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Soils and Agricultural Suitability of the Maryborough-Hervey Bay Area, Queensland

P.R. Wilson, H.M. Anderson,
and D.M. Brown
Resource Management

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Summary

In 1993, the Lower Mary River Land Use Advisory Committee defined the need for land resource information on 315 400 ha in the Maryborough area. The Maryborough Sugar Factory, Sugar Industry Reference Panel (SIRP) and Department of Natural Resources (DNR) funded this survey of 73 805 ha in the Hervey Bay, Beaver Rock, Susan/Prawle, Churchill Mines, Tuan Forest, and Yerra Pilerwa areas.

The survey is aimed at providing detailed land resource information for industry strategic planning, enhanced sustainable farming practices, catchment management, property management planning and regional planning. The main focus of this report and accompanying maps will be detailed descriptions of soil physical and chemical attributes, geological and landform patterns and limitations of the soil for agricultural purposes.

The complex distribution of 46 soils identified in the study can be attributed to the complex geology and geomorphic processes which have occurred. Rapid changes in soils and their associated attributes contribute to a general fragmentation of rural activities and infrastructure.

Soil attributes and soil chemistry are outlined in this report. Soils have been grouped into the Australian Soil Classification Soil Orders and subdivided on the basis of geology and geomorphology.

Land degradation, particularly waterlogging and salinity, are major limitations to sustainable agriculture in this area. Salinity has been aggravated by clearing of the native vegetation and irrigation of crops on recharge areas. Land degradation and environmental problems associated with acid drainage from the development of areas with Acid Sulfate Soils has been minimal and generally well managed. On-farm and catchment management strategies need to be maintained or implemented to manage all degradation and environmental problems.

The significant limitations to irrigated agricultural production for 25 land uses are identified. The severity of each limitation is assessed on a 1 to 5 class. The study shows 12 438 ha are suitable (class 1–3) for sugarcane using travelling irrigators or other overhead irrigation systems. The areas of each class for each land use are outlined in the report.

The highly variable summer dominant rainfall necessitates the requirement for irrigation to obtain reasonable yields for most agricultural land uses. Water supply and associated infrastructure are the main limitations to agricultural development. There is, however, considerable potential for development outside the irrigation areas, especially where water harvesting and on-farm storages can be implemented.

A Geographic Information System (GIS) provides a rapid presentation of site information, soil and land attributes limitations and suitability for 25 different land uses. All of the information is beneficial in providing information through a decision support system for land use planning, improved farming systems and land management. The report also provides a simplistic key for easy identification of soils in the area, detailed descriptions of the soils, an outline of the land suitability classification scheme and accompanying soils and land suitability maps.

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

Maryborough was established in the 1860's as a port for exporting agricultural products to the markets and as an immigration point of entry to Australia. The agricultural industry in the region was thriving in the late 1960's with wool, beef, sugarcane, timber, fishing and horticultural products moving through the area.

Today, the local agricultural industries have been put under a lot of pressure from competing land uses such as urban and rural residential development. This has brought with it the need for expansion of recreational areas, conservation areas, water storage for irrigation and domestic use, roads and other infrastructure needed to sustain an expanding population. The prediction for Hervey Bay to increase its population by 167% to 95 200 in the year 2020 is putting an enormous pressure on the Hervey Bay hinterlands covered by this study.

A total of 7.2% of sugarcane land in the Maryborough district has been converted to non-rural uses from 1980–95 (Haywood, 1996). The sugarcane industry and other agricultural industries has been forced onto the more marginal soil types, generally further from existing infrastructure and requiring expensive irrigation schemes (Elphinstone, 1996). Land available for future sugarcane or any other agricultural expansion within 40 km of Maryborough is restricted by the high proportion (47%) of crown land (Anon., 1995).

The future of rural industries, including sugarcane, is affected by a number of factors including:

* limited availability of suitable land for expansion of the sugar industry and other rural industries
* strong competition between existing and new rural land users for the limited areas of good quality agricultural land
* limited availability of detailed information to identify areas which are suitable for sugarcane and other agricultural production
* limited knowledge of the attributes of different soils and how they behave under various management options
* degradation of existing agricultural land resulting from inappropriate land use and management
* lack of detailed land resource information for strategic planning for rural industries, local authorities and government
* lack of user friendly and relevant land resource information to assist producers and other land managers to develop and adopt better sustainable natural resource management systems.

One of the overriding factors affecting rural industry development in the Maryborough area is the highly variable, summer dominant rainfall. Average annual rainfall for Maryborough is 1166 mm, but for the last 20 years, annual rainfall has been consistently below average. Out of this average rainfall, approximately 700 mm is effective rainfall which is beneficial for crop growth. The remaining rainfall generally occurs as small amounts which is lost to evaporation and not available to plants. As a consequence of this variable effective rainfall, irrigation is needed to obtain reasonable yields for most agricultural uses. Irrigation water can be supplied from declared irrigation schemes, on-farm water harvesting and water storages, and sewerage effluent irrigation schemes. Due to the geology in the study area, bore water is generally unreliable and/or salty.

The Maryborough-Hervey Bay soil survey and land use study of 73 805 ha (not including urban, marine wetlands, waterways) on the Pialba and Maryborough 1:100 000 map sheets (Figure 1) began in 1995. The survey was to supply land resource information for the whole area in a uniform format, incorporating information from previous surveys whenever possible. 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 survey and maps use the same land use criteria and soil types as used in the Childers and Bundaberg surveys.

The outcomes of the survey are 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 on part of the Pialba and Maryborough 1:100 000 map sheets
- 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 to agricultural production and land degradation. This report should be used in conjunction with the soils and suitability maps.

