					
Kolbore	0-0.1	0.07 (L)	0.22 (VL)		1(VL)	0.9(L)	0.03(VL)	0.2(L)
	0.2-0.3	0.05 (L)	0.1 (VL)					
	0.5-0.6	0.05 (L)	0.1 (VL)					

* Sampled under cultivated crops.

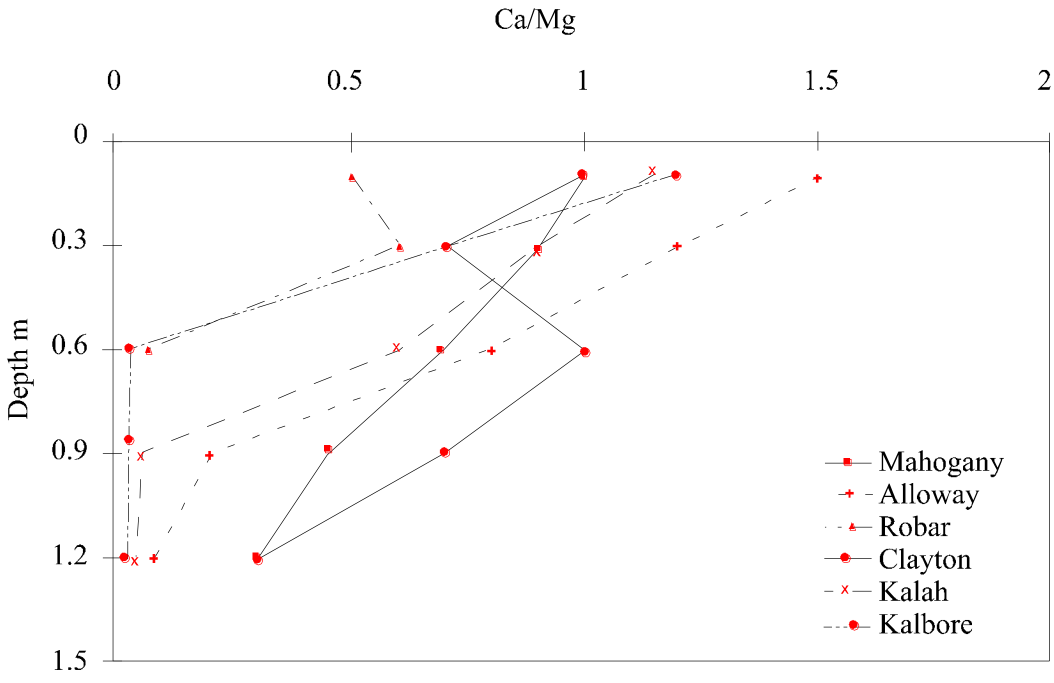


Figure 10. Mean profile calcium/magnesium ratios for soils of the Hydrosols

Plant Available Water Capacity (PAWC). . PAWC is mainly related to texture and rooting depth Any physical restriction on the effective rooting depth of the Hydrosols is dependant on the sodicity of the subsoils. The prolonged wetness of these soils would contribute to the overall water available to a crop. Table 8 shows estimated rooting depth and PAWC for the Hydrosols. The presence of hard segregations in the profile, such as iron nodules, contribute to variations in PAWC. The low to very low nutrient status, especially calcium, in all these soils would contribute to a greater reduction in rooting depth, and therefore reduced PAWC.

Table 8. Estimated PAWC (mm) and rooting depth (m) for soils of the Hydrosols

Soil	Rooting depth (m)	PAWC (mm)
Winfield	>0.9	<50
Mahogany	>0.9	58 - 68
Alloway	>0.9	63 - 65
Robur	0.6 - 0.9	47 - 52
Clayton	>0.9	60 - 80
Kalah	0.4 - 0.6	45 - 48
Kolbore	0.4 - 0.6	<50

Kurosols

Kurosols are soils with a strong texture contrast between A horizons and strongly acid (pH <5.5) B horizon. Only one soil (*Kolan*) consistently falls into this soil order. It has formed on moderately weathered mudstones and siltstones of the Elliott Formation, Burrum Coal Measures, Maryborough Formation, Graham's Creek Formation, Tiaro Coal Measures and Myrtle Creek Sandstone. The *Kolan* soil occupies
18 615 ha or 7.6% of the total study area. The Sodosol soils (*Turpin* and *Avondale)* and a Dermosol soil (*Woco*) have a minor component of Kurosols.

Table 9. Major attributes, classification and areas for soils of the Kurosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Kolan	Black or grey loam fine sandy to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.1 to 0.3m) over a strongly acid, mottled, sodic, grey or brown medium clay to heavy clay (0.5+m) over weathered rock.	Grey Kurosol Brown Kurosol	18615

Landscape

The *Kolan* soil occurs on hillslopes of rises and low hills with slopes of 1 to 15%, with an average of 5 to 8%.

Vegetation

Tall (18–25m) lemon scented gum (*Eucalyptus citriodora*), ironbarks (*E. drepanophylla, E. fibrosa*) and gum topped box (*E. moluccana*) are the main tree species on the *Kolan* soil. Gum topped box may be locally dominant.

Soil profile

The soil has a black or grey loamy surface over a conspicuously bleached A2 horizon up to 0.3 m abruptly changing to a mottled, grey or brown clay subsoil. Slickensides frequently occur in the lower part of the profile, and weathered fine grained sedimentary rocks occur at depth. Shallower soils usually occur on upper slopes. This soil has very similar profile attributes to the *Avondale* soil which has formed on deeply weathered fine grained sedimentary rocks. Differences in soil chemistry, vegetation and the degree of weathering of parent material distinguish these two soils. The clay profile is shown in Figure 11. The decrease in clay content at depth corresponds to weathered rocks.

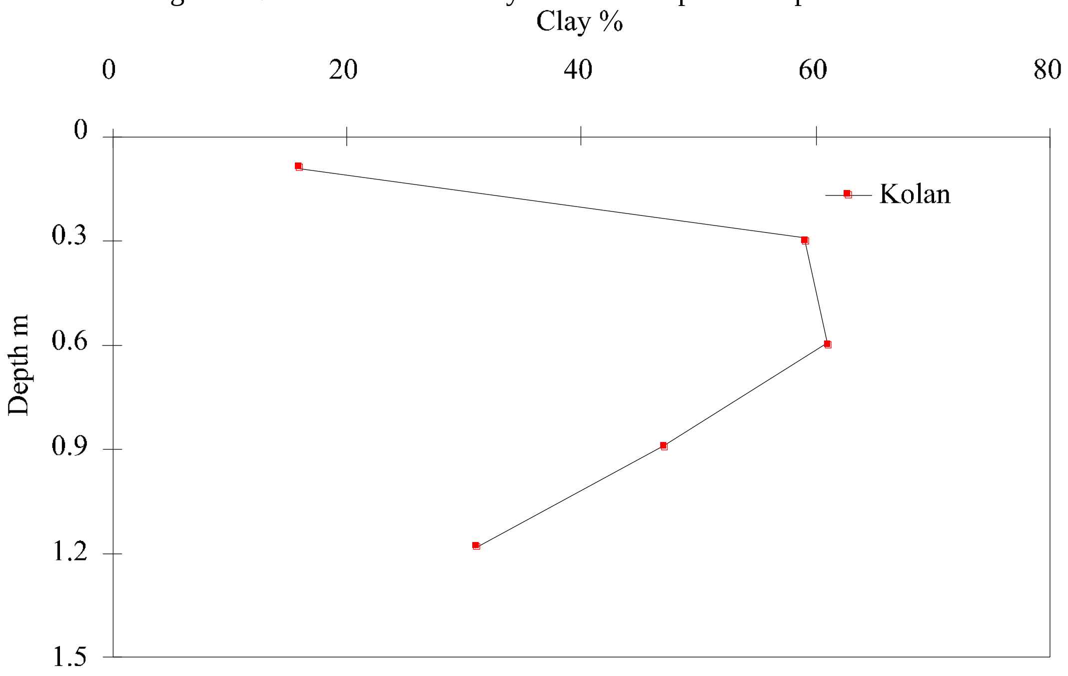


Figure 11. Mean clay content profile for the *Kolan* soil of the Kurosols

Soil chemistry

Soil pH.   Field pH in the surface of the *Kolan* soil ranges from 5.5 to 6 with subsoil pH ranging from 4.5 to 5.5. The *Avondale, Turpin* and *Woco* soils which have a minor component of Kurosols, generally have a pH range of 5 to 6.

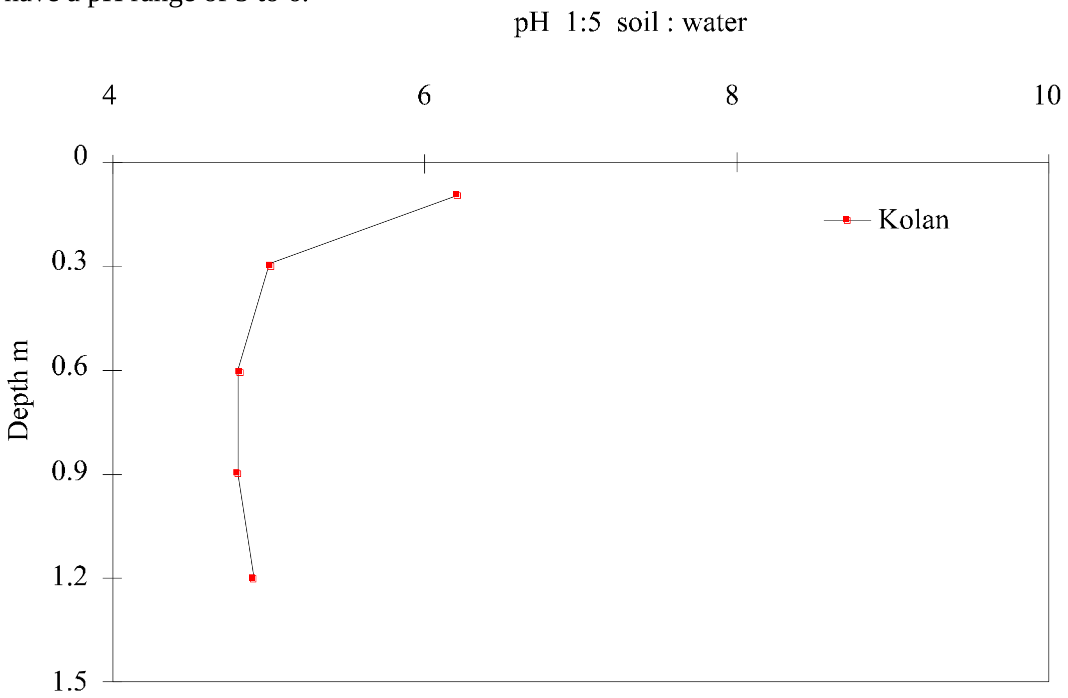


Figure 12. Mean pH (1:5) profile for the *Kolan* soil of the Kurosols

Salinity and Sodicity. The mean EC (1:5) and ESP (Exch Na/CEC x 100) profiles for the *Kolan* soil are shown in Figures 13 and 14 respectively. The salt bulge at 0.5 to 0.6 m corresponds to the soil becoming strongly sodic in the upper B horizons.

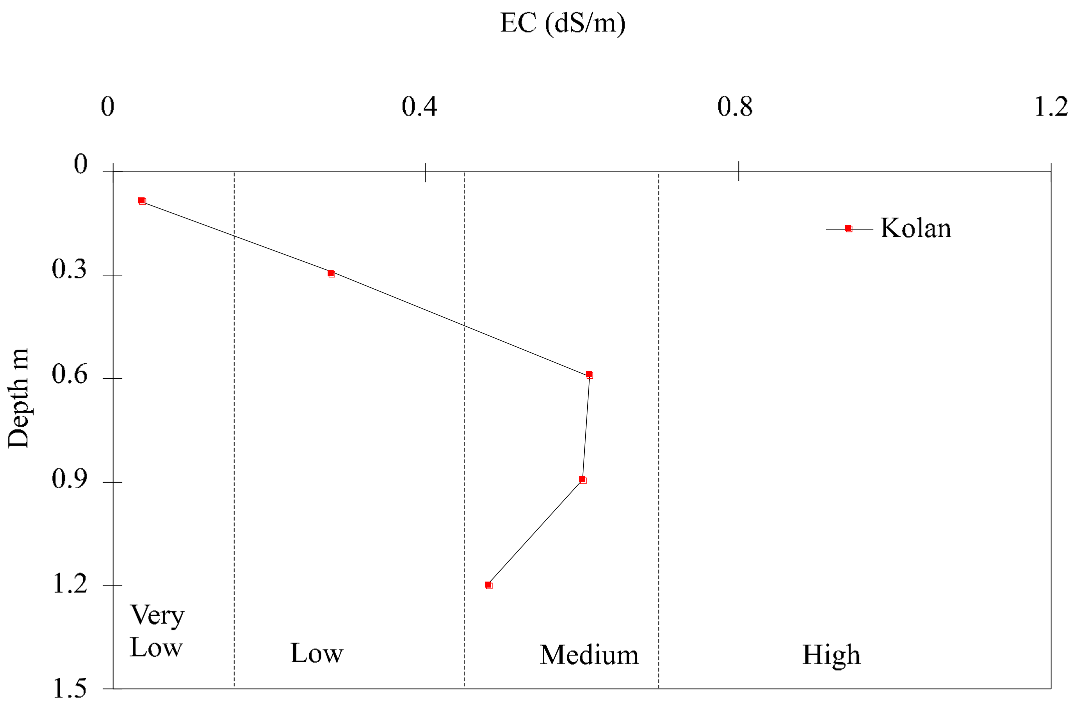


Figure 13. Mean EC (1:5) profile for the *Kolan* soil of the Kurosols

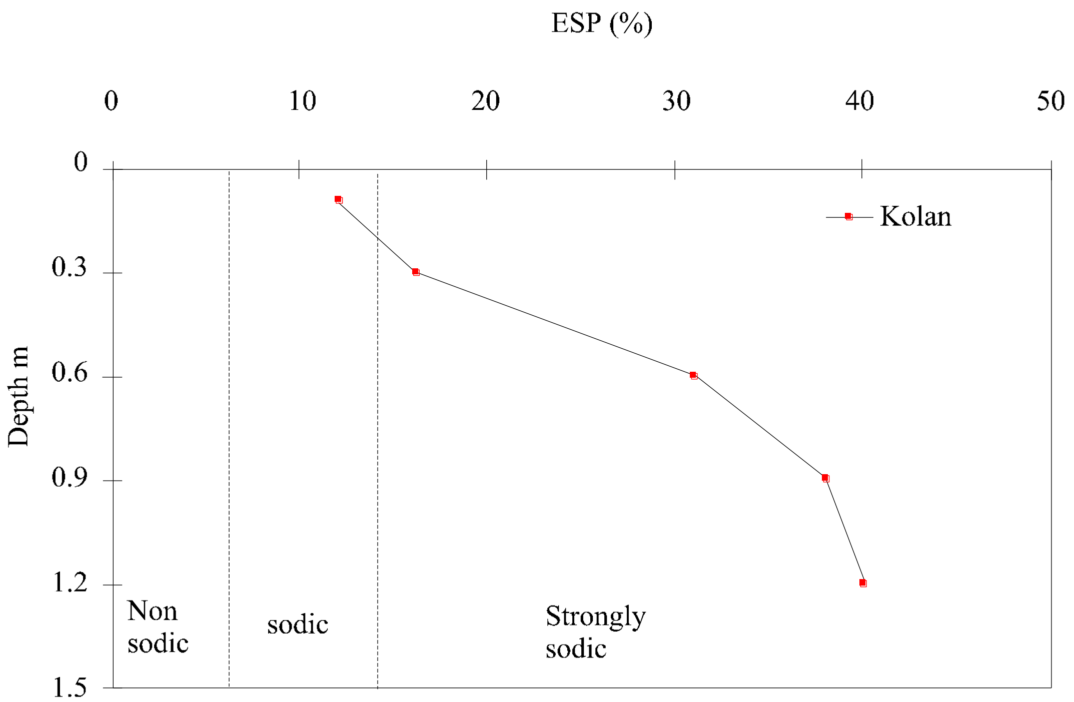


Figure 14. Mean ESP profile for the *Kolan* soil of the Kurosols

Effective Cation Exchange Capacity The ECEC increases to moderate levels of 18–18 meq/100g in the heavy clay subsoil. A clay activity ratio of approximately 30 meq/100g clay indicates a mixture of montmorillonite and kaolinite type clays. This clay activity ratio is considerably higher than the equivalent *Avondale* soil on the deeply weathered sedimentary rocks.

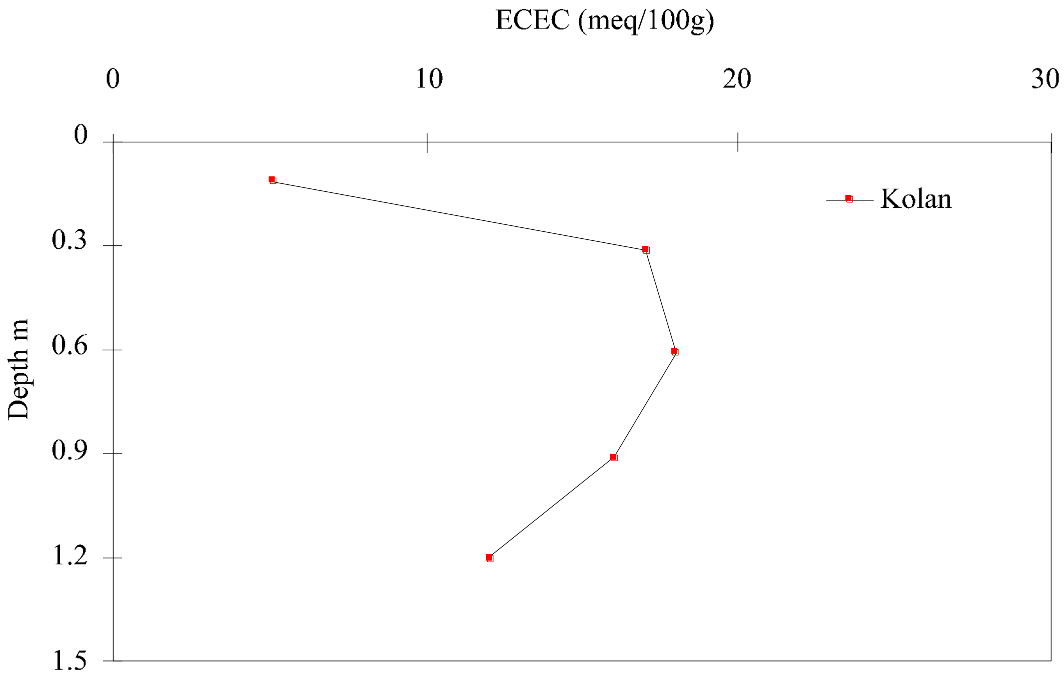


Figure 15. Mean effective cation exchange capacity (ECEC) profile for the *Kolan* soil of the Kurosols

Soil nutrients. Table 10 shows the nutrient levels for the *Kolan* soil. The medium levels of nutrients in the surface corresponds to surface accumulation of organic matter. This soil tends to have higher nutrient status than equivalent soils on the deeply weathered sedimentary rocks (for example, the *Avondale* soil) reflecting past bleaching environments. Calcium/magnesium ratios (Figure 16) indicate calcium accumulates at the surface with organic matter and a strong dominance of magnesium over calcium at depth.

Table 10. Mean profile soil nutrients for the *Kolan* soil of the Kurosols

	Depth (m)	**K meq/100g**	**Ca meq/100g**	**Acid P mg/kg**	**Bicarb P mg/kg**	**Organ. C %**	**Total N %**	**Zn mg/kg**
Kolan	0-0.1	0.22 (M)	2.2 (H)	-	2 (VL)	1.9 (M)	0.1 (M)	0.77 (M)
	0.2-0.3	0.16 (L)	0.3 (VL					
	0.5-0.6	0.15 (L)	0.11 (VL)					
	0.8-0.9	0.13 (L)	0.17 (VL)					
	1.1-1.2	0.13 (L)	0.27 (VL)					

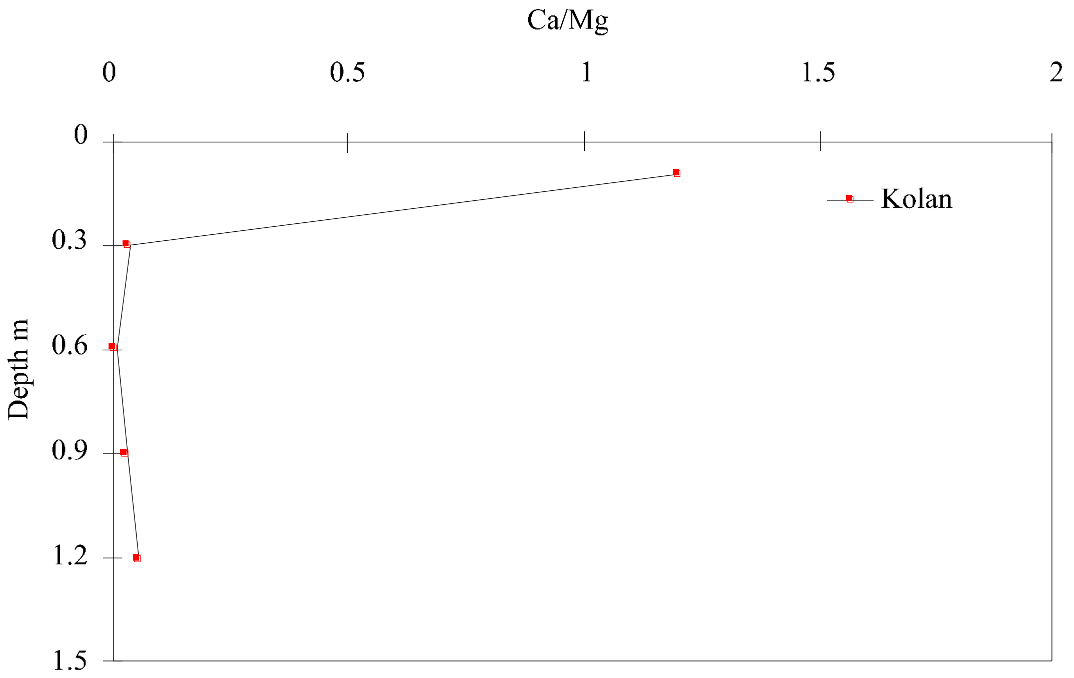


Figure 16. Mean profile calcium/magnesium ratios for the *Kolan* soil of the Kurosols

Plant Available Water Capacity (PAWC). The shallow rooting depth due to the strongly sodic, saline upper B Horizon results in a low PAWC (Table 11). The low nutrient status below the surface may further reduce rooting depth and PAWC.

Table 11. Estimated PAWC (mm) and rooting depth (m) for the *Kolan* soil of the Kurosols

Soil	Rooting Depth (m)	PAWC (mm)
Kolan	0.3-0.6	63-75

Sodosols

Sodosols are soils with a clear or abrupt textured B horizon which is sodic (ESP >6) in the major part of the upper 0.2 m of the B2 horizon and the pH is 5.5 or greater (Hydrosols are excluded).

Soils likely to possess a sodic B horizon may be indicated by the presence of a bleached A2 horizon abruptly changing to a clay B2 horizon with columnar or prismatic structure, a high pH (>8.5), the soapy nature of the clay when wet, and dispersion of the clay.

Nine sodosols have been recognised (Table 12) with soils formed on granitic rocks (*Gigoon, Doongul*), moderately weathered sedimentary rocks (*Tirroan, Givelda, Brooweena*), deeply weathered sedimentary rocks (*Turpin, Avondale*) and alluvial plains (*Auburn, Peep*). They occur extensively in the western part of the study area, occupying 123 132 ha or 50.4%.

The *Auburn* and *Peep* soils are similar in profile attributes except the *Auburn* soil occurs on the Burnett River alluvium which is derived from a broad range of rock types in the upper catchment, while the *Peep* soil occurs on alluvium derived from the rock types in local catchments. The soils occurring in association with *Auburn* or *Peep* are very different, for example, the *Auburn* soils frequently occur in association with a grey Vertosols (*Walla*), while dark or brown Dermosols (*Flagstone*) occur on lower terraces. The *Peep* soil may be associated with yellow, grey or red Kandosols/Tenosols (*Littabella*).

Table 12. Major attributes, classification and areas for soils of the Sodosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON GRANITES			
Gigoon	Black or grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.2 to 0.6m) over an acid to alkaline, mottled, brown or grey sandy clay to sandy medium heavy clay (0.5 to 1.2m) over weathered granite.	Brown Sodosol Grey Sodosol	26846
Doongul	Black or grey light sandy clay loam to clay loam sandy surface over a conspicuously bleached A2 horizon (0.1 to 0.25m) over a frequently mottled, grey or brown medium clay (0.2 to 0.85m) over weathered granite.	Grey Sodosol Brown Sodosol	4124
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Tirroan	Black or grey loamy sand, sandy loam to fine sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5m) over an acid, mottled, grey sandy medium clay (0.45 to 1.2m) over weathered rock.	Grey Sodosol	2579
Givelda	Black or grey loam fine sandy to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.3m) over an acid to neutral, mottled, brown or yellow medium clay to heavy clay (0.45 to 1.3m) over weathered rock.	Brown Sodosol Yellow Sodosol	1537
Brooweena	Black or grey fine sandy loam to clay loam surface over a conspicuously bleached A2 horizon (0.15 to 0.3m) over an acid to alkaline, mottled, brown or grey medium clay to heavy clay (0.3 to 0.75m) over weathered rock. Rock fragments throughout profile.	Brown Sodosol Grey Sodosol	49579
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Turpin	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5m) with ferruginous nodules over an acid, mottled, grey or brown medium clay to heavy clay (0.4 to 1.5m) over weathered rock.	Grey Sodosol Grey Kurosol Redoxic Hydrosol	5000
Avondale	Grey fine sandy loam to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.3m) with ferruginous nodules over an acid, mottled, grey or brown medium clay to heavy clay (0.35 to 1.5m) over weathered rock.	Grey Sodosol Grey Kurosol Redoxic Hydrosol	18087
Avondale rocky phase	As above with >20% rock fragments throughout the profile or rock within 0.3m of the surface.		2665

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL PLAINS OF THE BURNETT RIVER			
Auburn	Black or grey loam fine sandy, clay loam fine sandy to silty clay loam surface over a conspicuously bleached A2 horizon (0.15 to 0.4m) over an acid to alkaline, frequently mottled, grey or brown medium to heavy clay.	Brown Sodosol Grey Sodosol	2742
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
Peep	Black or grey find sandy loam to clay loam fine sandy and silty clay loam surface over a conspicuously bleached A2 horizon (0.15 to 0.45m) over an acid to alkaline, mottled, grey or brown medium clay.	Grey Sodosol Brown Sodosol Redoxic Hydrosol	9971

Landscape

The *Gigoon*, *Doongul*, *Tirroan*, *Givelda*, *Brooweena*, *Turpin* and *Avondale* soils occur on hillslopes or rises with *Gigoon* and *Brooweena* also occurring on low hills and hills. Slopes generally range from 1 to 10% on the rises and up to greater than 30% on the low hills and hills. The modal slope of all soils is 5 to 8%.

The *Avondale rocky phase* frequently occurs on the edges of breakaways where soils are steep (>15%) and shallow often with rock outcrops.

The *Auburn* and *Peep* soils occur on alluvial plains and terraces where slopes are generally less than 1%.

Vegetation

Dominated tree vegetation is related to soil type. The *Turpin*, *Avondale* and *Tirroan* soils have similar vegetation with trees dominated by stringybark (*E. umbra*) and rusty gum (*Angophora costata*) with scattered grey ironbark (*E. drepanophylla*), brown bloodwood (*E. trachyphloia*), pink bloodwood (*E. intermedia*) and paperbark (*Melaleuca* sp.).

The granite soils, *Gigoon* and *Doongul*, have different dominant vegetation. Narrow leaf ironbark (*E. crebra*) and lemon scented gum (*E citrodora*) are dominant on the *Gigoon* soil while *Doongul* is dominated by lemon scented gum and grey ironbark often with gum topped box.

The shallow gravelly *Brooweena* soil is often dominated by lemon scented gum mixed with a variety of other eucalypts.

Gum topped box is the dominant vegetation on the *Givelda* soil. Isolated pockets of vine scrub with emergent hoop pine are common.

The *Peep* and *Auburn* Sodosols on the alluvial plains are dominated by forest red gums (*E. teretocornis*) but is mostly cleared on the *Auburn* soil.

Soil profile

All the Sodosols have a black or grey sandy or loamy surface occur a conspicuous bleached A2 horizon changing abruptly or sharply or occasionally clearly to the clay subsoil (Figures 17a and 17b) usually with coarse angular blocky or prismatic structure.

The *Gigoon* and *Doongul* soils on granites are separated mainly on texture of surface horizons. *Gigoon* has a moderately thick (0.2 to 0.6 m) sandy surface while *Doongul* has a thin (0.1 to 0.25 m) loamy surface. Clay subsoils are usually mottled, brown or grey.

The *Tirroan* and *Givelda* soils on moderately weathered sedimentary rocks have a moderately thick (0.25 to 0.5 m) sandy surfaces and thin (0.15 to 0.3 m) loam surface respectively. *Tirroan* has a mottled, grey subsoil while *Givelda* has a mottled brown or yellow subsoil. The *Brooweena* soil has a thin (0.15 to 0.3 m) loamy surface over a gravelly, mottled, brown or grey or occasionally red subsoil. Subsoil colour in the *Brooweena* soil can vary greatly over short distances due to steeply deepening beds.

The *Turpin* and *Avondale* Sodosols on deeply weathered sedimentary rocks have been separated on surface attributes. *Turpin* has a thin to moderately thick (0.25 to 0.5 m) sandy surface while *Avondale* has a thin (0.15 to 0.3 m) loam surface. Both soils have mottled, grey or brown clay subsoils with magnetic iron nodules (maghemite) concentrated in the lower A2 and upper B2 horizons.

Auburn and *Peep* soils on alluvial plains have been separated on origin of parent material and occurrence of associated soils. Both soils have a thin to moderately thick (0.15 to 0.45 m) loamy surface over a frequently mottled, brown or grey clay subsoil. Manganiferous nodules usually occur and lime nodules may occur in strongly alkaline subsoils.

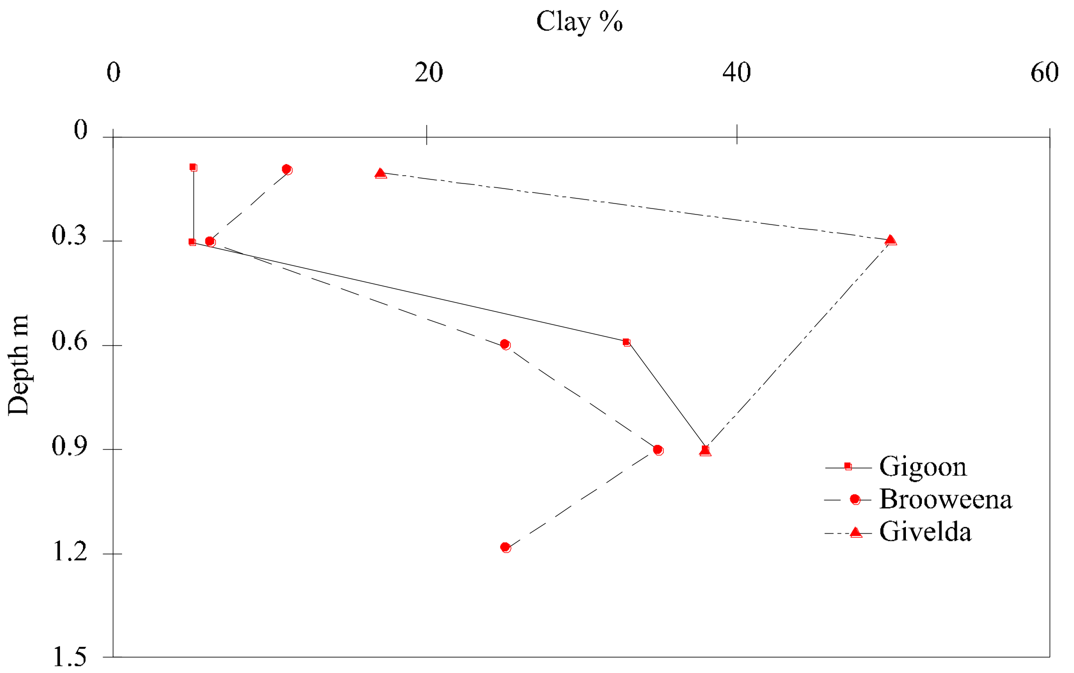


Figure 17a. Mean clay content profiles for the *Gigoon*, *Givelda* and *Broowena* soils of the Sodosols

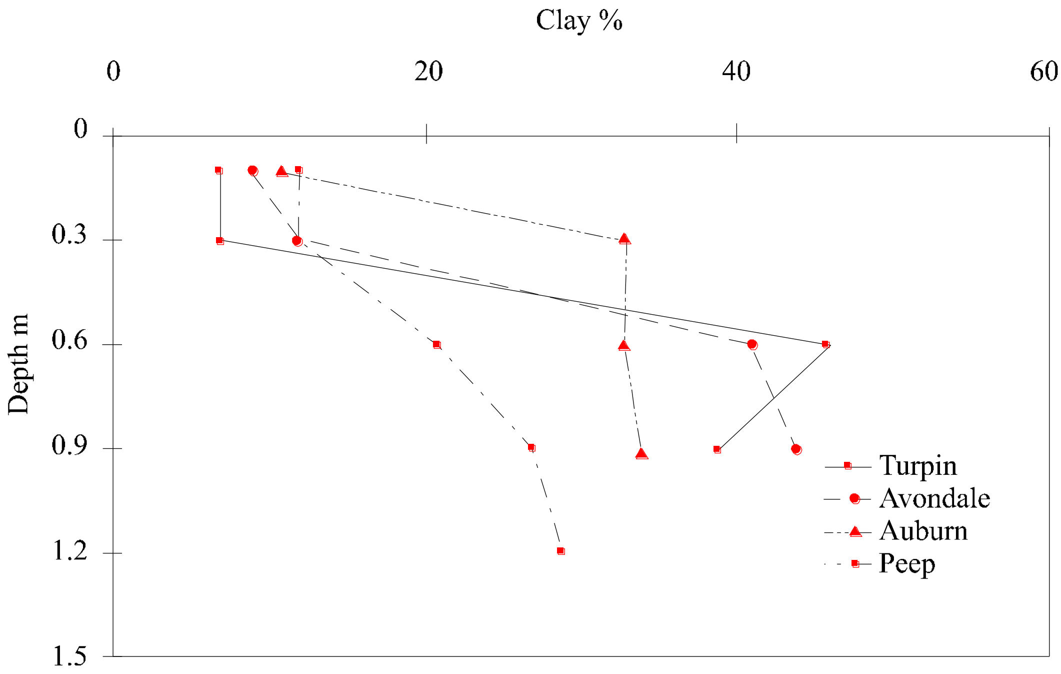


Figure 17b. Mean clay content profiles for the *Turpin*, *Avondale*, *Auburn* and *Peep* soils of the Sodosols

Soil chemistry

Soil pH. Profile pH generally reflects geology and geomorphology (Figures 18a and 18b). The *Turpin* and *Avondale* soils developed on deeply weathered sedimentary rocks consistently have lower pH than other Sodosols. Field pH of the subsoil range from 5.3 to 6.

The Sodosols on fresh rocks (*Gigoon, Givelda, Brooweena*) have variable subsoil pH generally ranging from 5.5 to 8 and occasionally 9. On average, these soils tend to the neutral range.

The Sodosols on alluvium (*Auburn, Peep*) also have variable pH reflecting the variability in parent material and deposition. *Auburn* has subsoil field pH ranging from 6 to 9.5 with neutral to alkaline pH (pH >7) predominating. Lime nodules are associated with the strongly alkaline (pH >8) subsoils. The *Peep* soil is more variable in pH reflecting the diverse local geology. Subsoil field pH ranges from 5.5 to 9 but predominates in the slightly acid to neutral range (pH 6-7.5).

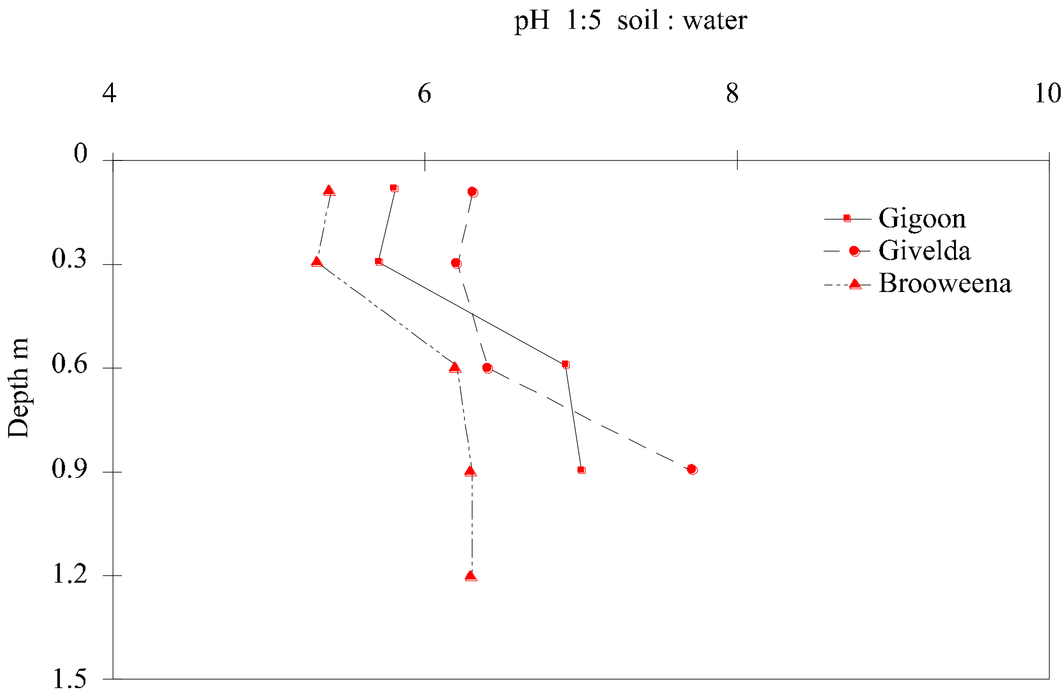


Figure 18a. Mean pH (1:5) profiles for the *Gigoon, Givelda* and *Broowena* soils of the Sodosols

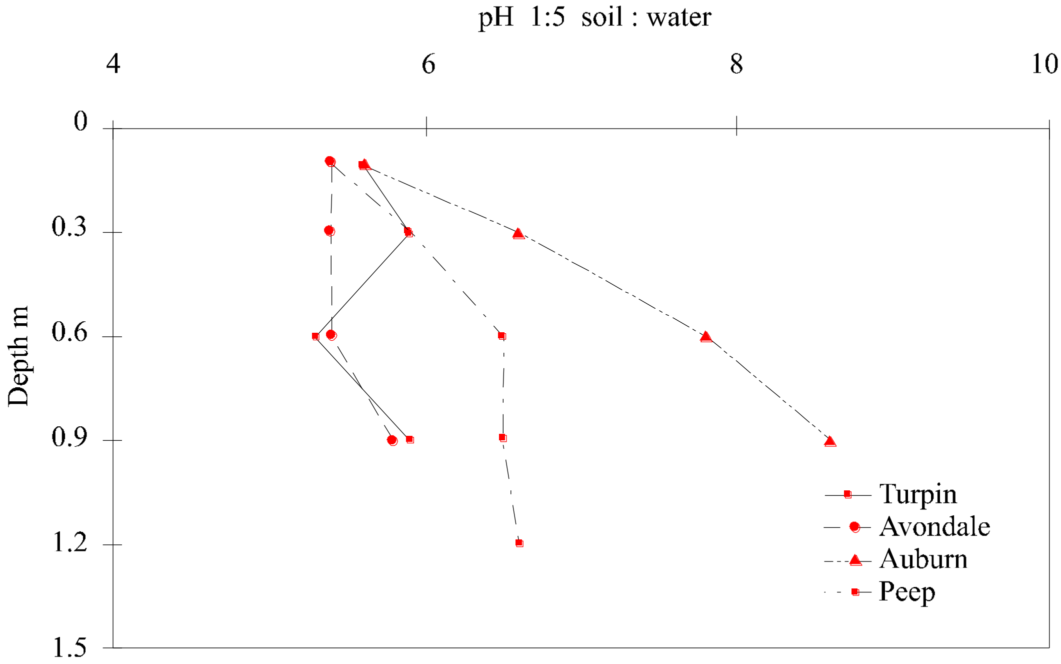


Figure 18b. Mean pH (1:5) profiles for the *Turpin, Avondale, Auburn* and *Peep* soils of the Sodosols

Salinity and sodicity. The marked increase in salt levels to medium to high levels in the subsoil correspond to the abrupt texture change and strongly sodic clays (Figures 19a and 19b). These elevated salt levels indicate impermeable subsoils. All Sodosols are strongly sodic in the upper B horizon. The high sodicity levels contribute to the slow permeability and salt accumulation in the profile. The peak in ESP cation corresponds to a peak in clay content (Figure 20).

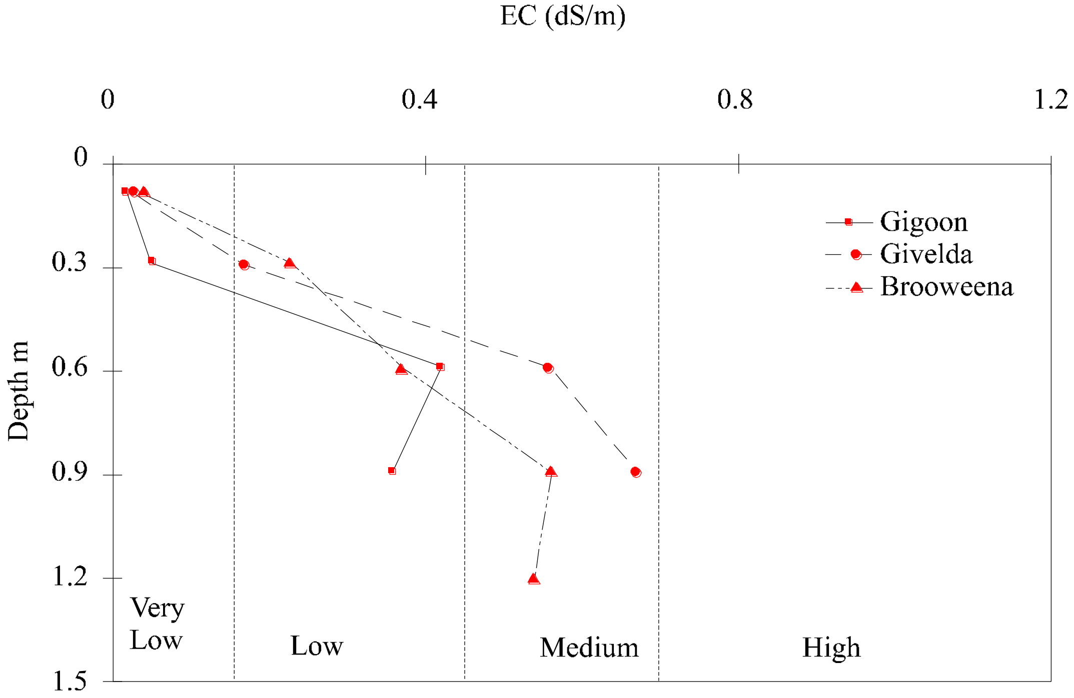


Figure 19a. Mean EC (1:5) profiles for the *Gigoon*, *Givelda* and *Broowena* soils of the Sodosols

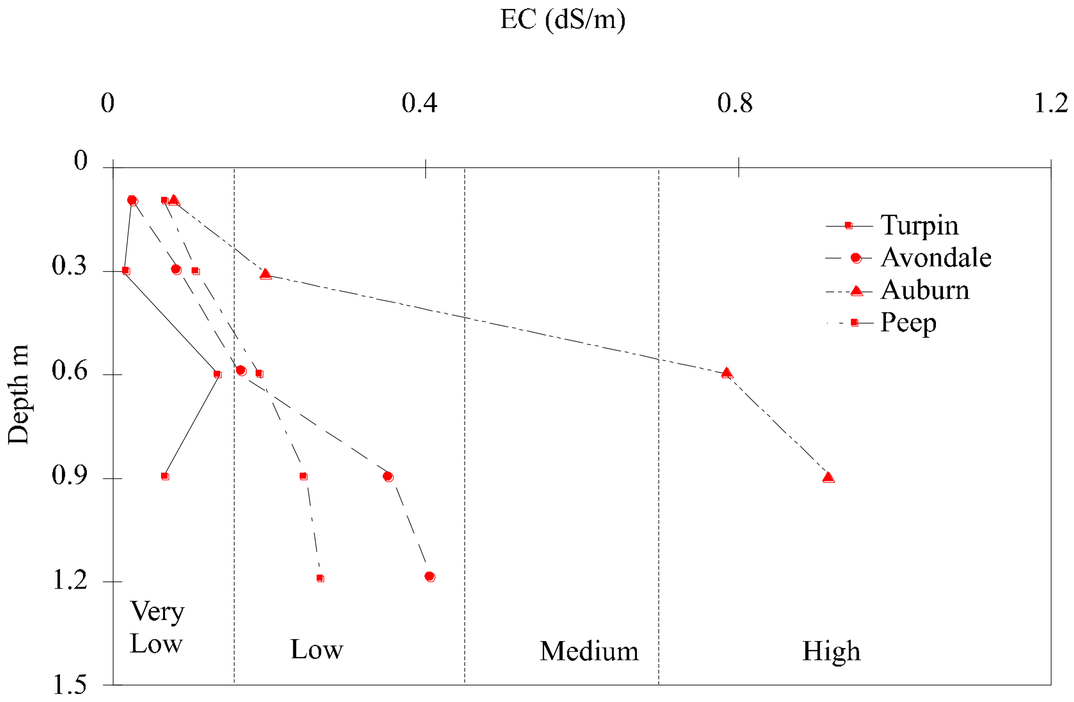


Figure 19b. Mean EC (1:5) profiles for the *Turpin*, *Avondale*, *Auburn* and *Peep* soils of the Sodosols

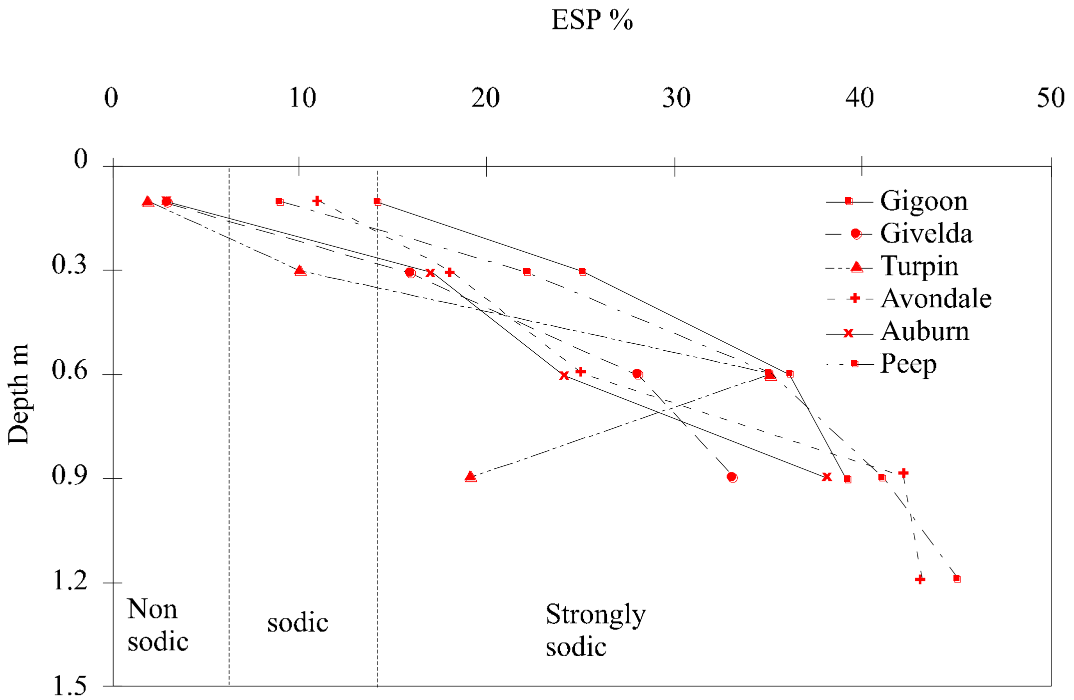


Figure 20. Mean ESP profiles for soils of the Sodosols

Cation Exchange Capacity

Cation exchange capacity of soils in the Sodosol group (Figure 21) strongly reflects clay content and clay minerology. A clay activity ratio of >0.4 meq/100g clay for the *Givelda*, *Gigoon*, *Auburn* and *Peep* soils indicates a contribution from montmorillonite and kaolinite type clays. The high CEC for the *Auburn* soil compared to *Peep* reflects a higher proportion of montmorillonite type clays contributed from the Upper Burnett River catchment. The lower clay activity ratio of 0.15 to 0.25 for the *Avondale* and *Turpin* soils indicates mainly kaolinite type clays developed on highly weathered sedimentary rocks.

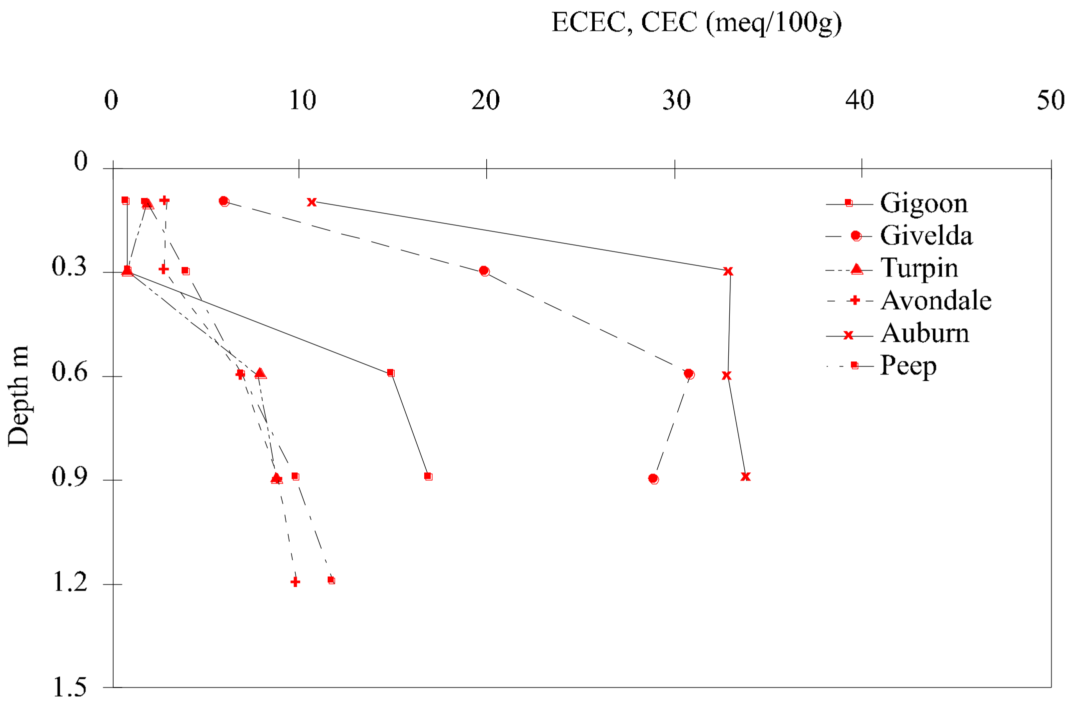


Figure 21. Mean effective cation exchange capacity (ECEC) and cation exchange capacity (CEC) profiles for soils of the Sodosols

Soil nutrients. Table 13 shows the mean nutrient levels of the Sodosols. Variability reflects geology, geomorphology and vegetation.

The low to very low nutrient levels in the *Gigoon, Turpin* and *Avondale* soils reflects the low levels of nutrients in the granitic rock and the highly leached deeply weathered sedimentary rocks. The sparse vegetation reflects the lower organic carbon and total nitrogen compared to other soils.

The *Givelda* soil developed on moderately weathered fresh sedimentary rocks is relatively more fertile for K, Ca and Zn than the *Turpin* and *Avondale* soils on the deeply weathered sedimentary rocks. The moderate nutrient levels of K, Ca, P and Zn in the *Auburn* soil is an indication of the generally more diverse rock types in the upper catchment compared to the low nutrients in the *Peep* soil which drains predominantly deeply weathered and moderately weathered sedimentary rocks. The *Auburn* soil occurring on upper terraces and plains of the Burnett River has lower nutrient levels than the younger soils, such as *Flagstone*.

The nutrient deficient soils generally show a marked surface accumulation of nutrients due to organic matter.

Calcium/magnesium ratios
Calcium/magnesium ratios show a strong calcium dominance in the surface associated with organic matter accumulation while clay subsoils are dominated by magnesium, particularly in the calcium deficient granites (Gigoon) and deeply weathered sedimentary rocks (Turpin, Avondale).

Table 13. Mean profile soil nutrients for soils of the Sodosols.

	Depth (M)	**K meq/100g**	**Ca meq/100g**	**Acid P mg/kg**	**Bicarb P mg/kg**	**Organ. C %**	**Total N %**	**Zn mg/kg**
Gigoon	0-0.1	0.11 (L)	0.64 (L)	-	3 (VL)	0.7 (L)	0.03(VL)	0.4 (L)
	0.2-0.3	0.05 (L)	0.13 (VL)					
	0.5-0.6	0.08 (L)	0.1 (VL)					
	0.8-0.9	0.11 (L)	0.1 (VL)					
Givelda	0-0.1	0.33 (M)	3.1 (H)	-	4 (VL)	1.8 (M)	0.1 (L)	1.6 (M)
	0.2-0.3	0.25 (M)	3.2 (H)					
	0.5-0.6	0.2 (M)	8.7 (H)					
	0.8-0.9	0.22 (M)	9.6 (H)					
Brooweena	0-0.1	-	-	4 (VL)	5 (VL)	1.3 (L)	0.09 (L)	1.1 (M)
Turpin	0-0.1	0.08 (L)	0.55 (L)	4 (VL)	2 (VL)	0.88 (L)	0.03(VL)	0.34 (L)
	0.2-0.3	0.02 (L)	0.08 (VL)					
	0.5-0.6	0.1 (L)	0.16 (VL)					
	0.8-0.9	0.08 (L)	0.08 (VL)					
Avondale	0-0.1	0.09 (L)	0.7 (L)	7 (VL)	3 (VL)	1.1 (L)	0.05 (L)	0.3 (L)
	0.2-0.3	0.05 (L)	0.4 (VL)					
	0.5-0.6	0.11 (L)	0.4 (VL)					
	0.8-0.9	0.12 (L)	0.5 (VL)					
Auburn	0-0.1	0.3 (M)	3.3 (H)	25 (M)	29 (M)	1.1 (L)	0.07 (L)	3.3 (M)
	0.2-0.3	0.32 (M)	2.5 (M)					
	0.5-0.6	0.16 (L)	3.1 (H)					
	0.8-0.9	0.26 (M)	3.4 (H)					
Peep	0-0.1	0.1 (L)	0.8 (L)	7 (VL)	3 (VL)	1.5 (L)	0.07 (L)	0.33 (L)
	0.2-0.3	0.04 (L)	0.14 (VL)					
	0.5-0.6	0.05 (L)	0.22 (L)					
	0.8-0.9	0.09 (L)	0.43 (L)					
	1.1-1.2	0.1 (L)	0.43 (L)					

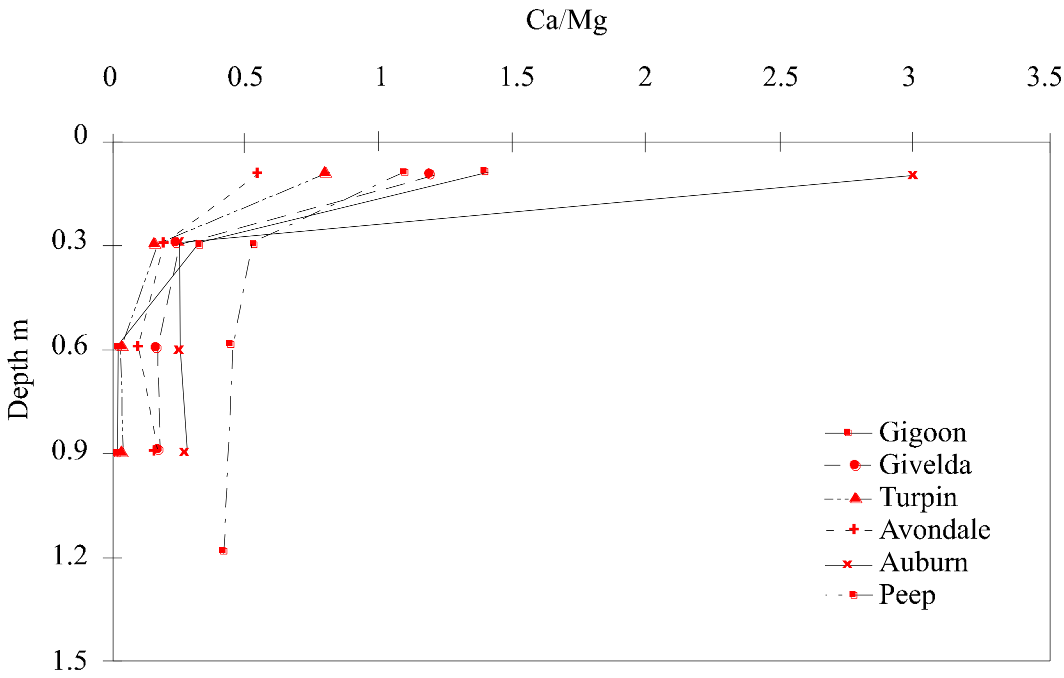


Figure 22. Mean profile calcium/magnesium ratios for soils of the Sodosols

Plant Available Water Capacity (PAWC). Table 14 shows the estimated PAWC and rooting depth for the Sodosols. PAWC reflects mainly surface texture depth of surface horizons and rooting depth. The sandy surfaced Sodosols, such as *Gigoon* and *Turpin*, have lower PAWC. The rooting depth is indicated by a salt bulge and highly sodic subsoils. The low nutrient status below the surface in the *Gigoon, Turpin, Avondale* and *Peep* soils may reduce rooting depth further than indicated in Table 14.

Table 14. Estimated PAWC (mm) and rooting depth (m) for soils of the Sodosols

Soil	Rooting Depth (m)	PAWC (mm)
Gigoon	0.3 - 0.6	37 - 55
Doongul	0.3 - 0.6	40 - 65
Tirroan	0.4 - 0.6	<50
Givelda	0.4 - 0.6	75 - 87
Brooweena	0.3 - 0.6	<50
Turpin	0.4 - 0.6	37 - 53
Avondale	0.4 - 0.6	43 - 55
Auburn	0.4 -0.9	50 - 85
Peep	0.4 - 0.8	42 - 62

Chromosols

Chromosols are soils with a clear or abrupt textural B horizon which is both non-sodic (ESP <6) and not strongly acid (pH >5.5) in the major part of the upper B2 horizon. Soils which are wet for extended periods (Hydrosols) are excluded.

Three soils (Table 15) have been mapped, the *Booyal* soil occurring on granodiorite, the *Tirroan non-sodic variant* occurring on upper slopes of moderately weathered sedimentary rocks (always associated with the *Tirroan* Sodosol), and the *Boyne* soil on alluvial plains of the Burnett River (always associated with the *Auburn* Sodosol). Dermosols are a minor association of the Chromosols. These minor soils occupy 1256 ha or 0.5% of the study area. The *Tirroan non-sodic variant* is very minor with profile attributes similar to the *Tirroan* Sodosol except the upper part of the clay subsoil is non-sodic.

Table 15. Major attributes, classification and areas for soils of the Chromosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON GRANITES			
Booyal	Black loam to clay loam surface (0.08 to 0.15m) over an acid to neutral, red or brown medium clay (0.4 to 0.6m) over weathered granodiorite.	Red Chromosol Red Dermosol Brown Chromosol Brown Dermosol	907
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Tirroan non sodic variant	Black or grey loamy sand, sandy loam to fine sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5m) over an acid, mottled, brown or yellow sandy clay to medium clay (0.45 to 1.2m) over weathered rock.	Brown Chromosol Yellow Chromosol	255
ALLUVIAL PLAINS OF THE BURNETT RIVER			
Boyne	Brown or grey loamy sand to clay loam fine sandy surface (0.35 to 0.45m) over an acid to neutral, red or brown light clay to medium clay.	Red Chromosol Red Dermosol Brown Chromosol	94

Landscape

The *Booyal* and *Tirroan non-sodic variant* soils occur on hillslopes of rises, low hills and hills. The *Boyne* soils occurs as slightly elevated areas on alluvial plains.

Vegetation

The vegetation on these soils is mostly cleared with minor remnants of narrow leaf ironbark (*E. crebra*), Moreton Bay ash (*E. tessellaris*) and gum topped bloodwood (*E. erythrophoia*) on the *Booyal* soil. The *Tirroan non-sodic variant* has vegetation similar to the *Tirroan* Sodosols.

Soil profile

Each soil has an abrupt to gradual textural change from a sandy to loamy surface to a structured clay subsoil (Figure 20).

The *Booyal* soil on granodiorite is characterised by a black loam to clay loam surface over a red or brown angular blocky clay. Soils are usually moderately deep (0.5 – 0.7m) over weathered rocks, indicated by a sharp decrease in clay content at 0.9m (Figure 21).

The *Tirroan non-sodic variant* on moderately weathered sandstones has profile attributes similar to the *Tirroan* Sodosol except the non-sodic clay subsoil is generally brown or yellow. *Boyne* has a sandy to loamy surface over a red angular blocky clay subsoil. An A2 horizon may occur usually in association with a mottled or brown subsoil.

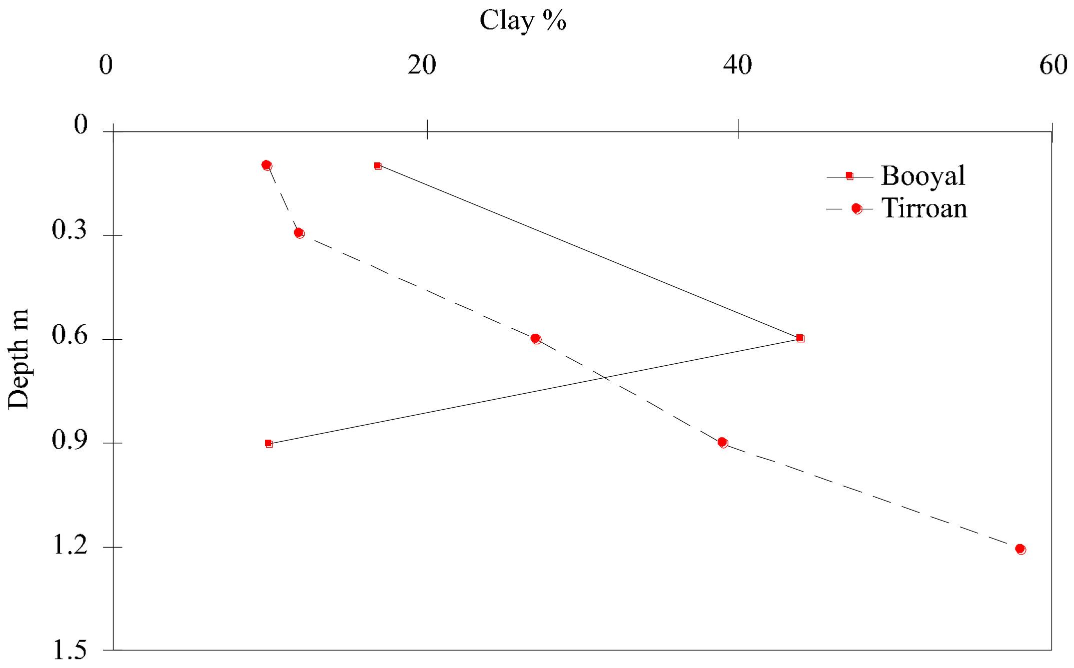


Figure 23. Mean clay content profiles for the *Booyal* and *Tirroan non-sodic variant* soils of the Chromosols

Soil chemistry

Soil pH. Field pH for the *Booyal* soil range from 6 to 6.7 in the surface to 6 to 7.5 in the subsoil while the *Boyne* soil has a surface field pH of 5.8 to 7 and a subsoil pH of 5.8 to 7, occasionally increasing to 8.5 at depth. The *Tirroan non-sodic variant* has field pH similar to the *Tirroan* Sodosol.

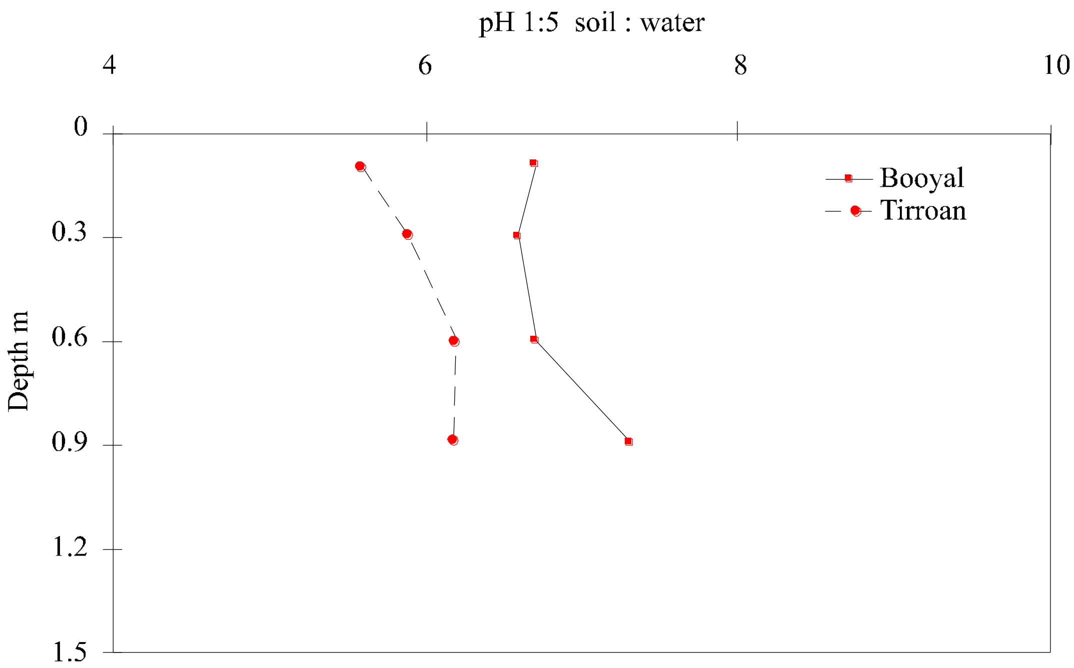


Figure 24. Mean pH (1:5) profiles for the *Booyal* and *Tirroan non-sodic variant* soils of the Chromosols

Salinity and sodicity. The *Booyal* and *Tirroan non-sodic variant* are non-saline and non-sodic throughout the profile. Analysis of the Boyne soil in the Mundubbera-Gayndah area indicates that this soil is also non-saline and non-sodic throughout the profile.

Cation Exchange Capacity. The cation exchange capacity of 21 – 22 meq/100g and 3 – 4 meq/100g in the subsoils of *Booyal* and *Tirroan* soils respectively strongly reflects clay minerology, even though both soils have similar clay content in the subsoils. The *Booyan* soil has a clay activity ratio of 50 meq/100g clay reflecting a high proportion of montimorillonite type clays. The *Tirroan non-sodic variant* soil has a clay activity ratio of <20 meq/100g indicating a dominance of Kaolinite type clays.

Soil nutrients. The nutrient levels of the *Booyal* and *Tirroan non-sodic variant* soils are shown in Table 16. The *Booyal* soil has moderate potassium and high calcium. The *Tirroan non-sodic variant* generally has low levels of all nutrients.

Table 16. Mean profile soil nutrients for soils of the Chromosols

	Depth (M)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Booyal	0-0.1	-	-	-	-	1.3 (L)	-	-
	0.2-0.3	-	-					
	0.5-0.6	0.12 (M)	13 (H)					
	0.8-0.9	0.16 (L)	14 (H)					
Tirroan	0-0.1	0.29 (M)	1.5 (L)	9 (VL) 40*(H)	11 (L) 31*(M)	1.6 (M)	0.1 (M)	0.5 (L)
	0.2-0.3	0.07 (L)	1.3 (L)					
	0.5-0.6	0.07 (L)	0.8 (L)					
	0.8-0.9	0.04 (L)	0.34 (VL)					
	1.1-1.2	0.05 (L)	0.23 (VL)					

* Sampled from cultivated soils

Calcium/magnesium ratios indicate a strong dominance of magnesium in the subsoil of the *Tirroan* soil reflecting similar trends in other weathered soils in the survey area. The *Booyan* soil developed on fresh granodiorite is calcium dominant.

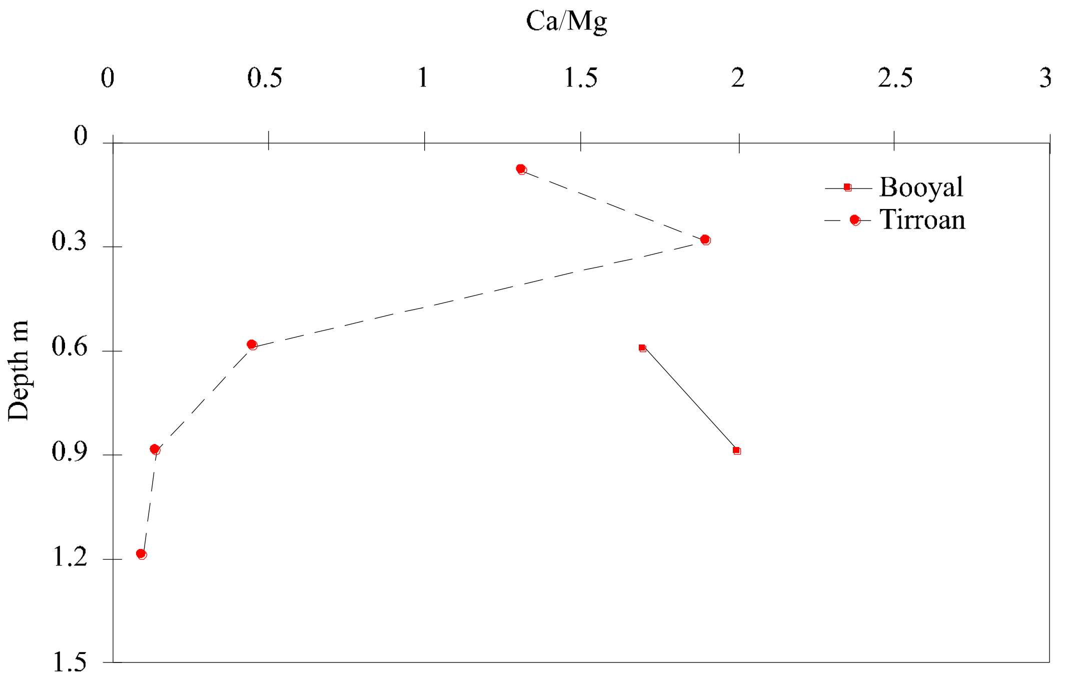


Figure 25. Mean profile calcium/magnesium ratios for soils of the Chromosols

Plant Available Water Capacity (PAWC). Estimated rooting depth for the *Booyal* and *Tirroan non-sodic variant* soil is 0.6 to 1 m depending on depth to rock. The *Boyne* soil would have a rooting depth of >1 m. Estimated PAWC's are not available. However, the *Booyal*, *Tirroan non-sodic variant* and *Boyne* soils would be expected to have a PAWC of 75-100 mm, 50-75 mm and 100-125 mm respectively.

Ferrosols

Ferrosols are soils with structured B horizons which are high in free iron oxide and which lack strong texture contrast between the A and B horizons. These soils are almost entirely formed on either basic or ultra basic igneous rocks, their metamorphic equivalents or alluvium derived therefrom.

In the study area, two Ferrosols (Table 17) are derived from deeply weathered (laterised) basalt in the Childers area and minor areas south of Gin Gin. Most of the basalt has weathered to the *Childers* Ferrosol which overlies a wide range of geological formations. The *Chin* soil has fine quartz gravel thoughout the profile indicating that it has formed from a mixture of deeply weathered basalt and sandstones of the Elliott Formation.

Ferrosols occupy 9396 ha or 3.8% of the study area and are highly productive agricultural soils.

Table 17. Major attributes, classification and areas for soils of the Ferrosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON BASALTS			
Childers	Red light clay surface over an acid, red light clay to medium clay.	Red Ferrosol	7904
HILLSLOPES ON DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS			
Chin	Red or brown clay loam to light clay surface over an acid to neutral, red clay loam to light clay. Fine rounded quartz gravel throughout the profile.	Red Ferrosol	1492

Landscape

Both soils occur as hillslopes and crests of rises, low hills and hills with slopes up to 30%.

Vegetation

All vegetation has been cleared with only very minor remnants of vinescrub or pink bloodwood (*E.intermedia*) woodlands along road reserves.

Soil profile

The *Childers* soil has a red structured clay throughout the profile (Figure 24) while the *Chin* soil has a structured clay loams to clay profile. Subsoils are subplastic.

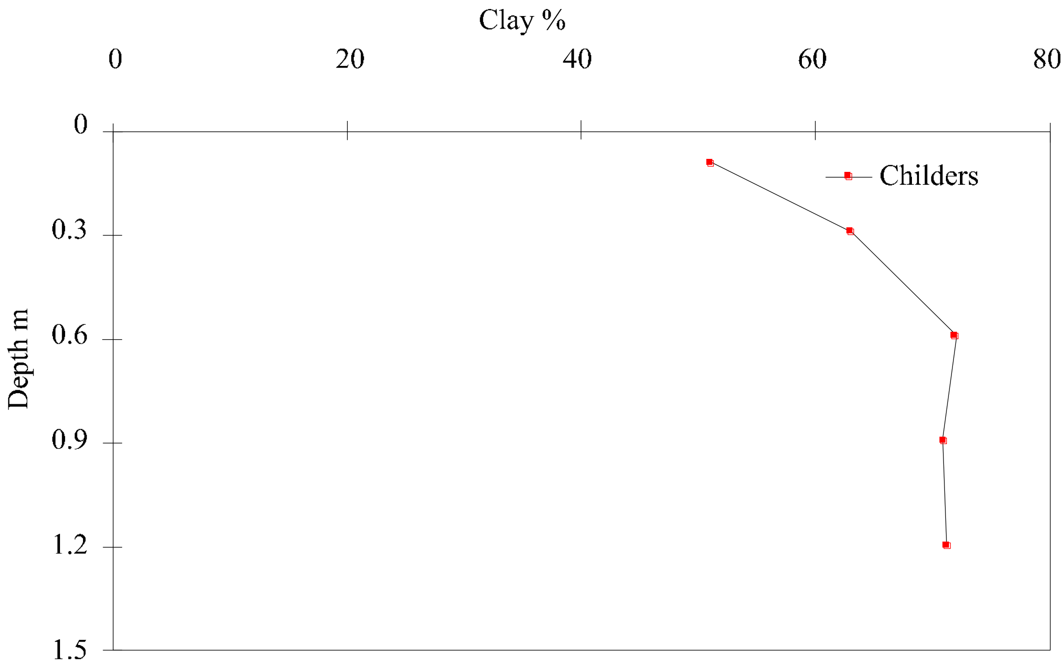


Figure 26. Mean clay content profiles for the *Childers* soil of the Ferrosols.

Soil chemistry

Soil pH. Surface pH ranges from 4.5 to 6.9 while subsoil values range from 4.3 to 6.0. In the field, pH can vary dramatically from area to area possible indicating past management practices such as fertiliser use.

A linear relation exists between pH in the subsoil of the *Childers* soil and effective cation exchange capacity (Figure 26). This indicates the presence of variable charge clays in these highly weathered soils. Gillman (1983, 1984) showed that the negative charge, which is responsible for cation retention, is dependent on soil pH in acidic soils with variable change. If pH becomes too acidic, the soil's ability to retain cations is reduced. In such soils dominated with variable charge, management must aim to raise soil pH by liming. The increase in pH obtained increases the negative charge on the soil surface for retention of cation against leaching.

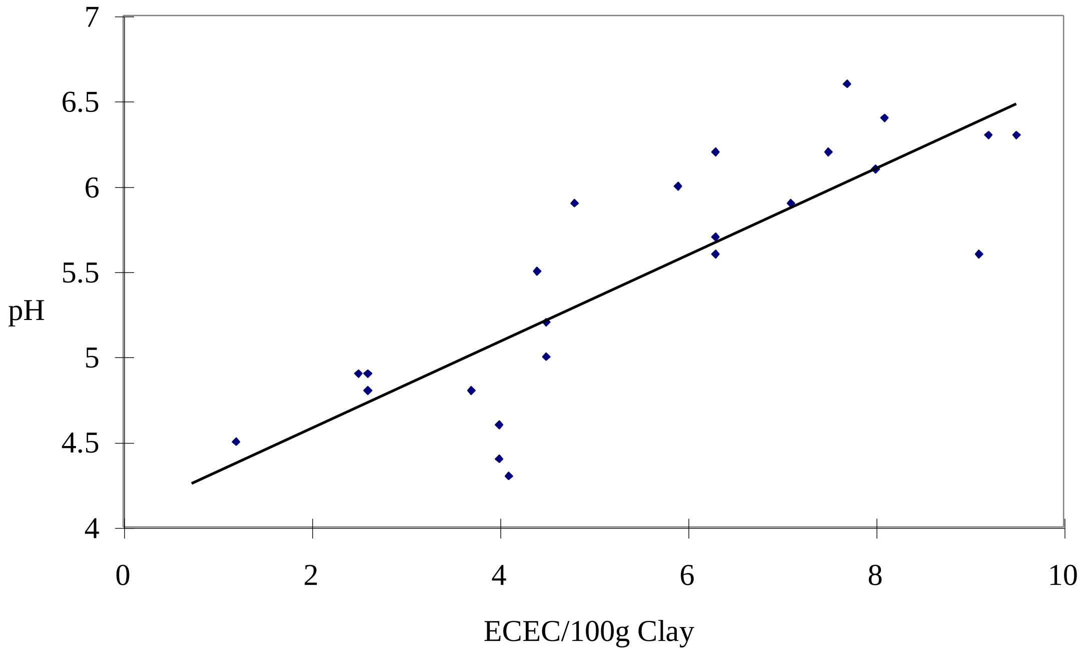


Figure 27. Changes in Clay Activity Ratio (ECEC meq/100 g clay) with pH for the *Childers* soil

Salinity and sodicity. The *Childers* soil has very low salinity (mean EC < 0.08 throughout the profile) and very low sodicity (mean ESP <4 throughout the profile) indicating high profile permeability.

Soil nutrients. The *Childers* soil has high to medium nutrient levels in all nutrients in the surface (Table 18) resulting from long term cultivation. In one undisturbed sample site, acid P and bicarbonate P levels are very low and in nearly all sites, exchangeable K levels at depth are very low. Mean calcium/magnesium ratios for the whole profile is above 2. Calcium dominance or co-dominance is typical of all well drained soils in the study area.

Table 18. Mean profile soil nutrients for the *Childers* soil of the Ferrosols

	Depth (M)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Childers	0-0.1	0.56 (M)	4.2(H)	5(VL) 50*(H)	6(VL) 41*(H)	2.4(M)	0.17(M)	2.8(M)
	0.2-0.3	0.2(M)	2.4(M)					
	0.5-0.6	0.15(L)	2(M)					
	0.8-0.9	0.09(L)	2(M)					
	1.1-1.2	0.07(L)	1.7(L)					

* Sampled from cultivated sites.

Plant available water capacity. Estimated rooting depth and PAWC for the *Childers* soil are shown in Table 19. The *Chin* soil would be expected to have a similar PAWC to the *Childers* soil.

Table 19. Estimated PAWC (mm) and rooting depth (m) for soils of the Ferrosols

Soil	Rooting depth (m)	PAWC (mm)
Childers	>1m	122-160
Chin	>1m	>120

Dermosols

Dermosols are soils with structured B horizons and lack a strong texture contrast between the A and B horizons. Vertosols, Hydrosols and Ferrosols are excluded.

In the study area a diverse range of 15 soils are included in this soil order (Table 20). They include soils formed on basalt, andesite and metamorphosed equivalents, deeply weathered sedimentary rocks, and alluvium associated with the Burnett River and local creeks.

This group of soils occupy 21 400 ha or 8.8% of the study area and represent the main group of soils under cultivation for sugar cane and horticulture.

The soils derived from the basic and intermediate rocks have structured loamy to clayey surfaces. They generally occur as minor soils on basalts around Childers and Gin Gin and on the Permian metamorphic and basaltic formations south of Gin Gin. The Dermosols on sedimentary rocks have sandy to loamy surfaces and occur over a wide area. The Dermosols on alluvium are generally restricted to narrow areas along the river or small localised areas.

Table 20. Major attributes, classification and areas for soils of the Dermosols.

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON BASALTS			
Doolbi	Black or brown clay loam to light clay surface over an acid to neutral, mottled, brown or yellow light clay to medium clay with manganiferous/ferromanganiferous nodules.	Brown Dermosol Yellow Dermosol	1074
Berren	Black or brown light clay surface over a neutral, brown light clay to medium clay, >20% basalt fragments throughout the profile.	Brown Dermosol	472
Kowbi	Black light clay to medium clay surface over a neutral, brown medium clay to heavy clay (0.4 to 0.5m) over weathered basalt.	Brown Dermosol	181
Corfield	Black or brown clay loam to light clay surface over a brown or red light clay to medium clay (0.35 to 0.6m) over weathered metabasalts.	Brown Dermosol Red Dermosol	2885
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS			
Gooburrum	Brown or black loamy sand to sandy clay loam surface over an acid to neutral, red clay loam to light clay.	Red Dermosol	2036
Isis	Grey sandy loam surface over a conspicuously bleached A2 horizon (0.3 to 0.7m) over an acid, mottled, yellow light clay to medium clay.	Yellow Dermosol	2046
Meadowvale	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.6m) gradually changing to a mottled, massive, yellow or brown sandy clay loam to sandy clay gradually changing to an acid, mottled, structured, yellow or brown light clay to medium clay.	Yellow Dermosol Brown Dermosol	3457
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FIND GRAINED SEDIMENTARY ROCKS.			
Watalgan	Black or brown clay loam surface over an acid, red light clay to medium clay with ferruginous nodules.	Red Dermosol	1014
Kepnock	Grey or black loam fine sandy to clay loam surface over a bleached A2 horizon (0.3 to 0.4m) over an acid, mottled, yellow light clay to medium clay with ferruginous nodules.	Yellow Dermosol	2020
Woolmer	Grey fine sandy loam to loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.35m) gradually changing to a mottled, massive, yellow or brown sandy clay loam to clay loam fine sandy gradually changing to an acid, mottled, structured, yellow or brown light clay to medium clay with ferruginous nodules.	Yellow Dermosol Brown Dermosol	2237

Botherm	Black clay loam surface over a conspicuously bleached A2 horizon (0.35m) over an acid, mottled, grey or brown light clay (0.85 to 1m) over weathered rhyolite.	Grey Dermosol Brown Dermosol	229
Woco	Grey or black loam fine sandy to clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.4m) over a strongly acid, mottled, sodic, grey or brown light clay to medium clay with ferruginous nodules.	Grey Dermosol Brown Dermosol Grey Kurosol Brown Kurosol	392
Bungadoo-Takoko Complex	A complex of Bungadoo (Dermosol) and Takoko (Tenosol) soils.		1798
Bungadoo	Black or grey clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.55m) over a strongly acid, mottled, brown, grey or yellow medium clay (0.75 to 0.9m) over weathered silicified rock, >20% silicified rock fragments throughout the profile.	Brown Dermosol Yellow Dermosol	See Bg-Tk
ALLUVIAL PLAINS OF THE BURNETT RIVER			
Flagstone	Black clay loam fine sandy to light clay surface over an acid to neutral, brown or black clay loam fine sandy to light clay (0.9+m) frequently over sandy D horizons.	Brown Dermosol Black Dermosol	1217
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
Drinan	Grey or black loam fine sandy to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.45m) with >10% manganiferous nodules over an acid, mottled, yellow, grey or brown light clay with manganiferous nodules.	Grey Dermosol Brown Dermosol Redoxic Hydrosol	342

Landscape

The *Doolbi, Berren, Kowbi* and *Corfield* Dermosols on basalts occur as hillslopes on rises, low hills and hills with slopes up to 30%.

Gooburrum, Watalgan and *Woolmer* soils on the deeply weathered sedimentary rocks generally occur as hill crests on rises and low hills or slightly elevated areas on level plains. The remaining Dermosols on sedimentary rocks, except *Botherm* and *Bungadoo,* generally occur as hillslopes on gently undulating rises with slopes generally < 8% or level plains. *Botherm* occurs as hillslopes on a rhyolitic low hill north of Childers while *Bungadoo* only occurs on the crests and hill slopes of the silicified Maryborough Formation ridge running north west-south east through the study area. Slopes are up to 20% with steeper slopes occurring on the western side of the ridge opposing the general easterly dip of the formation.

Vegetation

Vegetation is variable, generally corresponding to soil wetness and geology. A majority of the Dermosol soils have been cleared for agricultural uses and it is only the *Botherm, Woco* and *Bungadoo* soils which remain largely uncleared.

The very rocky soils of *Botherm* and *Bungadoo* generally have tall lemon scented gum (*Eucalyptus citriodora*) with other scattered eucalypts and a dense understory of brushbox (*Lophostemon confertus*). The *Woco* soil is of limited extent with stringy bark (*E. umbra*) and scattered bloodwood (*E. intermedia*) and tea tree *(Melaleuca viridiflora*).