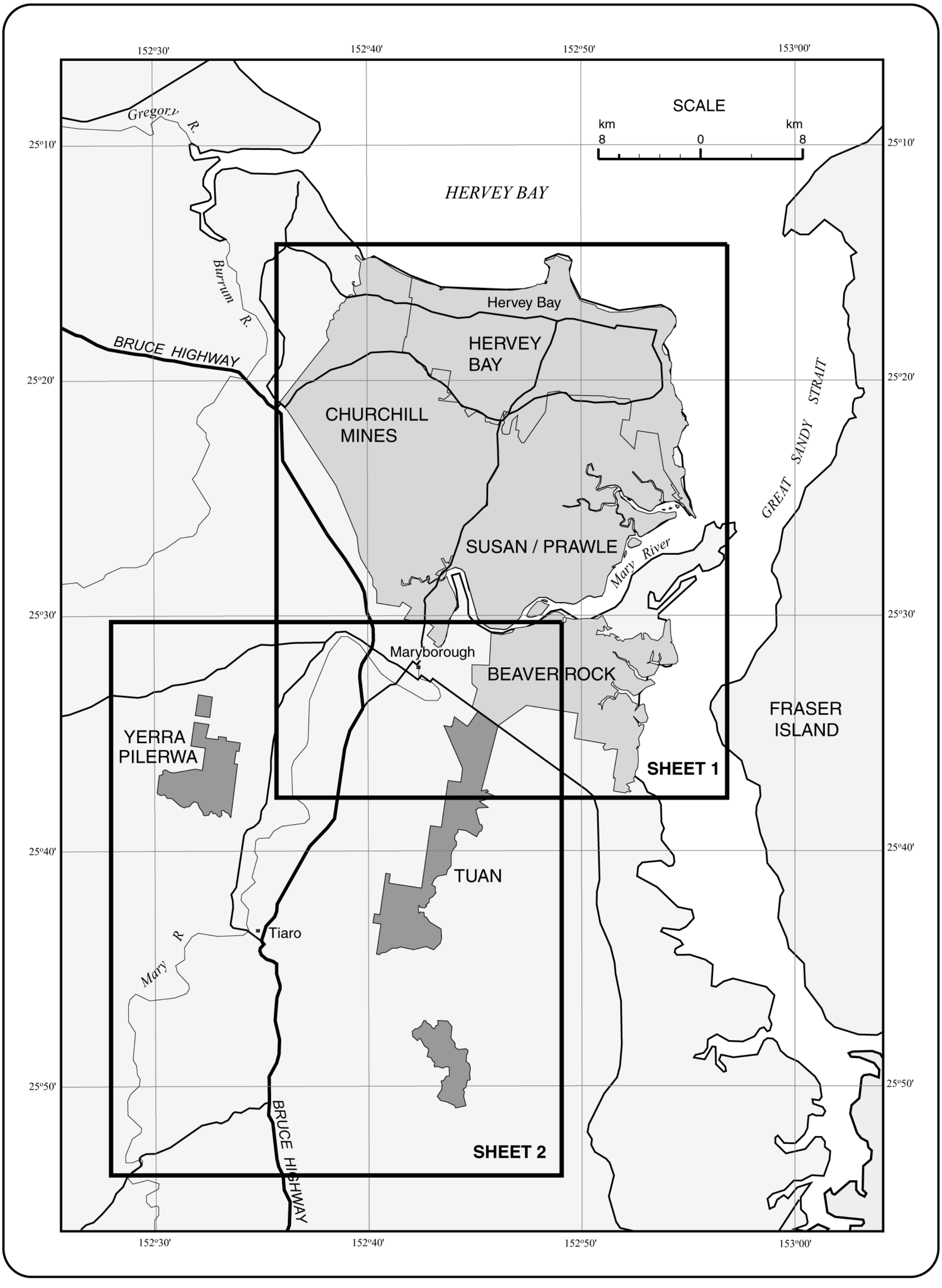

Figure 1. Locality map

2. Geology and geomorphology

The present landscape in the Maryborough-Hervey Bay study area is dominated by Cretaceous and Tertiary sedimentary rocks and Quaternary sediments. Within this complex area, 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.

In the Cretaceous period the marine deposits of the Maryborough formation (Km) were deposited. The upper layer of the Maryborough formation was silicified (Kms) followed by the deposition of the freshwater beds Burrum Coal Measures (Kb). In the late Cretaceous period much folding and faulting occurred giving rise to the Susan Anticlines. Ghost Hill Ridge and Takura Heights or Half Way Hill mark the eastern and western margins respectively of the Susan Anticline. Acid and intermediate volcanic rocks of the Graham's Creek Formation underlie the Maryborough Formation.

Sedimentation and alluvial deposits in the Tertiary period were laid down unconformably to form the Tertiary Elliott Formation (Te). The silicified upper Maryborough Formation, where exposed, was then eroded away to form the Takura Beds (Tt). The landscape was then silicified forming the Tertiary Duricrusted sediments (Td). Volcanic intrusions erupted through the surface, resulting in the Dundowran Basalt (Tmb) peaks. A diagrammatic representation of these formations is outlined in Figure 2.

The period from the Quaternary to present, has resulted in alluvial deposition (Qa) and coastal depositions (Qc). More detailed information on the geology is available from Ellis (1968).