The very rocky soils of *Botherm* and *Bangadoo* generally have tall lemon scented gum (*Eucalyptus citriodora*) with other scattered eucalyptus and a dense understory of brushbox (*Lophostemon confertus*). The Woco soil is of limited extent with stringy bark (*E. umbra*) and scattered bloodwood (*E. intermedia*) and tea tree (*Melaleuca viridiflora*).

Soil profile

The Dermosols formed on basaltic rocks generally have a black or brown clay loam to light clay surface gradually changing to a brown clay subsoil (*Berren*, *Kowbi*, *Corfield*) or mottled yellow clay subsoil (*Doolbi (*Figures 28a and 28b)). The darker subsoils generally indicate a predominance of swelling type clays (smectite clays) and usually have sub-angular blocky structure. The *Doolbi* soil is dominated by kaolin type clays with polyhedral structure. Manganiferous nodules in the *Doolbi* soil indicate a seasonally fluctuating watertable.

The Dermosols on the deeply weathered sedimentary rocks give rise to the most diverse range of soils with subsoil colours ranging from red to yellow to grey.

The well drained red *Gooburrum* and *Watalgan* soils grade into the moderately well drained yellow *Meadowvale* and *Woolmer* soils which grade into the imperfectly drained yellow *Isis* and *Kepnock* soils. These latter two soils usually grade into the *Woco* soil, Hydrosols or Sodosols on lower slopes. The increase in soil wetness corresponds to paler subsoil colours, bleached A2 horizons and greater numbers of ferruginous nodules.

The rocky *Bungadoo* and *Botherm* Dermosols have a clay loam surface over a conspicuously bleached A2 horizon gradually changing to a mottled, brown, yellow or grey clay subsoil.

The *Flagstone* Dermosols on alluvial plains of the Burnett River is a well drained, black or brown clay loam to clay soil.

The *Drinan* Dermosols on the alluvial plains of local creeks and rivers south of Gin Gin has a loamy surface over a conspicuously bleached A2 horizons over a mottled, grey or brown clay subsoil. Manganiferous nodules occur throughout the profile with a concentration in the lower A and upper B horizons. The nodules may be cemented to form a pan in localised areas.

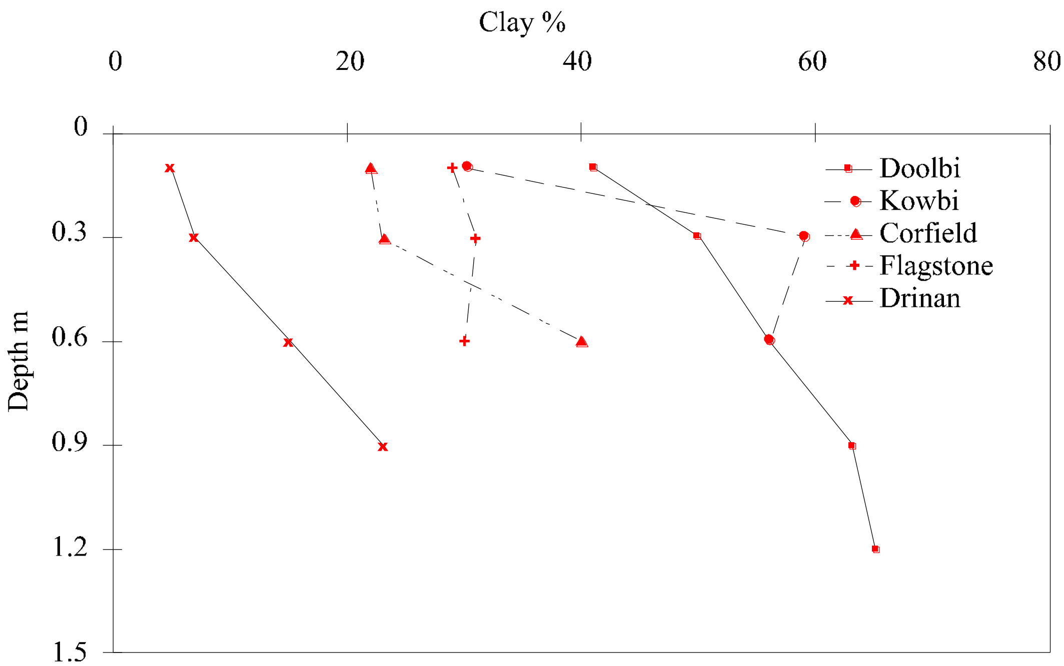


Figure 28a. Mean clay content profiles for the *Doolbi, Kowbi, Corfield, Flagstone* and *Drinan* soils of the Dermosols

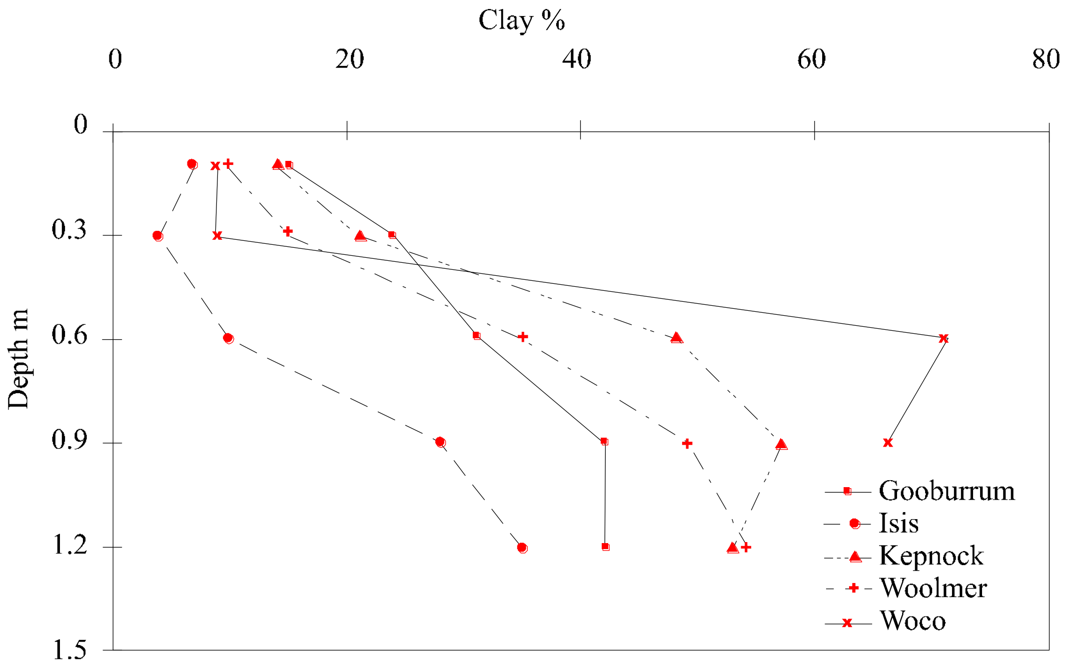


Figure 28b. Mean clay content profiles for the *Gooburrum, Isis, Kepnock, Woolmer* and *Woco* soils of the Dermosols

Soil chemistry

Soil pH. Soil pH is strongly related to parent material and leaching environment (Figures 29a and 29b). For the soils developed on basalt and metamorphic rocks, the highly weathered *Doolbi* soil has a strongly acid profile pH while the *Kowbi* and *Corfield* soils developed on fresh basic to intermediate rocks have slightly acid to neutral pH in the profile. The soils developed on deeply weathered sedimentary rocks (*Gooburrum, Isis, Meadowvale, Watalgan, Kepnock, Woolmer, Woco*) are typically medium to strongly acid (pH <6). The well drained soils (*Gooburrum, Watalgan*) occasionally have subsoil pH to 6.5.

The pH of the soils of alluvial origin reflects the age of the soils and possibly parent material. The *Flagstone* soil occurring on channel benches and younger terraces has neutral pH while the *Drinan* soil on older alluvial plains has slightly to medium acid pH.

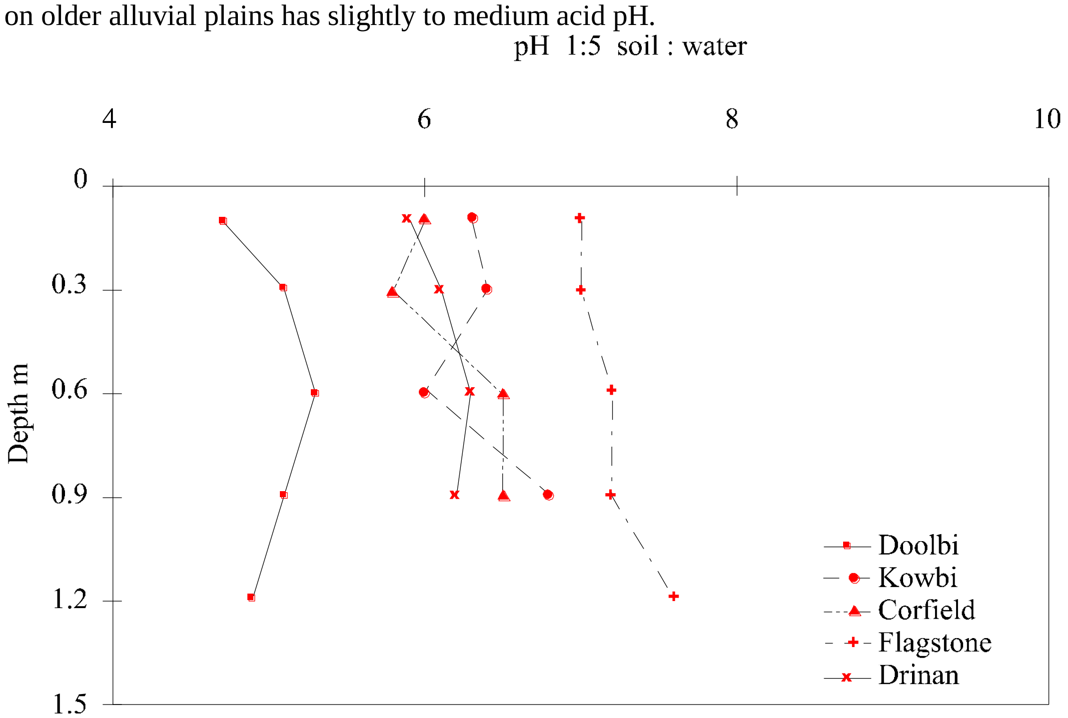


Figure 29a. Mean pH (1:5) profiles for the *Doolbi, Kowbi, Corfield, Flagstone* and *Drinan* soils of the Dermosols

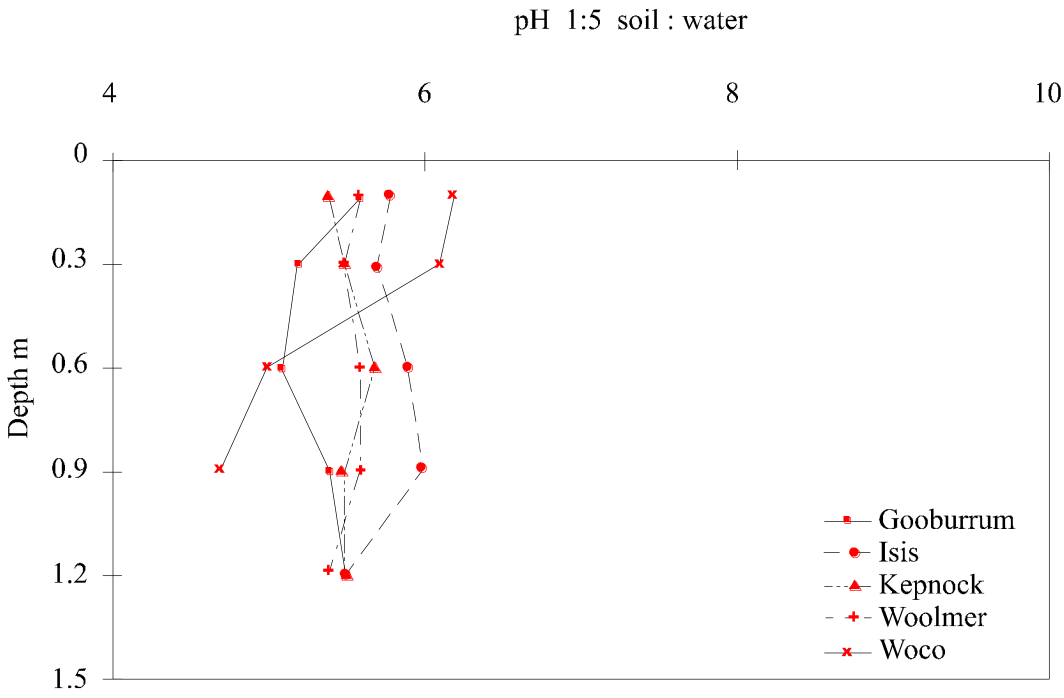


Figure 29b. Mean pH (1:5) profiles for the *Gooburrum, Isis, Kepnock, Woolmer* and *Woco* soils of the Dermosols

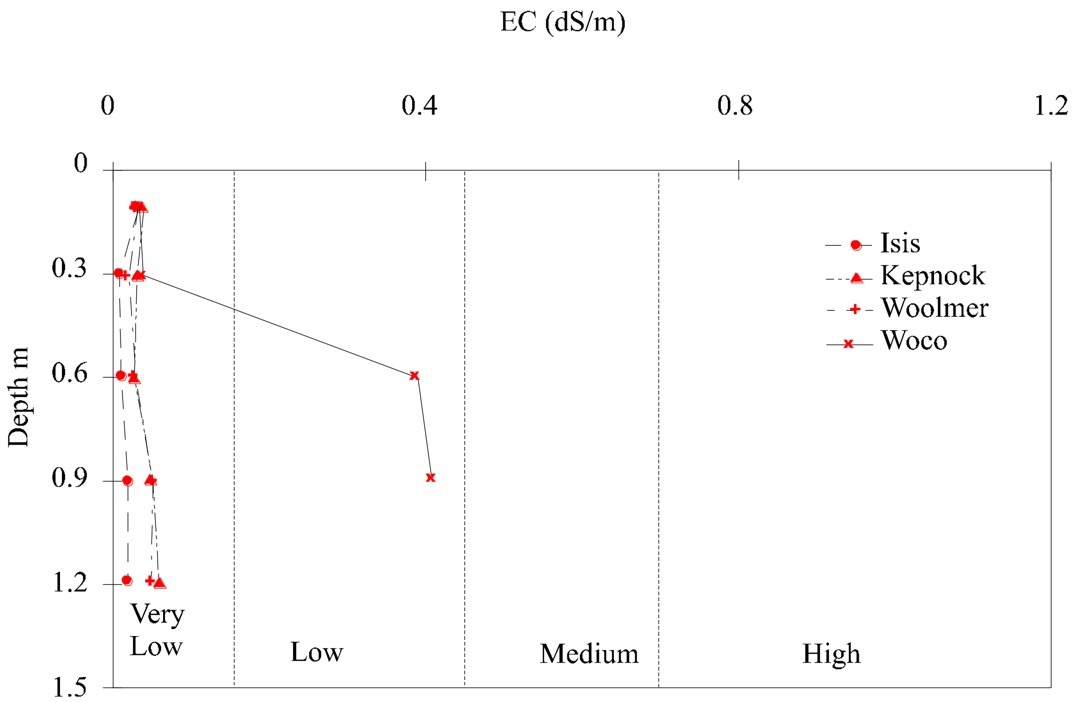


Figure 30. Mean EC (1:5) profiles for the *Doolbi, Kowbi, Isis, Kepnock, Woolmer, Woco, Flagstone* and *Drinan* soils of the Dermosols

Salinity. All the analysed profiles of the Dermosols, except *Woco*, have very low salt levels throughout the profile (Figure 30). The other Dermosols with no EC information (*Berren, Corfield, Gooburrum, Meadowvale, Watalgan, Botherm, Bungadoo, Boyne*) have good profile drainage and occur in elevated positions and would be expected to also have very low salts in the profile.

Sodicity. The Dermosols derived from basalts, metamorphic rocks and alluvium are typically non-sodic (ESP<6) throughout (Figure 31a). However, the *Drinan* soil grades into Sodosols and would be expected to have some sodicity at depth in some profiles.

The Dermosols developed on deeply weathered sedimentary rocks (*Gooburrum*, *Isis*, *Kepnock*, *Woolmer*, *Woco*) are generally sodic at depth with the *Woco* soil being strongly sodic at depth (Figure 31b). However, these soils are frequently strongly acid (pH <5.5) with an effective cation exchange capacity of <5 meq/100g and have moderate to strong, fine, stable structure which does not disperse on wetting. These factors would suggest that sodicity is not expressed.

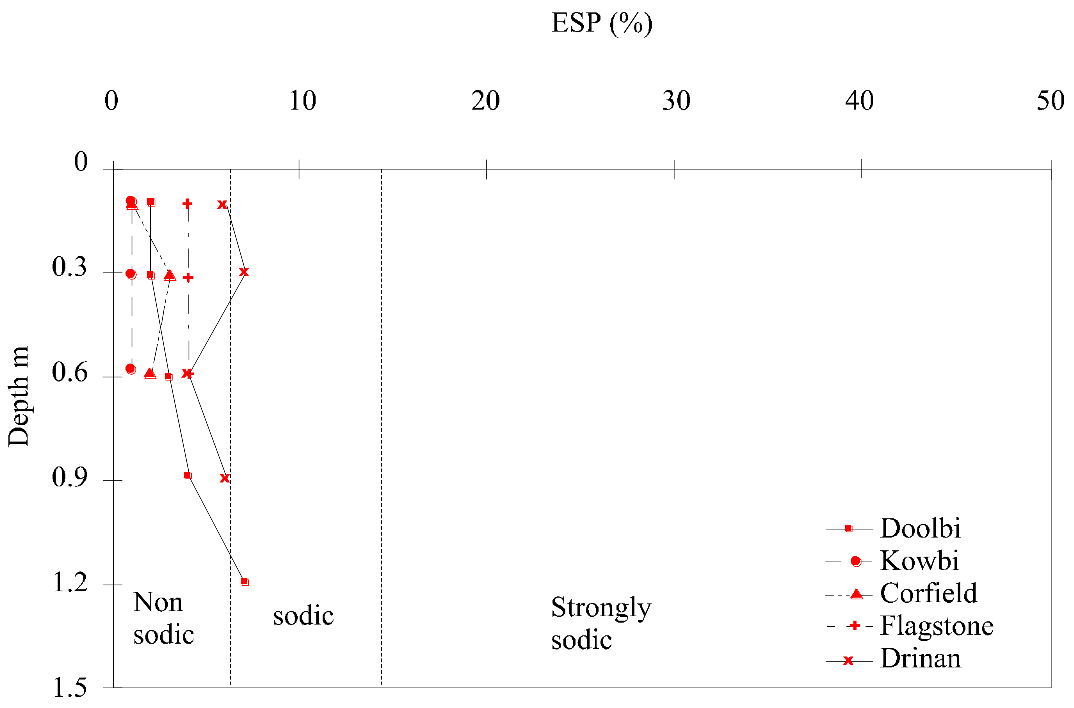


Figure 31a. Mean ESP profiles for the *Doolbi*, *Kowbi*, *Corfield*, *Flagstone* and *Drinan* soils of the Dermosol

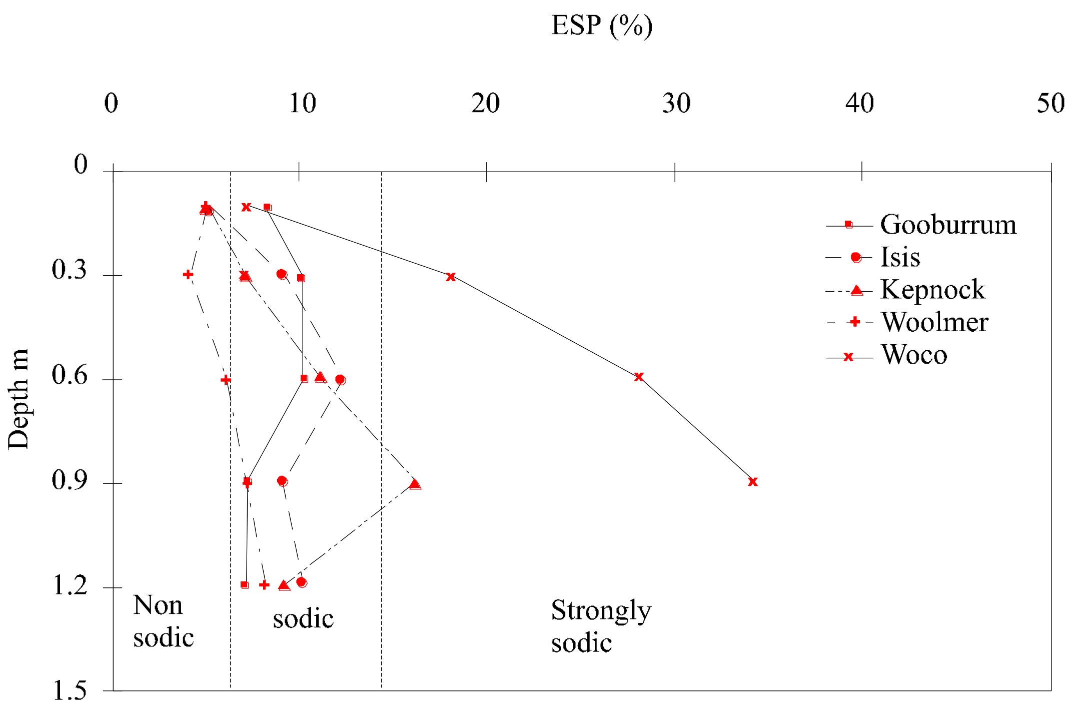


Figure 31b. Mean ESP profiles for the *Gooburrum*, *Isis*, *Kepnock*, *Woolmer* and *Woco* soils of the Dermosols

Cation Exchange Capacity. The Dermosols developed on fresh basalt and metamorphic rocks (*Kowbi*, *Corfield*) typically have a high CEC associated with high clay content and a clay activity ratio of >40 meq/100g clay. By contrast, the Doo*l*bi soil on deeply weathered basalts has similar high clay content but a low clay activity ratio of <10 meq/100g (Figure 32a).

Similarly, the *Drinan* soil on older elevated alluvial plains has a lower CEC compared to the *Flagstone* soil on younger alluvium. The lower clay activity ratio of the *Drinan* soil would suggest a higher degree of weathering of the clay minerals.

The Dermosols developed on deeply weathered sedimentary rocks (*Gooburrum, Isis, Meadowvale, Kepnock, Woolmer, Woco*) typically have very low ECEC and a low clay activity ratio of <15 meq/100g clay (Figure 32b). The slightly high ECEC in the surface and at depth reflects surface organic matter and clay content respectively.

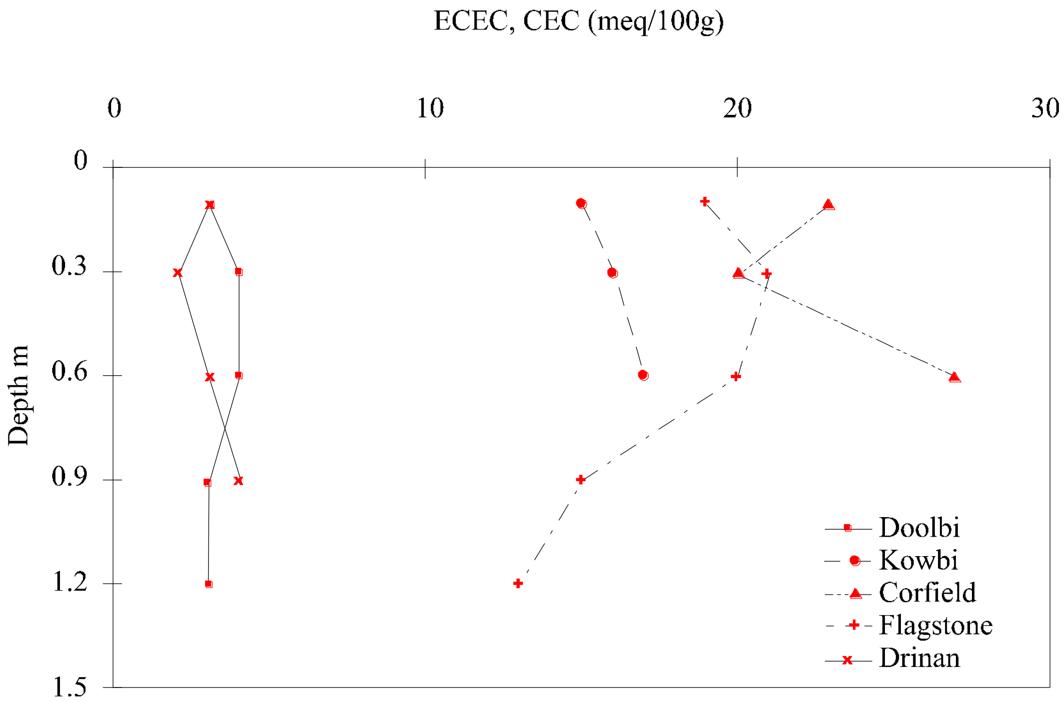


Figure 32a. Mean effective cation exchange capacity (ECEC) and cation exchange capacity (CEC) profiles for the *Doolbi, Kolbi, Corfield, Flagstone* and *Drinan* soils of the Dermosols

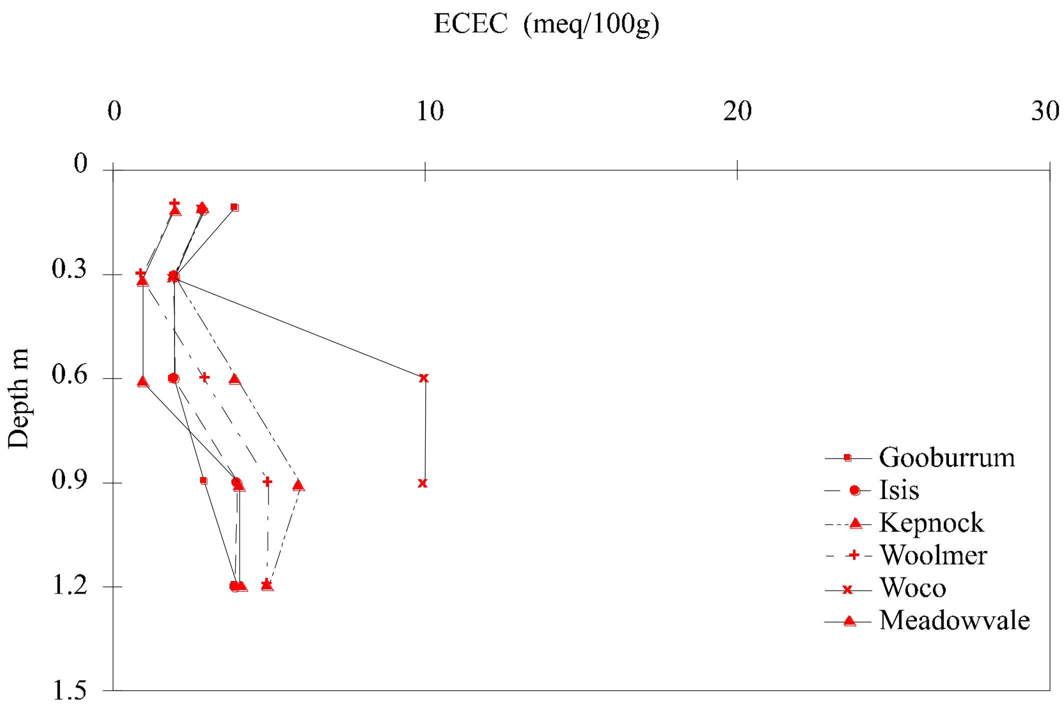


Figure 32b. Mean effective cation exchange capacity (ECEC) profiles for the *Gooburum, Isis, Meadowvale, Kepnock, Woolmer* and *Woco* soils of the Dermosols

Table 21. Mean profile soil nutrients for soils of the Dermosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Doolbi	0.1	0.5 (M)	1.9 (L)	55*(H)	56*(H)	1.4 (L)	0.13 (M)	2.2 (M)
	0.3	0.16 (L)	2.6 (M)					
	0.6	0.05 (L)	2.8 (M)					
	0.9	0.05 (L)	2.3 (M)					
	1.2	0.05 (L)	1.4 (L)					
Kowbi	0.1	0.33 (M)	7.7 (H)	19 (L)	29 (M)	2.1 (M)	0.13 (M)	1.2 (M)
	0.3	0.18 (L)	8.2 (H)					
	0.6	0.07 (L)	4.9 (M)					
	0.9	-	-					
	1.2	-	-					
Corfield	0.1	0.45 (M)	12 (H)	30 (M)	-	3.5 (M)	0.2 (M)	-
	0.3	0.15 (L)	9.2 (H)					
	0.6	0.1 (L)	7.8 (H)					
	0.9	-	-					
	1.2	-	-					
Gooburrum	0.1	0.1 (L)	2.3 (VL)	<5 (VL)	-	2(M)	0.07 (L)	-
	0.3	<0.1 (L)	0.6 (L)					
	0.6	<0.1 (L)	0.7 (L)					
	0.9	<0.1 (L)	1.2 (L)					
	1.2	<0.1 (L)	1.4 (L)					
Isis	0.1	0.05 (L)	1.4 (L)	8 (VL)	2 (VL)	1.3 (L)	0.05 (L)	0.2 (L)
	0.3	0.02 (L)	0.37 (VL)					
	0.6	0.02 (L)	0.73 (L)					
	0.9	0.02 (L)	0.25 (VL)					
	1.2	0.02 (L)	0.24 (VL)					
Meadowvale	0.1	0.1 (L)	1.1 (L)	6 (VL)	6 (VL)	1.4 (L)	0.06(L)	0.36(L)
	0.3	0.04 (L)	0.16(VL)					
	0.6	0.05 (L)	0.09(VL)					
	0.9	0.04 (L)	0.32(VL)					
	1.2	0.04 (L)	0.4 (VL)					
Kepnock	0.1	0.01 (M)	1.1 (L)	0.(60)* (H)	2(VL) (51)*(H)	1.2 (L)	0.06 (L)	0.4 (L)
	0.3	0.08 (L)	0.57 (L)					
	0.6	0.03 (L)	0.56 (L)					
	0.9	0.06 (L)	0.34 (VL)					
	1.2	0.04 (L)	0.33 (VL)					
Woolmer	0.1	0.12 (L)	0.92 (L)	3(VL)	1(VL) (22)*(M)	0.6 (L)	0.03 (VL)	0.22 (L)
	0.3	0.04 (L)	0.54 (L)	31*(M)				
	0.6	0.03 (L)	0.14 (VL)					
	0.9	0.09 (L)	0.23 (VL)					
	1.2	0.03 (L)	0.14 (VL)					
Woco	0.1	0.09 (L)	1.4 (VL)	-	1 (VL)	1.5 (L)	0.06 (L)	0.3 (L)
	0.3	0.04 (L)	0.13 (VL)					
	0.6	0.05 (L)	0.12 (VL)					
	0.9	0.1 (L)	0.08 (VL)					
	1.2	-	-					

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Flagstone	0.1	0.58 (M)	12 (H)	156*(VH)	(67)*(H)	1.5 (L)	0.09 (L)	1.7 (M)
	0.3	0.31 (M)	14 (H)					
	0.6	0.2 (M)	14 (H)					
	0.9	0.26 (M)	9.5 (H)					
	1.2	0.24 (M)	8.3 (H)					
Drinan	0.1	0.2 (M)	1.8 (L)	2(VL) 40*(M)	3(VL) 3*(M)	1.2 (L)	0.07 (L)	0.4 (L)
	0.3	0.06 (L)	1.2 (L)					
	0.6	0.06 (L)	0.61 (L)					
	0.9	0.03 (L)	0.17 (VL)					

* Sampled from cultivated soils.

Soil nutrients. Nutrient status of the Dermosols reflects the parent material, leaching environment and relative age of the soils (Table 21).

The soils developed on basic and intermediate rocks typically have medium to high nutrient levels in the surface while the highly leached *Doolbi* soil has relative lower K and Ca levels.

The soils developed on the deeply weathered sedimentary rocks (*Gooburrum, Isis, Kepnock, Woolmer, Woco*) typically have low to very low levels of all nutrients. The strong surface accumulation of Ca and K indicates organic matter accumulation. The better drained soils such as *Gooburrum*, typically have higher Ca levels whereas the poorer drained soils such as *Woco*, have lower Ca levels particularly in the subsoil. The lower nutrient levels in the wetter soils corresponds to the low nutrient levels in the Hydrosols developed on deeply weathered sedimentary rocks. Other Dermosols on the deeply weathered sedimentary rocks would be expected to show similar trends.

The *Flagstone* soil on the channel benches and younger terraces of the Burnett River is recognised locally as a very fertile soil. All nutrients, except organic C and total N are medium to high. The *Flagstone* soil is relatively more fertile than the *Auburn* Sodosol which occurs in close proximity but on an older alluvial plan. The *Drinan* soil on older alluvial plans is typically low in all nutrients reflecting relative age and possibly parent material.

Calcium/magnesium ratios reflect parent material and weathering environment. The soils on basalts, metamorphics and younger alluvium (*Doolbi*, *Kowbi*, *Corfield*, *Flagstone*) typically have higher calcium/magnesium ratios.

On deeply weathered sedimentary rocks, calcium/magnesium ratios are strongly related to site drainage. Well drained soils (*Gooburrum*) are associated with higher Ca/Mg ratios compared to the other imperfectly drained Dermosols. The poorly drained soils (Hydrosols) on similar geology are typically strongly magnesium dominant. High Ca/Mg ratios at the surface reflect surface organic matter accumulation.

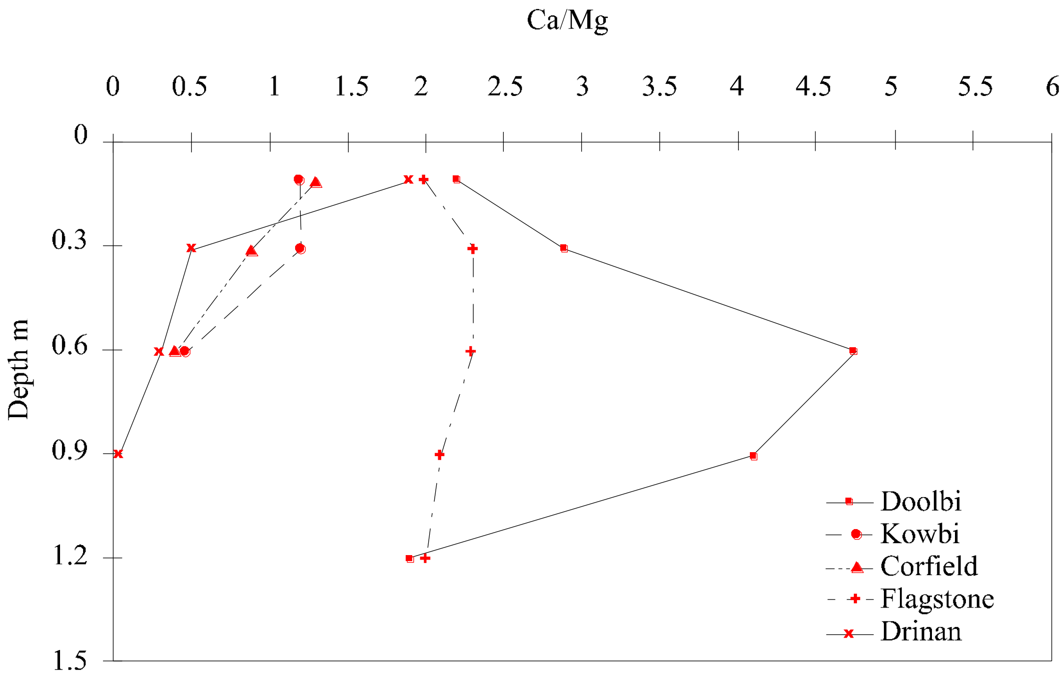


Figure 33a. Mean profile calcium/magnesium ratios for the *Doolbi, Kowbi, Corfield, Flagstone* and *Drinan* soils of the Dermosols

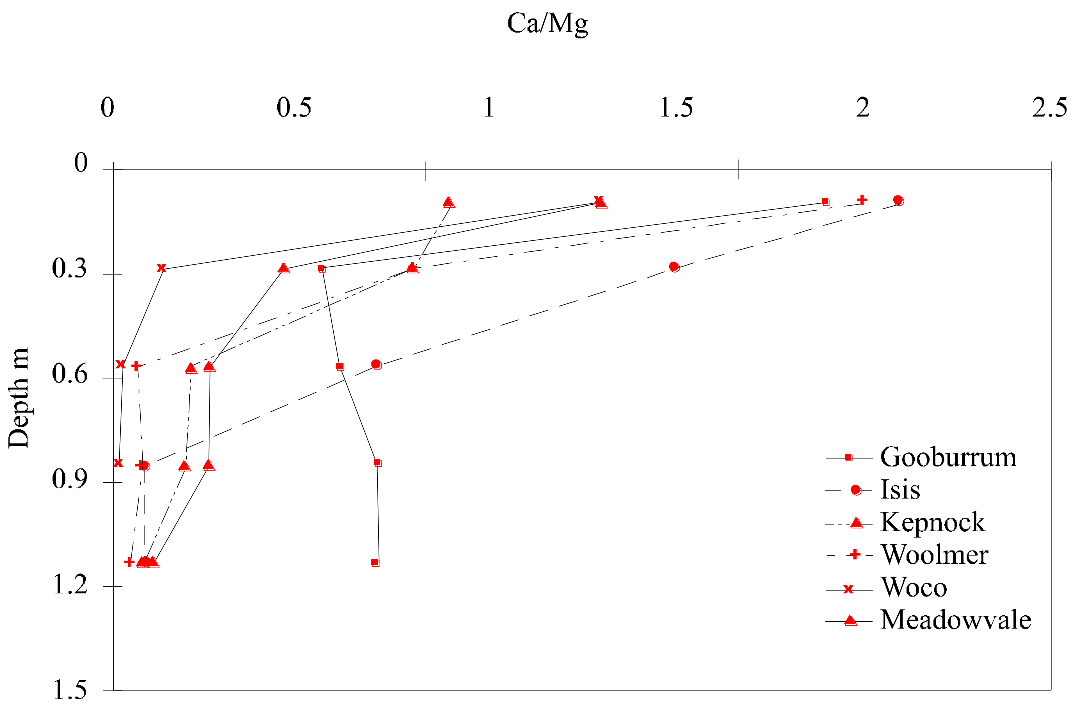


Figure 33b. Mean profile calcium/magnesium ratios for the *Gooburrum, Isis, Meadowvale, Kepnock, Woolmer* and *Woco* soils of the Dermosols.

Plant Available Water Capacity (PAWC). Estimated PAWC and rooting depth for the Dermosols are shown in Table 22.

PAWC reflects rooting depth, textures, clay type and amount of coarse fragments in the profile. The Dermosols with light surface textures (*Gooburrum, Isis, Meadowvale*) have lower PAWC compared to the equivalent soils with loamy surface textures (*Watalgan, Kepnock, Woolmer*).

The basaltic soils (*Berren, Kowbi, Corfield*) with a proportion of swelling clays (montmorillonite), higher cation exchange capacity and higher organic C, have higher PAWC per unit depth than the highly leached kaolinite clays of the *Doolbi* soil. The soils with a high proportion of rock fragments in the profile (*Berren, Bungadoo*) have very low PAWC. PAWC in the *Kepnock, Woolmer* and *Woco* soils have been reduced to cater for the presence of hard nodules in the profile.

Table 22. Estimated PAWC (mm) and rooting depth (m) for the soils of the Dermosols

Soil	Rooting Depth (m)	PAWC (mm)
Doolbi	>1	94-132
Berren	0.4-0.7	<50
Kowbi	0.4-0.7	93
Corfield	0.4-0.7	75-90
Gooburrum	>1	63
Isis	>1	57-61
Meadowvale	>1	68
Watalgan	>1	75-98
Kepnock	>1	74-105
Woolmer	>1	73-90
Botherm	0.6-1	75-90
Woco	0.4-0.8	65-76
Bungadoo	0.4-0.6	<50
Flagstone	>1	74-92
Drinan	>1	47-65

Kandosols

Kandosols are soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout. Only four Kandosols have been recognised (Table 23) with two soils formed on coarse grained sedimentary rocks (sandstones) and two soils on alluvial plains of local creeks and rivers. They occupy 3326 ha or 1.4% of the study area.

Table 23. Major attributes, classification and areas for soils of the Kandosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED COARSE GRAINED SEDIMENTARY ROCKS			
Farnsfield	Red or brown loamy sand to clay loam sandy surface over an acid to neutral, red sandy clay loam to light clay.	Red Kandosol	1037
Quart	Grey loamy sand to sandy loam surface over an acid, mottled, yellow sandy clay loam to clay loam.	Yellow Kandosol	1545
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS.			
Redbank	Brown or black fine sandy loam to clay loam sandy surface over an acid to neutral, red sandy clay loam to sandy clay.	Red Kandosol	168

Littabella	Black or grey sandy loam to loam fine sandy surface over an acid to neutral, yellow, grey or red sandy loam to clay loam sandy.	Yellow Kandosol Grey Kandosol Red Kandosol Orthic Tenosol	576

Landscape

The Kandosols on sandstones occur on hill crests and hill slopes of gently undulating plains, rises and occasionally as remnants on crests and upper slopes of low hills and hills. Slopes are generally <4% but may occur up to 8%.

The remaining Kandosols occur on alluvia plains which may have channel microrelief.

Vegetation

The vegetation on all soils has been mostly cleared with only minor remnants remaining in State Forests.

Soil Profile

Structure is typically single grain on massive at the surface and massive to weak polyhydrol or sub-angular blocky in the subsoil.

The Kandosols on the sandstones typically have sandy surfaces except *Farnsfield* which may increase to clay loam. Subsoil textures are sandy clay loam to occasionally light clay (Figure 34). As subsoil colours change from red (*Farnsfield*) to yellow (*Quart*) to grey (*Mahogany* - see Hydrosols), surface colours become paler, A2 horizons become paler and bleached, mottles increase and ferruginous nodules generally increase reflecting increased wetness in the profile.

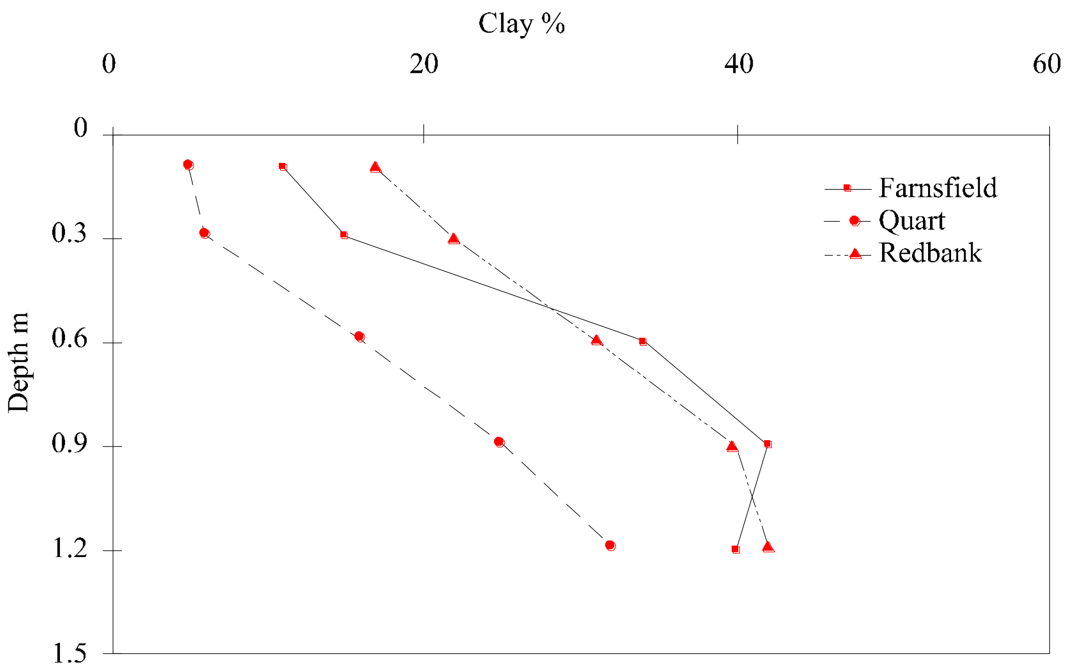


Figure 34. Mean clay content profiles for soils of the Kandosols

The Kandosols on alluvium have variable profile attributes reflecting alluvial deposition where changes can occur over short distances. Redbank is restricted to minor areas south of Gin Gin. It has a sandy loam to clay loam surface over a red, weak sub-angular blocky, sandy clay loam to sandy clay. Littabella is extremely variable and is generally confined to levees along larger creeks and rivers, such as the Gregory and Isis Rivers. Surface textures are predominantly sandy with yellow or grey sandy loam to clay loam subsoils. Red sandy subsoils also occur.

Soil chemistry

Soil pH. Soil pH for the Kandosols is typically slightly acid to medium acid (5.5 – 6.5) with occasional strongly acid pH (<5.5) in the *Farnsfield* and *Quart* soils. The pH generally decreases with depth which may reflect past liming practices on these intensively cropped soils (Figure 35).

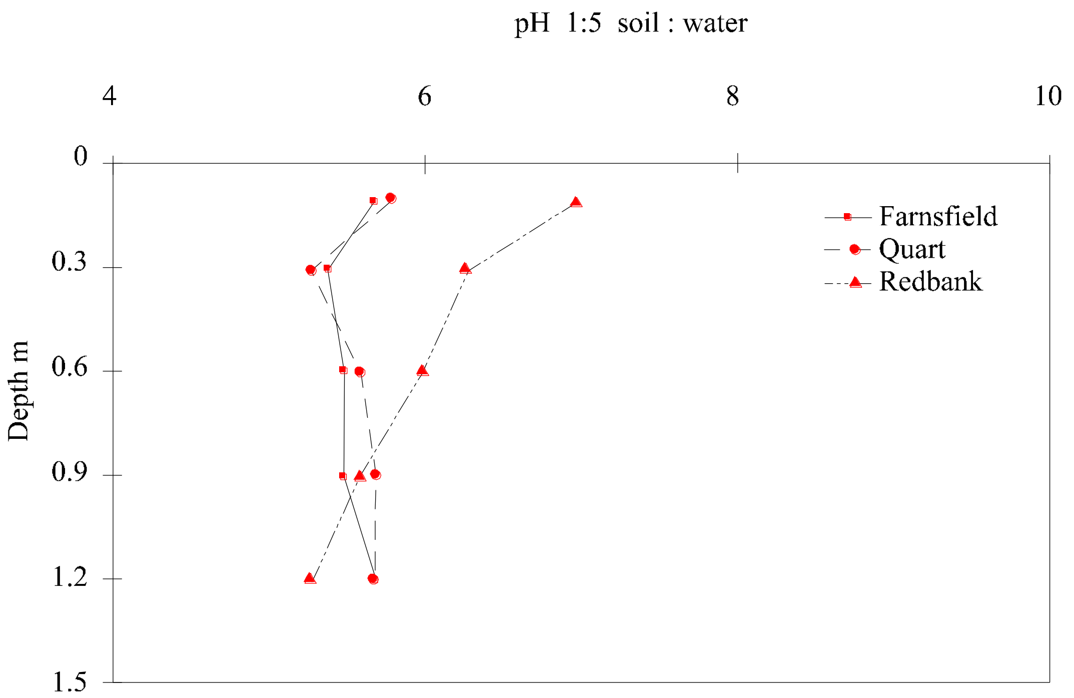


Figure 35. Mean pH (1:5) profiles for soils of the Kandosols

Salinity and Sodicity. Salt levels in the *Farnsfield* and *Quart* soils are typically very low in these permeable non-sodic soils. The *Redbank* soil has a strongly sodic subsoil which is non-dispersive and very stable (Figure 36).

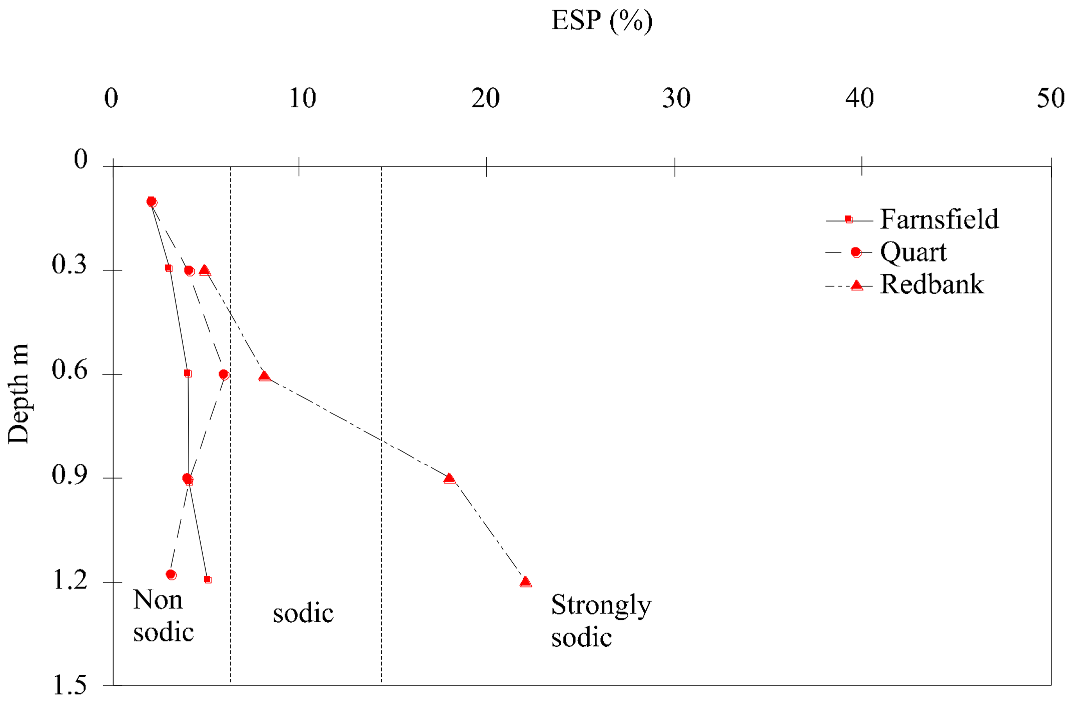


Figure 36. Mean ESP profiles for the *Farnsfield, Quart* and *Redbank* soils of the Kandosols

Cation exchange capacity. ECEC is low in all Kandosols with levels reflecting surface organic matter and clay content. All subsoils have a clay activity ratio of 10 meq/100 clay indicating kaolite type clays (Figure 37).

Soil nutrients. The *Farnsfield* and *Quart* soils developed on deeply weathered sedimentary rocks are typically low in all nutrients except in the surface due to organic matter accumulation (Table 24). These soils particularly the well drained *Farnsfield* soil, have higher nutrient levels than the poorly drained *Mahogany* Hydrosol which occurs in association with *Farnsfield* and *Quart*.

The well drained *Redbank* soil on local creek alluvium has higher nutrient levels compared to the *Drinan* Dermosol which occurs in association with Redbank but on lower slopes.

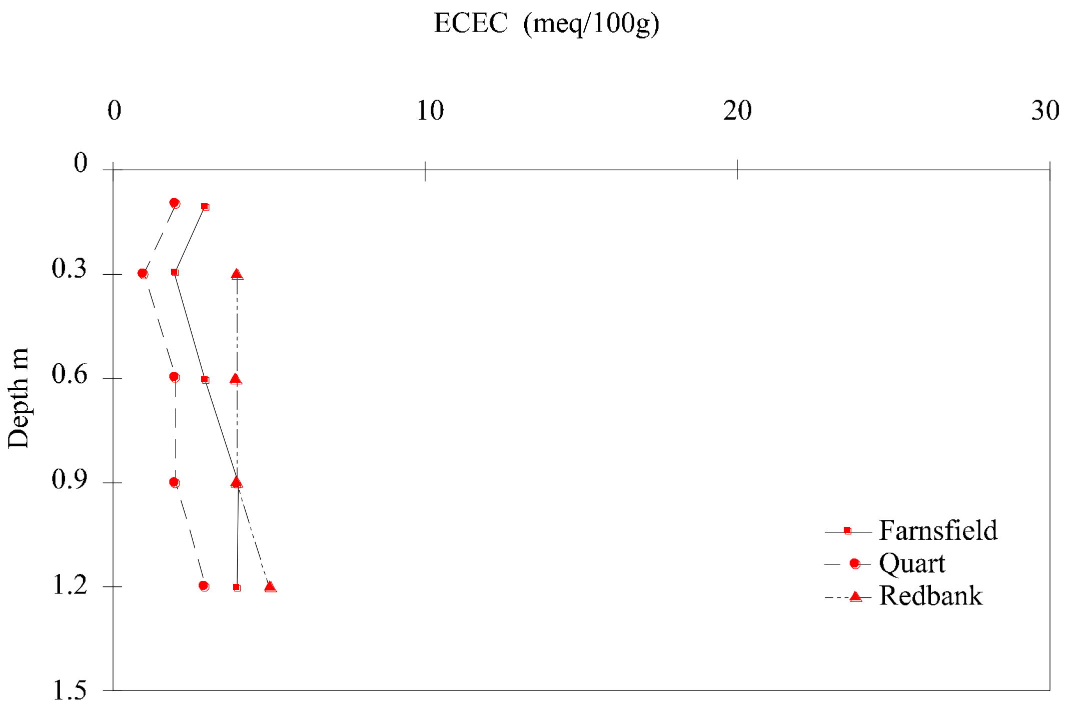


Figure 37. Mean effective cation exchange capacity (ECEC) profiles for soils of the Kandosols

Table 24. Mean profile soil nutrients for soils of the Kandosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organ. C %	Total N %	Zn mg/kg
Farnsfield	0-0.1	0.34(M)	2(L)	-	-	1.1(L)	0.05(L)	0.4(L)
	0.2-0.3	0.11(L)	1.2(L)	54*(H)	31*(L)			
	0.5-0.6	0.08(L)	1 4(L)					
	0.8-0.9	0.04(L)	1.8(L)					
	1.1-1.2	0.03(L)	1.6(L)					
Quart	0-0.1	0.2(M)	1.2(L)	3(VL) 60*(H)	2(VL) 43*(H)	0.8(L)	0.04(VL)	0.23(L)
	0.2-0.3	0.05(L)	0.4(VL)					
	0.5-0.6	0.04(L)	0.78(L)					
	0.8-0.9	0.09(L)	0.96(L)					
	1.1-1.2	0.1(L)	0.99(L)					
Redbank	0-0.1	-	-	-	-	1.3(L)	0.05(L)	-
	0.2-0.3	0.25(M)	2.5(M)	58*(H)	4*(VL)			
	0.5-0.6	0.21(M)	1.9(L)					
	0.8-0.9	0.1(L)	1.7(L)					
	1.1-1.2	0.05(L)	2(L)					

* Sampled from cultivated soils

Calcium/magnesium ratios decrease with depth with calcium generally being dominant or codominant corresponding to other well drained soils in the study area (Figure 38). Equal but poorly drained massive soils in the Hydrosols (*Mahogany*) are strongly magnesium dominant at depth.

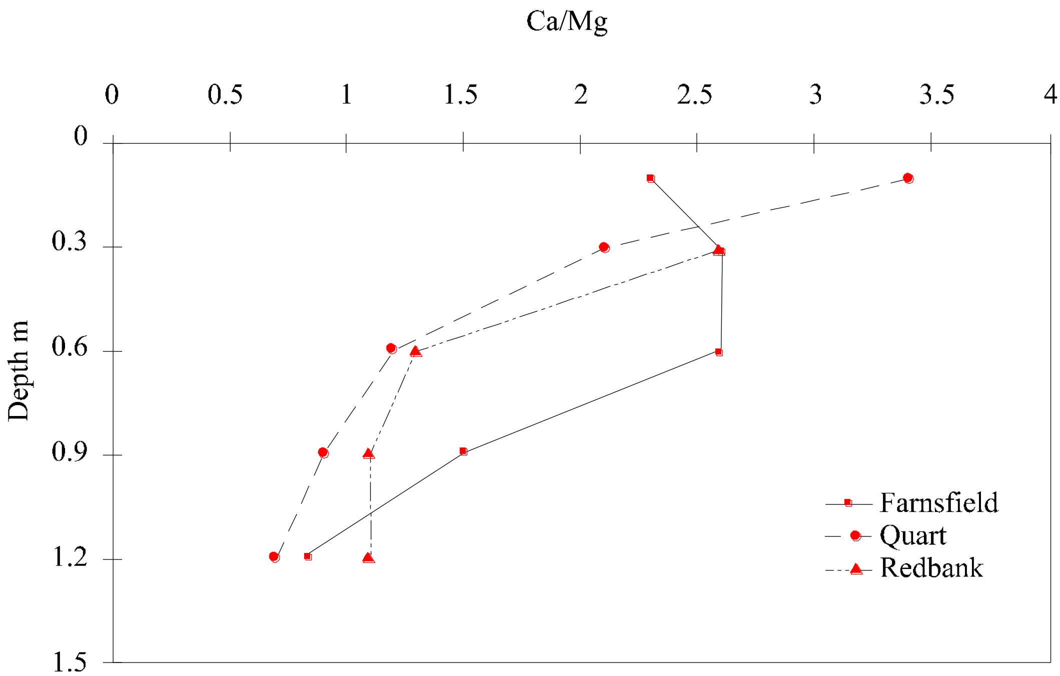


Figure 38. Mean profile calcium/magnesium ratios for soils of the Kandosols

Plant Available Water Capacity (PAWC). Estimated PAWC and rooting depth for the Kandosols are shown in Table 25. PAWC in these soils is largely dependant on soil texture (see Figure 34). The sandy surface textures of *Farnsfield*, *Quart* and *Littabella* give rise to lower PAWC, while the sandy clay loam to clay loam surface textures of *Farnsfield*, and *Redbank* and rarely *Quart* give rise to higher PAWC.

Table 25. Estimated PAWC (mm) and rooting depth (m) for soils of the Kandosols

Soil	Rooting depth (m)	PAWC (mm)
Farnsfield	>1	69-84
Quart	>1	54-82
Redbank	>1	79
Littabella	>1	<60

Rudosols

Rudosols are soils that have little if any pedological organisation apart from the minimal development of an A1 horizon (Table 26). There is little or no texture or colour change with depth unless stratified and the soils are apodal or only weakly structured. They are usually young soils.

The Burnett soil is the only soil mapped in this soil order but intergrades to a Tenosol. It is confined to the alluvium along the Burnett River and occupies 615 ha or 0.25% of the study area but represents an important agricultural soil.

Table 26. Major attributes, classification and areas for soils of the Rudosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
ALLUVIAL PLAINS OF THE BURNETT RIVER			
Burnett	Brown or black sandy loam to clay loam fine sandy surface over layered, brown sands to clay loams.	Static Rudosol Orthic Tenosol	615

Landscape

The *Burnett* soil occurs on lower channel benches, terraces, levees and scrolls along the Burnett River.

Vegetation

The vegetation has been cleared.

Soil profile

The *Burnett* soil has a brown or black sandy or loamy surface over a brown stratified subsoil. The subsoil textures range from sand to clay loam, sometimes with alternating thin layers of sand and loams. Surface structure ranges from massive to moderate granular. No analysed profiles are available in the Childers survey area.

Tenosols

Tenosols are soils with only weak pedological organisations apart from the A horizons. The Tenosols in the study area are confined to soils with conspicuously bleached A2 horizons over rock, or stratified soils with moderate surface structure (Table 27). These soils are minor and occur in association with other soils.

Table 27. Major attributes, classification and areas for soils of the Tenosols

Mapping Unit	Major attributes of dominant soil	Australian Classification	Area (ha)
HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Takoko	Black or grey clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.55m) over weathered silicified rock. >20% silicified rock fragments throughout the profile.	Bleached Tenosol	See Bungadoo -Takoko complex

The Takoko soil occurs on the silicified Maryborough Formation ridge running north west-south east through the study area and occurs as a complex in association with the *Bungadoo* soil.

The *Burnett* Tenosol occurs in association with the *Burnett* Rudosols while the *Avondale tenic variant* occurs in association with the *Avondale* Sodosol.

Landscape

The Takoko soils occurs on crests and hillslopes with slopes of 0-20%.

Vegetation

The vegetation is dominated by tall (18-20m) lemon scented gums (*E. citiodora*) with other eucalypts such as stringybark (*E. umbra*, *E. acmenoides*) and brown bloodwood (*E. trachyphloia*). A dense understory of brush box (*Lophostemon confertus*) is usually present.

Soil Profile

The Takoko soil has a black or grey clay loam surface and a conspicuously bleached A2 horizon over silicified rock. This soil has the same surface horizons as the *Bungadoo* soil.

The *Avondale Tenic Variant* has a loamy surface and a conspicuously bleached A2 horizon (as for the *Avondale* Sodosol) overlying deeply weathered sedimentary rocks. This soil frequently occurs on the edge of low cliffs or remnants of deeply weathered rock on hill crests.

The *Burnett* soil (as described in the Rudosols) sometimes has moderate structure in the surface. No analysed Tenosol profiles are available in the Childers area.

4. Limitations to irrigated land uses

A set of land use requirements for plant growth, machinery use, land preparation, irrigation and the prevention of land degredation has been defined for agricultural land uses in Queensland (Land Resources Branch Staff 1990). To assess the suitability of any parcel of land for a particular use, it is necessary that each of these land use requirements be considered. Attributes of land which cause it to have less than optimum conditions for a particular use are known as limitations.

Management is concerned with overcoming or reducing the effects of these limitations.

The main potential irrigated land uses in the Chiders area are spray irrigation of a range of crops and trickle irrigation of horticultural crops and tree crops. The land use requirements and limitations that have been identified as important for successfully irrigating crops in the Childers area are listed in Table 28.

Table 28. Land use requirements and limitations for irrigated farming systems in the Childers area (from Land Resources Branch Staff, 1990)

Land use requirements	**Limitations**
Frost free	clilmate (c)
Adequate water supply	water availability (m)
Adequare nutrient supply	nutrient deficience (nd)
Adequate retention of added nutrients against leaching	nutrient leaching (nl)
Low nutrient fixing conditions	nutrient fixation (nf)
Low levels of toxic elements	element toxicity (nt)
Adequate soil aeration	wetness (w)
Adequate soil depth for physical support	soil depth (d)
Absence of damaging floods	flooding (f)
Rock-free	rockiness (r)
Adequate production area	landscape capability (x)
Level land surface	microrelief (tm)
Land surface of acceptable slope	slopes (ts)
Ease of seedbed preparation and plant establishment	surface condition (ps)
Suitable timing for cultivation	narrow moisture range (pm)
Ability to harvest underground crops	soil adhesiveness (pa)
Minimum soil loss from erosion	water erosion (e)
Minimum potential to cause secondary salting	secondary salinisation (s)
Effecient water infiltration for irrigation	water infiltration (i)

All the limitations listed do not necessarily apply to each land use or to all soils. Some limitations are more important for some soils. Appendix 5 summarises the effects of the limitations on plant growth, machinery use and land degradations, and how the soil/land attributes are assessed.

The limitations appropriate to the Childers area are discussed individually. Management options for reducing the effects of these limitations are also discussed.

Climate (c)

The climate does not vary significantly over the study area, except the incidence of frosts. Local experience on the frequency and severity of frosts, and landscape position were used to determine the limitation classes for the various crops.

Seasonal adaption and tolerance of crops was considered for example, frosting was not assessed for summer crops. Frosts can suppress the growth of sensitive crops, kill plants or reduce yield through damage to flowers or fruits.

Generally, the incidence and severity of frosts in the study area is influenced by position in the landscape. Hill tops and coastal areas receive fewer and less severe frosts and are suitable for sensitive crops such as avocados and mangoes. The low lying channel benches and depressions in the terraces along the rivers can receive a large number of severe frosts per year (>20). These severely affected areas limit the suitable crops to deciduous plants such as low-chill stone fruits, grapes, and adaptable small crops and field crops.

Water availability (m)

All plants require an adequate water supply for optimum growth. Any restriction of the soil water supply to the plant imposes a limitation to potential crop yield. Under irrigation, a reduced plant available water storage capacity (PAWC) means more frequent irrigations to attain optimum yield. Recharging the soil water deficit completely is also important in irrigation.

The ease of extraction of water from the soil by the plant becomes more difficult as the soil becomes drier. The plant will suffer water stress before all PAWC is extracted. Shaw and Yule (1978) suggest that irrigation should be applied when accumulative evapotranspiration is 60% to 80% of PAWC. This is often termed readily available water.

The decision on when to irrigate and how much water to apply can be determined by considering the soil water store, drainage below the active root zone, runoff and the amount of water used by the crop (Yule 1989). This practice, called irrigation scheduling, should aim to optimise crop productivity, improve water use efficiency and reduce the likelihood of drainage and salinity problems (Keefer, 1989).

There are a number of methods used to monitor soil and plant water status to enable irrigation scheduling to be undertaken. Bourne and Harris (1985) describe briefly the various soil and plant-water indicators for irrigation scheduling such as tensiometers, electrical resistance blocks, neutron moisture meters, pressure bombs, infra red thermometer guns, soil core sampling and evaporation pans.

Evaporation from a Class A pan has been used for many years as an indicator of crop water use, as a good correlation exists between evapotranspiration of a crop and evaporation from a free water surface (Bourne and Harris 1985). The relationship is expressed as a number (crop co-efficient, Kc) and depends on the crop, planting date and stage of growth (Doorenbos and Pruitt, 1977).

Bureau of Sugar Experiment Stations (BSES) staff have developed a chart which outlines how to use pan evaporation figures to determine sugar cane water use. The chart and Daily Class A pan evaporation for Bundaberg are available on request from BSES.

Estimated PAWCs (Shaw and Yule 1978) for the various SPCs are shown in Tables 5, 8, 11, 14, 19, 22, 25. Estimated PAWC is largely determined by predicted rooting depth, the amount of hard segregations or rock in the profile and surface textures.

The sodic subsoils of the sodic duplex soils (*Gigoon, Duingal, Brooweena, Tirroan, Robur, Kolbore, Kalah, Kolan, Turpin, Avondale, Woco, Theodolite, Auburn, Peep*) and other sodic soils (*Duingal, Walla*) offer resistance to plant roots and water entry. Gardner and Coughlan (1982) concluded that this restriction is caused by a throttle in the B horizons of these soils. This throttle is largely caused by unfavourable structure, high ESP or high bulk density. Generally, it is suggested that the start of the throttle may be similar to the rooting depth.

Nutrient deficiency (nd)

Addition of fertilisers is an accepted practice for many land uses. This limitation is used where nutrient levels are inherently low and amelioration requires a large initial fertiliser application. Phosphorus will need to be applied to all unfertilised soils.

Soils on the deeply weathered sedimentary rocks, except the red soils, are typically low to very low in all nutrients, particularly potassium and calcium in the subsoils.

The basaltic soils (*Doolbi, Kowbi, Berren, Corfield*) have relatively good soil nutrition in the natural state while other soils are variable with nutrient levels generally related to relative age of the soils, lithology and weathering environment.

Nutrient leaching (nl)

Nutrient leaching occurs on well drained or highly permeable soils, usually associated with light textures and a low cation exchange capacity. The coarse textured uniform soils (*Kinkuna, Coonarr, Wallum, Mahogany, Winfield*) and Ferrosols (*Childers, Chin*) have these features. Split fertiliser applications or slow release fertilisers may be beneficial to overcome this limitation.

Nutrient fixation (nf)

Where nutrients are bonded or fixed to soil minerals, additional management is required. Humic or organic soils and soils high in iron-aluminium oxides fix phosphorous. The highly humic surface of the *Woodgate* soil (an unmapped soil association with *Coonarr*) and the Ferrosols (*Childers, Chin*) would be expected to require higher rates of phosphorus fertiliser initially to counteract the greater phosphorus fixing characteristics of the surface horizons.

Element toxicity (nt)

Plant growth may be inhibited by either high levels or a high proportion of specific cations in solution. Strongly acidic soils (pH <5.5) may have high levels of elements such as aluminium and manganese. Crop tolerance to these conditions needs to be considered. The Podosols, Kurosols, highly leached Hydrosols and Ferrosols frequently have strongly acid pH.

Wetness (w)

Waterlogging or excessively wet soil reduces oxygen supply to the roots of plants and soil micro-organisms and affects chemical reactions (Yule 1989). Less water and nutrients are taken up by the roots when the soil is wet and this reduces growth and yield (Hodgson 1986). Tolerance to waterlogging depends on the crop, stage of growth and soil and air temperatures (Williamson and Kriz 1970).

For comparison, sugar cane has a moderate to high tolerance of short periods of waterlogging and maize a low rating (Landon 1984). Horticultural crops are usually susceptible to waterlogging.

To reduce waterlogging, excess water must be removed from the plant root zone quickly. This removal can be improved by laser levelling, increasing slope, using short irrigation times and ensuring adequate hill or bed height.

Wetness can cause problems with timeliness of operations resulting in delays in seedbed preparation, in planting, weed and insect control preparations and harvesting. Reduced yields or loss of a complete crop may result if planting cannot be carried out.

All soils in the study area are affected by wetness to varying degrees. Generally, soils on the deeply weathered Elliott Formation which occur in drainage depressions or lower slope positions are poorly drained. Soils on upper slope positions are generally imperfectly to well drained.

Wetness in the soils on the alluvial plains is greatly influenced by slight changes in elevation. Both *Auburn* and *Walla* soils are very strongly sodic at depth corresponding to medium to high salt levels. This suggests that surface water does not penetrate to depth and most of any excess surface water is lost by surface flow to drainage lines. In these soils, surface drains are essential to improve drainage.

The ability to dispose of water is an important consideration in the reclamation of soils which occur in low lying areas or on level plains. Subsurface drainage is impractical in most sodic soils due to the impermeable dispersible subsoil.

Soil depth (d)

All crops require an adequate depth of soil to provide physical support for the aerial portion of the plant. The effects of rooting depth on water availability and wetness have been discussed earlier. Requirements for physical support will increase with crops that have large canopies such as tree crops. Uprooting of trees is particularly a problem in shallow, wet soils during windy conditions.

The effective rooting depth is determined by the depth of soil to rock, hardpan or other impermeable layers (see wetness limitation). Suitability subclasses have been determined through consultation with crop specialists and local producers.

Flooding (f)

Flooding is defined here as over-flow from natural water courses as distinct from surface water ponding due to insufficient drainage capacity.

The flood attributes which affect agriculture are the depth and duration of inundation, velocity, rate of water level rise, time of year and frequency of occurrence (Lawrence *et al.*, 1982). The extent to which a flood becomes damaging is largely dependant upon the type of crop.

An evaluation of the severe flooding in the Mulgrave and Babinda areas in 1977, showed the major variables influencing yield losses of sugar cane were the size of the crop when flooded, period of submergence to the growing point, cane varieties and the characteristics of the water such as the strength of the current and silt content. Tolerant varieties can withstand complete submergence of three to four days (BSES, 1977).

Subsequent problems of flooding include an increased incidence of weeds and diseases and difficulties with machinery operations. The deposition of sand and silt or the removal of topsoil and scouring has resulted in many cane assignments in Queensland being transferred away from flood prone land. There should be an awareness that, against the agricultural benefits of farming on the flood plain, there are costs associated with flooding which must be considered.

Floods in the study area are mainly associated with rain depressions or cyclones with major floods usually associated with heavy rainfall in the upper catchment. Heavy rainfall in the local area usually results in minor flooding of limited duration.

Agricultural development has expanded onto the more fertile flood prime land. Land management should aim at stabilising the flood plain in high risk areas. This includes not clearing and cultivating within 40 metres of the river bank, maximising height and cover of crops during the flood prone time of the year to protect the soil against water scouring, and establishing permanent pastures where deposition and scouring regularly occur.

Floods are mainly restricted to the relatively narrow channel benches of the Burnett River and local creeks and rivers. Water velocities are higher and it is here where sand and silt deposition regularly occurs and bank erosion and scouring is most severe. The lower channel benches are the most severely and most regularly affected.

It is only on the channel benches that the flooding limitation has been noted but, due to the complex nature of the topography of these channel benches, only the lower channel benches have a more severe limitation (Appendix V). Local creeks and rivers are assessed similarly.

Islands in the Burnett River, stream channels, and river and creek banks should not be developed for agricultural purposes. In all these areas, the natural tree vegetation should be maintained.

Crop damage depends on its susceptibility to flooding. Sugar-cane is moderately tolerant of inundation and different varieties will vary. Horticultural crops, such as small crops (melons, pumpkins, tomatoes, capsicums), avocados, papaws, pineapples, citrus and mangoes are very sensitive to flooding. Lychees are more tolerant and will withstand flooding for short periods. Other crops, such as maize, sorghum and soybeans are sensitive.

Rockiness (r)

Rock fragments (including pebbles, gravel, stones, cobble and boulders) and bedrock within the plough depth will interfere with the use of agricultural machinery, and possibly cause damage. The volume of rock fragments within the soil is extremely variable and difficult to estimate. Levels of tolerance also vary between farmers and between different agricultural enterprises.

In general, crops which require several cultivations annually and have low harvest heights (sugar cane, navybeans, soybeans) have a low tolerance to rock. Root crops (potato, peanuts) are very sensitive. Horticultural tree crops can tolerate considerable amounts.

The size and amount of coarse fragments, as defined by McDonald *et al.* (1990) were used to determine the suitability subclasses. Rock fragments are consistently a problem on the *Brooweena*, *Avondale rocky phase*, *Berren* and *Bungadoo-Takoko* complex soils.

Erosion control measures should be implemented on sloping soils to reduce the concentration of rock fragments at the surface resulting from soil loss.

Landscape complexity (x)

Effective management of suitable land requires that an area of land is practical to utilise for a particular use. The size of production areas may be limited by complex soil patterns or where land is dissected by creek and gullies. Small and/or narrow and/or isolated land offers restrictions on farm layout, and the efficiency and ease of machinery use.

Assessment is based on the size, accessibility and proximity of adjoining suitable land. When the area of contiguous suitable soil in a UMA is not a minimum production area, the area of any contiguous suitable soil in adjacent UMAs is also included in the assessment of production area size. Criteria relating to production area size is dependant on the type of agricultural enterprise. For example, field crops such as maize and sorghum, will be more severely affected on small areas than high value horticultural crops (see Appendix V).

In UMAs with subdominant soils (<60%) and the component soils have different suitability classes, the highest suitability class is downgraded according to the proportional area of each and/or the criteria relating to production area size.

For example, if a UMA contains two subdominant soils with a sugar cane suitability class of two and three, with the largest contiguous area of each soil being 1.5 to 2.5 ha then, under these conditions, effective management will be reduced through variation in crop growth, machinery use or land degradation. Therefore, the highest suitability class is downgraded.

Complex soil patterns are a problem mainly on the alluvial plains and on the Elliott Formation but often the individual areas of different soils are unknown due to the broad scale of mapping.

Microrelief (tm)

Microrelief including gilgai and small channels, will affect the efficiency of irrigation, and the depressions will pond water, causing uneven crop productivity. Gilgai is the main form of microrelief in the study area and land planing is necessary to enable irrigation to occur. The extent of land planing will depend largely on the vertical interval of the gilgai. Generally, problems with plant growth will become greater as the cut on the mound becomes deeper and exposes subsoil with adverse chemical and physical properties. Loveday (1981) states that after irrigation, filled areas are likely to settle to varying degrees and will necessitate re-levelling to eliminate low spots. The soil should be cultivated to the depth of greatest fill to decrease the incidence of differential settling.

The *Walla* soil has weakly developed gilgai in areas which have not been cultivated. Extreme care in levelling these gilgai is necessary to avoid exposure of the strongly sodic subsoil. Gypsum will be necessary to assist crop establishment and improve water penetration if levelling is required on such soils.

Slope (ts)

The topography limitation has a direct affect on the ease of machinery operations and land use efficiency in general. It covers the slope limits for the safe use of machinery.

The slope limit for the safe and efficient use of machinery is 15%. However, all land greater than 15% in the study area, except the Ferrosols, is unsuitable or marginal for agricultural development due to other limitations.

Surface condition (ps)

The establishment of a uniform plant stand of desired density is important for successful crop production. Germination, seedling emergence and crop establishment may be affected by adverse physical conditions of the soil surface. These conditions include hardsetting, crusting or coarse structure.

Smith and McShane (1981), Gardner and Coughlan (1982) and Elliott and McDonald (1989) have demonstrated that emergence and crop establishment can be a problem on sodic duplex soils. Crusting, excessive clodiness and varying soil moisture in the seedbed are the major factors involved. These factors would be expected in the duplex soils and clays with shallow A horizons (*Auburn, Avondale, Doongul, Givelda, Kolan, Peep, Walla*). Retention of crop residues and minimum tillage will assist in maintaining and improving soil structure. Green cane harvesting would seem appropriate on these soils. Applying gypsum to the soil or to the irrigation water should also reduce the problem.

Surface soils with a high proportion of fine sand and silt, and with low organic matter content (*Auburn, Boyne, Clayton, Drinan, Kalah, Kepnock, Kolan, Kolbore, Woco, Woolmer*) slake and seal under rapid wetting. They present problems with seedling emergence and water infiltration. Adding gypsum to irrigation water using a dissolvenator may decrease slaking and may improve infiltration.

Planting into moist soil is regarded as the best method for establishing crops on these soils. Stubble retention and minimum tillage is recommended to improve structure and decrease the severity of crusting. Controlled traffic and a permanent bed farming system may also be useful on these soils.

Narrow moisture range (pm)

Soils have a specific moisture content range during which tillage can successfully be carried out. The most opportune time to till clay soils is approximately just drier than the plastic limit (PL), (Utomo and Dexter, 1981). At this moisture content, a soil is dry enough to shatter if tilled; if wetter than the PL, the soil will smear or remould. The current state of a soil relative to the PL can be estimated by attempting to firm a quantity of soil into a ball and then roll it into a 3 mm diameter rod. At the PL the soil will form a crumbly ball and just fail to make a 3 mm rod (Daniells and Larsen, 1990).

Braunack and McPhee (1988) showed that finer tilths were produced at soil water contents nearer the plastic limit, than with wetter profiles. However, a fine seedbed could also be produced by increasing the number of implement passes over a range of moisture contents. This is a more expensive option however.

The clay soils have a narrow moisture range for tillage while the hardsetting fine loamy surface soils have a moderate moisture range.

Soil adhesiveness (pa)

Root crops that produce their harvestable material below the ground surface, such as peanuts and potatoes, require soils that do not adhere to the harvested product. This limitation would be most severe on the massive fine loamy surfaced soils and clays.

Water erosion (e)

Water erosion causes long term productivity decline on unprotected sloping land through the loss of soil, organic matter and nutrients. Crop damage, higher working costs, uneven harvest heights and damage caused by silt deposition also results from soil erosion.

Within the study area, erosion potential is determined by slope, soil erodability and management. Slope limits for the soils and crop are outlined in Appendix V. Land with slopes less than the limit is considered suitable for permanent cultivation. Land uses such as horticultural tree crops and pastures have higher slope limits than other uses because of the reduced cultivation and increased plant cover.

Secondary salinisation (s)

Under stable climatic conditions, in a natural environment, a hydrological equilibrium occurs between water intake from rainfall and water lost through plant uptake, evaporation, runoff and leakage to groundwater (Shaw *et al.,* 1986). Practices associated with agriculture, particularly clearing and irrigation are major ways in which this hydrological balance is disturbed. Increases in accession to groundwater may result in raised watertables which may be either non-saline or saline.

Intake or recharge areas are those areas in which there is a downward component to groundwater flow near the soil surface. These recharge areas tend to occur upslope and on convex topography often with shallow or permeable soils over fractured rock (Shaw *et al.,* 1986).

In discharge (seepage) area, there is an upward component to groundwater flow near the soil surface which may result in secondary salinisation. Discharge areas occur at breaks of slope, in flat or incised areas or in regions of concave slope.

High salt levels are associated with fine grained sedimentary rocks and deeply weather basalts while sandstones and granites usually have low salt levels.

Salinisation is consistently evident on the sodic duplex soils developed on fine grained sedimentary rocks found on discharge areas (*Kalah, Kolbore, Turpin, Avondale, Woco*) and occasionally on other poorly drained soil (*Huxley, Duingal, Robur, Theodolite, Peep, Mahogany, Alloway, Clayton, Kolan*).

Losses to groundwater must be reduced in the recharge areas to avoid salinisation of the discharge areas. Furrow irrigation is therefore not recommended on soils of the recharge areas. Spray irrigation or trickle irrigation is recommended to avoid excessive losses to deep drainage.

Shaw *et al.* (1982) considered that effective drainage will be difficult to achieve, especially on the sodic soils of low hydraulic conductivity which are present in the potential discharge areas. Any area with existing natural salinisation is considered unsuitable for development.

Water infiltration (i)

Recharging the soil water deficit completely is important in irrigation. Recharge is affected by surface infiltration and soil permeability. Local experience indicates that the fine loamy surface soils slake and surface seal under irrigation, particularly spray irrigation. The slow rate of infiltration can result in incomplete recharge of the rooting zone, increased runoff and more frequent irrigation. Soils with a high sodicity in the upper profile have low soil permeability and therefore reduced ability to recharge the soil profile.

For furrow irrigation, gradients and lengths of furrows should be designed to meet the water application rate, the infiltration characteristics of the soil and the sensitivity of the crop to waterlogging (Loveday, 1981). The potential for soil erosion in the furrow must also be considered (Shaw and Yule, 1978). These requirements show why laser levelling is very important, especially on low slopes.

Little data are viable to indicate the maximum and minimum slopes required for furrow irrigation although Muchow and Yule (1983) suggest slopes should exceed 0.1% (1:1000). Problems associated with furrow irrigation on slopes less than 0.1% will be reduced if furrow lengths are shortened.

On more steeply sloping land (greater than 1%) the furrow gradient can be reduced by aligning furrows across the slope. Furrow irrigation is not suitable on excessively permeable soils. Furrow irrigation would be suitable on the *Auburn* and *Walla* soils only.

5. Land suitability

Land suitability assessment involves estimating the potential of land for various land uses based on soil and land attributes in the existing state. Land resource information collected during the soil survey was used for evaluation.

Using procedures similar to those described by Land Resources Branch Staff (1990), a classification system (Appendix V) was developed to assess the suitability of land in the Coastal Burnett - Wide Bay region to grow sugar cane, horticultural crops, grain crops and pastures under irrigation.

The significant limitations to agricultural production were identified for each of the 1787 unique map areas (UMA's) delineated in the study. Each occurrence of a mapping unit is termed a UMA. The overall land suitability class for land in the Childers area was determined usually by the most severe limitation. The severity of each limitation was assessed on a 1 to 5 scale (Appendix IV). A combination of limitations may lead to a downgrading of the suitability class.

Table 29 identifies the total area suitable for the various agricultural land uses in the study area.

Table 29. Areas suitable for agricultural land uses in the Childers area

Agricultural land use	Total area (ha) suitable (Class 1, 2, 3)	Areas (ha) suitable (Class 1, 2, 3) within the Bundaberg Irrigation Area
Asparagus	42 697	24 001
Avocado	11 706	10 133
Beans	24 888	11 829
Citrus	21 047	13 751
Crucifers	42 697	24 001
Cucurbits	42 004	23 483
Grape	30 131	18 275
Improved pasture	58 934	35 798
Lucerne	15 155	12 200
Lychee	73 313	37 008
Macadamia	17 166	11 983
Maize	26 125	17 757
Mango	32 570	21 247
Navybean	25 261	12 205
Peanut	15 992	9 993
Pineapple	32 747	21 149
Potato	36 014	18 308
Sorghum	26 125	17 757
Soybean	20 241	12 656
Stone fruit	30 085	18 275
Sugar cane	47 032	31 327
Sweet corn	34 982	19 581
Sweet potato	41 588	23 337
Vegetables	42 004	23 483

The Childers study area has sugar cane assigned areas of 15 623 ha, 6 770 ha and 1 055 ha for the Isis, Bingera and Millaquin Mills respectively. These assignments are dominantly within the Bundaberg Irrigation Area (BIA). Allowing 20% loss of land to roads, headlands, houses, gullies etc, the total area under sugar cane and associated infrastructure is approximately 29 300 ha. A majority of this area is assessed as suitable for sugar cane.

Within the total area of 31 327 ha suitable for sugar cane (Table 29) in the BIA, 3526 ha is located in State Forests within the BIA. Any future expansion of rural industries in the study area is dependant on water supplies from irrigation schemes, rivers, underground resources or on-farm storages. From Table 29, considerable potential for rural development exists outside the current BIA.

6. References

Baker, D.E. (1991), *Interpreting soil analyses for soil surveys conducted in Queensland*. Department of Primary Industries, Bulletin QB 91001.

Bourne, J.F. and Harris, G.A. (1985), *Irrigation scheduling. Timing and Rate decisions.* Queensland Department of Primary Industries, Information Series QI85024.

Braunack, M.V. and McPhee, J.E. (1988), The effect of initial soil water content and tillage implement on seedbed formation. In *Symposium Proceedings of Soil Management 88, 19-21 September, 1988, Darling Downs Institute of Advanced Education, Toowoomba.*

BSES (1977), *Assessment of flood damage in the Mulgrave and Babinda areas, 1977. Internal Report, Bureau of Sugar Experiment Stations, Queensland, Australia.*

Coaldrake, J.E. (1961), *The ecosystems of the coastal lowlands (Wallum) of Southern Queensland.* CSIRO Australia, Bulletin No. 283.

Daniels, I. and Larsen, D. (eds) (1990), *Soilpak.* NSW Agriculture and Fisheries.

Doorenbos, J. and Pruitt, W.D. (1977), *Crop water requirements.* FAO Irrigation and Drainage Paper 24, (Revised), FAO, Rome.

Ellis, P.L. (1968). *Geology of the Maryborough 1:250 000 sheet area.* Queensland Department of Mines, Geological Survey of Queensland, Report No. 26.

Elliott, P.J. and McDonald, W.J. (1989), *Gaynor Research Site Report, dry season 1986.* Department of Primary Industries, Queensland Government, RQM90001.

Forster, B.A. and Macnish, S.E. (1987), Field evaluation of the suitability for irrigation of caneland in the Isis Mill area with particular emphasis on salinity and drainage hazard. Landscape, Soil and Water Salinity. *In Proceedings of the Bundaberg regional salinity workshop, Bundaberg, April 1987.* Queensland Department of Primary Industries, Conferences and Workshop Series QC87001.