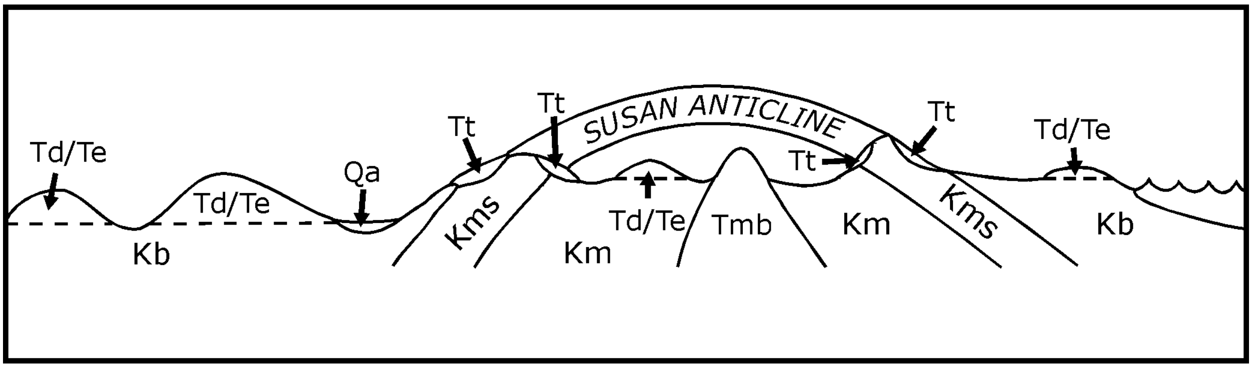

Figure 2. Diagrammatic representation of the geology in the Hervey Bay area

Sedimentary rocks

The Maryborough Formation and the Burrum Coal Measures are comprised mainly of fine-medium sandstones, siltstones, mudstones, shale-pyritic and coal. These parent materials give rise to a wide range of soils discussed fully in Chapter 3.

The hard and resistant silicified Maryborough Formation and Takura Beds form a prominent south west-north east ridge through the Hervey Bay area. Extremely gravely soils have formed on the ridge and adjacent slopes. The moderately weathered rocks of the Maryborough Formation, Burrum Coal Measures and Graham's Creek formation have been exposed by the erosion of the deeply weathered landscape. The underlying moderately weathered rocks are generally softer than the deeply weathered rocks resulting in undulating rises and low hills and can be distinguished from the deeply weathered formations in that the rocks clearly retain strata bedding and evidence of primary minerals (eg. feldspars). These features are lost during deep weathering. Where coarse grained sediments (sandstones) of the Tertiary Elliott Formation occur, sand moves downslope over other formations, predominantly the moderately and deeply weathered sedimentary rocks.

The colluvial mixing of some basalt with the sedimentary rocks occurs adjacent to the Dundowran Basalt. The basaltic influence has resulted in a neutral to alkaline pH in soils surrounding the basalt. Outside this influence, pH is typically acid.

The flat lying Tertiary Elliott Formation rests unconformably on the older Cretaceous Maryborough Formation, Burrum Coal Measures and Jurassic-Cretaceous Grahams Creek Formation. Recent erosion processes have dissected the deeply weathered sediments to expose other formations and generally creating an undulating landscape.

A period of deep weathering after the formation of the Elliott sediments resulted in extensive silicification (duricrust). The duricrusted surface occurs as elevated level plains and hillcrests. The undulating landscapes with fine grained sedimentary rocks (mudstones, shales, siltstones, fine sandstones) generally give rise to soils with loamy (fine sandy loam to clay loam) surfaces. The coarse grained deeply weathered sedimentary rocks (sandstones) generally give rise to a wide variety of sandy (sand to sandy loam) surfaced soils. Local hydrology is reflected in soil colour with red or yellow colours generally occurring on the upper slopes, while grey or gleyed colours always occur on lower slopes. The level plains have predominately formed seasonally wet, relatively deep soils.

Basalts

Tertiary basalts are confined to the Dundowran Basalt. This basalt was extruded through the sedimentary rocks to form a series of low hills. The upper slopes predominately form a shallow gravely soil while alkaline, moderately deep soils occur on mid slopes. The lower slopes on the Maryborough Formation adjacent to the basalt give rise to neutral to alkaline soils as described above.

Alluvium

The alluvial plains along the Mary River are the largest continuous area of alluviums in the study area. The remaining alluvium are generally restricted to narrow areas along creeks which drain the local landscapes.

The alluvium of the Mary River comprises channel benches, scrolls, flood plains, terraces, alluvial plains and swamps. The channel benches, scrolls and flood plains occur low in the landscape adjacent to the Mary River. Regular flooding and associated silt deposition or occasionally scouring are a feature. Mineral composition of the alluvium reflects the geology of the Mary River catchment. The lower channel benches are generally subject to fluctuating watertables due to their low elevation and proximity to the river.

The terraces and alluvial plains may be subject to rare flooding but generally represent alluvial deposition from the past. Elevation and proximity to past stream channels are the main geomorphic processes determining soil attributes. Alluvial deposits become finer further away from stream channels while wetness generally increases as elevation decreases. Therefore, better drained, sandier soils occur on the elevated edge of terraces and alluvial plains, and poorer drained clays occur on backplains and swamps.

The alluvium associated with creeks draining the local geology comprises narrow alluvial plains and minor levees. Mineral composition of the sediments reflects the local geology which is predominantly deeply weathered or moderately weathered sedimentary rocks. Larger streams frequently have incised drainage lines with adjacent sandy levees and finer sediments on the backplains. The smaller stream alluvial plains generally do not have a defined drainage line resulting in uniform sediment deposition over the plains. These plains are generally poorly drained with fluctuating seasonal watertables.

Beach ridges

Sand deposition by wave action during previous sea rises has developed beach ridges parallel to the current coastline around Hervey Bay with minor deposits along the Great Sandy Strait.

Coastal marine sediments deposited during previous sea level rises occurred in the Pleistocene (~70 000 years BP) sand Holocene (~6000 years BP) periods. Beach ridge attributes reflect the age of development.

Adjacent to Hervey Bay, the Pleistocene sands are characteristically more elevated and further from the current coastline than the Holocene sands. As a result, watertables are 2–3 metres below the surface compared to 0–2 metres in the Holocene sands. The age of development is reflected in a relatively thick white sand over a massive, thick coffee rock pan corresponding to the depth of the watertable while the younger sands have brown sand (no pan) at depth.