Gardner, E.A. and Coughlan, K.J. (1982), *Physical factors determining soil suitability for irrigation crop production in the Burdekin - Elliott River area.* Queensland Department of Primary Industries, Agricultural Chemistry Branch, Technical Report 20.

Gillman, G.P. (1983), Nutrient availability in acid soils of the tropics following cleaning and cultivation, *Proceedings of the International Workshop on Soils*, Townsville, Queensland, Australia. September 1983. Australian Centre for International Agricultural Research, 39-46.

Gillman, G.P. (1984), Using variable change characteristics to understand the exchangeable cation status of acid soils, *Australian Journal of Soil Research* **22**, 71-80

Gin Gin Land Use Study Committee, (1972), *The Gin Gin district, a land use study.*

Glanville, T.J., Macnish, S.E. and Scarborough, R.C. (1991), *Land Management Manual Coastal Burnett Districts.* Queensland Department of Primary Industries, Training Series QE91004.

Hodgson, A.S. (1986), Can you afford waterlogging? *Australian Cotton Grower,* August - .October 1986, 4-5.

Isbell, R.F. (1996), *The Australian Soil Classification.* CSIRO, Australia.

Isbell, R.F., Thompson, C.H., Hubble, G.D., Beckmann, G.G. and Paton, T.R. (1967), *Atlas .... of Australian Soils, explanatory data for sheet 4 Brisbane - Charleville - Rockhampton - Clermont area.* CSIRO/Melbourne University press.

Isis Land Use Study Committee, (1971), *The Isis District Queensland, a land use study.*

Keefer, G.D. (1989). Research developments in irrigation scheduling and application of water use models. In Hazard, W.H., Shaw, R.J. and Bourne, J.P. (eds). *Irrigation Management Workshop Proceedings, Queensland Agricultural College,* 24-27 June 1986. Queensland Department of Primary Industries, Conference and Workshop Series, QC89008, 1019-28.

Kent, P.M. (in Prep.), *Land Resources of the Burnett Region, Part 11, Central.* Department of Natural Resources, Queensland, Land Resources Bulletin.

Land Resources Branch Staff, (1990), *Guidelines for agricultural land evaluation in Queensland.* Queensland Department of Primary Industries, Information Series QI90005.

Landon, J.R. (ed) (1984), *Booker Tropical Soil Manual, A handbook for soil survey and agricultural land evaluation in the tropics and subtropics.* Booker Agricultural International Limited.

Lawrence, R.J., O'Hara, R.J. and Connor, T.B. (1982), Floods versus farmers - Flood management for agriculture. *Proceedings Australian Society of Sugar Cane Technologists,* 1982 Conference, 59-65.

Loveday, J. (1981), Soil management and amelioration. In T.S. Abbott, C.A. Hawkins and P.G.E. Searle (eds) *National Soils Conference 1980 Review Papers,* Australian Society Soil Science Inc., Glen Osmond, South Australia.

McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. and Hopkins, M.S. (1990), *Australian Soil and Land Survey Field Handbook.* 2nd edition, Inkata Press, Melbourne.

Muchow, R.C. and Yules, D.F. (1983), Research for improved crop management. Irrigation. In Muchow, R.C. (ed), *Proceedings of Agro-Research for Australia's Semi Arid Tropics,* 21-25 March, 1983, Darwin.

Queensland Coastal Lowlands Land Use Study Committee, (1976), *The Maryborough coastal land use study.*

Reed, R.E. (1988) Soil survey specifications. In *Australian soil and land survey handbook: Guidelines for conductivity surveys* (Gunn, R.H., Beattie, J.A., Reid, R.E., VanderGraff, R.H.M.), Inkata Press, Melbourne.

Shaw, R.J., Hughes, K.K., Dowling, A.J. and Thorburn, P.J. (1986), Principles of landscape, soil and water salinity - processes and management options, Part A in Landscape Soil and Water Salinity. *Proceedings of the Burdekin Regional salinity workshop, Ayr, April 1986.* Queensland Department of Primary Industries Publication QV86003.

Shaw, R.J., Thorburn, P.J., McShane, T.J., Maltby, J.E. and Robson, C.K. (1982), The effectiveness of drainage in a region of variable aquifer hydraulic conductivity in the Lower Burdekin Region, north Queensland. In R.J. Smith and A.J. Rixon (eds.), *Rural Drainage in Northern Australia*, proceedings of Symposium, Darling Downs Institute of Advanced Education, 129-42.

Shaw, R.J. and Yule, D.F. (1978), *The assessment of soils for irrigation, Emerald, Queensland.* Queensland Department of Primary Industries, Agricultural Chemistry Branch, Technical Report 13.

Smith, C.D. (1985), *Land suitability study of Isis Mill cane growing area.* Queensland Department of Primary Industries, Project Report Q085021.

Smith, G.D. and McShane, T.J. (1981), *Modification and management of irrigated soils in the Lower Burdekin Valley Queensland.* Queensland Department of Primary Industries, Agricultural Chemistry Branch, Technical Report 17.

Thompson, C.H., Bridges, E.M. and Jenkins, D.A. (1994), An exploratory examination of some relict hardpans in the coastal lowlands of southern Queensland. In A.J. Ringrose-Voase and G.S. Humphreys (eds), *Soil Micromorphology: Studies in management and genesis,* Proceeding IX International Working meeting on Soil Micromorphology, Townsville, Australia, July 1992. Development in Soil Science 22, Elsevur, Amsterdam, pp 233-245.

Utomo, Q.H. and Dexter, A.R. (1981), Soil friability. *Journal of Soil Science* **32**, 203-213.

van Wijk, C.L. (undated). *Bundaberg Irrigation Area soils association map.* Queensland Department of Primary Industries and Irrigation and Water Supply Commission.

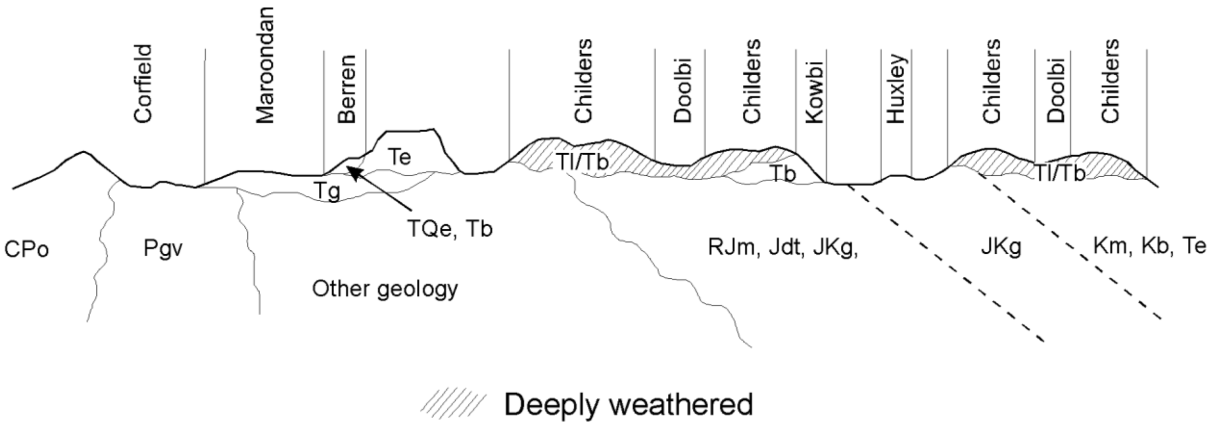
Williamson, R.E. and Kriz, G.J. (1970), Response of agricultural crops to flooding, depth of watertable and soil gaseous composition. *Transactions of the American Society of Agricultural Engineers* **13,** 215-220.

Yule, D.F. (1989), Irrigation management for efficient water use. In W.H. Hazard, R.J. Shaw, and J.P. Bourne, (eds), *Irrigation Management Workshop Proceedings, Queensland Agricultural College 24-27 June 1986,* Queensland Department of Primary Industries, Conference and Workshop Series QC89008.

Appendix I

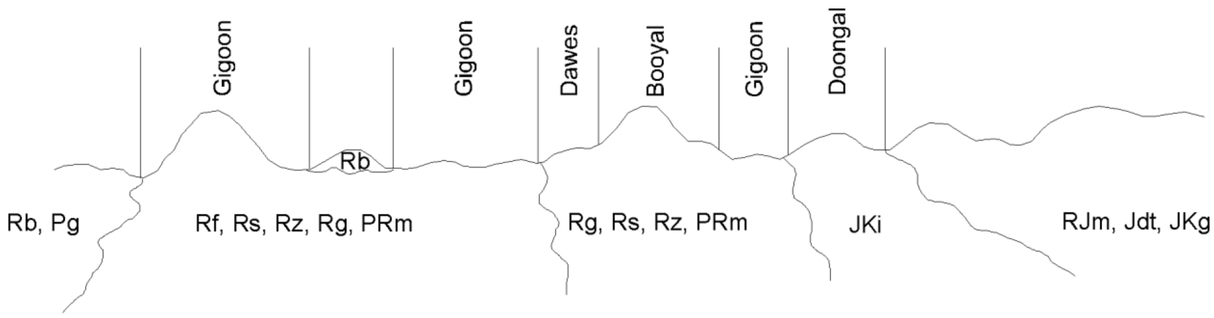
Diagrammatic cross-sections showing idealised relationship between:

(a) basalts and intermediate volcanics/metamorphic rocks, landform and soils



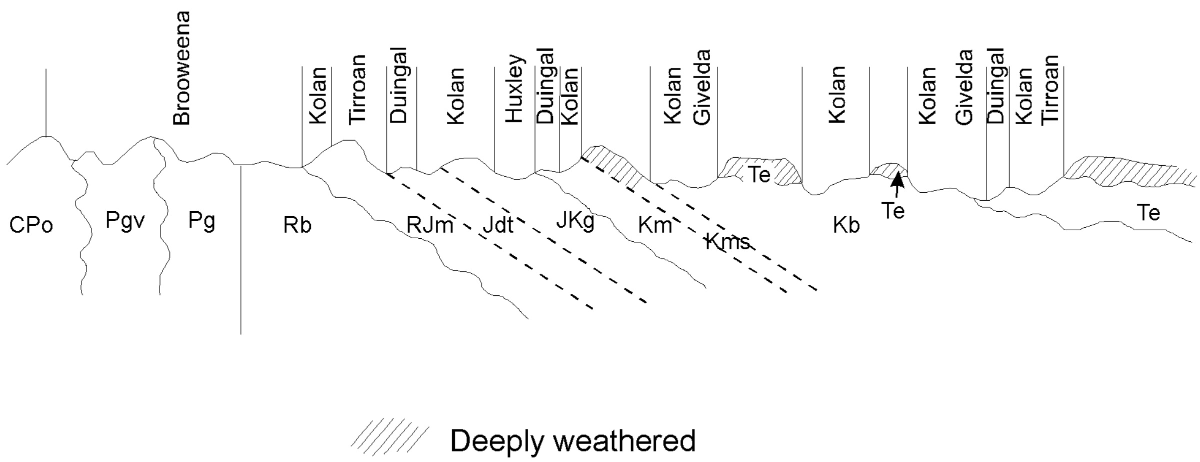
Geology reference	Upper slopes	Lower slopes	Vegetation
T1/Tb	Red Ferrosol (*Childers*)	Brown and yellow Dermosol (*Doolbi*)	Cleared
Tb	Brown Dermosol (*Kowbi*)	Grey and brown Vertosol (*Huxley*) (very minor)	Cleared
JKg andesite		Grey and brown Vertosol (*Huxley*)	Cleared
TQe,Tb	Brown Dermosol (*Berren*)		Cleared
Tg	Black Vertosol (*Maroondan*)	Black Vertosol (*Maroondan*)	Cleared
Pgv, CPo	Brown and red Dermosol (*Corfield*)	Brown and red Dermosol (*Corfield*)	Cleared

(b) granites, landform and soils



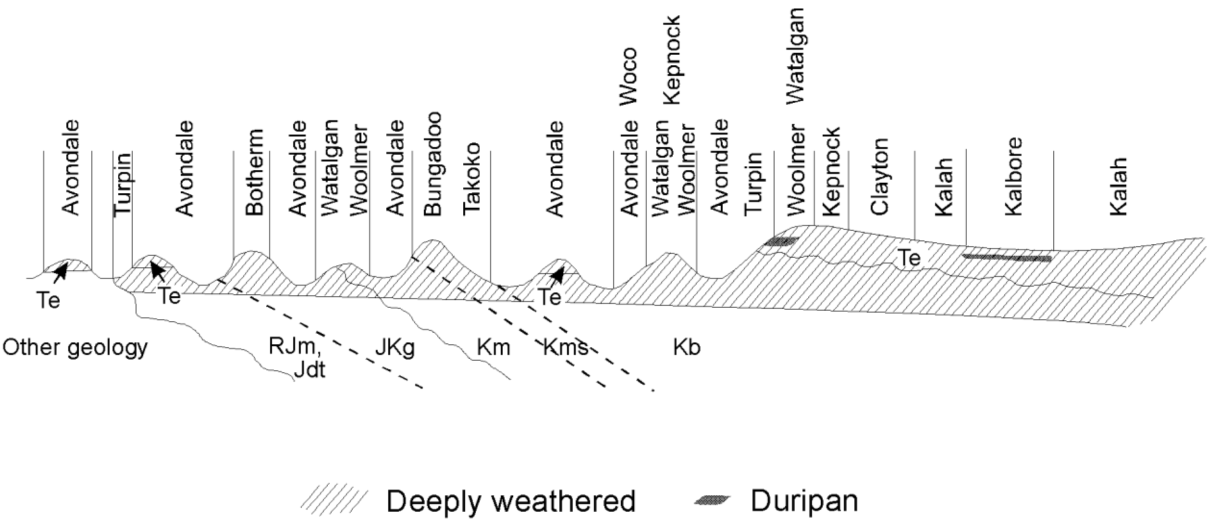
Geology reference	Hillslopes	Vegetation
JKi	Grey and brown Sodosol (*Doongul*)	>18m lemon scented gum, ironbarks, gum topped box
Rf, Rs, Rz, Rg, PRm	Brown and grey Sodosol (*Gigoon)*	15-25m narrow leaved ironbark, lemon scented gum, forest red gum
Rs, Rz, PRm, Rg	Brown and black Vertosol, black Dermosol (*Dawes*)	12-20m ironbarks, gum topped bloodwood
Rz, Rg	Red and brown Chromosol, red and brown Dermosol (*Booyal*)	12-20mm ironbark, gum topped bloodwood

(c) moderately weathered sedimentary rocks, landform and soils



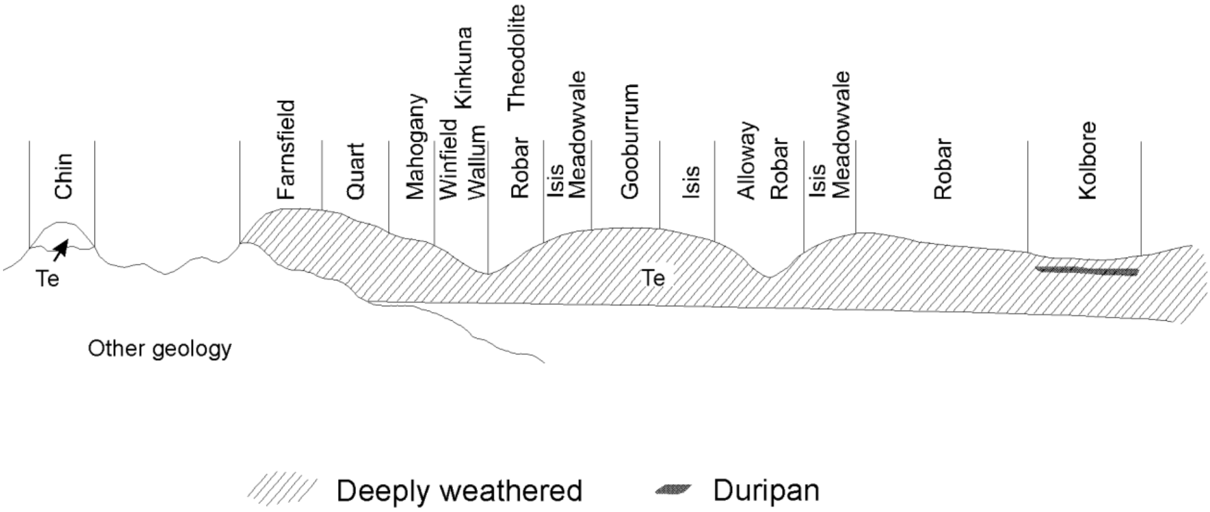
Geology reference	Crests and upper slopes	Lower slopes	Vegetation
Te, Kb, Km, JKg, Jdt, RJm	Grey and brown Kurosol (*Kolan*)	Grey and brown Kurosol *(Kolan*)	>18m lemon scented gum, ironbarks, gum topped box
	Brown and yellow Sodosol (*Givelda*)	Brown and yellow Sodosol (*Givelda*)	>18m lemon scented gum, ironbark, gum topped box or very minor vine scrub
		Grey and brown Vertosol (*Duingal*)	>18m lemon scented gum, ironbarks, gum topped box
JKg andersite		Grey and brown Vertosol (*Huxley*)	Cleared
Rb, Pg, Pgv, CPo	Brown and grey Sodosol (*Brooweena*)	Brown and grey Sodosol (*Brooweena*)	>18m lemon scented gum, ironbark gum topped low or very minor vine scrub
Te, RJm	Grey Sodosol (*Tirroan*) Brown and yellow Chromosol (*Tirroan non-sodic variant)*	Grey Sodosol (*Tirroan)*	>18m stringybarks, bloodwoods, lemon scented gum, *Angophora costata*

(d) deeply weathered fine grained sedimentary rocks, landform and soils



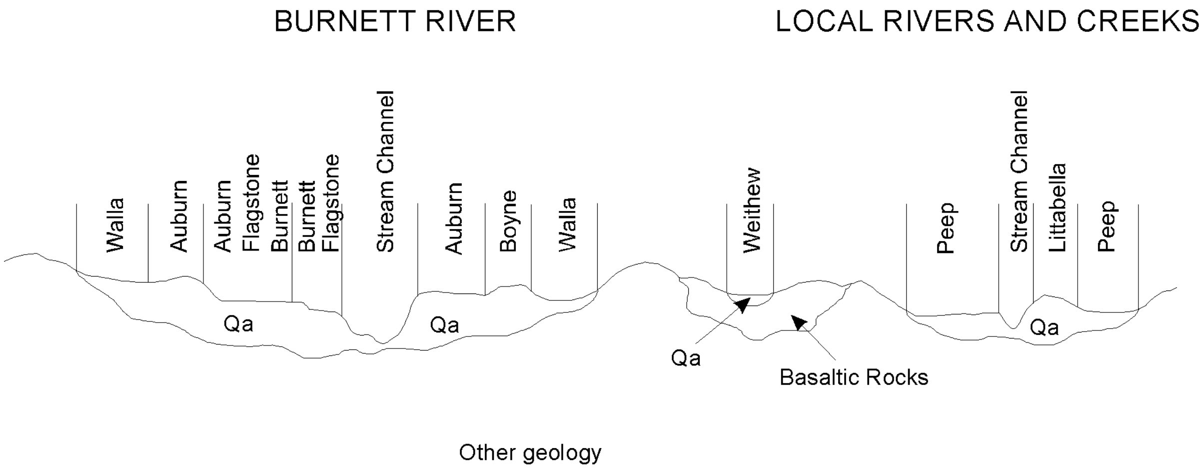
Geology reference	Crests and upper slopes	Lower slopes	Level Plains	Vegetation
Te, Kb, Km, JKg, Jdt	Red Dermosol (*Watalgan*)			> 18 lemon scented gum, bloodwoods, stringybarks
Kms	Brown and yellow Dermosol/Tenosol with > 20 silicified rocks (*Bungadoo/Takoko*)			> 18 lemon scented gum, stringybark and dense understory of *L. confertus*
JKg (rhyolite)	Grey and brown Dermosol (*Botherm*)			> 18 lemon scented gum, stringybark and dense understory of *L. confertus*
Te, Kb,Km, JKg, Jdt, RJm	Yellow and brown Dermosol (*Kepnock, Woolmer*)			12-18m stringybarks, bloodwoods, usually with *Acacia* and other shrub understory
Te			Yellow Dermosols (*Kepnock*)	12-18m stringybarks, bloodwoods, usually with *Acacia* and other shrub understory
Te, Kg, Kn, JJg, Jdt, Rjm	Grey and brown Sodosol Kurosol (*Avondale*)	Grey and brown Sodosol/Dermosol/ Kurosol/Hydrosol (*Avondale, Woco*)		< 18m stringybarks, tea tree/*Angophora*
Te, Kb, Km, JKg, Jdt, RJm with sandstone s (Te, RJm) upslope		Grey and brown Sodosol/Kurosol/ Hydrosol (*Turpin*)		< 18m stringybarks, tea tree/*Angophora*
Te			Hydrosol (*Clayton, Kalah)* Hydrosol (*Kolbore*)	< 18m stringybarks, tea tree/*Angophora* < 18m stringybarks, tea tree/*Angophora or* < 18 m scattered tea tree and/or dense understory of *Melaleuca nodosa*

(e) deeply weathered coarse grained sedimentary rocks, landform and soils



Geology reference	Crests and upper slopes	Lower slopes	Level plains	Vegetation
Te	Red Kandosol (*Farnsfield*)			>18m bloodwood, lemon scented gum, stringybarks
	Red Dermosol (*Gooburrum*)			>18m bloodwood, lemon scented gum, stringybarks
	Red Ferrosol (*Chin*)			>18m bloodwood, lemon scented gum, stringybarks
Te		Podosol (*Kinkuna, Wallum*)	Podosol (*Kinkuna, Wallam*)	> 18m turpentine or <18m stringybarks with heath understory or heath
Te	Yellow Dermosol (*Meadowvale)*		Yellow Dermosol (*Isis)*	12-18m stringybarks, bloodwoods with *Acacia* and other scrub understory
	Yellow Kandosol (*Quart*)		Redoxic Hydrosol (*Winfield*)	12-18m stringybarks, bloodwoods with *Acacia* and other scrub understory
Te		Redoxic Hydrosol (*Mahogany, Alloway, Robur*)	Redoxic Hydrosol (*Alloway, Robur*)	< 18m stringybarks, tea trees/B*anksia robur*, *Banksia oblongfolia*
Te			Redoxic Hydrosol (*Kolbore*)	< 18m teatrees/dense understory of *Melaleuca nodosa*
			Podosol (*Theodolite*)	Heath with *Melaleuca nodosa*

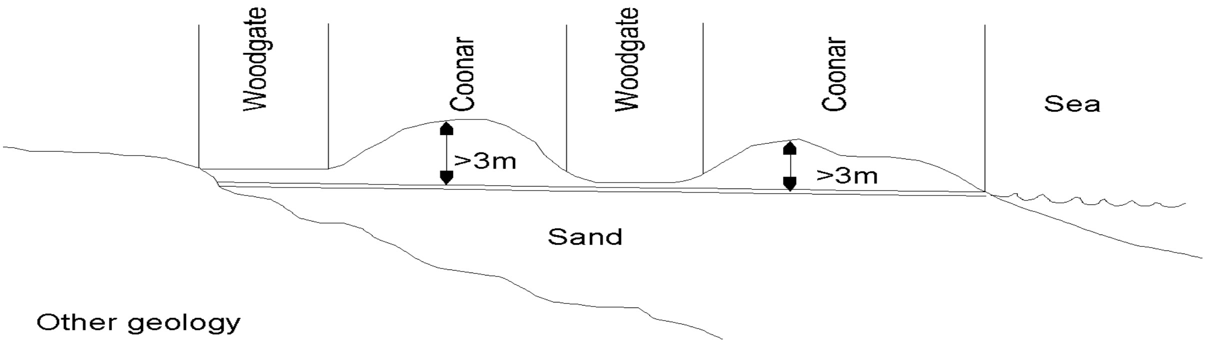
(f) alluvium, landform and soils



Geology reference	Alluvial plains	Terraces	Channel benches, levees, scrolls	Vegetation
Qa Burnett River	Brown and grey Sodosol (*Auburn*)	Brown and grey Sodosol (*Auburn*)		Cleared
	Grey Vertosol (*Walla*)			Cleared
	Red and brown Chromosol, red Dermosol (*Boyne*)			Cleared
		Brown and black Dermosol (*Flagstone*)	Brown and black Dermosol (*Flagstone*)	Cleared
		Stratic Rudosol, orthic Tenosol (*Burnett*)	Stratic Rudosol, orthic Tenosol (*Burnett*)	Cleared
Qa Local rivers and creeks	Grey and brown Sodosol; redoxic Hydrosol (*Peep*)			15-20m stringy barks, *Angophora, Melaleuca*, gum topped box, forest red gum, or cleared
	Grey and yellow Dermosol, redoxic Hydrosol (*Drinan*)			Cleared
	Red Kandosol (*Redbank*) (very minor)			Cleared

Geology reference	Alluvial plains	Terraces	Channel benches, levees, scrolls	Vegetation
			Yellow and grey and red Kandosol, orthic Tenosol (*Littabella*)	15-20m stringy barks, *Angophora, Melaleuca*, gum topped box, forest red gum, or cleared or scrub
Qa Local creeks draining Basalt	Black and grey Vertosol (*Weithew*)			Cleared

(g) beach ridges, landform and soils



Coffee rock pan

Geology reference	Ridges	Swales	Vegetation
Qs, Qpcb	Aquic Podosol (*Coonar*)		> 6m *Callitris* with heath understory or <5m heath
Qs, Qpcb	Aquic Podosol (*Woodgate*)		< 5m heath

Appendix II

A key to soils in the Childers study area

A. ***Soils that have a Bhs* or Bh* horizons***

⇒ **PODOSOLS**

••• Soils on beach ridges.	•• Thick (>3 m) A horizons over a Bh horizon.		• **Coonar** (Ca)
	•• A horizon <1.5 m over a Bh horizon. .		• **Woodgate** (Wg)
••• Soils on deeply weathered sedimentary rocks	•• A Bhs, Bh horizon over sand.		• **Kinhuna** (Kn)
	•• A Bhs, Bh horizon over a massive sandy clay loam to sandy clay.		• **Wallum** (Wm)
	•• A Bhs, Bh horizon over a sodic structured clay.		• **Theodolite** (Th)

****

B. ***Soils with***
1. A clay field texture or 35% or more clay in all horizons, and
2. Unless wet, have open cracks at some time in most years which are at least 5 mm wide and extend upward to the surface or to the base of any plough layer, and
3. At some depth in the profile, slickensides* and/or lenticular peds*.

⇒ **VERTOSOLS**

••• Soils on granites .	•• Brown or black B horizon		• **Dawes** (Dw)
••• Soils on basalts and andesites . . .	•• Black B horizon (minor brown)	• Black B horizon >0.3 m over rock	• **Maroondan** (Mr)
		• Black B horizon <0.3 m over rocks	• **Maroondan shallow phase** (MrSp)
		• Black B horizon over grey clay >0.2 m thick .	• **Maroondan grey variant** (MrGv)
	•• Grey B Horizon . . .		• **Huxley** (Hx)
••• Soils on moderately weathered sedimentary rocks . .	•• Acid grey B horizon		• **Duingal** (Dg)
	•• Alkaline grey B horizon		• **Dungal alkaline variant** (Dg Av)
••• Soils on alluvium. . .	•• Along major rivers .	• Grey B horizon	• **Walla** (Wl)
	•• Along local creeks and rivers (adjacent to basalt)	• Grey or black B horizon	• **Weithew** (Wh)

C. Soils in which the greater part of the profile is saturated for at least several months in most years.

⇒ **HYDROSOLS**

••• Soils on deeply weathered sedimentary rocks . .	•• Sandy surface without iron (maghemite) nodules	• Sandy throughout profile, grey B horizon.	• **Winfield** (Wf)
		• Massive sandy clay loam to sandy clay B horizon	• **Mahogany** (Mh)
		• Structured non-sodic clay B horizon.	• **Alloway** (Al)
		• Structured sodic clay B horizon	
		- no pan in profile	• **Robur** (Rb)
		- duripan at <1.2 m . . .	• **Kolbore** (Kl)
	•• Sandy surface with iron (maghemite) nodules	• Coarse structured sodic clay B horizons	• **Turpin** (Tp)
	•• Loamy surface without iron (maghemite) nodules.	• Structured non sodic clay B horizon	• **Clayton** (Cl)
		• Structured sodic clay B horizon	
		- no pan in profile	• **Kalah** (Kh)
		- duripan at <1.2 m	• **Kolbore** (Kl)
	•• Loamy surface with iron (maghemite) nodules	• Coarse structured sodic clay B horizon	• **Avondale** (Av)
		• Fine structured (friable) sodic clay B horizon . . .	• **Woco** (Wo)
••• Soil on alluvium . . .	•• Along local creeks and rivers.	• Structured non sodic grey clay B horizons with manganiferous nodules	• **Drinan** (Dn)
		• Mottled grey or brown sodic B horizons	• **Peep** (Pp)

****

D. Soils with a clear or abrupt textural B horizon which is strongly acid (pH <5.5) in the major part of the upper 0.2 m of the B2 horizon.

⇒ **KUROSOLS**

••• Soils on moderately weathered sedimentary rocks . .	•• Red mottled grey or brown clay B horizon.		• **Kolan** (Ko)
	•• Grey mottled red clay B horizon		• **Kolan red variant** (KoRv)

••• Soils on deeply weathered sedimentary rocks. . .	•• Sandy surface with iron (maghemite) nodules		• **Turpin** (Tp)
	•• Loamy surface with iron (maghemite) nodules	• Coarse structured clay B horizon	• **Avondale** (Av)
		• Fine structured (friable) clay B horizon	• **Woco** (Wo)

****

E. Soils with a clear or abrupt textural B horizon in which the pH in $\geq$ 5.5 and which is sodic (ESP*$\geq$6) in the major part of the upper 0.2 m of the B2 horizon.

⇒ SODOSOLS

••• Soils in granites.	•• Sandy A horizon over a mottled brown or grey B horizon		• **Gigoon** (Gn)
	•• Loamy A horizon over a grey or brown B horizon		• **Doongul** (Do)
••• Soils on moderately weathered sedimentary rocks. . .	•• Sandy A horizons . . .	• Mottled brown or yellow B horizon with no rock fragments	• **Tirroan** (Tr)
	•• Loamy A horizon . .	• Mottled brown or yellow B horizon with no rock fragments. . . .	• **Givelda** (Gv)
		• Shallow mottled variable B horizon with rock fragments . .	• **Brooweena** (Bw)
••• Soils on deeply weathered sedimentary rocks	•• Sandy A horizon	• A horizon >0.5 m	• **Robur** (Rb)
		• A horizon <0.5 m with iron (maghenite) nodules	• **Turpin** (Tp)
	•• Loamy A horizon with iron (maghenite) nodules.	• Rock at >0.3 m	• **Avondale** (Av)
		• Rock at <0.3 m	• **Avondale rocky phase** (AvRp)
••• Soils on alluvium . . .	•• Along major rivers. . . .	• Grey or brown B horizon - grey or brown throughout	• **Auburn** (Ab)
		- grey or brown over red subsoil	• **Auburn red variant** (AbRv)
	•• Along local creeks and rivers	• Mottled grey or brown B horizon	• **Peep** (Pp)

F. Soils with a clear* or abrupt* textural B horizon in which the pH is $\geq$ 5.5 in the major part of the upper 0.2 m of the B2 horizon.

⇒ CHROMOSOLS

••• Soils on granites.	•• Red or brown B horizon		• **Booyal** (Bl)
••• Soils on alluvium	•• Along major rivers . .	• Red or brown B horizon	• **Boyne** (By)
••• Soils on moderately weathered sedimentary rocks.	•• Sandy A horizon over yellow or grey B horizons		• **Tirroan non-sodic variant** (TrPv)
	•• Loamy A horizon . . .	• Shallow mottled variable B horizon with rock fragments . .	• **Brooweena** (Bw)
••• Soils on deeply weathered sedimentary rocks	•• Sandy A horizon . . .	• Mottled yellow B horizon	• **Isis** (Is)

****

G. Soils which
1. Have B2 horizons with structure more developed than weak throughout the major part of the horizon, and
2. Have B2 horizons in which the fine earth fraction (< 2 mm) of the major part has a free iron oxide greater than
5% Fe.

⇒ FERROSOLS

••• Soils on basalt . .	•• Red B horizon with low ECEC (<5 m equiv.)	• No ferruginous nodules.	• **Childers** (Cd)
		• >20% ferruginous nodules.	• **Childers nodular variant** (CdNv)
••• Soils on deeply weathered sedimentary rocks (mixed with basalt).	•• Red B horizon with fine quartz gravel (> 2 mm) throughout...		• **Chin** (Ch)

H. Soils, which have B2 horizons with structure more developed than weak throughout the major part of the horizon.

⇒ DERMOSOLS

••• Soils on granites.	•• Black loam to clay loam surface over a red or brown B horizon . . .		• **Booyal** (Bl)
	•• Black clay surface over a brown or black clay B horizon		• **Dawes** (Dw)
	•• Mottled yellow non-sodic clay B horizon . .		• **Gigoon non sodic variant** (GnPv)
••• Soils on basalt . .	•• Mottled yellow or brown B horizons . . .		• **Doolbi** (Db)
	•• Brown B horizon, >20% rock throughout profile		• **Berren** (Be)
	•• Brown B horizon . . .		• **Kowbi** (Kb)
••• Soils on metabasalts and other metamorphics . . .	•• Brown or red B horizon		• **Corfield** (Cf)
••• Soils on deeply weathered sedimentary rocks	•• Sandy surface	• Red B horizon	• **Gooburrum** (Gb)
		• Mottled yellow B horizon	• **Isis** (Is)
		• Yellow massive surface over mottled yellow B horizon	• **Meadowvale** (Md)
		• Red B horizon	• **Watalgan** (Wt)
	•• Loamy surface	• Mottled yellow B horizon	• **Kepnock** (Kp)
		• Yellow massive surface over mottled yellow B horizon	• **Wolmer** (Wr)
		• Mottled grey or brown B horizon on rhyolite .	• **Botherm** (Bh)
		• Strongly acidic (pH<5.5) fine structured (friable), sodic mottled grey or brown B horizon	• **Woco** (Wo)
		• Mottled brown, grey or yellow B horizon with silicified rock from Maryborough Formation.	• **Bungadoo** (Bg)
••• Soils on alluvium	•• Along major rivers . . .	• Brown or black B horizons	• **Flagstone** (Fs)
		• Red B horizons	• **Boyne** (By)
	•• Along local creeks and rivers	• Mottled yellow, brown or grey B horizon with manganiferous nodules	• **Drinan** (Dn)

I. Soils which 1. Have well developed B2 horizons in which the major part is massive* or has only a weak* grade of structure, and 2. Have a maximum clay content in some part of the B2 horizon which exceeds 15% (SL+).

⇒ **KANDOSOLS**

••• Soils on deeply weathered sedimentary rocks.	•• Red B horizon	• No rock	• **Farnsfield** (Ff)
		• >20% rock fragments .	• **Farnsfield rocky phase** (FfRp)
	•• Yellow B horizon . . .		• **Quart** (Qr)
	•• Grey B horizon		• **Mahogany** (Mh)
••• Soils on alluvium. .	•• Along local creeks and rivers	• Loamy surface over red B horizon	• **Redbank** (Rd) page 38
		• Sandy to loamy surface over yellow or grey B horizon, sandy surface over red B horizons	• **Littabella** (Lt) page 39

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J. Soils with negligible (rudimentary) pedalological organisation apart from the minimal development of an A1 horizon. There is little or no texture or colour change with depth unless stratified, and the soils are apedal or only weakly structured in the A horizon.

⇒ **RUDOSOLS**

••• Soils on alluvium	•• Along major river .	• Stratified and/or uniform sand	• **Burnett** (Bn)

****

K. Other soils with only weak pelodological organisation apart from the A horizons.

⇒ **TENOSOLS**

••• Soils in granites. .	•• Bleached sand		• **Gigoon sandy variant** (GrSv)
••• Soils on deeply weath. sedimentary rocks	•• Sandy surface	• Yellow sandy B horizon	• **Winfield yellow variant** (WfYv)
		• Red sandy B horizon .	• **Winfield red variant** (WfRv)
	•• Loamy surface with a bleached A2 horizon. .	• Silicified rock from Maryborough F. throughout profile	• **Takoko** (Tk)
		• A2 over other rocks . .	• **Avondale tenic variant** (AvTv)
••• Soils on alluvium	•• Along major rivers	• Structured A horizon < 0.5 m over a stratified and/or sandy subsoil . .	• **Burnett** (Bn)
	•• Along local creek and rivers	• Yellow, grey or red sandy B horizons	• **Littabella** (Lt)

****

Terms and abbreviations used in soils key.

Bh horizons	Organic-aluminium compounds are strongly dominant with little or no evidence of iron compounds.
Bhs horizon	Iron and organic compounds are both present.
Clear or abrupt textural B horizons	The boundary between the horizon and the overlying horizon is clear, abrup or sharp and is followed by a clay increase (usually 20% increase) giving a strong texture contrast.
ESP	Exchangeable sodium percentage.
Lenticular peds	Lense shaped peds.
Maryborough F	Maryborough Formation.
Massive	A soil appears as a coherent, or solid, mass which is largely devoid of peds.
Slickensides	Polished and groved surfaces that are produced by one mass sliding past another.
Weak grade of structure	Some peds are disarnable and when disturbed less than one-third of the soil material is found to consist of peds.
Weath	Weathered.

APPENDIX III
Soil profile classes

(A1) ALLOWAY

Concept: Bleached sandy surface over a mottled non-sodic, structured, gleyed subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Redoxic Hydrosol.

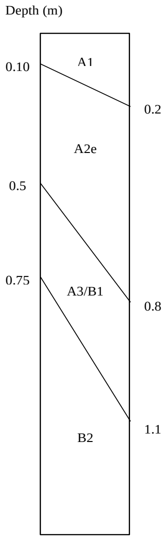
Great Soil Group: Gleyed podzolic soil.

Principle Profile Form: Gn3.04, Dg2.41, Dg4.41, Dy3.41.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating rises. Slopes 0 to 2%.

Vegetation: 15 to 18m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Eucalyptus hallii / Eucalyptus trachyphloia / Eucalyptus acmenoides*.



A1: Grey (7.5 YR 4/1, 4/2, 5/1, 10 YR 4/1, 4/2, 5/1, 5/2); loamy sand to sandy loam; massive; pH 5 to 6. Clear to diffuse change to

A2e: Conspicuously bleach. Frequently mottled; loamy sand to sandy loam; massive; pH 5.5 to 5.8. Clear to diffuse change to

A3, B1: Mottled; grey or yellow (10 YR 6/4, 7/2, 7/3, 7/4, 8/3); sandy clay loam, or occasionally light sandy clay loam increasing to sandy clay in the B1; frequently 2 to 50% ferruginous nodules 2 to 20mm; pH 5.5 to 6.5. Clear to diffuse change to

B2: Mottled; grey or occasionally yellow (10 YR 7/2, 7/3, 8/2, 8/3, 8/4, 2.5 Y 7/1, 7/2, 8/2); moderate or strong 2 to 10mm polyhedral or subangular blocky; light clay to medium clay; frequently 10 to 90% ferruginous nodules 2 to 20mm; pH 5 to 6.5.

Sites: 226, 227, 268, 280, 309, 317, 338, 348, 349, 353, 354, 361, 363, 368, 392, 393, 401, 406, 410, 419, 420, 430, 431, 444, 445, 446, 447, 449, 452, 462, 511, 514, 518, 523, 541, 542, 545, 546, 547, 548, 565, 585, 597, 612, 666, 670, 673, 674, 682, 692, 706, 715, 716, 731, 734, 741, 753, 757, 765, 1154, 1199.

Analysed sites: BIA (30, 35), CBW (6,18)

(Ab) AUBURN

Concept: Sodic texture contrast soil with a loamy surface over a mottled, brown or grey clay subsoil on alluvial plains of major rivers.

Australian Classification: Brown Sodosol, Grey Sodosol.

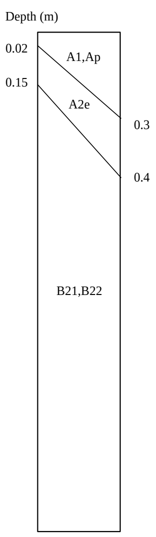
Great Soil Group: Solodic soil, minor soloth and solodized solonetz.

Principle Profile Form: Dy3.43, Dy3.42, Dy3.41, Db2.43, Dy2.43.

Geology: Quaternary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: Cleared.



A1, Ap: Black or grey (7.5 YR 3/2, 4/2, 10 YR 3/2, 4/2); loam fine sandy, clay loam fine sandy, silty clay loam; massive; pH 5.8 to 6.3. Clear to abrupt change to

A2e: Conspicuously bleached. Mottled; loam fine sandy, clay loam fine sandy, silty clay loam; massive; pH 5.5 to 6.5. Abrupt to sharp change to

B21, B22: Mottled; brown or grey (7.5 YR 4/2, 4/3, 5/2, 5/3, 6/2, 10 YR 4/2, 4/3, 4/4, 5/2, 5/3, 6/2, 6/3), usually paler at depth; light medium clay to heavy clay; strong 5 to 20mm angular blocky or 20 to 40mm prismatic parting to angular blocky or occasionally 50 to 100mm coarse columnar; <2 to 10% manganiferous nodules <6mm, occasionally <2% carbonate nodules <6mm in lower B2; pH 6 to 9.5.

Sites: 97, 98, 150, 179, 180, 184, 188, 215, 244, 587, 606, 1007, 1009, 1023, 1037, 1226, 1302, 1319, 1320, 1329, 1330, 1339, 1340, 1351, 1352, 1360, 1370

Analysed sites: BIA 41, ATB 21, CB12

Auburn red variant AbRv: as above; gradual to diffuse change at 0.6 to 1.3m to

D: Red or brown (5YR 4/4, 4/6, 5/6, 7.5YR 4/6, 10YR 4/6); medium to heavy clay; strong 5 to 20mm angular blocky.

Auburn sandy variant AbSv: Black or grey loamy sandy to sandy loam surface to 0.35 to 0.6m over a B2 as above.

Sites: 926, 990, 1022, 1081

(Av) AVONDALE

Concept: Sodic texture contrast soil with a shallow (<0.35m) loamy surface containing maghemite nodules over a grey subsoil on deeply weathered fine grained sedimentary rocks.

Australian Classification: Grey Sodosol, Grey Kurosol, minor Brown Sodosol, Brown Kurosol, Redoxic Hydrosol.

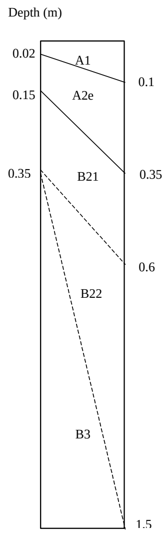
Great Soil Group: Soloth.

Principle Profile Form: Dy3.41.

Geology: Mudstones, siltstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Grahams Creek Formation (JKg), Tiaro Coal Measures (Jdt).

Landform: Gently undulating plains and rises to undulating rises and low hills. Slopes 0 to 10%.

Vegetation: 15 to 18m mid-dense *Eucalyptus umbra, Angophora costata* with scattered *Eucalyptus drepanophylla / Eucalyptus trachyphloia / Eucalyptus intermedia / Melaleuca viridiflora*.



A1: Grey or occasionally black (5YR 4/2, 7.5 YR 3/2, 4/2, 5/2); fine sandy loam to clay loam fine sandy; massive; frequently <2 to 50% ferruginous (maghemite)nodules <6mm; pH 5.5 to 6. Clear to abrupt change to

A2e: Conspicuously bleached. Mottled; fine sandy loam to clay loam fine sandy; massive; <2 to 50% ferruginous (maghemite) nodules < 6mm; pH 5.5 to 6.0 Abrupt to sharp change to

B21: Mottled; grey or occasionally brown (7.5 YR 4/2, 5/2, 5/3, 6/2, 10 YR 5/2, 5/3); medium clay to medium heavy clay; strong 5 to 20mm angular blocky or occasionally 20 to 50mm prismatic parting to angular blocky; <2 to 50% ferruginous (maghemite) nodules <6mm; pH 5.3 to 6. Clear to diffuse change to B22 or B3.

B22: Frequently occurs in deeper profiles. Mottled; grey (7.5YR, 10YR, 5/1, 5/2, 6/2); medium heavy clay to heavy clay; strong 5 to 20mm angular blocky, frequently with slickensides; pH 5.3 to 5.8. Clear to diffuse change to

B3: Mottled; grey (7.5 YR 5/1, 5/2, 6/1, 6/2, 10 YR 5/2, 6/2, 6/3, 7/2) medium clay to heavy clay; strong 5 to 20mm angular blocky; rock fragments; pH 5 to 5.5.

Sites: 56, 61, 63, 77, 82, 92, 101, 102, 104, 134, 137, 161, 162, 252, 335, 366, 499, 506, 509, 553, 570, 604, 624, 660, 683, 694, 697, 700, 701, 702, 703, 704, 707, 710, 712, 713, 902, 907, 908, 917, 929, 931, 941, 979, 988, 1054, 1061, 1062, 1070, 1165, 1169, 1186, 1187, 1191, 1193, 1196, 1197, 1201, 1203, 1204, 1206, 1207, 1208, 1209, 1212, 1286, 1291, 1292, 1293, 1295.

Analysed sites: BIA (32, 33), ATB10, QCB136

Avondale Rocky Phase AvRp: > 20% rock fragments or rock at 0.3m.

Sites: 977, 978, 1141.

Avondale Tenic Variant AvTv: Bleached Tenosol. A1 and A2 horizons as above over weathered rock.

(Be) BERREN

Concept: Very gravelly brown clay soil on basalt.

Australian Classification: Brown Dermosol.

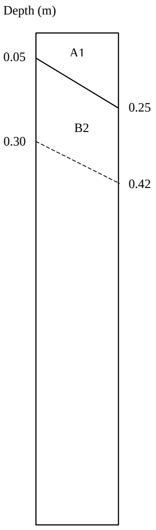
Great Soil Group: Prairie Soil.

Principle Profile Form: Uf6.31.

Geology: Tertiary basalt (Tb), Berrembea Basalt (TQe).

Landform: Hillslopes on undulating hills to rolling low hills.

Vegetation: Cleared.



A1: Black or brown (7.5 YR 2/2, 10 YR 3/2, 3/3); light clay with 50 to 90% basalt fragments 60 to 200mm; strong 2 to 5m granular; pH 7.0. Clear change to

B2: Brown (7.5 YR 3/3, 10YR 3/4); light medium clay with 20 to 50% basalt fragments 60 to 200mm; strong 5 to 10m subangular blocky; pH 6.8 to 7.0

Sites: 997, 1231, 1324, 1341

(Bh) BOTHERM

Concept: Gravelly, loamy surface over a structured, grey or brown clay subsoil on Graham's Creek rhyolite.

Australian Classification: Grey Dermosol, Brown Dermosol.

Great Soil Group: Gleyed podzolic soil, yellow podzolic soil.

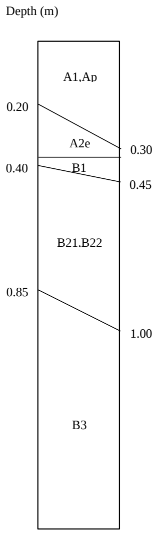
Principle Profile Form: Gn3.04, Gn3.74, Gn3.91p.

Geology: Rhyolite of the Graham's Creek Formation (JKg).

Landform: Hillslopes on rises and low hills. Slopes 6 to 17%.

Vegetation: Mostly cleared.

Coarse fragments: 2 to 20%, 6 to 60 mm on surface and throughout profile.



A1, Ap: Black (7.5 YR 3/2); clay loam; moderate 2 to 5 mm granular; <2 to 10% ferruginous nodules; pH 5.5 to 6. Abrupt to gradual change to

A2e: Frequently conspicuously bleached. Clay loam; moderate 2 to 5 mm granular or subangular blocky; < 2% ferruginous nodules; pH 5.5. Clear change to

B1: Brown (7.5 YR, 5 YR 5/3); light clay; moderate 2 to10 mm subangular blocky; pH 5.5. Clear to gradual change to

B21, B22: Mottled; grey or brown (5 YR 5/5, 7.5 YR 5/2, 5/3) usually paler at depth; light clay; increasing to light medium clay at depth; strong 2 to 5 mm subangular blocky; pH 5.3 to 5.5. Diffuse change to

B3: Yellow (5 YR 6/4); light clay; moderate subangular blocky; pH 5.3.

Sites: 645, 646, 661

(Bl) BOOYAL

Concept: Black loamy surface over a red or brown blocky clay on weathered granodiorite.

Australian Classification: Red Chromosols, Brown Chromosol, Red Dermosols, Brown Dermosol.

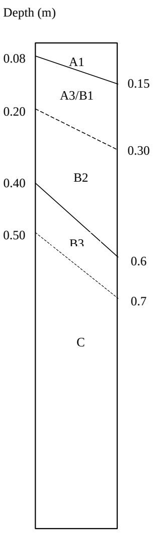
Great Soil Group: Non-calcic brown soil.

Principle Profile Form: Dr2.12, Gn3.12, Db2.12, Dr3.12, Db1.12.

Geology: Granodiorites of the Tawah Granite (Rz), undifferentiated granite (Rg).

Landform: Hillslopes on rises, low hills and hills.

Vegetation: Mostly cleared, minor 15 to 18m *Eucalyptus crebra*, *Eucalyptus tessellaris*, *Eucaluptus erythrophloia*.



A1: Black (5YR 2/2, 7.5 YR 3/1, 3/2, 10 YR 3/1); loam to clay loam; moderate 2 to 5mm granular; pH6 to 6.5. Clear change to

A3, B1: Brown or occassionally black (5 YR 3/3, 4/3, 7.5 YR 3/2, 4/3); clay loam sandy to light clay; moderate 2 to 10mm angular blocky; pH 6 to 6.5. Gradual to clear change to

B2: Red or brown (2.5 YR 3/3, 4/4, 4/6, 5 YR 4/3, 4/4, 4/6, 7.5 YR 4/3, 10 YR 4/3) frequently mottled in lower B2; light medium clay to medium clay; strong 5 to 20mm angular blocky; pH 6 to 7.5. Clear to gradual change to

B3: Frequently mottled; brown or red (5 YR 4/4, 5/3, 7.5 YR 4/4, 5/3, 5/4, 10 YR 5/3, 5/4, 5/6, 6/3); sandy light clay to light medium clay; weak or moderate 5 to 20mm angular blocky or 20 to 40mm prismatic; pH 6.5 to 8.5. Gradual to diffuse change to

C: Weathered rock

Sites: 1, 2, 4, 291, 292, 294, 295, 297, 608, 1090, 1099, 1307, 1323.

Analysed sites: CB14.

(By) BOYNE

Concept: Brown massive surface over a red structural clay on alluvium.

Australian Classification: Red Chromosol, Red Dermosol, Brown Chromosol.

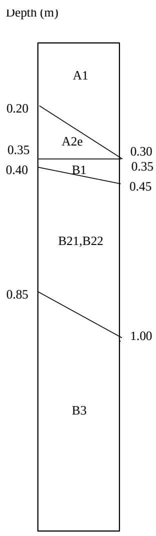
Great Soil Group: Red-brown earth.

Principle Profile Form: Dr2.23, Dr2.13, Dr2.12, Dr3.43, Gn3.13. Db1.12, Dy2.12.

Geology: Quaternary alluvium.

Landform: Alluvial plains.

Vegetation: Cleared.



Ap,A1: Brown or grey (5 YR 4/2, 4/3, 7.5YR 4/2, 10YR 3/3); loamy sand to clay loam fine sandy; massive or weak 2 to 5mm cast or granular; pH 5.8 to 7. Abrupt to clear change to A2 or B1/B21.

A2: Occasionally occurs. Occasionally bleached; massive or weak 2 to 5mm granular; pH5.5 to 6. Clear to abrupt change to

B1, B21: Occasionally mottled; red or occasionally brown (2.5 YR 5/4, 5/6, 5 YR 4/4, 5/4, 7.5 YR 4/3); light clay to medium clay; moderate or strong 5 to 20mm angular blocky; pH 5.8 to 7. Gradual to diffuse change to.

B21: Occasionally mottled, red (2.5 YR 4/6, 5/5, 5YR 3/6, 4/4, 4/6); light medium clay to medium clay; strong 5 to20mm angular blocky; pH 5.8 to 8.5.

Sites: 186, 187, 214, 1021, 1028, 1030

(Bw) BROOWEENA

Concept: Sodic textured contrast soil with a loamy surface and abundant (>20%) rock fragments throughout the profile over highly fractured fine grained sedimentary rock.

Australian Classification: Brown Sodosol, Grey Sodosol, minor Red Chromosols, Brown Chromosols.

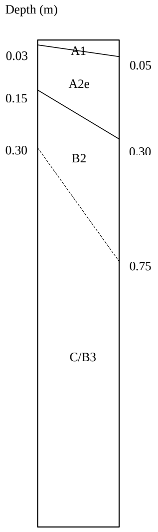
Great Soil Group: Soloth, solodic soil.

Principle Profile Form: Dy3.41, Dy3.42, Dy3.43, Db2.41, Db2.42, Db2.43, Dr3.41.

Geology: Mudstones, siltstones, sandstones of the Broweena Formation (Rb), Gympie Group (Pg), minor rhyolites of The Gympie Group (Pg) and minor metasediments of the Goodnight Beds (CPo)

Landform: Hillslopes on rises, low hills and hills.

Vegetation: 18 to 20m mid-dense *Eucalyptus citriodora / Eucalyptus crebra / Eucalyptus drepanophylla / Eucalyptus moluccana / Eucalyptus exserta / Eucalyptus fibrosa.*



A1: Black or grey (5YR 4/2, 7.5 YR 2/2, 3/2, 4/2); fine sandy loam, loam, sandy clay loam, clay loam; massive with rock fragments; pH 5.5 to 6. Clear to abrupt change to

A2e: Conspicuously bleached. Sandy clay loam to clay loam; massive with >5% rock fragments; pH 5.5 to 6. Abrupt change to

B2: Mottled; brown or grey or minor red (5 YR 4/3, 5/3, 5/4/, 7.5 YR 4/2, 4/3, 4/4, 5/3, 5/4, 6/2, 6/3, 10 YR 4/2, 4/3, 5/2, 5/3, 5/4, 6/2, 6/3, 6/4); light medium clay to heavy clay; strong to moderate 5 to 20mm angular blocky, subangular blocky or 20 to 50mm prismatic parting to 5 to 20mm angular blocky; > 10% rock fragments; pH 5.5 to 8.5. Clear to diffuse change to

C, B3: Weathered rock or weathered rock with clay.

Soil colour and depth can change dramatically over short distances due to steeply dipping strata.

Sites: 9, 10, 11, 12, 14, 167, 201, 480, 485, 486, 635, 652, 656, 659, 938, 939, 944, 945, 968, 969, 970, 971, 973, 974, 976, 986, 987, 992, 995, 1000, 1001, 1002, 1003, 1004, 1005, 1013, 1014, 1015, 1038, 1039, 1044, 1045, 1048, 1050, 1051, 1065, 1066, 1071, 1072, 1076, 1077, 1091, 1093, 1094, 1097, 1098, 1101, 1103, 1106, 1122, 1129, 1130, 1131, 1133, 1134, 1145, 1146, 1150, 1157, 1158, 1159, 1160, 1163, 1164, 1232, 1254, 1268, 1314, 1348, 1353.

Analysed sites: ATB24

(Bn) BURNETT

Concept: Layered alluvial soil.

Australian Classification: Stratic Rudosol, Orthic Tenosol.

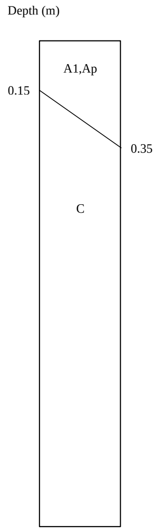
Great Soil Group: Alluvial soil.

Principle Profile Form: No provision, Um7.11.

Geology: Quaternary alluvium (Qa).

Landform: Levees and scrolls on floodplains, terraces.

Vegetation: Cleared.



A1, Ap: Brown or black (7.5 YR 3/2, 3/3, 4/2, 4/3, 10 YR 3/2, 3/3); sandy loam, fine sandy loam, loam fine sandy, clay loam fine sandy; massive to moderate 2 to 5mm granular; pH 6 to 6.5. Abrupt to clear change to

C: Brown (7.5 YR 4/3, 4/4, 5/4, 10YR 4/4, 5/4); sand, loamy sand, fine loamy sand, fine sandy loam, loam fine sandy, clay loam fine sandy; layered; massive to moderate 2 to 10mm subangular blocky; pH 6 to 8. Clear to diffuse changes between layers.

Sites: 96, 136, 181, 242, 591, 593, 991, 1006, 1025, 1031, 1227, 1229, 1367, 1368, 1369

(Bg) BUNGADOO

Concept: Very stony soil with bleached loamy surface on silicified Maryborough Formation.

Australian Classification: Brown Dermosol, Yellow Dermosol.

Great Soil Group: No suitable group, affinities with soloth.

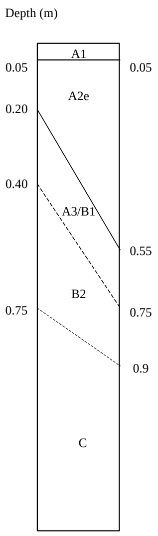
Principle Profile Form: Gn3.04, Gn3.84.

Geology: Silicified mudstones, siltstones of the Maryborough Formation (Km).

Landform: Hillslopes on rises and low hills. Slopes 0 to 20%.

Vegetation: 18 to 20m mid-dense *Eucalyptus citriodora / Eucalyptus acmenoides / Eucalyptus trachyphloia / Eucalyptus umbra / Lophostemon confertus.*

Coarse fragments: >20%, 20 to 60 mm.



A1: Black or grey (7.5 YR 3/2, 4/2, 5/3); clay loam; massive or weak cast; >20% rock fragments 20 to 600 mm; pH 5.8 to 6.3. Clear change to

A2e: Conspicuously bleached. Clay loam; massive; > 20% rock fragments 20 to 600 mm; pH 5 to 5.5. Clear to gradual change to

A3/B1: Mottled; grey or yellow (7.5YR 6/2, 10 YR 6/3, 6/4, 6/5); light clay; moderate 2 to 5mm subangular blocky; >20% rock fragments 20 to 600mm; pH 5 to 5.5. Diffuse change to

B2: Mottled; brown or yellow (7.5YR 5/4, 10 YR 5/4, 6/3, 6/4, 6/5) frequently becoming paler at depth; strong 2 to 10mm polyhedral or subangular blocky; >20% rock fragments 20 to 600mm; pH 5. Clear to diffuse change to

C: Silicified sedimentary rock.

Sites: 66, 79, 668, 935, 942, 952, 1055

(Cd) CHILDERS

Concept: Acid, red clay soil with strong polyhedral structure developed from basalt.

Australian Classification Red Ferrosol.

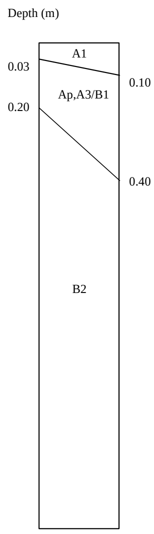
Great Soil Group: Krasnozem.

Principle Profile Form: Uf6.31, Uf5.31.

Geology: Tertiary laterite over Tertiary basalt (Tl/Tb), Elliott Formation (Tl/Te), Maryborough Formation (Tl/Km), Graham's Creek Formation (Tl/JKg) Tiaro Coal Measures (Tl/Jdt).

Landform: Crests and hillslopes on rises, low hills and hills.

Vegetation: Cleared.



Ap: Red (10 R 3/2, 3/3, 4/4, 2.5 YR 3/2, 3/3, 3/4, 3/6, 4/3, 4/4); light clay; strong 2 to 5mm granular; pH 4.5 to 6. Clear to abrupt change to.

B2 Red (10 R 3/3, 3/4, 4/4, 4/6, 2.5 YR 3/6, 4/4); light clay to light medium clay; strong 2 to 5mm polyhedral; pH 5 to 6.3.

Sites: 24, 26, 29, 32, 33, 72, 196, 270, 284, 286, 288, 298, 299, 502, 504, 522, 533, 535, 559, 640, 644, 648, 657, 680, 685, 1111

Analysed sites: QCB (208, 214, 215), ATB (4, 6), CBW (8, 22, 24, 26).

Childers Ferric nodular variant CdFv: >20% ferrugenous nodules in the B2 horizon

Sites: 30, 34, 271, 530, 534

(Ch) CHIN

Concept: Red soil with polyhedral structure and fine rounded quartz gravel throughout the profile developed from basalt and sandstone.

Australian Classification Red Ferrosol.

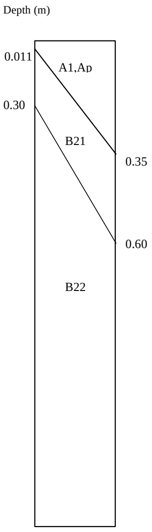
Great Soil Group: Krasnozem, Euchrozen.

Principle Profile Form: Uf6.31, Uf5.31, Gn3.11, Gn3.12, Um6.33.

Geology: Tertiary laterite (Tl).

Landform: Hillslopes on rises, low hills.

Vegetation: Cleared.



A1, Ap: Red, brown or occasionally black (2.5 YR 3/2, 3/3, 3/4, 5YR 3/3, 7.5YR, 3/3); clay loam to light clay; weak to strong 2 to 5mm granular; frequently <2% ferruginous/ferromanganiferous nodules <2mm; pH 5.5 to 6; <2% rounded quartz gravel 2 to 6mm. Clear to abrupt change to

B21, B1: Red (2.5 YR 3/3, 3/4, 5YR 3/6, 4/4); clay loam to light clay; moderate or strong 2 to 5mm polyhedral; <2% ferruginous/ferromanganiferous nodules <2mm; pH 5.5 to 7; <2% rounded quartz gravel 2 to 6mm. Diffuse to gradual change to

B22: Red (10 R 3/4, 4/4, 2.5YR 3/6, 4/4, 4/6, 4/8, 5/6, 5YR 4/6); clay loam to light medium clay; moderate or strong 2 to 5mm polyhedral; <2% ferruginous/ferromanganiferous nodules <2mm; pH 5.5 to 7.0; <2% rounded quartz gravel 2 to 6mm.

Sites: 193, 194, 195, 197, 1082, 1083, 1244, 1249, 1252, 1253, 1262, 1263, 1313, 1331, 1344

(Cn) COONAR

Concept: Thick (>3m) bleached sand over coffee rock on beach ridges.

Australian Classification: Aquic Podosol.

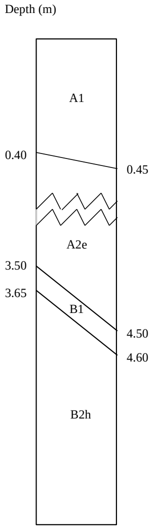
Great Soil Group: (Giant) Podzol.

Principle Profile Form: Uc 2.33.

Geology: Quarternary sand.

Landform: Beach ridge.

Vegetation: 2 to 5m isolated to sparse *Banksia aemula* with an understory of heath. Occasionally 6 to 12m mid-dense *Callitris columellaris.*



A1: Dark or grey (7.5 YR 4/1, 10 YR 3/1); sand; single grain; pH 4 to 5.5. Clear to gradual change to

A2e: Conspicuously bleached (5 YR, 7.5YR, 10YR 8/1); sand; single grain; pH 6 to 6.3. Clear change to

B1: Grey (5YR 4/1, 7.5YR 4/2); sand; single grain; pH 5.5 to 6. Clear change to

B2h: Black (7.5YR 2/1); sand; coffee rock pan; pH 4.0 to 4.5.

Sites: 794, 1275, 1276.

(Cl) CLAYTON

Concept: Fine loamy surface over a acid or neutral, mottled, fine polyhedral structured clay on deeply weathered fine grained sedimentary rocks.

Australian Classification: Redoxic Hydrosol.

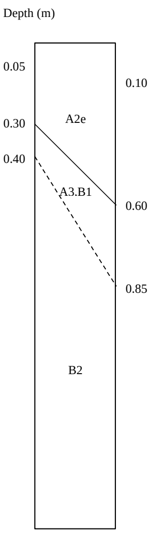
Great Soil Group: Gleyed podzolic soil, no suitable group.

Principle Profile Form: Gn3.04, Dy3.41, Dy3.42, Gn3.05.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 12 to 18 sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Eucalyptus intermedia / Eucalyptus hallii / Eucalyptus trachyphloia /Eucalyptus acmenoides / Eucalyptus exserta.*



A1: Grey (7.5 YR 4/1, 4/2, 5/1); fine sandy loam, loam fine sandy, clay loam fine sandy; massive; pH 5.5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Mottled; fine sandy loam, loam fine sandy; clay loam fine sandy; massive; pH 5.5 to 5.8. Clear to gradual change to

A3 or B1: Mottled; grey or occasionally yellow (7.5 YR 7/2, 7/3, 7/4, 10 YR 6/4) massive A3 or weak or moderate 2 to 5m subangular or polyhedral B1; <2 to 50% ferruginous nodules 2 to 6mm; pH 5.5 to 6. Clear to gradual change to

B2: Mottled; grey or occasionally yellow (7.5 YR 6/4, 10 YR 6/2, 7/3, 7/4); light clay to medium heavy clay; strong 2 to 5mm polyhedral; <2 to 50% ferruginous nodules 2 to 6mm; pH 5.5 to 8.

Sites: 58, 59, 83, 87, 89, 91, 128, 129, 139, 160, 266, 390, 396, 400, 416, 422, 489, 516, 517, 525, 532, 549, 550, 681, 746, 747, 758, 818, 905, 947, 1064, 1180, 1211.746, 747, 758, 818, 905, 947, 1064, 1180, 1211.

Analysed sites: CBWS4, CBW4

(Cf) CORFIELD

Concept: Brown or red uniform or gradation textured soil on metalbasalt.

Australian Classification: Brown Dermosol, Red Dermosol.

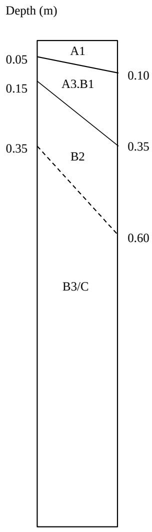
Great Soil Group: Prairie soil.

Principle Profile Form: Uf6.31, Gn3.12, Uf 6.41. Gn3.52.

Geology: Metalbasalts and andesites of the Gympie Group (Pg, Pgv), phyllites and metavolcanics of the Goodnight Beds (CPo).

Landform: Hillslopes on rises and low hills. Slopes 2 to 30%.

Vegetation: Cleared.



A1: Black or brown (5YR 3/2, 3/3, 7.5YR 2/2, 3/2, 3/3, 10YR 3/2); clay loam to light clay; moderate or strong 2 to 5 mm granular; pH 6 to 7. Clear to gradual change to

A3/B1: Brown or red (5YR 3/3, 4/3, 4/4, 7.5YR 3/2, 3/3); light clay to medium clay; strong 2 to 10mm subangular blocky; pH 6 to 6.5. Clear to diffuse change to

B2: Occasionally mottled; brown or red (2.5 YR 4/3, 4/4, 4/6, 5YR 4/3, 4/4, 4/6, 7.5YR 3/3, 3/4, 4/3); light medium clay to medium clay; strong 2 to 10mm subangular blocky, occasionally weak to moderate 10 to 20mm lenticular breaking to strong 2 to 5mm subangular blocky; frequently <20% soft manganiferous segregations or manganiferous nodules <6mm; pH 6.5 to 7. Clear to gradual change to

B3/C Brown or red (5YR 4/3,4/4, 5/4, 7.5YR 3/3, 4/3, 4/4, 5/4, 10YR 4/3); light medium clay; moderate or strong 2 to 10mm subangular blocky; rock fragments; frequently <10% soft manganese segregations <2mm; pH 6.8 to 7.5

Sites: 993, 994, 996, 1016, 1041, 1042, 1043, 1084, 1087, 1120, 1121, 1123, 1235, 1239, 1240, 1241, 1250, 1267, 1269

Analysed sites: BIA 55

Corfield limestone variant CfLv:
Red structured clay on limestone.

Sites: 13, 975

(Dw) DAWES

Concept: Brown and black clays on weathered granodiorite.

Australian Classification: Brown Vertosol, Black Vertosol, Black Dermosol.

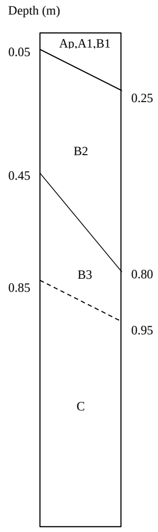
Great Soil Group: Brown clay, black earth, prairie soil.

Principle Profile Form: Ug5.32, Ug 5.12, Uf 6.31.

Geology: Granodiorites of the Muskat Flat Granodiorite (Rs), Tawah Granite (Rz), Moolboolaman Granodiorite (PRm).

Landform: Hillslopes on undulating rises.

Vegetation: Mostly cleared, minor 12 to 20m mid-dense *Eucalyptus melanophloia, Eucalyptus erythrophloia.*



Ap, A1, B1: Black or occasionally brown (7.5 YR 3/2, 3/3, 10 YR 2/2, 3/2); light medium clay to medium clay, strong 2 to 10mm granular, or sub-angular blocky B1; pH 6.5 to 7. Clear to abrupt change to

B2: Brown or black (7.5YR 3/3, 4/3, 4/4, 10YR 2/2, 3/2); medium clay to heavy clay; strong 2 to 5mm lenticular or 5 to 10mm subangular blocky; pH 7 to 8.5. Clear to gradual change to

B3: Brown (7.5YR 4/3, 4/4, 5/4); light clay to medium clay with fragments of weathered granodiorite; weak to strong 5 to 20mm subangular blocky; pH 7 to 9. Gradual to diffuse change to

C: Weathered granodiorite

Sites: 5, 6, 7, 8, 1085, 1272

Analysed sites: ATB5

(Do) DOONGUL

Concept: Sodic texture contrast soil with a very shallow (<0.25mm) bleached clay loam surface over a coarse structured, mottled, grey clay on weathered granite.

Australian Classification: Grey Sodosol, Brown Sodosol.

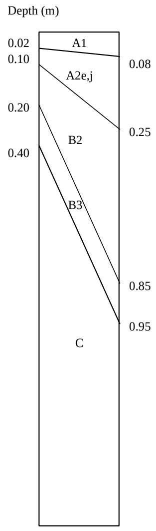
Great Soil Group: Soloth, solodic soil, solodized solonetz.

Principle Profile Form: Dy2.41, Dy3.42, Dy3.41, Dy2.32.

Geology: Hornblende-phyric microdiorite (JKi).

Landform: Hillslopes of undulating rises.

Vegetation: 22 to 30m sparse to mid-dense *Eucalyptus citriodora, Eucalyptus drepanophylla / Eucalyptus moluccana / Eucalyptus tereticornis.*



A1: Black or grey (7.5 YR 3/2, 4/2); light sandy clay loam to clay loam sandy; massive or weak 2 to 5mm granular; pH 5.5 to 6. Clear abrupt change to

A2e,j: Conspicuously bleached, occassionally sporadically bleached. Frequently mottled; light sandy clay loam to clay loam sandy; massive; pH 5.7 to 6.3. Abrupt to sharp change to

B2: Frequently mottled especially in upper B2; grey or brown (5YR 5/2, 5/3, 7.5YR 4/2, 5/2, 5/3, 10YR 5/2, 5/3); light medium to medium clay; moderate or strong 20 to 100mm prismatic or columnar or 10 to 20mm angular blocky; pH 5.5 to7. Clear to gradual change to

B3: Occasionally mottled; grey or brown (5YR 5/2, 5/3, 7.5YR 5/2, 5/3, 6/4, 10YR 4/2, 6/2); sandy light medium clay to medium clay with rock fragments; moderate or strong 20 to 50mm prismatic or 5 to 20mm angular blocky; pH 5.5 to 7.5. Clear to gradual change to

C: Weathered rock

Sites: 71, 1143, 1144, 1151, 1152, 1166, 1172,1202,1214, 1289,1294, 1289, 1294

(Db) DOOLBI

Concept: Mottled yellow or brown soil developed from basalt.

Australian Classification: Brown Dermosol, Yellow Dermosol.

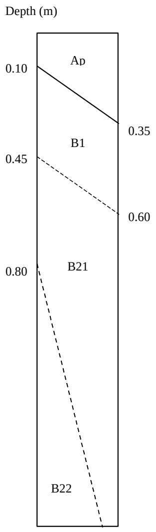
Great Soil Group: Xanthozem.

Principle Profile Form: Uf6.41, Gn3.71.

Geology: Tertiary laterite over Tertiary basalt (Tl/Tb), Elliott Formation (Tl/Te), Maryborough Formation (Tl/Km), Grahams Creek Formation (Tl/JKg), Tiaro Coal Measures (Tl/Jdt).

Landform: Gentle plains to lower slopes of rises and low hills. Slopes 0 to 10%.

Vegetation: Cleared.



Ap: Black, brown on occassionally grey (7.5 YR 3/1, 3/2, 4/2, 4/3); clay loam to light clay; moderate or strong 2 to 5 mm granular; frequently < 2 to 20% ferruginous/manganiferous nodules; pH 5.5 to 6.3. Abrupt to clear change to

B1: Frequently occurs. Faint mottles, brown (7.5 YR 4/3, 5/3, 5/4, 5/5); light clay; strong 2 to 5 mm polyhedral or subangular blocky; frequently < 2 to 20% ferruginous/manganiferous nodules; pH 5.5 to 6.3. Diffuse to gradual change to

B21: Mottled; brown or yellow (7.5 YR 5/4, 5/5, 6/6, 10 YR 5/4, 5/5, 5/6); light clay to light medium clay; strong 2 to 5 mm polyhedral; < 2 to > 20% ferruginous/manganiferous nodules; pH 5 to 6.8. Diffuse to gradual change to

B22 Frequently occurs. Mottled; brown or grey (7.5 YR 5/3, 5/4, 10 YR 5/1, 5/3, 5/4, 6/2); light clay to medium clay; strong 2 to 5 mm polyhedral; <2 to >50% ferruginous nodules; pH 5.5.

Sites: 73, 271, 272, 273, 289, 491, 503, 521, 556, 558, 560, 562, 586, 609, 662.

Analysed sites: CBW (9, 10, 11, 27)

Doolbi gleyed variant DbGv: Mottled red or brown surface over a gleyed subsoil. Occurs in drainage lines.

Sites: 31, 637, 658.

(Dn) DRINAN

Concept: Bleached fine loamy surface over a mottled non-sodic grey or yellow clay with manganiferous nodules on alluvium.

Australian Classification: Grey Dermosol, Yellow Dermosol, Redoxic Hydrosol.

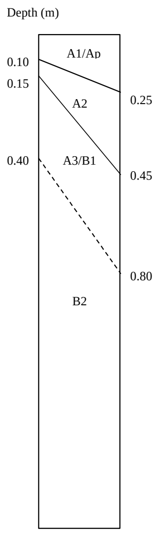
Great Soil Group: Gleyed podzolic soil, yellow podzolic soil.

Principle Profile Form: Gn3.04, Gn3.84, Gn3.94, Gn3.71.

Geology: Quaternary alluvium (Qa).

Landform: Gently undulating plains.

Vegetation: Cleared.



A1,Ap: Grey or black (7.5 YR 3/1, 3/2, 4/2, 10YR 4/2); loam fine sandy to clay loam fine sandy; massive or weak 2 to 5mm granular; <2 to 20% manganiferous nodules 2 to 20mm; pH 5.5 to 6.5. Abrupt to clear change to

A2e: Conspicuously bleached. Loam fine sandy to clay loam fine sandy; massive or weak 2 to 5mm subangular blocky; 10 to >50% manganiferous nodules 2 to 6mm; pH 5.8 to 6.5. Gradual to diffuse to

A3: Mottled; grey, yellow or brown (10 YR 5/3, 6/3, 6/4); clay loam fine sandy to light clay; massive or moderate 5 to 10mm subangular blocky; 10 to 50% manganiferous nodules 2 to 6mm; pH 5.5 to 6.5. Gradual to diffuse to

B2: Mottled; grey or brown (10YR 5/2, 5/3, 5/4, 5/6, 6/2, 6/3, 6/4); light clay to light medium clay; moderate or strong 2 to 10mm subangular blocky; 2 to 50% manganiferous nodules 2 to 10mm; pH 5.3 to 6.5.

Sites: 607, 1220, 1259, 1335

Analysed sites: CB13, ATBNGPf

(Dg) DUINGAL

Concept: Bleached, mottled, acid, grey clay on fine grained sedimentary rocks.

Australian Classification: Grey Vertosol, minor Brown Vertosol.

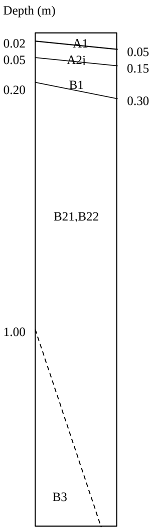
Great Soil Group: Grey clay.

Principle Profile Form: Ug3.2.

Geology: Mudstones, sillstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Graham's Creek Formation (JKg) Tiaro Coal Measures (Jdt).

Landform: Hillslopes of gently undulating to undulating plains and rises.

Vegetation: 18 to 25m mid-dense *Eucalyptus moluccana*.



A1: Black (7.5 YR 3/2); light clay to light medium clay, moderate 2 to 10mm granular or cast; pH 5. to 6.5. Abrupt to clear change to

A2j: Sporadically bleached. Mottled; grey (7.5 YR 4/1, 4/2, 4/3, 5/2); light clay to light medium clay; moderate 2 to 10mm granular or subangular blocky; pH 5.5 to 6. Abrupt to clear change to

B21: Mottled; grey (7.5 YR 4/2, 5/1, 5/3, 10 YR 4/2, 5/3); light medium clay to medium heavy clay; strong 2 to 10mm subangular blocky; pH 5 to 6. Gradual change to

B21, B22: Mottled; grey or occasionally brown (5YR 6/2, 7.5YR 5/2, 5/3, 6/3, 10YR 5/2, 5/3, 6/2, 6/3, 2.5YR 5/2, 5/3) usually paler at depth; medium clay to heavy clay; moderate or strong 2 to 5mm lenticular; pH 4. 5 to 6. Graduant to diffuse change to

B3: Mottled; grey (7.5YR 4/2, 6/2, 10YR 7/2); medium clay to medium heavy clay with rock fragments; moderate lenticular or subangular blocky.

Sites: 508, 933, 948, 980, 981, 1073, 1075, 1096, 1178, 1225, 1260

Variant: Alkaline B22 with lime nodules

(Fs) FLAGSTONE

Concept: Brown or black structured clay loam to clay soil on alluvium.

Australian Classification: Brown Dermosol, Black Dermosol.

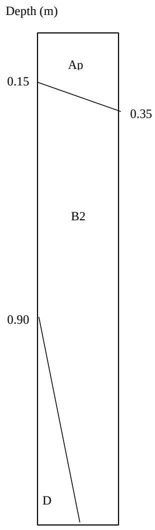
Great Soil Group: Prairie soil, brown earth.

Principle Profile Form: Um6.31, Um6.32, Gn3.22, Gn3.42, Uf 6.31,Uf6.32, Gn 3.52, Uf6.41.

Geology: Quaternary alluvium (Qa).

Landform: Channel benches, terraces, levees.

Vegetation: Cleared.



Ap: Black (7.5 YR 2/2, 3/2, 10 YR 2/2, 3/2) clay loam fine sandy to light clay; weak to strong 2 to 5mm granular or subangular blocky; pH 6 to 6.5. Clear to gradual hange to

B2: Occasionally mottled; brown or black (7.5 YR 3/2, 4/3, 4/4, 10 YR 2/2, 3/1, 3/2, 3/4); clay loam fine sandy, silty clay, light clay, light medium clay; moderate or strong 5 to 30mm subangular blocky or moderate 10 to 50mm prismatic parting to strong subangular blocky; pH 6 to 7.5. Clear to diffuse change to

D: Frequently occurs. Brown or black (7.5 YR 3/2, 4/3, 4/4, 5/4); loamy sand, sandy loam, fine sandy loam, sandy clay loam; massive; pH 6 to 7.5.

Sites: 182, 183, 243, 912, 946, 950, 1010, 1026, 1027, 1032, 1034, 1036, 1222, 1228, 1308

Analysed sites: ATB22

(Ff) FARNSFIELD

Concept: Red, brown or black massive surface over a red, massive subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Red Kandosol.

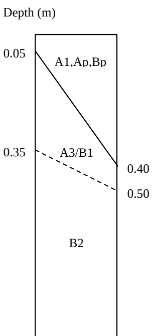
Great Soil Group: Red earth.

Principle Profile Form: Gn2.11, Gn2.12, Um 5.52.

Geology: Sandstones of the Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating plains and rises.

Vegetation: Cleared.



A1,Ap/Bp: Red, brown or black (2.5 YR3/3, 4/2, 4/3, 5 YR 3/2, 4/2, 4/3, 7.5 YR 3/3, 4/3); loamy sandy to clay loam sandy; massive; pH 5.5 to 6.5. Abrupt to clear change to

A3/B1: Frequently occurs. Red or brown (2.5 YR 3/4, 4/3, 5/6, 5 YR 3/3, 3/6, 4/4, 7.5 YR 4/4); light sandy clay loam to clay loam sandy; massive; pH 5.5 to 7.0. Diffuse change to

B2: Red (10 R 4/6, 4/8, 2.5 YR 4/6, 4/8); sandy clay loam, clay loam sandy, clay loam, light clay; massive or weak 2 to 10mm subangular blocky or polyhedral; pH 5.5 to 7.

Sites: 223, 235, 249, 250, 263, 264, 265, 290, 307, 478, 579, 599, 957, 961, 962, 963, 964, 1047, 1271

Analysed sites: ATB8, CBW (1, 2, 3).

(Gn) GIGOON

Concept: Sodic texture contrast with a coarse sandy surface over a brown or grey clay subsoil on weathered granite.

Australian Classification: Brown Sodosol, Grey Sodosol.

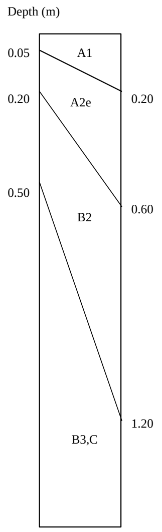
Great Soil Group: Soloth, solodized solonetz, solodic soil.

Principle Profile Form: Dy5.41, Dy3.42, Dy3.41, Dy3.43, Dg4.41.

Geology: Granites of the Bloomfield Granite (Rf), Musket Flat Granodiorite (Rs), Tawah Granite (Rz), undifferentiated granite (Rg), Moolboolaman Granodiorite (PRm)

Landform: Hillslopes of rises, low hills and hills.

Vegetation: 15 to 25m mid-dense *Eucalyptus crebra, Eucalyptus citriodora, Eucalyptus tereticornis/Eucalyptus intermedia/Eucalyptus exserta/Eucalyptus drepanophylla.*



A1: Black or grey or occasionally brown (7.5 YR 2/2, 3/2, 3/3, 4/1, 4/2); loamy sand to sandy loam; massive; pH 5.5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Loamy sand to sandy loam; massive; pH 5.5 to 6. Abrupt to sharp change to

B2: Mottled; brown or grey or occasionally yellow (7.5 YR 4/2, 5/2, 5/3, 5/4, 6/3, 10 YR 4/2, 5/2, 5/3, 6/2, 6/3, 6/4, 7/2, 7/3); sandy clay to sandy medium heavy clay; moderate or strong 50 to 100mm columnar, 20 to 100mm prismatic or 10 to 50mm angular blocky; pH 5.5 to 9.5. Gradual to diffuse change to

B3: Mottled; brown or grey (7.5 YR 5/3, 6/3, 10 YR 5/2, 6/4); sandy clay to sandy light medium clay; weak or moderate 10 to 20mm angular blocky or 20 to 50mm prismatic; pH 5.5 to 9. Clear to diffuse change to

C: Weathered rock.

Sites: 17, 18, 20, 22, 23, 25, 71, 293, 636, 653, 863,1040, 1049, 1067, 1086, 1088, 1089, 1100. 1102, 1104, 1105, 1108, 1109, 1110, 1112, 1114, 1117, 1118, 1119, 1125, 1126, 1127, 1128, 1147, 1148, 1149, 1156, 1161, 1162, 1273, 1306

Analysed sites: CBWS13.

Gigoon sand variant GnSv: Bleached Tenosol. Bleached sand over weathered granite.

Sites: 1107, 1116, 1124, 1132

Gigoon Non-sodic variant GnPv: Yellow Dermosol. Mottled yellow non-sodic clay subsoil with polydedral structure.

(Gv) GIVELDA

Concept: Sodic texture contrast soil with a very shallow (< 0.3 mm) loamy surface over a brown or yellow clay subsoil on moderately weathered fine grained sedimentary rocks.

Australian Classification: Brown Sodosol, Yellow Sodosol.

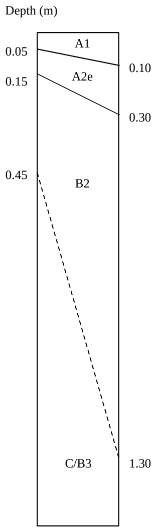
Great Soil Group: Soloth, solodic soil.

Principle Profile Form: Dy3.41, Dy3.42.

Geology: Siltstones and fine sandstones of the Burrum Coal Measures (Kb), Maryborough Formation (Km) and Graham's Creek Formation (JKg).

Landform: Hillslopes on rises and low hills.