Adjacent to the sheltered waters of Great Sandy Strait, gentle wave action has reworked local marine sediments and resulted in fragmented, low sandy beach ridges during the Holocene period. These Holocene sands overlie older Pleistocene clayey marine sediments and occasionally the Tertiary Elliott Formation. Variation in the beach ridges reflects elevation, watertable effects and probably the source of the sands. Shell fragments from marine molluscs are occasionally evident many kilometres inland.

Coastal Marine Plains

Coastal marine sediments have been deposited during previous sea level rises and frequently occur as level plains, swamps and tidal flats adjacent to Hervey Bay and Great Sandy Strait. The older Pleistocene sediments (~70 000 years BP) generally occur inland of the Holocene sediments (~6000 BP) and at slightly higher elevation (1–3 m), and are characteristically wet (due to elevation), pale heavy clays overlying the Tertiary and Cretaceous geology.

The more recent Holocene marine sediments associated with the last major sea level rise and current sea level sediments frequently overlie the Pleistocene sediments. These recent sediments are very poorly drained sands, loams and clays occurring in swamps and tidal areas. In swamps, thin freshwater sediments overlie the marine sediments.

3. Soils

Background

Reconnaissance mapping in the study area includes the Atlas of Australian Soils (Isbell *et al.,* 1967), the Maryborough Coastal Land Use Study (Queensland Coastal Lowlands Land Use Committee, 1976a), Maryborough-Elliott River Land Use Study (Queensland Coastal Lowlands Land Use Committee, 1976b), sugarcane land suitability survey - vacant crown land, Maryborough (Turner and Hughes, 1983), an assessment of the ecosystems of the coastal lowlands (Coaldrake, 1961), and the geology of the Maryborough map sheet (Ellis, 1968).

Other specific purpose studies include the soil surveys of the Dundowran-Eli Creek area (Searle, 1994) and Beaver Rock Road area (Wilson, 1994), a steeplands soil study of the Hervey Bay, Bauple and Yerra-Pilerwa areas (Smith, 1983), a soil conservation map of the Cassava areas in the Torbanlea area (Lavercombe and Stone, 1986), a salinity investigation for CSR on the Cassava area (Hughes and Kingston, 1988) and an assessment of sugarcane suitability in part of the Tuan State Forest (Leverington, 1993). The Childers land use study (Wilson, 1997) occurs to the west.

A study by Leverington (1986) assessed the land suitability for the Maryborough Sugar Factory's sugarcane growing area while Macnish and Leverington (1984) and the Maryborough Sugar Factory area planning study (DPI, 1988) assessed the suitability of cane assigned areas. Turner and Hughes (1983) also assessed sugarcane suitability on vacant crown land in the Maryborough area. Information from these studies were used in the current study.

Mapping for this study was done at medium to low intensity (1:50 000 to 1:100 000) by free survey (Reid, 1988). Soil landscape boundaries were checked with a combination of ground observations and aerial photo interpretations. A total of 1199 sites have been described and entered on computer file.

It should be noted that the maps are published at 1:50 000. On average, the total number of sites to area mapped equates to approximately one described per 60 ha. A greater density of observations was generally done in undisturbed vegetated areas or more productive land types. The mapping information becomes less reliable at a larger (more detailed) scale.

A total of 45 soils profile classes (SPCs) have been identified (Appendix I) in the Maryborough-Hervey Bay study area and a brief distribution of 42 SPCs is shown on the accompanying map. The three minor unmapped soils occur in association with other dominant soils. Classification of the soils is based on the Australian Soil Classification system developed by Isbell (1996). A key to the soils in Appendix II is designed to assist in the identification of soils at any point inspection and should be used in conjunction with the soils map. All morphological terms used in this report are defined in McDonald *et al.* (1990) and Isbell (1996). General texture groups referred to in the text are: sandy – sand, loamy sand, clayey sand, sandy loam (<20% clay); loamy – fine sandy loam, loam, sandy clay loam, clay loam (20–35% clay); clayey – light clay to heavy clay (>35% clay).

The mapping units on the map are named after the dominant soil. Mapping units 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. The mapping units have been grouped based on the dominant Australian Classification Soil Order (Isbell, 1996), for example, Podosols. Subdivision of the grouped mapping units is based on geology and geomorphology. The boundary between two district soils may occur over metres or hundreds of metres because 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 operation for sugarcane has resulted in ploughed surfaces 0.3–0.4 m thick. In many soils this will destroy all surface horizons, with the result that the ploughed layer is often a mixture of the original surface and subsurface horizons.

A total of 15 analysed sites (Appendix III) in the area provides information on soil chemistry. A further 21 sites were analysed specifically to test for acid sulfate soils and potential acid sulfate soils. Analytical methods and nutrient ratings are based on Baker and Eldershaw (1993). Comments on soil chemistry are based on the analysed sites together with information from the Childers soil survey (Wilson, 1997).

Soil chemistry is discussed in terms of soil pH, salinity, sodicity, soil nutrients and plant available water capacity (PAWC). Soil pH represents the degree of acidity (pH <7) and alkalinity (pH >7) in a soil. Salinity is a measure of the concentration of soluble salts present in a soil. Electrical conductivity (EC) (1 part soil:5 parts water) measures total soluble salts in dSm^{-1} and chlorides are measured in %. Sodicity is the ratio of exchangeable sodium and cation exchange capacity expressed as a percent (ESP). Soils with an ESP <6 are non sodic, ESP 6–15 are sodic, ESP >15 are strongly sodic. Soil fertility is the ability of a soil to supply nutrients for normal plant growth.

PAWC is an estimate of the amount of water in the soil profile available for plant growth over the effective rooting depth. The model developed by Littleboy (1997) from the model of Shaw and Yule (1978) was used to estimate plant available water capacity (PAWC). The model uses -1500kPa moisture to estimate the amount of water in the soil profile available for plant growth. Effective rooting depth was taken to be 1.0 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 <1.0 m.

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. Major attributes, the classification and areas of the Podosol soils can be found in Table 1. The podosols represent a relatively minor group of the study area.

Landscape

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

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 0.75 m) over a brown ortstein or black coffee rock pan (0.45 to 1.0 m) over grey sand.	Semiaquic Podosol Aquic Podosol	415
Theodolite	Grey sand surface over a conspicuously bleached A2 horizon (0.25 to 0.5 m) over a brown sand B2 horizon (0.35 to 0.65 m) over a bleached sand (0.75 to 1.1 m) over an acid, mottled, structured, grey sandy light clay to sandy medium clay.	Aquic Podosol*/ Redoxic Hydrosol	134
Wallum	Grey or black sand surface over a conspicuously bleached A2 horizon (0.25 to 0.5 m) over a brown sand B2 horizon (0.35 to 0.8 m) over a bleached sand (0.65 to 1.1 m) over an acid, mottled, massive grey sandy clay loam to sandy light clay.	Aquic Podzol*/ Redoxic Hydrosol	8
BEACH RIDGES			
Burrum	Grey sand surface over a conspicuously bleached A2 horizon (1.1 to 2 m) over a black coffee rock pan.	Aquic Podosol	615
Toogum	Grey or black sand over a conspicuously bleached A2 (0.65 to 0.85 m) over an acid to neutral, brown or brown mottled grey sand	Aquic Podosol	147

* Indicates that one soil overlies another soil. The Theodolite podosol has formed in the A2 horizon of a Redoxic Hydrosol; similarly for Wallum.

The *Toogum* soil occurs on the younger Holocene beach ridges whilst the *Burrum* podosols occurs on the older Pleistocene beach ridges along the coastline around the Hervey Bay area.

Vegetation

The *Kinkuna*, *Theodolite* and *Wallum* 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.

The *Burrum* soil has isolated to sparse *Eucalyptus umbra* and *Banksia aemula* with an understory of heath. The *Toogum* soil has typical coastal vegetation of *Casuarina* woodlands with scattered teatree and Morton Bay ash.

Soil profile

All podosols have a sandy, black or grey surface over a conspicuously bleached A2 horizon over a sandy brown humic/ortstein or black coffee rock layer. The *Kinkuna, Theodolite* or *Wallum* soils on the Elliott Formation typically have an ortstein layer due to the accumulation of iron and organic compounds at approximately 1.0 m.

Soil chemistry

Soil pH. All podosols have acid laboratory pH (pH 4.6–6) 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 reflects the presence of organic acids in the surface organic matter and accumulation of organic complexes in the subsoil humic coffee rock and ortstein horizons.

Salinity. All profiles have very low salt levels (EC <0.02 dS/m, Cl <0.002%).

Sodicity. Effective Cation Exchange Capacity (ECEC) is extremely low (<1 meq/100 g soil). Subsoils of *Kinkuna, Theodalite* and *Wallum* are sodic (ESP 7–19), however, sodicity in association with low ECEC, low clay activity (<10 meq ECEC/100 g clay) and low dispersion ratio (<0.02) indicates that sodicity is not expressed. Higher exchangeable sodium percentage (ESP 10) levels exist in the clay subsoil of the *Theodolite* soil.

Soil nutrients. All podosols are low in all nutrients with a surface accumulation due to organic matter (Table 2).

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

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Kinkuna	0-0.1	0.08 (L)	0.45 (VL)	6 (VL)	4 (VL)	2.2	0.05 (VL)	0.1 (L)	0.3 (L)
	0.5-0.6	0.03 (L)	0.2 (VL)						
Theodolite	0-0.1	0.03 (L)	0.06 (VL)	--	--	0.66	0.03 (VL)	--	--
	0.5-0.6	0.01 (L)	0.04 (VL)						
Burrum	0-0.1	0.05 (L)	0.57 (L)	4 (VL)	7 (VL)	0.5	0.01 (VL)	0.47 (M)	0.82 (M)
	0.5-0.6	0.02 (L)	0.08 (VL)						
Toogum	0-0.1	0.06 (L)	0.16 (VL)	3 (VL)	5 (VL)	3.1	0.06 (L)	0.02 (VL)	0.17 (VL)
	0.5-0.6	--	0.06 (VL)						

VL – very low; L – low; M - medium

Plant available water capacity (PAWC). All Podosols have an estimated mean PAWC of <50 mm and a predicted rooting depth of >1 m. Coffee rock or ortstein pans are generally thin and discontinuous on the deeply weathered Elliott Formation and not expected to restrict rooting depth. The thick dense coffee rock pan in the *Burrum* soil at approximately 1–2 m would restrict root growth. However, due to the low nutrient levels particularly calcium, in all Podosols, root growth and therefore water extraction in the subsoil would be expected to be low.

Vertosols

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

One Vertosol has been mapped (Table 3), a grey clay on the Maryborough formation.

They are a very minor group of soils, occupying 23 ha.

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

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
MODERATELY WEATHERED SEDIMENTARY ROCKS			
Duingal	Black light clay to light medium clay surface over a sporadically bleached A2 horizon (0.05 to 0.15 m) over an acid, mottled, grey or occasionally brown medium clay to heavy clay (1+m) over weathered rock.	Grey Vertosol Brown Vertosol Grey Dermosol	23

Landscape

The *Duingal* soil on the moderately weathered Maryborough Formation occurs on hillslopes of gently undulating to undulating rises with slopes less than 8%. Soils are generally shallower on upper slopes. *Duingal* occurs in association with the *Kolan* soil (Kurosol) and has similar profile morphology except for the surface horizons.