Vegetation: 18 to 20m mid-dense *Eucalyptus moluccana / Eucalyptus crebra / Eucalyptus citriodora / Eucalyptus tereticornis.*



A1: Black or grey (7.5 YR 3/2, 4/2, 10 YR 3/2); loam fine sandy to clay loam and clay loam fine sandy; massive or weak 2 to 5mm cast; pH 5.8 to 6.5. Clear change to

A2e: Conspicuously bleached. Mottled; loam fine sandy to clay loam and clay loam fine sandy; massive; frequently manganiferous nodules; pH 5.8 to 6. Abrupt to sharp change to

B2: Mottled; brown or yellow, rarely red (5 YR 4/4, 5/4, 5/6, 7.5YR 4/3, 5/4, 6/4, 6/6, 10 YR 5/4, 5/6, 6/4) frequently becoming paler (10 YR 5/2, 6/2) at depth; medium clay to heavy clay; strong 5 to 20mm angular blocky or 20 to 50mm prismatic parting to 10 to 20mm angular blocky; frequently manganiferous nodules; pH 5.5 to 8.0 Clear to diffuse change to

C, B3: Weathered rock or clay with abundant rock fragments.

Sites: 41, 99, 151, 166, 218, 253, 588, 590, 594, 910, 911, 914, 916, 923, 951, 1221, 1224, 1301

Analysed sites: CBW911

(Hx) HUXLEY

Concept: Grey cracking clay on andesite and basalt.

Australian Classification: Grey Vertosol, Brown Vertosol.

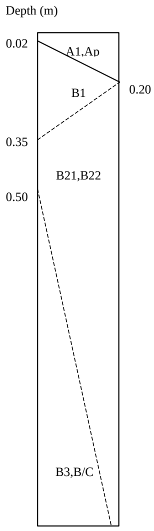
Great Soil Group: Grey clay.

Principle Profile Form: Ug5.24, Ug5.22.

Geology: Andesite of the Grahams Creek Formation (JKg) and Tertiary basalt (Tb).

Landform: Hillslopes of gently undulating plains to low hills. Slopes predominantly <5%.

Vegetation: Cleared.



A1, Ap: Black (7.5 YR 3/1, 3/2, 10 YR 3/2); light medium clay to heavy clay; moderate or strong 2 to 10 mm granular or subangular blocky; pH 5.5 to 6. Clear to abrupt change to

B1: Grey (7.5 YR 4/2); light medium clay to heavy clay; strong 2 to 10mm subangular blocky; frequently manganiferous segregations; pH 5.5 to 6.5. Gradual to diffuse change to

B21, B22: Mottled; grey or brown (7.5 YR 4/2, 5/3, 10 YR 4/2, 5/2, 5/3, 2.5 Y 5/2) becoming paler at depth; medium clay to heavy clay; strong 2 to 20 mm lenticular, frequently subangular blocky in B21; <2 to 10% manganiferous segregations <6mm; pH 5.5 to 7.5 (rarely 9.0). Diffuse change to

B3,B/C: Mottled; grey or brown (7.5 YR 5/2, 5/4); light medium clay to medium clay; weak to strong 2 to 10 mm subangular blocky; pH 5.5 to 7.5; rock fragments.

Sites: 28, 569, 641, 647, 649, 650, 654, 655, 728.

(Gb) GOOBURRUM

Concept: Brown or black massive sandy surface over a red structured subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Red Dermosol.

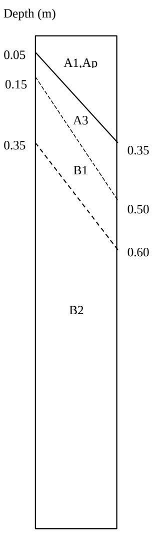
Great Soil Group: Red podzolic soil, non-calcic brown soil.

Principle Profile Form: Gn3.11p, Gn3.12p, Dr2.11p, Um 6.33p, Gn 3.14.

Geology: Elliott Formatiion (Te).

Landform: Plains and hillslopes on rises.

Vegetation: Mostly cleared.



A1, Ap: Brown or black (5 YR 3/2, 4/2, 4/3, 7.5 YR 3/2, 3/3, 4/1, 4/2, 4/3); loamy sand to sandy clay loam; massive; pH 5.5 to 6.5. Clear change to

A2: Occurs in undisturbed soils (minor)

A3, B1: Red or brown (2.5 YR 4/3, 4/4, 5/6, 5 YR 3/3, 4/3, 4/4, 4/6, 5/6, 7.5YR 5/4, 5/6); sandy clay loam to clay loam sandy; massive; pH 5.5 to 6.5. Gradual to diffuse change to

B2: Red (10 R 3/6, 4/6, 4/8, 2.5 YR 3/6, 4/6, 4/8); clay loam sandy, clay loam, sandy clay, light clay; moderate or strong 2 to 5 polyhedral; pH 5.5 to 7.

Sites: 206, 221, 222, 224, 225, 229, 230, 231, 232, 234, 488, 490, 493, 507, 510, 526, 527, 537, 566, 572, 676, 763, 924, 928, 956, 958, 1358

Analysed sites: BIA 31

Gooburrum mottled variant GbMv: Mottled B2

(Is) ISIS

Concept: Sandy bleached surface over a mottled, yellow, structured subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Yellow Dermosol, ocassionally Brown Dermosol.

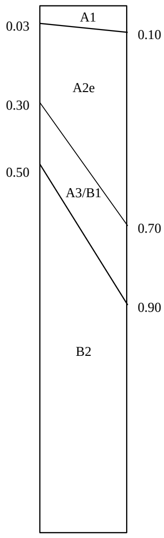
Great Soil Group: Yellow podzolic soil.

Principle Profile Form: Gn3.84, Dy3.41.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating rises.

Vegetation: Mostly cleared.



A1: Grey (7.5 YR 4/1, 4/2, 5/1, 5/2, 10 YR 4/2, 5/2); sandy loam to fine sandy loam; massive; pH 5.5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Sandy loam to fine sandy loam; massive; pH 5.5 to 6. Clear to diffuse change to

A3, B1: Yellow (10 YR 6/4, 6/5, 6/6, 7/4, 7/5, 7/6); sandy clay loam, clay loam sandy increasing to sandy clay, light clay in the B1; massive or weak 2 to 5mm polyhedral; frequently ferruginous nodules 2 to 6 mm; pH 5.5 to 6.5. Clear to diffuse change to

B2: Mottled; yellow or occassionally brown (5 YR 6/6, 7/5, 10 YR 5/6, 6/5, 6/6, 7/5); light clay to medium clay; moderate or strong 2 to 5mm polydedral or subangular blocky; frequently ferruginous nodules; pH 5.5 to 6.5.

Sites: 339, 40, 53, 120, 121, 124, 189, 256, 276, 308, 312, 314, 316, 327, 328, 405, 408, 483, 496, 497, 500, 519, 543, 544, 551, 552, 571, 575, 589, 592, 629, 742, 764, 984

Analysed sites: QCB137

(Kh) KALAH

Concept: Sodic texture contrast soil with fine loamy surface over a grey clay subsoil on deeply weathered fine grained sedementary rocks.

Australian Classification: Redoxic Hydrosol.

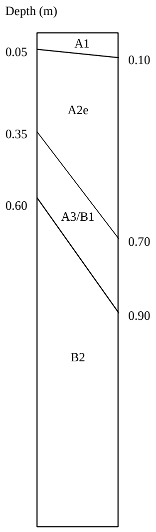
Great Soil Group: Soloth, solodic soil.

Principle Profile Form: Dy3.41, Dy3.43, Dg2.41, Dy3.42, Dg2.42, Gn3.04.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 10 to 18 sparse to mid-dense *Melaleuca viridiflora, Eucalyptus umbra* frequently with scattered *Eucalyptus halli / Eucalyptus intermedia / Eucalyptus trachyphloia / Angophora costata.*



A1: Grey (7.5 YR 4/1, 4/2, 5/2, 5/3); fine sandy loam to loam fine sandy; massive; pH 5.5 to 6. Clear to gradual change to

A2: Conspicuously bleached. Mottled; fine sandy loam to loam fine sandy; massive; pH 5.5 to 5.8. Clear to diffuse change to

A3/B1: Frequently occurs. Mottled; grey or occasionally yellow (7.5 YR 6/3, 7/3, 10 YR 6/3, 6/4, 7/3, 7/4); sandy clay loam, clay loam sandy, sandy clay, light clay; massive; pH 5.5 to 6. Abrupt to gradual change to

B2: Mottled; grey or occasionally yellow (7.5 YR 7/1, 7/2, 10 YR 6/1, 6/2, 6/4, 7/4) usually paler at depth; light medium clay to medium heavy clay; strong 10 to 20mm angular blocky or 20 to 50mm prismatic parting to angular blocky; pH 5.5 to 8.

Sites: 37, 44, 45, 47, 51, 61, 86, 93, 94, 123, 141, 157, 159, 371, 399, 414, 417, 711, 722, 760, 777, 830, 833, 838, 839, 844, 849, 850, 856, 857, 865, 874, 875, 877, 881, 882, 891, 1063, 1213.

Analysed sites: CBWS (3,6), NS3, IJ (1, 2).

(Kn) KINKUNA

Concept: Bleached sand over an orstein pan/coffee rock on sandstone.

Australian Classification: Aquic Podosol, Semiaquic Podosol.

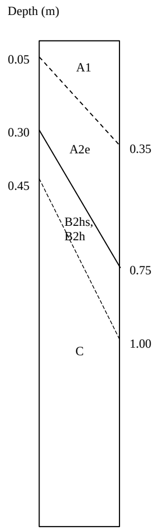
Great Soil Group: Podzol.

Principle Profile Form: Uc2.32, Uc 2.33.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on undulating rises. Slopes 0 to 6%.

Vegetation: 3 to 6m, sparse to mid-dense *Banksia aemula, Eucalyptus umbra* with an understory of heath. Occasionally 0.5 to 1m heath or 12 to 25m *Syncarpia glomulifera, Eucalyptus acmenoides.*



A1: Black or grey (7.5 YR, 10 YR 2/1, 3/1, 4/1, 5/1); sand to loamy sand; single grain; pH 3.5 to 5.8. Gradual to diffuse change to

A2: Conspicuously bleached. Sand; single grain; pH 4.5 to 6. Clear to abrupt change to

B2 hs, h: Brown or black (5 YR, 7.5 YR 3/2, 3/3, 4/3, 4/4); sand; orstein pan or coffee rock pan; pH 4.5 to 6. Clear to diffuse change to

C: Grey (7.5 YR 5/2, 6/2, 6/3, 7/3, 8/2, 10 YR 7/3, 7/4, 8/3, 8/4); sand to sandy loam; single grain or massive; pH 5 to 6;

Sites: 111, 112, 115, 130, 310, 313, 342, 346, 367, 374, 427, 435, 436, 455, 463, 474, 476, 555, 578, 601, 616, 689, 740, 766, 767, 775, 776, 786, 807, 810, 815, 821, 824.

Analysed sites: ATB POD, F (1, 18)

Variant: Colour B2 (no pan)

Sites: 108, 109, 113, 116, 322, 343, 451, 743, 785, 816.

(Kp) KEPNOCK

Concept: Loamy surface over a mottled, yellow, structured subsoil on deeply weathered fine grained sedimentary rocks.

Australian Classification: Yellow Dermosol.

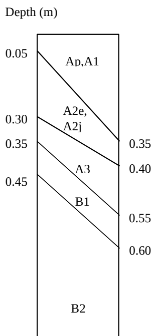
Great Soil Group: Yellow podzolic soil, no suitable group.

Principle Profile Form: Gn3.84, Gn3.81.

Geology: Mudstones, siltstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km).

Landform: Level plains to hillslopes on gently undulating rises.

Vegetation: Cleared.



A1,Ap: Grey on black (7.5 YR 3/2, 4/1, 4/2, 10 YR 4/2, 5/2); loam fine sandy, sandy clay loam, clay loam, clay loam fine sandy; massive; pH 5.5 to 6. Clear change to

A2e,j: Conspicuously or sporadically bleached. Loam fine sandy, sandy clay loam, clay loam fine sandy; massive; pH 5.5 to 6. Clear to diffuse change to

A3: Mottled; yellow or brown (10 YR 5/4, 6/4); clay loam, clay loam fine sandy; massive or weak 2 to 5mm polyhedral; frequently 2 to 50% ferruginous or ferromanganiferous nodules <6mm; pH 5.5 to 6.5. Gradual to diffuse change to

B1: Mottled; yellow (7.5 YR 6/5, 10 YR 6/4, 6/5, 6/6); clay loam sandy to light clay; weak or moderate 2 to 5mm polyhedral or subangular blocky; 2 to 50% ferruginous or ferromanganiferous nodules <6mm; pH 5.5 to 6.5. Gradual to diffuse change to

B2: Mottled; yellow (7.5 YR 6/5, 6/6, 7/6, 10 YR 6/5, 6/6); light clay to medium clay; moderate or strong 2 to 5mm polyhedral or subangular blocky; 10 to 50% ferruginous or ferromanganiferous nodules <6mm; pH 5.5 to 6.5.

Sites: 164, 233, 267, 279, 325, 326, 487, 520, 538, 589, 610, 762, 922, 927, 965, 966, 1053, 1175, 1181, 1205.

Analysed sites: CBWS(9, 11), CBW (5, 14, 17, 25).

(Ko) KOLAN

Concept: Sodic textured contrast soil with a shallow(< 0.3 m), loamy surface over a red mottled, grey or brown clay subsoil on moderately weathered fine grained sedimentary rocks.

Australian Classification: Grey Kurosol, Brown Kurosol.

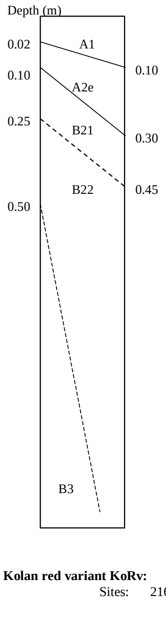
Great Soil Group: Soloth.

Principle Profile Form: Dy3.41.

Geology: Mudstones, siltstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Grahams Creek Formation (JKg), Tiaro Coal Measures (Jdt), Myrtle Creek Sandstone (RJdm).

Landform: Hillslopes of rises and low hills. Slopes 1 to 15%.

Vegetation: 18 to 25m mid-dense *Eucalyptus citriodora, Eucalyptus drepanophylla, Eucalyptus moluccana / Eucalyptus acmenoides / Eucalyptus exserta / Eucalyptus fibrosa. Eucalyptus moluccana* may be locally dominant.



A1: Black or grey (7.5 YR 2/2, 3/2, 4/2, 10 YR 3/2); loam fine sandy to clay loam fine sandy; massive to moderate 2 to 5mm granular; pH 5.5 to 6. Clear to abrupt change to

A2e: Conspicuously bleached. Loam fine sandy to clay loam fine sandy, massive; frequently <2 to 10% ferriginous nodules <6mm; pH 5.5 to 6; sharp to abrupt change to

B21: Mottled; grey or brown (5 YR 4/2, 5/2, 5/3, 7.5 YR 4/2, 4/3, 5/2, 5/3, 10 YR 4/2, 5/2); medium clay to heavy clay; strong 2 to 10mm angular to subangular blocky; frequently <2% ferrugenous nodules < 6 mm; pH 5.0 to 5.5. Clear to gradual change to

B22: Red mottled; grey or brown (7.5 YR 5/2, 5/3, 6/3, 10 YR 5/2, 5/3, 6/2); medium clay to heavy clay; strong 5 to 20mm angular blocky, frequently slickensides present; pH 4.5 to 5.5. Gradual to diffuse change to

B3: Mottled; grey (7.5 YR 5/2, 6/3, 7/2, 10 YR 6/1, 6/2, 7/1, 7/2, 2.5 YR 7/2); light medium clay to heavy clay; moderate to strong 5 to 20mm angular blocky; fragments of mudstone or siltstone; pH 4.5 to 5.5.

Sites: 15, 42, 64, 65, 67, 69, 78, 81, 208, 209, 211,244, 254, 255, 258, 259, 260, 261, 262, 501, 540, 638, 651, 626, 633, 634, 639, 663, 669, 913, 918, 925, 930, 932, 934, 936, 937, 949, 953, 954, 955, 983, 985, 1029,1035, 1056, 1057, 1058, 1059, 1060, 1068, 1074, 1139, 1140, 1142, 1153, 1174, 1189, 1198, 1285, 1288.

Analysed sites: CBW918

Kolan red variant KoRv: Red B2 with 20 to 50% grey mottles.
Sites: 216, 257, 935, 1304, 1309

(Kl) KOLBORE

Concept: Sodic textured contrast soil with a grey clay subsoil over a duripan on deeply weathered sedimenatary rocks.

Australian Classification: Salic Hydrosol, Redoxic Hydrosol.

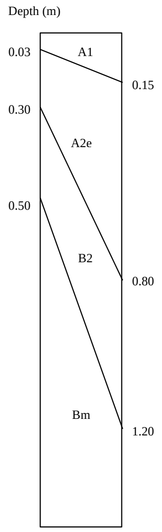
Great Soil Group: Solodic soil, soloth.

Principle Profile Form: Dy3.42, Dy3.41, Dg2.41, Dg2.42, Dy3.43.

Geology: Elliott Formation (Te)

Landform: Drainage depressions in level plains and level plains.

Vegetation: 6 to 15 isolated to sparse *Melaleuca viridiflora / Eucalyptus umbra* with scattered *Angophora costata / Eucalyptus hallii* or 2 to 3m mid-dense *Melaleuca nodosa.*



A1: Grey (7.5 YR 4/1, 5/1, 5/2, 10 YR 4/1); loamy sand, sandy loam, fine sandy loam, loam fine sandy; massive; pH 5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Frequently mottled in lower A2; loamy sand, sandy loam; fine sandy loam, loam fine sandy; massive; pH 5 to 8. Abrupt to sharp change to

B2: Mottled; grey or occasionally brown (7.5 YR 5/2, 5/3, 6/1, 6/2, 7/1, 7/2, 7/3, 10 YR 5/3, 6/2, 7/2, 7/3, 2.5 YR 7/1, 7/2, 7/3); sandy clay to sandy medium clay; strong 10 to 20mm angular blocky or 20 to 50mm prismatic or columnar; pH 5.5 to 9. Sharp to clear change to

m: Mottled; grey or brown (7.5 YR 6/2, 10 YR 4/3, 5/3, 5/4, 6/2, 6/3, 7/2); very hard, brittle duripan.

Sites: 57, 50, 52, 88, 122, 138, 385, 387, 391, 394, 403, 721, 725, 751, 752, 768, 770, 781, 782, 791, 793, 809, 817, 819, 826, 832, 834, 841, 843, 846, 848, 852, 853, 858, 869, 871, 872, 873, 878, 879, 883, 886, 890, 892, 894, 895, 896, 897.

Analysed sites: CBWS7

(Lt) LITTABELLA

Concept: Massive, yellow or grey, sandy to loamy soils and sandy red soils on local alluvium.

Australian Classification: Yellow Kandosol, Grey Kandosol, Red Kandosol, Orthic Tenosol.

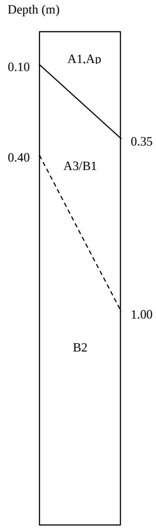
Great Soil Group: Yellow earth, no suitable group, earthy sand.

Principle Profile Form: Um5.52, Um4.23, Gn2.71, Gn2.94, Uc5.22.

Geology: Quaternary alluvium (Qa).

Landform: Levees and scrolls on alluvial plains.

Vegetation: Mostly cleared, minor dense scrub.



A1,Ap: Black or grey (7.5 YR 3/2, 4/2); sandy loam, fine sandy, loam, loam fine sandy; massive or weak 2 to 5mm cast; pH 5.5 to 6.0. Clear change to

A2: Occasionally occurs as a colour, sporadically or conspicuously bleached A2. Sandy loam, fine sandy loam, loam fine sandy; massive; pH 5.5 to 6.

A3/B1: Brown, grey or red (5 YR 5/3, 5/4, 7.5 YR 4/3, 5/4, 10 YR 6/3); sandy loam to loam fine sandy; massive; pH 6 to 8. Diffuse change to

B2 Occasionally mottled; red or grey (5 YR 5/6, 7.5YR 6/3, 10 YR 6/2); sandy loam, loam fine sandy, sandy clay loam, clay loam sandy; massive; pH 6 to 8.

Sites: 62, 84, 117, 574, 618, 619, 679.

(Kb) KOWBI

Concept: Brown non cracking clay soil on basalt.

Australian Classification: Brown Dermosol.

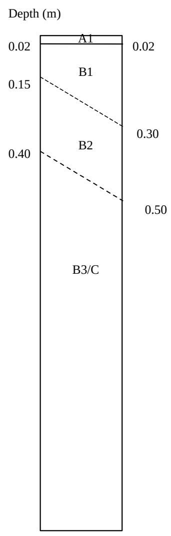
Great Soil Group: Prairie Soil.

Principle Profile Form: Uf6.31.

Geology: Tertiary basalt (Tb).

Landform: Hillslopes on rises and hills. Slopes 8 to 20%.

Vegetation: Cleared.



A1: Black (7.5 YR 3/2); light medium clay to medium clay; strong <2 mm granular; pH 6.0. Abrupt change to.

B1: Black or brown (7.5 YR 3/2, 3/3); medium clay to heavy clay; strong 2 to 10 mm subangular blocky; pH 6.5 to 7.0. Gradual change to

B2: Brown (7.5 YR 3/3, 4/3); medium clay to heavy clay; strong 2 to 10 mm subangular blocky; pH 7.0 to 7.5. Gradual change to

B3/C: Brown (7.5 YR 4/3, 4/4, 5/3, 5/4); heavy clay with rock fragments; strong subangular blocky; pH 7.0 to 7.5.

Sites: 27, 642, 643.

Analysed sites: ATB20

(Mh) MAHOGANY

Concept: Bleached sandy surface over a mottled, grey, massive subsoil on deeply weathered sandstones.

Australian Classification: Redoxic Hydrosol, Grey Kandosol.

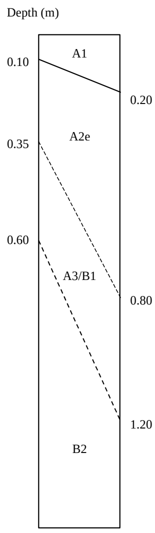
Great Soil Group: No suitable group.

Principle Profile Form: Gn2.94, Dg4.81, Dg2.81, Gn2.81p.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on undulating rises. Slopes 0 to 5%.

Vegetation: 15 to 20m mid-dense *Eucalyptus umbra / Eucalyptus trachyphloia / Eucalyptus intermedia / Eucalyptus acmenoides.*



A1: Grey or occasionally black (7.5 YR, 10 YR 3/1, 4/1, 4/2, 5/1); sand, loamy sand to sandy loam, massive or single grain; pH 5 to 6. Clear to diffuse change to

A2e: Conspicuously bleached. Sand to sandy loam, massive; pH 5 to 6. Diffuse change to

A3/B1: Mottled; grey or yellow (10 YR 6/3, 6/4, 7/3, 7/4, 8/3, 2.5 YR 7/4); sandy loam to sandy clay loam; massive; occasionally ferruginous nodules 2 to 20mm; pH 5 to 6.5. Diffuse to gradual change to

B2: Mottled; grey (10 YR 6/3, 7/2, 7/3, 8/2, 8/3, 8/4, 2.5 Y 7/2, 7/3, 8/2); sandy clay loam, clay loam sandy, sandy clay; massive; frequently ferruginous nodules 2 to 20mm; pH 5.5 to 6.5.

Sites: 106, 114, 126, 202, 236, 269, 275, 278, 281, 311, 329, 347, 350, 352, 355, 356, 362, 398, 421, 424, 429, 433, 438, 440, 441, 442, 443, 458, 460, 461, 465, 468, 469, 475, 581, 583, 600, 628, 675, 688, 759, 761, 789, 1170, 1176, 1179, 1183, 1188, 1192.

Analysed sites: ATBGPf ATBGPc, ATBGE, ATBTUR, F (2, 5, 8, 9, 10, 11) CBW (7, 13, 16, 19).

(Mr) MAROONDAN

Concept: Black cracking clay on basalt.

Australian Classification: Black Vertosol, occasionally Brown Vertosol.

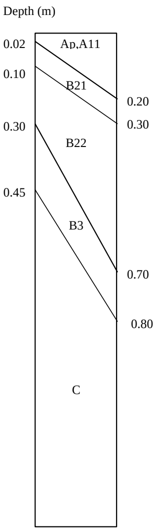
Great Soil Group: Black earth, occasionally brown clay.

Principle Profile Form: Ug 5.12, Ug 5.14, Ug 5.13, Ug 5.32.

Geology: Tertiary Gin Gin basalt (Tg).

Landform: Hillslopes on undulating rises.

Vegetation: Cleared.



Ap/A11: Black or occasionally brown (7.5 YR 2/1, 2/2, 3/1, 3/2, 10 YR 2/2, 3/1, 3/2, 3/3, 3/4); light medium clay to heavy clay; strong <2 to 5mm granular; pH 6.0 to 7.5. Abrupt to gradual change to

B21: Frequently occurs. Black or occasionally brown (7.5 YR 2/1, 2/2, 3/2, 10 YR 2/2, 3/2, 4/3); light medium clay to heavy clay; strong 2 to 5mm subangular blocky; occasionally <2% manganiferous modules <6mm; pH 6.0 to 7.5. Clear to gradual change to

B22: Black or occasionally brown (7.5YR 2/1, 2/2, 3/1, 3/2, 3/3, 10YR 2/2, 3/1, 3/2, 4/3); light medium clay to heavy clay; strong <5mm lenticular; frequently <10% manganiferous modules <6mm; pH 7.0 to 8.8. Clear to diffuse change to

B3: Black, brown or grey (7.5YR 3/2, 4/2, 4/3, 10YR 4/2, 4/3, 5/3, 5/4); light clay to heavy clay with angular basalt fragments; moderate or strong 2 to 10mm subangular blocky or lenticular; frequently <2% manganiferous nodules <6mm; pH 7.0 to 9.0. Clear to gradual change to

C: Weathered rock

Sites: 169,176, 190, 605, 1011, 1242, 1255, 1256, 1257, 1266, 1270, 1310, 1322, 1325, 1326, 1327, 1332, 1343, 1345, 1346, 1347, 1354, 1357, 1359.

Analysed sites: TG6, A23.

Maroondan shallow phase Mr Sp: <0.3m black clay over weathered rock

Sites: 152, 170, 174, 177, 1233, 1234, 1274, 1356

Maroondan grey variant Mr Gv: At depths >0.3 to 0.7m. B23: Grey (10YR 4/2, 5/2, 5/3, 2.5YR, 4/1, 4/2, 5/1); medium clay to heavy clay; strong <5mm lenticular; frequently <10% manganiferous and /or calcareous nodules <6mm; pH 8.0 to 9.0

Sites: 168, 169, 173, 1012, 1311, 1342, 1349.

(Md) MEADOWVALE

Concept: Bleached sandy surface over a yellow massive subsoil over a mottled, structured clay subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Yellow Dermosol, Brown Dermosol.

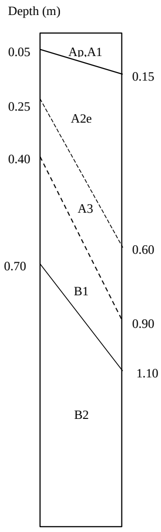
Great Soil Group: Yellow podzolic soil.

Principle Profile Form: Gn3.84, Gn3.04.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on undulating rises. Slopes 0 to 5%.

Vegetation: 15 to 25m mid-dense *Eucalyptus umbra, Eucalyptus trachyphloia / Eucalyptus intermedia.*



A1: Grey (7.5 YR 4/1, 4/2, 5/2, 10 YR 5/1, 5/2); loamy sand to sandy loam; massive; pH 5.5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Loamy sand to sandy loam; massive; pH 5.5 to 6. Gradual to diffuse change to

A3: Mottled; yellow (10 YR 6/4, 6/5, 6/6, 7/4, 7/5, 7/6); sandy loam, light sandy clay loam, sandy clay loam; massive; pH 5.5 to 6. Diffuse change to

B1: Mottled; yellow or brown (10 YR 5/5, 5/6, 6/5, 6/6, 7/5, 7/6); sandy clay loam, clay loam sandy, sandy clay; massive or weak 2 to 10mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20mm; pH 5.5 to 6. Clear to diffuse change to

B2: Mottled; yellow or brown (10 YR 5/5, 5/6, 6/3, 6/4, 6/5, 6/6, 6/8, 7/4, 7/5, 7/6); sandy clay, light clay to medium clay; moderate or strong 2 to 10 mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20mm; pH 5.5 to 5.8.

Sites: 43, 46, 48, 60, 85, 140, 158, 163, 228, 247, 256, 318, 320, 372, 382, 389, 395, 402, 407, 411, 412, 415, 418, 494, 514, 567, 568, 621, 672, 687, 690, 695, 720, 724, 727, 733, 736, 737, 738, 744, 745, 803, 823, 855, 864, 884, 888, 898, 901, 906, 1136, 1138, 1190

Analysed sites: F(4, 16, 17), IJ3, ATBYEmh, BIA4

(Pp) PEEP

Concept: Sodic texture contract soil on local alluvia.

Australian Classification: Grey Sodosol, Brown Sodosol, minor Redoxic Hydrosol.

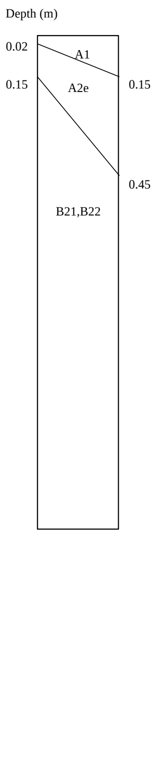
Great Soil Group: Solodic soil, soloth.

Principle Profile Form: Dy3.42, Dy3.41, Dy3.43.

Geology: Quarternary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: 15 to 20m sparse to mid-dense, variable, *Eucalyptus umbra, Angophora costata / Eucalyptus exserta / Melaleuca* species or *Eucalyptus moluccana / Eucalyptus tereticornis.*



A1: Grey or black (7.5 YR 3/2, 4/2, 5/1, 5/2, 10 YR 3/2, 4/2,5/2); fine sandy loam, loam fine sandy, clay loam fine sandy, silty clay loam; massive; pH 5.5 to 6.0. Clear to gradual change to

A2e: Conspicuously bleached. Mottled; loam fine sandy, clay loam fine sandy, silty clay loam; massive; pH 5.5 to 7.0. Sharp to clear change to

B21: Mottled; grey or brown (7.5YR 4/2, 5/2, 5/3, 6/2, 6/3, 10YR 4/2, 5/1, 5/2, 5/3, 6/2, 6/3); light medium clay to medium heavy clay; moderate or strong 5 to 20mm angular blocky or 20 to 50mm prismatic parting to angular blocky; pH 5.5 to 9.

Sites: 19, 21, 54, 55, 70, 118, 135, 143, 172, 207, 217, 321, 331, 339, 345, 529, 576, 620, 678, 686, 709, 717, 799, 805, 899, 904, 919, 998, 1018, 1113, 1115, 1210, 1243, 1245, 1246, 1247, 1265, 1315, 1318, 1333, 1336, 1337, 1355, 1364, 1365.

Analysed sites: CBWS5, ATBSc

(Qr) QUART

Concept: Bleached sandy surface over a mottled, yellow, massive subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Yellow Kandosol.

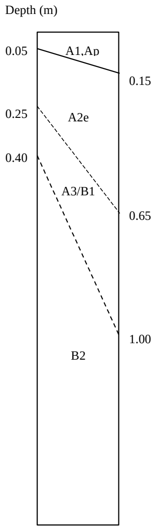
Great Soil Group: Yellow earth.

Principle Profile Form: Gn2.74, Gn2.61p.

Geology: Sandstones of the Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating rises. Slopes 0 to 4%.

Vegetation: Mostly cleared.



A1,Ap: Grey (7.5 YR, 10 YR 4/1, 4/2, 5/1, 5/2); loamy sand to sandy loam; massive; pH 5.5 to 6. Clear to gradual change to

A2: Conspicuously bleach. Loamy sand to sandy loam; massive; pH 5.5 to 6. Diffuse change to

A3/B1: Yellow (7.5 YR 7/6, 10 YR 6/4, 6/5, 6/6, 7/4, 7/6); sandy loam, light sandy clay loam, sandy clay loam, clay loam sandy; massive; pH 5.7 to 6. Diffuse change to

B2: Mottled; yellow (7.5 YR 6/5, 6/6, 7/6, 10 YR 6/5, 6/6, 7/5, 7/6); sandy clay loam, clay loam sandy, clay loam; massive; frequently ferruginous nodules 2 to 20mm; pH 5.5 to 6.5.

Sites: 107, 125, 274, 277, 282, 306, 323, 324, 409, 473, 479, 484, 512, 573, 580, 598, 622, 684, 735, 756, 959, 960, 1046.

Analysed sites: ATBYE, F3, CBW (12, 15, 20).

(Rb) ROBUR

Concept: Sodic texture contrast soil with moderately deep (0.5-1m) sandy surface over a grey or gleyed clay subsoil on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Redoxic Hydrosol.

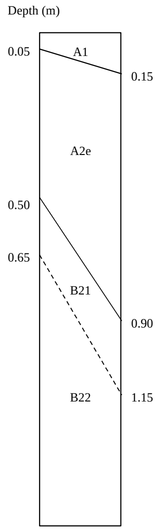
Great Soil Group: Soloth, minor solodic soil.

Principle Profile Form: Dy3.41, Dg2.41, Dg2.42.

Geology: Elliott Formation (Te).

Landform: Level plains, hillslopes.

Vegetation: 10 to 18m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Eucalyptus hallii / Eucalyptus trachyphloia*, frequently with an understory of *Banksia oblongifolia / Banksia robur*.



A1: Grey (7.5 YR 4/1, 4/2, 5/1, 5/2);loamy sand to sandy loam, massive; pH 5.5 to 5.8. Clear to gradual change to

A2e: Conspicuously bleached. Loamy sand to sandy loam; massive; pH 5.5 to 6. Abrupt to clear change to

B21: Mottled; grey (10 YR 6/2, 6/3, 7/2); sandy clay to sandy light medium clay; week to moderate 10 to 50mm angular blocky or prismatic; frequently <2 to 20% ferruginous nodules 2 to 20mm; pH 5 to 6.5. Gradual to diffuse change to

B22: Mottled; grey (10 YR 6/1, 6/2, 6/3, 7/1, 7/2, 2.5 YR 7/1); sandy light medium clay to heavy clay; strong 10 to 20mm angular blocky or 20 to 50mm prismatic parting to 10 to 20mm angular blocky; frequently 2 to 50% ferruginous nodules 2 to 20mm; pH 5 to 8.

Sites: 8, 49, 90, 119, 127, 205, 330, 341, 351, 357, 358, 359, 369, 373, 379, 380, 381, 383, 388, 404, 428, 439, 448, 453, 464, 467, 471, 481, 492, 531, 554, 577, 613, 617, 630, 671, 691, 698, 718, 719, 723, 729, 730, 732, 748, 749, 750, 754, 755, 769, 771, 778, 779, 783, 788, 790, 792, 797, 798, 800, 801, 802, 804, 806, 808, 825, 827, 828, 829, 831, 835, 836, 837, 840, 842, 845, 847, 851, 854, 861, 862, 866, 867, 868, 870, 876, 880, 885, 887, 893, 900, 1195.

Analysed sites: CBWS (2,8), F (12,13), QCB216

(Rd) REDBANK

Concept: Massive red loamy soil on local alluvium.

Australian Classification: Red Kandosol.

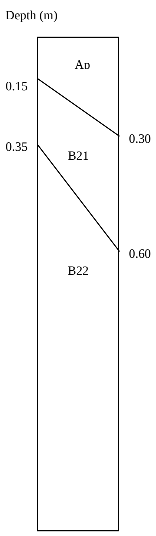
Great Soil Group: Red earth.

Principle Profile Form: Um5.52, Gn2.11.

Geology: Quaternary alluvium (Qa).

Landform: Alluvial plains.

Vegetation: Cleared.



Ap: Brown or black (2.5YR 4/2, 5YR 2/2, 7YR 3/3, 4/3, 10YR 3/4); fine sandy loam, loam fine sandy, clay loam sandy; massive; pH 6.0 to 6.3. Abrupt to clear change to

B21: Red or brown (2.5YR 3/3, 4/4, 5YR 3/4, 10YR 4/4); fine sandy clay loam, clay loam; massive or weak 5 to 10mm subangular blocky; pH 6.0 to 6.8. Gradual to diffuse change to

B22: Red (2.5YR 4/6, 4/8); fine sandy clay loam, clay loam, sandy light clay; weak 5 to 10mm subangular blocky; <2 to10% manganiferous concretions or soft segregations <2mm to 6mm; pH 5.5 to 7.0.

Sites: 192, 1219, 1316, 1362.

Analysed sites: ATB17

(Tk) TAKOKO

Concept: Bleached loam on Silicified Maryborough Formation.

Australian Classification: Bleached Tenosol.

Great Soil Group: No suitable group, affinities with (bleached) lithosol.

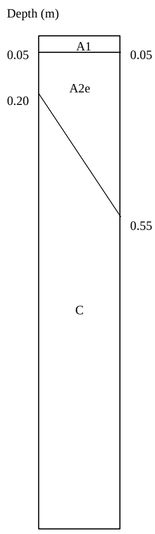
Principle Profile Form: No provision.

Geology: Silicified mudstones, siltstones of the Maryborough Formation (Km).

Landform: Hillslopes and hillcrests on rises and low hills. Slopes 0 to 20%.

Coarse Fragments: >20%, 20 to 600mm.

Vegetation: 18 to 20m mid-dense *Eucalyptus citriodora / Eucalyptus acmenoides / Eucalyptus trachyphloia / Eucalyptus umbra / Lophostemon confertus.*



A1: Black or grey (7.5 YR 3/2, 4/2, 5/3); clay loam; massive or weak 2 to 5mm cast; >20% rock fragments 20 to 600mm; pH 5.8 to 6.3. Clear change to

A2e: Conspicuously bleached. Clay loam; massive; >20% rock fragments 20 to 600mm; pH 5.0 to 5.5. Clear to gradual change to

C: Silicified sedimentary rocks.

(Th) THEODOLITE

Concept: Bleached sand over a coloured sand B2 horizon over a sodic structured clay on sandstones.

Australian Classification: Aquic Podosol/Redoxic Hydrosol.

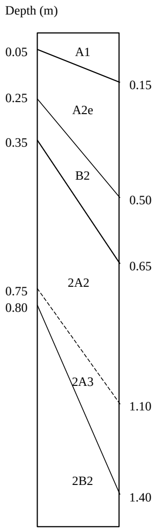
Great Soil Group: Podzol.

Principle Profile Form: Uc2.21, Uc2.23, Uc2.32, Uc2.34.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 3 to 6m very sparse to sparse *Eucalyptus umbra* with an understory of heath or 1 to 3m mid-dense to dense *Melaleuca nodosa* mixed with heath species.



A1: Grey (7.5 YR 4/1, 5/1, 5/2, 10 YR 4/1); and to sandy loam; single gram; pH 5 to 5.5. Clear to gradual change to

A2e: Conspicuously bleached. Sand to loamy sand; single grain; pH 5 to 6. Clear change to

B2: Brown or occasionally grey with brown or yellow mottle (5YR 3/3, 7.5 YR 4/3, 5/3, 5/4); sand to loamy sand; single grain; occasionally orstein pan; pH 5 to 6. Clear to gradual change to

2A2: Conspicuously bleached. Frequently mottled; sand to sandy loam; massive or occasionally single grain; pH 5 to 6. Clear to diffuse change to

2A3: Mottled; grey or occasionally yellow (7.5 YR 7/3, 10 YR 6/4, 7/2, 7/4, 8/2, 2.5 YR 7/2, 8/2); sandy loam to sandy clay loam; massive; pH 5 to 6. Clear to abrupt change to

2B2: Mottled; grey (7.5 YR 6/2, 7/2, 10 YR 6/4, 7/2, 7/3, 8/2, 2.5 Y 8/2); sandy clay to sandy medium clay; moderate >20mm angular blocky or prismatic; pH 5 to 6.

Sites: 370, 375, 377, 378, 426, 459, 528, 611, 772, 773, 812, 820, 822.

Analysed sites: F14

(Tp) TURPIN

Concept: Sodic texture contrast soil with a shallow (0.25 to 0.5m) sandy surface containing maghemite nodules over a grey subsoil on deeply weathered fine grained sedimentary rocks.

Australian Classification: Grey Sodosol, Grey Kurosol, Brown Sodosol, Brown Kurosol, Redoxic Hydrosol.

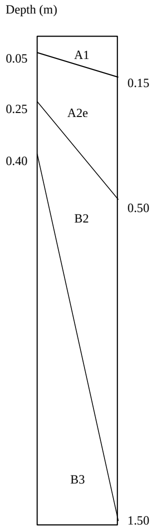
Great Soil Group: Soloth.

Principle Profile Form: Dy3.41, Dg2.41.

Geology: Mudstones, siltstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km), Graham's Creek Formation (Jkg), Tiaro Coal Measures (Jdt), Myrtle Creek Sandstone (RJdm).

Landform: Hillslopes on gently undulating to undulating rises. Slopes 2 to 12%.

Vegetation: 12 to 18m mid-dense *Eucalyptus umbra, Angophora cosata / Eucalyptus trachyphloia / Eucalyptus intermedia / Eucalyptus exserta / Melaleuca viridiflora.*



A1: Grey or occasionally black (7.5 3/2, YR 4/1, 4/2, 5/2); loamy sand to sandy loam; massive; pH 5.5 to 5.8. Clear to gradual change to

A2: Conspicuously bleached. Mottled; loamy sand to sandy loam; massive; frequently <2 to 50% ferruginous (maghemite) nodules in lower A2. Abrupt change to

B2: Mottled; grey or brown (7.5 YR 5/2, 5/3, 6/2, 6/3, 10 YR 5/2, 5/3, 6/1, 6/2, 6/3, 7/1, 7/2) becoming paler at depth; light medium clay to heavy clay; strong 2 to 10mm angular blocky; frequently <2 to 50% ferruginous (maghemite) nodules <6mm, 2 to 20% nodules usually in upper B; pH 5.3 to 6.0. Clear to diffuse change to

B3: Mottled; grey (7.5YR 5/2, 6/1, 6/2, 10YR 6/1, 6/2, 7/1, 7/2, 8/2); clay with rock fragments.

Sites: 305, 315, 319, 334, 364, 432, 466, 472, 477, 482, 498, 584, 614, 631, 664, 665, 811, 814, 889, 1167, 1171, 1177, 1182, 1184.

Analysed sites: CBWS1, QCB216, F7, ATBYP1

(Tr) TIRROAN

Concept: Sodic texture contrast soil with a bleached sandy surface over grey sandy clay subsoil on moderately weathered sandstones.

Australian Classification: Grey Sodosol.

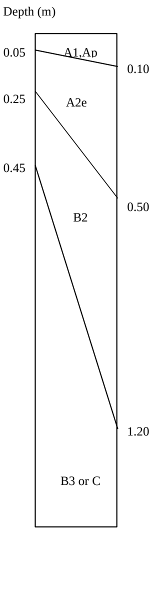
Great Soil Group: Soloth, rarely solodic soil.

Principle Profile Form: Dy3.41, Dy3.42.

Geology: Sandstones of the Elliott Formation (Te), Mytle Creek Sandstone (RJdm).

Landform: Hillslopes on undulating rises and low hills.