Vegetation

The vegetation has predominantly been cleared. In uncleared areas, vegetation is typically gum topped box (*Eucalyptus moluccana*).

Soil profile

All vertosols have clay textures throughout the profile. The sporadically bleached A2 horizon is destroyed under cultivation. The subsoil is an acid, strongly sodic, mottled, medium to heavy grey clay. Profile morphology indicates strongly sodic subsoils, similar to the *Kolan* soil (Kurosol).

Soil chemistry

The *Duingal* soil has not been sampled.

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' colors 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 and 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 segregations can be relict and may not be indicative of a saturated condition.

Fourteen hydrosols have been recognized (Table 4) with a diverse range of soil profile attributes. Hydrosols occupy 34 162 ha or 46% of the area.

Minor hydrosols may be associated with other dominant soil orders such as the Sodosols (*Turpin, Avondale*). Other minor soil orders such as Kandosols, 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.

Table 4. 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.			
Alloway	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.5 to 0.8 m) over an acid, mottled, non sodic, grey light clay to medium clay.	Redoxic Hydrosol Grey Dermosol	1030

Table 4 (continued)

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 0.8 m) over an acid, mottled, massive, grey sandy clay loam to sandy light clay.	Redoxic Hydrosol Grey Kandosol	71
Robur	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.5 to 1.0 m) over an acid, mottled, sodic, grey sandy light clay to heavy clay.	Redoxic Hydrosol Grey Sodosol	10086
Winfield	Grey sand to loamy sand surface over a conspicuously bleached A2 horizons (0.3 to 0.85 m) over an acid, mottled massive, grey loamy sand to sandy loam.	Redoxic Hydrosol	Unmapped soil
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 0.6 m) over an acid to neutral, mottled, non sodic, grey or occasionally yellow light clay to medium clay.	Redoxic Hydrosol	1422
Kalah	Grey fine sandy loam to loam fine sandy surface over a conspicuously bleached A2 horizon (0.35 to 0.7 m) over an acid to neutral, mottled, sodic, grey light medium clay to heavy clay.	Redoxic Hydrosol	6609
Kolbore	Grey loamy sand to loam fine sandy surface over a conspicuously bleached A2 horizon (0.3 to 0.8 m) over an acid to alkaline, mottled, sodic, grey sandy light clay to medium clay (0.5 to 1.3 m) over a very hard, brittle, mottled duripan.	Salic Hydrosol Redoxic Hydrosol	997

Table 4 (continued)

Mapping Unit	**Major Attributes of Dominant Soil**	**Australian Classification**	**Area (ha)**
ALLUVIAL PLAINS OF THE MARY RIVER			
Beaver	Black loam to clay loam surface (0.05 to 0.2 m) over an acid black or dark grey light medium clay to medium clay (0.75 to 0.9 m) over an acid, mottled, grey medium clay to heavy clay.	Redoxic Hydrosol	79
Walker	Black or occasionally grey silty clay loam to light medium clay surface (0.05 to 0.25 m) over an acid to neutral, mottled, grey or black light medium clay to heavy clay (0.4 to 1.2 m) over an acid to neutral, mottled, grey, medium clay to heavy clay.	Redoxic Hydrosol Black Dermosol	105
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
Woober	Black on grey clay loam, silty clay loam, silty clay to light medium clay surface over a bleached A2 horizon (0.2 to 0.3 m) over an acid, mottled, grey light medium clay to medium heavy clay.	Redoxic Hydrosol	6902
MARINE PLAINS			
Fairydale	Black clay loam to light clay surface (0.15 to 0.4 m) over an acid, mottled, grey light clay to medium clay (0.8 to 1.2 m) often with jarosite over an acid to neutral, often mottled, grey to brown coarse sand to sandy clay loam D horizon to 1.5 m.	Redoxic Hydrosol	370
Jaro	Black loam to light clay surface (0.05 to 0.25 m) over an acid, mottled, grey light medium clay to heavy clay (0.6 to 1.0 m) over an acid, grey medium clay to heavy clay with jarosite.	Redoxic Hydrosol Extratidal Hydrosol	2520
Maroom	Black or grey sandy loam to sandy clay loam surface over a conspicuously or sporadically bleached A2 horizon (0.15 to 0.6 m) over an acidic to neutral, mottled, grey or brown or occasionally black light clay to medium heavy becoming paler at depth.	Redoxic Hydrosol	813

Table 4 (continued)

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
Tandora	Black clay loam to light medium clay surface (0.05 to 0.25 m) over an acid to neutral, mottled, grey medium clay to heavy clay.	Redoxic Hydrosol	3158

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 often due to changes in the local hydrology from clearing and irrigation.

Vegetation

All the hydrosols support extensive areas of native vegetation. Tea trees (*Melaleuca quinquenervia, M. viridiflora*, *M. nodosa*) are conspicuous tree species usually mixed with scattered eucalypt species (*Eucalyptus umbra, Corymbia trachyphloia, C. 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.

Soil profile

Subdivision of the seven hydrosols developed on sedimentary rocks is based on geomorphology, 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.

Generally, imperfectly drained yellow soils occur on slightly elevated areas or upslope of the Hydrosols. *Quart* (Kandosols) grades into *Mahogany* which grades into Podosols and *Winfield* or *Robur*. *Isis* (Chromosols) grades into *Alloway* or *Robur*. *Kepnock* (Dermosol) on level plains grades into *Clayton* which grades into *Kalah* and *Kolbore* while *Kepnock* (Dermosol) on hillslopes grades into Sodosols, Kurosols, Dermosols and Hydrosols (*Avondale, Woco*) on lower slopes.

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

Subsoils range from massive sandy clay loam and sandy clays (*Mahogony*) 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 ferruginous nodules in the profile indicating fluctuating watertables.

The Hydrosols on alluvial plains of the Mary River occur in swamps and backplains (*Beaver*) and on lower channel benches (*Walker*). *Beaver* grades into *Granville* (Dermosol) while *Walker* grades into *Mary* (Dermosol). The Hydrosols on local creeks (*Woober*) usually adjoins other Hydrosols on lower slopes of rises on sedimentary rocks and may grade into Sodosols (*Peep*) on larger streams lower in the catchment. *Beaver*, *Walker* and *Woober* have a loam or silty clay surface and a mottled light medium to medium heavy clay subsoil. The *Woober* soil has a bleached A2 horizon which is indicative of a frequently perched watertable. The *Beaver* soil has a black humic surface indicative of organic matter under swampy (anaerobic) conditions.

The Hydrosols formed on marine plains (*Fairydale, Jaro, Maroom, Tandora*) occupy low lying level plains and swamps adjacent to Hervey Bay and Great Sandy Strait and adjoin various beach ridge systems and mangrove wetlands. The *Jaro* and *Fairydale* soils have developed on Holocene (~6000 years BP) sediments and contain variable amounts of pyrite (FeS_2) derived from microbial action reducing sulfates from sea water. Jarosite (a iron-potassium-sulfur compound) frequently occurs in these soils due to the partial oxidation of the sulfur.

The older *Maroom* and *Tandora* soils have no pyrite at depth (5 m) due to long-term exposure to the atmosphere since the Pleistocene (~70 000 years BP) period. The *Maroom* has a thin deposit of Holocene sand overlying the Pleistocene clay.

These Hydrosols have a black clay loam to clay surface with the exception of *Maroom* which has a black sandy surface. Subsoils range from light clay to heavy clay frequently with strong lenticular structure and slickensides. *Fairydale* and *Maroom* soils have sand to sandy clay loam D horizons.

Soil chemistry

Soil pH. Most hydrosols are typically acid (pH <6.5) throughout the profiles. The texture contrast hydrosols (*Robor, Kalah and Kolbore*) are more variable and may have neutral pH (pH 7–8) in the subsoil. The *Kolbore* soil may have strongly alkaline field pH (pH 8.5–9) subsoils.

The *Walker* and *Woober* soils have variable pH reflecting the diverse local geology. Subsoil field pH ranges from 5.5 to 7.

The actual and potential acid sulfate soils (*Fairydale, Jaro*) formed on marine plains have typically an acid field pH (pH 4–5) in the subsoil, and whenever jarosite occurs, field pH is typically less than 3.8. A field pH 5.5–7 typically occurs at depth in the saturated layers.

The *Maroom* and *Tandora* soils have a strongly acid to neutral subsoil field pH of 5.5 to 7.0 and 6.0 to 6.5 respectively.

Salinity. The Hydrosols developed on sandstones (*Alloway, Mahogany, Robur*) and the non sodic Hydrosol developed on fine sedimentary rocks (*Clayton*) typically have very low salt levels in the subsoil (EC <0.1 dS/m, Cl <0.01%). However, these soils can develop surface salting due to the evaporation of water from the shallow seasonal non saline watertable.

The impermeable *Kalah* and *Kolbore* soils frequently have moderate to high salt levels (range EC 0.12–1.4 dS/m, Cl 0.007–0.2%) at depth and on the surface (range EC 0.02–1.5 dS/m, Cl 0.001–0.3%). The *Kolbore* soil with the impermeable duripan at depth is particularly prone to salting.

Salt accumulation on the surface and throughout the profile frequently occurs on soils developed on the alluvial deposits (*Woober* subsoil EC 0.77 dS/m, Cl 0.097%) and marine sediments (*Maroom* surface EC 0.13 dS/m, Cl 0.007%, subsurface EC 0.67 dS/m, Cl 0.067%; *Fairydale* surface EC 1.12 dS/m, Cl 0.116%, subsurface EC 0.85 dS/m, Cl 0.087%; *Jaro* surface EC 0.25–3.03 dS/m, Cl 0.013–0.495%, subsurface EC 0.08–2.63 dS/m, Cl 0.044–0.377%, *Tandora* surface EC 0.22–1.61 dS/m, Cl 0.016–0.206%, subsurface EC 0.21–1.42 dS/m, Cl 0.017–0.188%. The *Jaro* soil typically has a salty watertable close to the surface (<2 m), while the extratidal *Jaro* soil is subject to occasional marine inundation (EC 11.36–19.81 dS/m, Cl 2.118–4.218%).

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

Sodicity. ESP of the Hydrosols generally reflects lithology. The *Alloway, Mahogany* and *Robur* soils developed on deeply weathered sandstones have deep sandy A horizons with corresponding lower ESP (average ESP 10) in the upper 0.2 m of the B horizon compared to the other Hydrosols developed on fine grained sedimentary rocks (average ESP 27).

The abrupt change in ESP of the *Robur* (average ESP 9 lower A to 21 upper B) and *Kalah* (average ESP 9 lower A to 25 upper B) soils reflects the abrupt change from the A to B horizons. The higher ESP levels generally correspond to greater EC levels. The soils on the marine plains are typically strongly sodic (ESP 43–52 at 1 m).

Soil nutrients. All Hydrosols developed on deeply weathered sedimentary rocks *(Alloway, Kalah, Kolbore, Mahogany, Robur*) are low to very low in all nutrients (Table 5) reflecting the highly leached environment. The soils on marine plains (*Fairydale, Taro, Taroom, Maroom, Tandora*) typically have moderate to high nutrients reflecting the accumulation of organic material on the surface and probably parent material. Phosphorus levels are moderate and potassium levels are high. The *Woober* soil occurring on alluvium draining the local geology (mainly sedimentary rocks) is typically low to very low in all nutrients. No information is available for *Beaver, Walker* and *Winfield* soils.