Vegetation: 18 to 22m mid-dense, variable, *Eucalyptus acmenoides, Eucalyptus trachyphloia / Eucalyptus umbra / Eucalyptus exserta / Eucalyptus intermedia/ Eucalyptus citriodora / Angophora costata.*



A1, Ap: Black or grey (7.5 YR 3/2, 4/2); sandy loam, loamy fine sand, fine sandy loam; massive; pH 5.5 to 6. Clear change to

A2e: Conspicuously bleached. Mottled; loamy sand; massive; pH 5.5 to 6. Abrupt to sharp change to

B2: Mottled; grey (7.5YR 4/2, 5/2, 6/1, 6/2 10YR 5/2, 5/3, 6/2) frequently becoming paler at depth; sandy light medium clay to sandy medium heavy clay; weak to strong 10 to 50mm prismatic or angular blocky; pH 5.5 to 6.0 rarely up to 8.0. Clear to gradual to change to

B3 or C: Mottled; grey (7.5YR 5/1, 5/2, 5/3, 6/1, 6/3); sandy light medium clay to medium clay with sandstone fragments, strong 10 to 20mm angular blocky; pH 5.5 to 6.0; or weathered rock.

Sites: 982, 1078, 1079, 1137, 1168, 1173, 1215, 1216, 1217, 1218, 1230, 1261, 1282, 1283, 1284, 1287, 1334, 1350, 1363.

Tirroan non-sodic variant TrPv: Brown or Yellow Chromosol
A1/Ap, A2: as per Tirroan.
B2: Mottled; brown or yellow (5YR 6/4, 7.5YR 5/3, 6/3, 10YR 6/3, 6/6); sandy clay to medium clay; moderate or strong 2 to 10mm subangular blocky; pH 5.5 to 6.0.

Sites: 1080, 1238, 1248, 1251, 1264.

Analysed sites: ATB18, ATB RPc

(Wl) WALLA

Concept: Grey cracking clay on alluvial plains.

Australian Classification: Grey Vertosol.

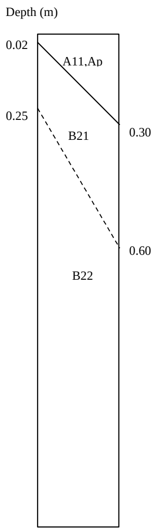
Great Soil Group: Grey clay.

Principle Profile Form: Ug3.2, Ug5.24.

Geology: Quarternary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: Cleared.



A11, Ap: Grey on black (7.5 YR 3/2, 4/2, 10 YR , 3/2, 4/2); light clay to medium clay; moderate 2 to 5mm granular or subangular blocky; pH 5.8 to 6.8. Clear change to

A2j: Frequently occurs in uncultivated soils. Sporadically bleached. Light clay to medium clay, weak or moderate 5 to 10mm subangular or angular blocky. Clear to gradual change to

B21: Mottled; grey (7.5 YR 4/2, 10 YR 4/2, 4/3, 5/2, 2.5YR 4/2); medium clay to heavy clay; strong 5 to 20mm angular blocky; pH 5 to7.5. Diffuse change to

B22: Mottled, grey or brown (10 YR 5/1, 5/2, 5/3, 2.5YR 5/1, 5/2, 5/3, 6/2); medium heavy clay to heavy clay; strong 2 to 5mm lenticular; pH 5 to 9.

Sites: 3, 175, 178, 185, 212, 213, 915, 920, 1017, 1019, 1020,1024,1033, 1223, 1237, 1303, 1321, 1328, 1361, 1366.

(Wm) WALLUM

Concept: Bleached sand over a coloured sand B2 horizon (occasionally an orstein pan) over a massive sandy clay loam to sandy clay on sandstones.

Australian Classification: Aquic Podosol/Redoxic Hydrosol.

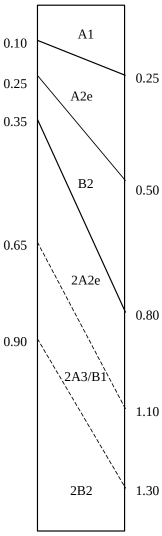
Great Soil Group: (Rudimentary) Podzol, Podzol.

Principle Profile Form: Uc2.21, Uc2.23, Uc2.22, Uc2.32.

Geology: Elliott Formative (Te).

Landform: Level plains.

Vegetation: 3 to 12m mid-dense to isolated *Eucalyptus umbra* with an understory of heath or 12 to 20m sparse to mid-dense *Eucalyptus acmenoides / Eucalyptus umbra / Eucalyptus intermedia / Syncarpia glomulifera.*



A1: Grey or black (7.5 YR, 10 YR 3/1, 4/1, 5/1); sand to loamy sand; single grain; pH 4.5 to 5.5. Clear to diffuse change to

A2e: Conspicuously bleached. Sand, single grain; pH 5 to 6. Clear change to

B2: Occasionally mottled; brown or occasionally yellow (5 YR 3/3, 4/4, 7.5 YR 5/3, 5/4, 6/3, 6/4, 10 YR 5/3, 7/4, 7/6); sand; single grain; pH 5 to 6. Clear to diffuse change to

2A2e: Conspicuously bleached. Sand; single grain; pH 5 to 6. Gradual to diffuse change to

2A3/B1: Mottled; grey or occasionally yellow (10 YR 7/2, 7/3, 7/4, 8/2, 8/3, 8/4); sandy loam to light sandy clay loam; massive; occasionally ferruginous nodules; pH 5.0 to 6. Diffuse change to

2B2: Mottled; grey (10 YR 7/2, 7/3, 8/2, 8/3, 8/4, 2.5 Y 7/1, 8/2); sandy clay loam to sandy clay; massive; pH 5 to 6.

Sites: 110, 113, 340, 344, 360, 365, 376, 384, 386, 423, 425, 434, 437, 450, 456, 457, 482, 615, 739, 774, 786.

(Wh) WEITHEW

Concept: Dark cracking clay on local alluvium.

Australian Classification: Black Vertosol, occasionally Grey Vertosol.

Great Soil Group: Black earth, occasionally Grey clay.

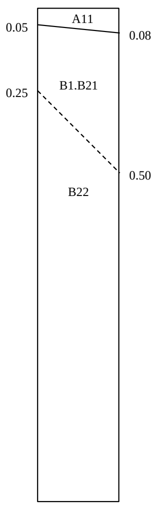
Principle Profile Form: Ug5.16, Ug5.24.

Geology: Quarternary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: Cleared.

Depth (m)



A11: Black (7.5 YR 3/1,3/2); light clay to light medium clay; strong 2 to 5mm granular; pH 6.0 to 6.5. Abrupt to clear change to

B1, B21: Black or grey (7.5 YR 2/2, 3/1, 4/2, 10 YR 3/1, 4,2); light medium clay to medium clay; strong 2 to 10mm subangular blocky; pH 6.0 to 8.5. Gradual to diffuse change to

B22: Mottled; grey (7.5YR 4/2, 10 YR 4/1, 5/2, 2.5YR 4/1); medium clay to heavy clay; strong 2 to 5mm lenticular; pH 6.5 to 9.0.

Sites: 3, 296, 1258, 1338.

(Wt) WATALGAN

Concept: Black or brown clay loam surface over a paler A2 horizon over a red structured clay subsoil on deeply weathered fine grained sedimentary rocks.

Australian Classification: Red Dermosol.

Great Soil Group: Red podzolic soil.

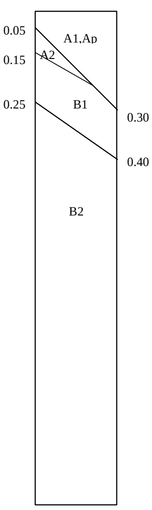
Principle Profile Form: Gn3.14, Dr2.21, Gn3.11p.

Geology: Mudstones, sillstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km).

Landform: Level plains to hillslopes of rises and low hills.

Vegetation: Mostly cleared. Minor 8 to 25m mid-dense *Eucalyptus citriodora, Eucalyptus acmenoides / Eucalyptus drepanophylla / Eucalyptus crebra.*

Depth (m)



A1,Ap: Black or brown (5 YR 2/2, 3/2, 3/3, 7.5 YR 2/3, 3/3, 4/3); clay loam; weak to strong 1 to 5mm granular or cast; <2% to >50% ferruginous nodules <6 mm; pH 5 to 6. Clear to gradual change to

A2: Occurs in undisturbed soils. Red or brown (2.5 YR 3/3, 4/3, 5 YR 4/3, 4/4, 4/6, 7.5 YR 4/4); clay loam, weak or moderate 2 to 5mm granular or subangular blocky; <2% to >50% ferruginous nodules <6 mm; pH 5.5 to 6. Clear to gradual change to

B1: Red (10 R 4/4, 2.5 YR 3/4, 4/4, 4/6, 5 YR 4/4, 4/6); light clay; moderate or strong 2 to 5mm subangular blocky or polyhedral; <2% to >50% ferruginous nodules < 6 mm; pH 5.5 to 6. Gradual to diffuse change to

B2: Red (10 R 3/6, 4/4, 4/6, 2.5 YR 3/6, 4/6, 4/8); light clay to medium clay; strong 2 to 5mm polyhedral; <2% to 50% ferruginous nodules <6 mm; pH 5.5 to 6.3.

Sites: 68, 80, 100, 248, 557, 602, 921, 940, 943, 967, 972, 999, 1052, 1069, 1095.

Watalgan mottled variant WtMv: Mottled B2.

(Wf) WINFIELD

Concept: Bleached, massive, grey sand.

Australian Classification: Redoxic Hydrosol.

Great Soil Group: (Bleached) Earthy sand.

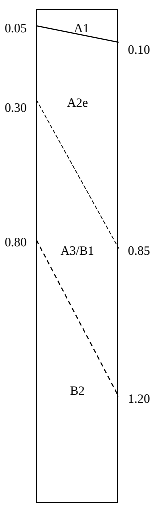
Principle Profile Form: Uc2.23, Uc2.22.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 10 to 18m mid-dense *Eucalyptus umbra / Eucalyptus trachyphloia / Eucalyptus hallii / Eucalyptus intermedia.*

Depth (m)



A1: Grey or occasionally black (7.5 YR 3/1, 4/1, 4/2, 10 YR 4/1, 5/1); sand to loamy sand; single grain or massive; pH 5 to 6. Clear to gradual change to

A2e: Conspicuously bleached. Sand to loamy sand; single grain or massive; pH 5.5 to 6. Diffuse change to

A3/B1: Mottled; grey, brown or yellow (7.5YR 5/3, 10 YR 7/3, 7/4); loamy sand to sandy loam; massive; pH 5.5 to 6. Diffuse change to

B2 Mottled; grey (7.5YR 6/3, 10 YR 7/2, 8/3); loamy sand to sandy loam; massive; frequently < 50% ferromanganiferous nodules 2 to 20mm; pH 5.5 to 6.

Sites: 251, 397, 413, 454, 470, 495, 784, 787, 1185.

Winfield yellow variant: Yellow B2 (10YR 7/4,7/6).

Sites: 470

Winfield red variant: Pale A2, red B2 (5YR 4/6).

Sites: 1135

(Wo) WOCO

Concept: Loamy surface over a strongly acid, mottled, sodic, grey or brown clay subsoil with polyhedral structure on deeply weathered fine grained sedimentary rocks.

Australian Classification: Grey Dermosol, Brown Dermosol, Grey Kurosol, Brown Kurosol, Redoxic Hydrosol.

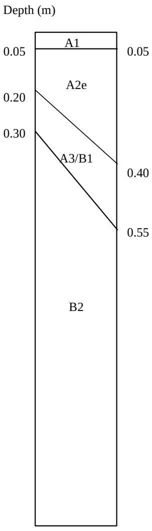
Great Soil Group: Soloth.

Principle Profile Form: Gn3.04, Dy3.41.

Geology: Mudstones, siltstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km).

Landform: Level plains to lower slopes of gently undulating rises. Slopes 0 to 6%.

Vegetation: 15 to 18m mid-dense *Eucalyptus umbra / Melaleuca viridiflora / Eucalyptus intermedia / Lophostemon suaveolens.*



A1: Grey or black (7.5 YR 3/2, 4/2, 10 YR 4/2); loam fine sandy to clay loam; 2 to 5mm weak or moderate granular; pH 5.5 to 6. Clear change to

A2e: Conspicuously bleached. Loam fine sandy to clay loam; massive or weak 2 to 5mm granular; pH 5.5 to 6. Clear to gradual change to

A3, B1: Mottled; brown, grey or yellow (7.5 YR 4/3, 5/3, 6/4, 10 YR 6/4, 7/3); clay loam to light clay; 2 to 20% ferruginous (maghemite) nodules <2 to 6mm; weak or moderate 2 to 5mm subangular blocky or polyhedral; pH 5.0 to 5.8. Clear to diffuse change to

B2: Mottled; grey or brown (10 YR 5/2, 5/4, 6/3, 7/3); light clay to medium clay; strong to 2 to 5mm polyhedral or subangular blocky; 10 to 20% ferruginous (maghemite) nodules <2 to 6mm; pH 5 to 5.5.

Sites: 35, 36, 287, 563, 625, 632, 677, 693, 708.

Analysed sites: CBWS(10, 12)

(Wr) WOOLMER

Concept: Bleached, loamy, yellow, massive soil over a mottled, structured, yellow clay on deeply weathered fine grained sedimentary rocks.

Australian Classification: Yellow Dermosol, Brown Dermosol.

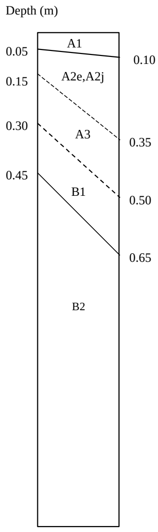
Great Soil Group: Yellow podzolic soil, no suitable group.

Principle Profile Form: Gn3.84, Gn3.81.

Geology: Mudstones, siltstones, fine sandstones of the Elliott Formation (Te), Burrum Coal Measures (Kb), Maryborough Formation (Km).

Landform: Crests of gently undulating plains and rises. Slopes 0 to 4%.

Vegetation: Mostly cleared. Minor 15 to 18m mid-dense *Eucalyptus umbra, Eucalyptus trachyphloia / Eucalyptus intermedia.*



A1: Grey (7.5 YR 4/1, 4/2, 10 YR 4/2); fine sandy loam to loam fine sandy; massive; pH 5.5 to 6. Clear to gradual change to

A2e,j: Conspicuously bleached, occasionally sporadically bleached. Massive; pH 5.5 to 6. Gradual to diffuse change to

A3: Brown or yellow (7.5 YR 5/4, 6/4, 6/5, 10 YR 5/3, 5/4, 5/5, 5/6, 6/5); loam fine sandy to sandy clay loam; massive; <2 to 20% ferruginous (maghemite) nodules <6mm; pH 5.5 to 5.8. Gradual to diffuse change to

B1: Mottled; yellow or brown (7.5 YR 5/5, 6/6, 10 YR 5/5, 5/6, 6/6); sandy clay loam, clay loam sandy, clay loam fine sandy; massive or weak 2 to 5mm polyhedral on subangular blocky; 2 to 50% ferruginous (maghemite) nodules <6mm; pH 5.5 to 5.8. Clear change to

B2: Mottled; yellow or brown (7.5 YR 5/5, 6/6, 10 YR 5/4, 5/5, 5/6, 6/4, 6/6); light clay to medium clay; moderate to strong 2 to 5mm polyhedral; 10 to 50% ferruginous (maghemite) nodules <6mm; pH 5 to 6.8.

Sites: 16, 103, 133, 210, 283, 285, 332, 333, 336, 337, 513, 524, 539, 623, 667, 696, 699, 705, 714, 726, 813, 909, 1155, 1194, 1200.

Analysed sites: CBW (21, 23) ATBBIG

(Wg) WOODGATE

Concept: Humic surface over a bleached sand over coffee rock at <1m on beach ridges.

Australian Classification: Aquic Podosol.

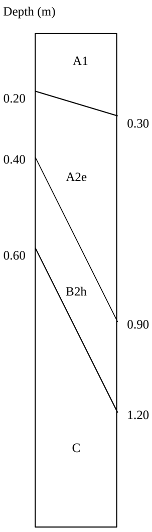
Great Soil Group: Humus podzol.

Principle Profile Form: Uc 2.33.

Geology: Quarternary sand.

Landform: Beach ridge.

Vegetation: 1 to 2m mid-dense to dense heath. Occasionally 6 to 12m mid-dense *Melaleuca quinquenervia.*



A1: Black or grey (7.5 YR 1/1, 2/1, 3/1, 4/1,10 YR 4/1); sand to sandy loam; single grain, pH 4.0 to 5.5. Clear to diffuse change to

A2e: Conspicuously bleached. Sand; single grain; pH 5 to 6.0. Clear change to

B2h: Black (5 YR 3/2, 7.5YR 1/1, 3/1,3/2); sand; coffee rock pan; pH 4.5 to 6. Clear to gradual change to

C: Pale (7.5YR 7/2); sand; single grain, pH 6 to 6.5.

Sites: 144, 146, 795, 796

Appendix IV

Land suitability classes

Class definition

Five land suitability classes have been defined for use in Queensland, with land suitability decreasing progressively from Class 1 to Class 5. Land is classified on the basis of a specified land use which allows optimum production with minimal degradation to the land resource in the long term.

Class 1	Suitable land with negligible limitations. This is highly productive land requiring only simple management practices to maintain economic production.
Class 2	Suitable land with minor limitations which either reduce production or require more than the simple management practices of class 1 land to maintain economic production.
Class 3	Suitable land with moderate limitations which either further lower production or require more than those management practices of class 2 land to maintain economic production.
Class 4	Marginal land which is presently considered unsuitable due to severe limitations. The long term or precise effects of these limitations on the proposed land use are unknown. The use of this land is dependent upon either undertaking additional studies to determine its suitability for sustained production or reducing the effects of the limitation(s) to achieve production.
Class 5	Unsuitable land with extreme limitations that preclude its use.

Land is considered less suitable as the severity of limitations for a land use increase, reflecting either (a) reduced potential for production, and/or (b) increased inputs to achieve an acceptable level of production and/or (c) increased inputs required to prevent land degradation. The first three classes are considered suitable for the specified land use as the benefits from using the land for that land use in the long term should outweigh the inputs required to initiate and maintain production. Decreasing land suitability within a region often reflects the need for increased inputs rather than decreased potential production. Class 4 is considered presently unsuitable and is used for marginal land where it is doubtful that the inputs required to achieve and maintain production outweigh the benefits in the long term. It is also used for land where reducing the effect of a limitation may allow it to be upgraded to a higher suitability class, but additional studies are needed to determine the feasibility of this.

Class 5 is considered unsuitable having limitations that in aggregate are so severe that the benefits would not justify the inputs required to initiate and maintain production in the long term. It would require a major change in economics, technology or management expertise before the land could be considered suitable for that land use. Some class 5 lands however, such as escarpments, will always remain unsuitable for agriculture.

Appendix V

Coastal Burnett-Wide Bay

Land suitability classification scheme for irrigated c1rops

The classification scheme is a summary of each limitation describing the effects of the limitation on plant growth, machinery use and land degradation, and how the soil/land attributes are assessed, and how the limitation classes are determined. The classes are defined in Appendix IV. The codes listed in this appendix for each limitation are the soil/land attribute level recorded in the UMA file.

Irrigation method is assumed to be spray (travelling irrigators or other overhead spray method) unless otherwise stated. Furrow irrigation is a separate land use.

The agricultural land uses listed are:

Asparagus
Avocado
Beans
Citrus
Crucifers (cabbage, cauliflowers, etc)
Cucurbits (melons)
Furrow irrigation
Grape
Improved pasture
Lucerne
Lychee
Macadamia
Maize
Mango
Navybean
Peanut
Pineapple
Potato
Sorghum
Soybean
Stonefruit (peaches, nectarines)
Sugar cane
Sweet corn
Sweet potato
Vegetables (tomato, zucchini)

CLIMATE (c)

Effect

Frosts may suppress growth, kill plants and reduce yield.

Assessment

The incidence and severity of frosts are used to distinguish affected areas.

Limitation class determination

Crop tolerance and local experience of the incidence and severity of frosts. For example, severe frosts cause severe damage to sugar cane stalk tissue which reduces sugar content unless it is harvested within two weeks, depending on weather conditions.

Soil/land attribute level	Limitation classes for various crops			
	Avocado, Macadamia, Mango	Citrus, Vegetables, Cucurbits, Pineapple, Sweet Potato, Beans, Sweet Corn, Lychee	Sugar Cane	Cruciferae, Asparagus, Potato, Grapes. All other crops *
Frost free to light frosts (hill tops or near coastal areas) Code: C1	2	1	1	1
Regular frosts Code: C2	5	3	2	1
Severe frosts (channel benches, depressions in lower terraces) Code: C3	5	4	3	1

* All other crops refers to crops listed in this appendix. Seasonal adaptation is not considered, for example, summer crops are not grown in winter.

WATER AVAILABILITY (m)

Effect

Plant yield will be decreased by periods of water stress particularly during critical growth periods.

Assessment

Plant available water capacity (PAWC) is used as a measure of the amount of water in a soil available to plants over the rooting depth.

PAWC is based on predicted values (Gardner and Coughlan 1982, Shaw and Yule 1978). Generally, soil texture, structure and clay mineralogy over the effective rooting depth[1] are important attributes affecting PAWC.

Limitation class determination

PAWC classes relate to the frequency of irrigation for spray or furrow irrigation only:

>100 mm = 15 days
75 to 100 mm = 12 to 15 days
50 to 75 mm = 8 to 12 days
<50 mm = 8 days

Irrigation frequency considers crop rooting depth, seasonal evaporation rates and the amount of labour and equipment required. For example, shallow rooted crops require more frequent irrigation compared to deep rooted crops, while winter crops require less frequent irrigation compared to summer crops. More frequent irrigation requires a greater amount of labour and/or more equipment. Negligible limitations apply to microsprinkler or drip irrigation systems where small amounts of water are added frequently.

Soil/land attribute level	Limitation class for various crops			
	Microsprinkler/drip irrigation - Avocado, Citrus, Macadamia, Mango, Lychee, Stone fruit, Grapes, Veges, Cruciferae	Cucurbits, Asparagus, Potato, Navybean, Beans, Sweet corn, Sweet potato	Peanuts, Lucerne, Maize, Sorghum (forage), Soybean, Pastures, Pineapples	Sugar cane
Soil PAWC (to 0.9 m)				
>100 mm Code: M1-M3	1	2	1	1
75-100 mm Code: M4	1	2	1	2
50-75 mm Code: M5	1	2	2	3
<50 mm Code: M6	1	3	3-4	4

[1] Effective rooting depth is taken to the depth of optimal water extraction by roots. For example, tree crops 1-1.5 m, small crops 0.5 m, field crops, sugar cane and grapes 0.9 m; or to the depth of high salt concentration, rock; or impermeable layers.

WETNESS (w)

Effect
Waterlogged soils will reduce plant growth and delay effective machinery operations.

Assessment
Internal and external drainage are assessed. Indicator attributes of internal drainage include texture, grade and type of structure, colour, mottles, segregations and impermeable layers. Drainage class[1] and soil permeability[2] (McDonald *et al.* 1990) are assessed in relation to plant rooting depth. Slope and topographic position determine external drainage.

Limitation class determination
Consultation, crop tolerance information and the effects of delays in machinery operations.

[1] Drainage class: This accounts for all aspects of internal and external drainage in the existing state.
Drainage class
1 Very poorly drained
2 Poorly drained
3 Imperfectly drained
4 Moderately well drained
5 Well drained
6 Rapidly drained

[2] Permeability
H Highly permeable (>500 mm/day)
M Moderately permeable (50-500 mm/day)
S Slowly permeable (5-50 mm/day)
V Very slowly permeable (<5 mm/day)

Soil/land attribute level	Limitation classes for various crops								
	(a) Depth req. 0 to 1.5 m (Code: W3)				(b) Depth req. 0 to 1 m (Code: W1)		(c) Depth req. 0 to 0.5 m (Code: W2)		
Drainage class permeability	Avocado	Citrus, Macadamia	Mango	Lychees	Lucerne Stone-fruit, Grape	Maize, Sorghum (forage), Sweet corn, Soybean	Sugar cane	Navybean, Peanuts, Beans	Veges, Cruciferae, Cucurbits, Asparagus, Potato, Pineapple, Sweet potato
6H	1	1	1	1	1	1	1	1	1
5H	2	1	1	1	1	1	1	1	1
5M	3	2	1	1	2	1	1	2	1
4H	3	2	1	1	2	1	1	2	1
4M	4	3	1	2	3	2	1	3	2
4S	5	4	2	3	4	3	2	4	3
4V	5	4	2	3	4	3	2	4	3
3H	4	3	2	2	3	2	2	3	2
3M	5	4	2	3	4	3	2	4	3
3S	5	5	3	4	5	4	3	5	4
3V	5	5	3	4	5	4	3	5	4
2H	5	5	3	5	5	5	3	5	5
2M	5	5	3	5	5	5	3	5	5
2S	5	5	4	5	5	5	4	5	5
2V	5	5	4	5	5	5	4	5	5
1H	5	5	5	5	5	5	4	5	5
1M	5	5	5	5	5	5	4	5	5
1S	5	5	5	5	5	5	5	5	5
1V	5	5	5	5	5	5	5	5	5

SOIL DEPTH (d)

Effect

Shallow soils limit root proliferation and anchorage. Plants may be uprooted during strong winds.

Assessment

Effective soil depth: Depth to decomposing rock, pan or impermeable layer.

Limitation class determination

Consultation.

Soil/land attribute level Effective soil depth	Limitation classes for various crops		
	Tree crops	Sugar cane	All other crops
> 1 m Code: D1	1	1	1
0.6 to 1 m Code: D2	2	1	1
0.4 to 0.6 m Code: D3	3	1	1
0.3 to 0.4 m Code: D4	4	2	1
< 0.3 m Code: D5	5	5	5

SOIL NUTRIENT SUPPLY (n)

Effects

Reduced plant growth is associated with the shortage (deficiency) or oversupply (toxicity) of mineral nutrients.

Assessment

The need for fertiliser treatment additional to standard application rates and practices. Undeveloped soils low in nutrients will require additional fertiliser initially. Minor elements can be added at low cost. Assessment is based on the nutrient levels of the surface 0 to 0.3 m. Soils which are highly permeable to depth greater than the root zone have a high leaching potential resulting in loss of nutrients from the root zone. Humose and organic horizons (Isbell 1996) have a potential to absorb nutrients such as phosphorus.

Specific problems assessed are:
- Soils deficient in P and K (nd).
- Low nutrient retention capacity with high leaching rates (nl).
- Sorption of P in humose/organic soils (nf).
- Low pH as an indicator or possible element toxicity and reduced nutrient availability (nt).

Limitation class determination
- Nutrient deficient soils: Additional applications.
- Low nutrient retention: Split dressing and/or very high application rates.
- Nutrient sorption: Applications of from 50 to 100% in excess of standard P application rates.
- pH: Documented data relating low pH to element toxicity and nutrient availability.

Soil/land attribute level	Limitation classes for various crops
	All crops
Standard fertiliser rates and practices. Code: NO	1
Nutrient levels	
P >20 ppm Code: P1 to P2	1
P <20 ppm Code: P3 to P4	2
K >.2 meq Code: K1 to K2	1
K <.2 meq Code: K3	2
Highly permeable soils with water table fluctuations deeper than 1.5 m. Code: 6H to 3H (see wetness limitations)	2
Humose/organic soils. Code: N1	2
Soil pH to 0.3 m:	
pH >5.5 Code: H3 to H5	1
pH <5.5 Code: H1 to H2	2

ROCKINESS (r)

Effect

Coarse (rock) fragments[1] and rock in the plough zone interfere with the efficient use of, and can damage agricultural machinery. Surface rock in particular interferes with the harvesting machinery of sugar cane, soybean, root crops and some vegetables.

Assessment

Based on the size, abundance (McDonald *et al*. 1990) and distribution of coarse fragments in the plough layer, as well as machinery and farmer tolerance of increasing size and content of coarse fragments.

Limitation class determination

Consultation, particularly related to farmer tolerances which are implicitly related to profitability and technological capability.

Soil/land attribute level		Limitation classes for various crops				
Size	Amount (%)	Avocado, Macadamias, Citrus, Mango, Lychee, Stone fruit, Grapes, Pastures	Pineapple	Sugar cane, Maize, Sorghum (forage), Sweet corn	Soybean, Veges, Cucurbits, Lucerne, Soybean, Cruciferae, Asparagus, Beans	Peanut, Sweet potato, Potato, Navybean
No coarse fragments Code: RO		1	1	1	1	1
6 - 20 mm	<2	1	1	1	1	2
(Pebbles)	2-10	1	1	1	2	3
Codes: P1-5	10-20	1	1	2	3	4
	20-50	1	2	3	4	5
	>50	2	3	4	5	5
20 - 60 mm	<2	1	1	1	2	5
(Gravel)	2-10	1	1	2	3	4
Codes: G1-5	10-20	1	2	3	4	5
	20-50	2	3	4	5	5
	>50	3	4	5	5	3
60 - 200 mm	<2	1	1	2	3	4
(Cobble)	2-10	1	2	3	4	5
Codes: C1-5	10-20	2	3	4	5	5
	20-50	3	4	5	5	5
	>50	4	5	5	5	5
200 - 600 mm	<2	1	2	3	4	5
(Stone)	2-10	2	3	4	5	5
Codes: S1-5	10-20	3	4	5	5	5
	20-50	4	5	5	5	5
	>50	5	5	5	5	5
>600 mm	<2	2	3	4	5	5
(Boulders or rock)	2-10	3	4	5	5	5
Codes: B1-5	10-20	4	5	5	5	5
R1-5	20-50	5	5	5	5	5
	>50	5	5	5	5	5

[1] Coarse fragments are particles greater than 2 mm and not continuous with underlying bedrock (McDonald *et al.* 1990). Rock is defined as being continuous with bedrock.

MICRORELIEF (tm)

Effect

Uneven and lower crop productivity due to uneven water distribution, for example, water ponding in depressions.

Assessment

Levelling of uneven surface is required for efficient irrigation and surface drainage. The vertical interval of gilgai, channel and other microrelief dictates and the amount of levelling required.

Limitation class determination

Local opinion and consultation.

Soil/land attribute level Vertical interval	Limitation classes for various crops All crops
<0.1m Code: MO	1
0.1 to 0.3 m Code: M1	3
0.3 to 0.6 m Code: M2	4
>0.6 m Code: M3	5

FLOODING (f)

Effect

Yield reduction or plant death caused by anaerobic conditions and/or high water temperature and/or silt deposition during inundation, as well as physical removal or damage by flowing water. Flowing water can cause erosion.

Assessment

Assessing the effects of flooding on an individual UMA is difficult. Flooding frequency has been used to distinguish between suitable and unsuitable land only in extreme frequency situations or for intolerant crops. Where flood frequency is significant but not extreme, a '0' (zero) has been used to indicate the occurrence of flooding, but due to insufficient knowledge[1], it is not used to downgrade this suitability class.

Limitation class determination

Consultation.

Soil/land attribute level	Limitation classes for various crops			
	Sugar cane, Soybean, Maize, Sorghum (forage), Asparagus, Sweet corn	Avocado, Macadamias, Citrus, Pineapple, Mango, Lychee, Stone fruits, Grapes	Lucerne, Navybean, Beans, Peanuts	Veges, Cucurbits, Potato, Sweet potato, Cruciferae
No flooding or flooding less than 1 in 10 years. Code: FO, F1	1	1	1	1
Flooding frequency of approximately 1 in 2 to 1 in 10 years - levees and back swamps and some higher channel benches. Code: F2	0	5	0	1
Flooding frequency approaches annual occurrence - lower channel benches. Code: F3	4	5	5	1

[1] Sugar cane is commonly grown on these lands despite regular flooding. Whatever the real effects of flooding they do not detract from the value of the land.

LANDSCAPE COMPLEXITY (x)

Effect

An area of suitable land may be too small to justify its use as an isolated production area for a particular land use. This occurs where there is soil complexity or topographic dissection.

Assessment

After the limitation classes for all other limitations are determined for each UMA, one or more of the following are assessed:

- Area of contiguous suitable soil less than the minimum production area[1].
- Dissected topography.

When the area of contiguous suitable soil in a UMA is less than a minimum production area, the area of any contiguous suitable soil in adjacent UMAs is also included in the assessment of the minimum production area. Distance to adjoining irrigation and/or other infrastructure is important, for example, if greater than 0.5 km, suitability is downgraded.

Limitation class determination

The minimum production areas for each land use are determined by consultation. The suitability may be modified according to the proximity and extent of non-contiguous suitable land.

Soil/land attribute level	Limitation classes for various crops				
Production area (ha)	Veges, Sweet potato, Sweet corn, Cruciferae, Asparagus, Beans	Mango, Avocado, Macadamias, Citrus, Lychee, Stone fruits, Pineapple, Grapes	Sugar cane, Lucerne	Sorghum (forage), Maize, Peanut, Soybean, Navybean	Cucurbits, Potato
>10 Code: X0	1	1	1	1	1
5-10 Code: X1	1	1	1	4	1
2.5-5 Code: X2	1	1	3	5	2
1.5-2.5 Code: X3	1	2	4	5	2-3
<1.5 Code: X4	4	3	5	5	4

[1] Minimum production area: The minimum area of land which is practicable to utilise for a particular land use. It may be based on implicit economic criteria, but is not related to an ‘economic production unit’ or so called ‘living area’.

TOPOGRAPHY (ts)

Effect

The safety and/or efficiency of farm vehicle operation is affected by:

- land slopes in relation to roll stability and side slip.
- erosion control layouts with short rows and sharp curves in row crops on land with variability in degree and direction of slope (complex slopes).

Assessment

- Steepness of slope in relation to safety and efficiency.
- Variation in slope causing short rows in erosion control layouts.
- Variation in slope direction causing excessive row curvature in erosion control layouts.

Limitation class determination

- Local experience and consultation regarding the upper machinery slope limit for various land uses.
- Farmer tolerance of short rows.
- Inability of trailing implements to effectively negotiate curves with less than 30 m radius.

Soil/land attribute level	Limitation classes for various crops		
Slope (%)	Avocado, Citrus, Stone fruits, Mango, Lychee, Macadamias, Grapes	Sugar cane, Maize, Veges, Sorghum (forage), Soybean, Peanut, Cucurbits, Sweet corn, Sweet potato, Pineapple, Navybean, Lucerne, Cruciferae, Asparagus, Potato, Beans	Pastures
0-15% Code: S0	1	1	1
15-20% Code: S1	2	4	1
20-30% Code: S2	4	5	2
>30% Code: S3	5	5	5
Complex slopes 0-15% Code: C	1	0[1]	1

[1] Complex slopes are not downgraded. A ‘0’ (zero) is used to flag that minimum tillage and modified erosion control structures have to be applied in lieu of conventional erosional control structures.

SOIL PHYSICAL CONDITION (p)

Effect

- Germination and seedling development problems are associated with adverse conditions of the surface soil such as hardsetting, coarse aggregates, and crusting clays (ps)[1].
- Soils with a narrow moisture range for cultivation can create difficulties in achieving favourable tilth (pm)[1].
- Soil adhesiveness can cause harvest difficulties and affect the quality of subsurface harvest material (pa)[1].

Assessment

- Soils with indicative morphological properties are evaluated in the context of local experience or knowledge of plant characteristics, for example, seed size, tuberous roots.
- Local experience indicates problems associated with certain soils, for example, narrow moisture range for cultivation.

Limitation class determination

- Plant tolerance limits and requirements in relation to germination and harvesting are matched with soil properties and supported by local experience.
- Local opinion of the severity of the problem of narrow moisture range.

Soil/land attribute level	Limitation classes for various crops							
	Peanut	Navybean, Lucerne	Veges, Cruciferae, Cucurbits, Maize, Sorghum (forage), Sweet corn, Pineapple, Asparagus, Beans	Potato, Sweet potato	Sugar cane	Soybean	Avocado, Macadamias, Citrus, Stone fruits, Mango, Lychee, Grapes	Pastures
No restrictions Code: S0, M0, A0	1	1	1	1	1	1	1	1
Hardsetting massive soils with sandy loam to clay loam surface textures with dry moderately firm consistency Code: S1	2	2	1	2	1	2	1	2
Hardsetting massive soils with loam fine sandy to clay loam fine sandy surface textures with dry very firm consistency Code: S2	3	3	2	3	2	3	1	3
Crusting clays Code: S3	2	2	2	2	1	3	1	2
Large Aggregate size >20 mm Code: S4	4	4	3	2	2	4	1	3
Moderate moisture range Code: M1	2	2	2	2	2	2	1	1
Narrow moisture range Code: M2	3	3	3	3	3	3	1	2
Slightly adhesive soils Code: A1	2	1	1	1	1	1	1	1
Moderately adhesive soils Code: A2	3	1	1	2	1	1	1	1
Strongly adhesive soils Code: A3	4	1	1	3	1	1	1	1

[1] (ps, pm and pa) are abbreviated to Codes (S, M and A) respectively.

SECONDARY SALINISATION (s)

Effect
Drainage losses from permeable soils, usually higher in the landscape, may cause secondary salinisation downslope.

Assessment
Soil permeability (McDonald *et al.* 1990) and position in the landscape are used to determine intake areas, and the effect that deep drainage may have on watertables downslope. High watertable may occur above areas where heavy textured slowly permeable soils occur. Drainage class, permeability (see wetness) and position in landscape determine the likelihood of salinisation.

Limitation class determination
Drainage class, soil permeability and position in the landscape. Soil hydraulic conductivity, groundwater level and salinity measurements are required for a wide range of soils and landscapes. Any UMA with existing salinity is class 5.

Land/soil attribute level	Limitation classes for all crops			
Soil drainage/permeability at 1 m (see wetness limitation)	Landscape position			
	Upper slopes (U)	Lower slope (L)	Drainage depressions (D) +	Level plains
6H	0 *	0	-	1
5H	0	0	-	1
5M	0	0	-	1
4H	0	2	-	1
4M	0	2	-	1
4S	0	3	-	2
4V	0	3	-	2
3H	0	2	5	1
3M	0	3	5	2
3S	0	4	5	3
3V	0	5	5	3
2H	0	3	5	2
2M	0	4	5	3
2S	0	5	5	4
2V	0	5	5	4
1H	-	4	5	3
1M	-	4	5	3
1S	-	4	5	3
1V	-	4	5	3
existing salinisation	5	5	5	5

* 0 - intake areas
\+ Drainage depression - level to gently inclined, long, narrow, shallow open depression with smoothly concave cross-section, rising to inclined side slopes.

EROSION (e)

Effect

Land degradation and long term productivity decline will occur on unprotected arable land due to excessive soil erosion.

Assessment

Soil loss will depend on soil erodibility and land slope for a particular crop and surface management system. For each soil type there is a maximum slope above which soil loss cannot be reduced to acceptable levels by erosion control measures or surface management practices.

Limitation class determination

Slope limits are determined in consultation with soil conservation extension and research personnel, and extension and research agronomists. The implications of the classes are:

e1	surveyed row direction only required
e2	conventional parallel structures required or some surface management practices[1]
e3	e2 measures and some surface management practices
e4 or e5	non-arable land

[1] Surface management practices: A range of options aimed at minimum soil disturbance, combined with the retention of harvest residue material as a surface cover.

Soil/land attribute level		Limitation classes for various crops			
Slope %		Avocado, Macadamia, Citrus, Mango, Stone fruit, Lychee, Grapes, Pastures	Sugar cane, Lucerne	Maize, Sorghum, Veges, Cruciferae, Cucurbits, Asparagus, Sweet corn, Pineapple, Sweet potato	Navybean, Peanuts, Potato, Soybean,Beans
Ferrosols					
	Code:				
0	EO	1	1	1	1
0 - 2	E1	1	1	1	1
2 - 5	E2	1	2	2	3
5 - 8	E3	1	2	3	4
8 - 12	E4	2	3	4	5
12 - 15	E5	2	4	5	5
15 - 20	E6	3	5	5	5
20 - 30	E7	4	5	5	5
>30	E8	5	5	5	5
Vertosols, clayey Dermosols, coarse surfaced well drained Dernosols, Chromosols, Rudosols and Kandosols					
	Code:				
0	A0	1	1	1	1
0 - 2	A1	1	1	2	2
2 - 5	A2	1	2	3	3
5 - 8	A3	2	3	4	4
8 - 12	A4	3	4	5	5
12 - 15	A5	3	5	5	5
15 - 20	A6	4	5	5	5
>20	A7	5	5	5	5
Sodosols, Hydrosols, Podosols, Kurosols, loamy surfaced Dermosols and Tenosols					
	Code:				
0	B0	1	1	1	1
0 - 1	B1	1	1	2	3
1 - 3	B2	1	2	3	4
3 - 5	B3	2	3	4	5
5 - 8	B4	3	4	5	5
8 - 12	B5	4	5	5	5
>12	B6	5	5	5	1

WATER INFILTRATION (i)

Effect

The amount of water applied and rate of application must match the infiltration characteristics of the soil in order to wet up the soil profile (recharge), to minimise deep drainage and runoff, and to determine the most suitable furrow length for flood irrigation. Additional management requirements for spray and furrow irrigation are associated with surface sealing, slow permeability and runoff. Additional management requirements for furrow irrigation are associated with short furrows or waterlogging in the upper end of furrows if furrow lengths are too long. Furrow gradient affects soil erosion.

Assessment

Soil surface physical conditions (see p limitation), surface infiltration and soil permeability (see w limitation) are assessed. Indicator attributes of surface infiltration and permeability include texture, grade and type of structure, sodicity, pH, salt bulge.

Limitation class determination

Consultation.

Surface infiltration and soil permeability are considered in relation to slow soil profile recharge, excessive water loss (deep drainage) or additional management requirements. Surface infiltration (disc permeameter) and hydraulic conductivity measurements are required.

Slope in relation to excessive soil loss. Furrow irrigation for crops other than sugar cane is not recommended on slopes >1% for sodic texture contrast soils and 2% for other soils, or slopes >0.5% in the direction of irrigation (across the slopes) for sodic texture contrast soils and 1% for other soils. Slope limits need further substantiation for each soil, crop management system.

Soil/land attribute level	Limitation classes for various crops	
	All crops Spray irrigation	All crops Furrow irrigation
Soil profile recharge		
Slow surface infiltration - hardsetting massive soils with surface textures of loam fine sandy to clay loam fine sandy and dry very firm consistency. Code: S2 (see p limitation)	2	2
Other soils	1	1
Subsoil permeability to 0.5 m		
V	2	2
S	2	2
M	1	1
H	1	1
(Codes: see w limitation)		
Hardsetting massive soils with surface textures of loam fine sandy to clay loam fine sandy (Code: S2) and slow to very slow subsoil permeability at 0.5 m (Code: V/S)	3	3
Deep drainage		
Slowly permeable soils which are strongly sodic (ESP>14) and a salt bulge (EC 1:5 > .3dS/m) and/or strongly alkaline (pH>8.5) or at <1 m. Code: V (see w limitation)	0*	0
Soils which are sodic (ESP> 6) and low in salt at 1 m. Code: S (see w limitation)	0	4
Permeable soils which are non-sodic (ESP <6) and low in salts, or sandy textures at 1 m. Code: M, H (Codes: see w limitation)	0	5

*0 (zero) - suitable. Insufficient information to separate into classes 1, 2 or 3.