Table 5. Mean profile soil nutrient for soils of the Hydrosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Alloway	0-0.1	0.11 (L)	0.4 (VL)	<5 (VL)	--	0.9 (L)	0.04 (VL)	0.6 (M)	0.3 (L)
	0.5-0.6	0.03 (L)	0.25 (VL)						
Clayton	0-0.1	0.11 (L)	0.56 (VL)	--	3 (VL)	1.2 (L)	0.05 (VL)	0.23 (L)	0.2 (L)
	0.5-0.6	0.02 (L)	0.9 (L)						
Jaro	0-0.1	1.13 (VH)	2.3 (H)	36 (M)	89 (H)	7.2 (VH)	0.41 (H)	0.17 (L)	0.8 (M)
	0.5-0.6	1.19 (VH)	2.2 (H)						

Table 5 (continued)

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Kalah	0-0.1	0.19 (L)	0.5 (L)	4 (VL)	4 (VL)	1.1 (L)	0.05 (VL)	0.14 (L)	0.2 (L)
	0.5-0.6	0.06 (L)	0.23 (VL)						
Kolbore	0-0.1	0.07 (L)	0.22 (VL)	--	1 (VL)	0.9 (L)	0.03 (VL)	0.05 (VL)	0.2 (L)
	0.5-0.6	0.05 (L)	0.1 (VL)						
Mahogany	0-0.1	0.1 (L)	0.63 (L)	5 (VL)	3 (VL)	1.55 (M)	0.07 (L)	0.18 (L)	0.26 (L)
	0.5-0.6	0.04 (L)	0.27 (VL)						
Robur	0-0.1	0.04 (L)	0.47 (VL)	7 (VL)	2 (VL)	0.79 (L)	0.03 (VL)	0.08 (VL)	0.2 (L)
	0.5-0.6	0.02 (L)	0.1 (VL)						
Tandara	0-0.1	1.2 (VH)	6.9 (H)	3 (VL)	16 (L)	6.2 (VH)	0.37 (H)	1.1 (M)	1.7 (M)
	0.5-0.6	0.56 (H)	1.5 (L)						
Woober	0-0.1	0.06 (L)	0.46 (VL)	3 (VL)	4 (VL)	1.6 (M)	0.06 (L)	0.07 (L)	0.21 (L)
	0.5-0.6	0.06 (L)	0.14 (VL)						

VL – very low; L – low; M – medium: H - high; VH - very high

Plant available water capacity (PAWC). PAWC (Table 6) is mainly related to texture and rooting depth. Any physical restriction on the effective rooting depth of the Hydrosols is dependent on the sodicity of the subsoils. The prolonged wetness of these soils would contribute to the overall water available to a crop but would also reduce root distribution below the watertable due to anaerobic conditions. 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 soils developed on deeply weathered sedimentary rocks would contribute to a greater reduction in rooting depth, and therefore reduced PAWC.

Table 6. Estimated PAWC (mm) and rooting depth (m) for soils of the Hydrosols

Soil	Rooting depth (m)	PAWC (mm)
Alloway	>1	63–65
Clayton	>1	60–80
Jaro	0.3–1	45–117
Kalah	0.4–0.6	45–48
Kolbore	0.4–0.6	<50
Mahogany	>1	58–68
Robur	0.6–0.9	47–52
Tandora	0.4–0.6	59–80
Winfield	>1	<50
Woober	0.4–0.8	45–70

Kurosols

Kurosols are soils with a strong texture contrast between A horizons and strongly acid (pH <5.5) B horizon. Only the *Kolan* soil type and its *red* and *rocky phase variants* consistently fall into this soil order. It has formed on moderately weathered mudstones and siltstones of the Elliott Formation, Burrum Coal Measures, Maryborough Formation and rhyolite of the Graham's Creek Formation. The *Kolan* soil occupies 2577 ha or 3.5% of the total study area. The Sodosol soils *Turpin* and *Avondale,* and a Dermosol soil *Woco* have minor components of Kurosols. The key attribute, classification and areas of the Kurosols can be found in Table 7.

Table 7. 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 or sporadically bleached A2 horizon (0.15 to 0.3 m) over a strongly acid, mottled, sodic, grey or brown medium clay to heavy clay (0.5+ m) over weathered rock.	Grey Kurosol Brown Kurosol	2423
Kolan Red variant	Black or grey loam fine sandy to clay loam fine sandy surface over a conspicuously or sporadically bleached A2 horizon (0.15 to 0.3 m) over a strongly acid, mottled, sodic, red medium clay to heavy clay (0.5+ m) over weathered rock.	Red Kurosol	117
Kolan Rocky phase	As above with >20% coarse fragments in the surface.	Grey Kurosol Brown Kurosol	37

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 (18–25 m) lemon scented gum/spotted gum (*Corymbia citriodora*), ironbarks (*Eucalyptus 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 *Kolan* soil occasionally occurs in association with a Vertosol (*Duingal*), and a sandy surfaced

Sodosol (*Tirroan*) on upper slopes adjacent to coarse grained sedimentary rocks.

The *Kolan* soil has a black or grey loamy surface over a conspicuously bleached A2 horizon up to 0.3 m abruptly changing to a red mottled, grey or brown clay subsoil. The ploughed surface of these soils frequently result in the loss or incorporation of the A2 horizon. Slickensides frequently occur in the lower part of the profile, and 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 *Kolan red variant* soil has a grey mottled red subsoil, generally occurring on better drained areas.

Soil chemistry

Soil pH. Field pH in the surface ranges from 5.5 to 6 (laboratory pH 6.2) with subsoil pH ranging from 4.5 to 5.5 (laboratory pH 4.8). The *Avondale, Turpin* and *Woco* soils, which have a minor component of Kurosols, have a laboratory pH range in the upper B horizon of 4.6 to 5.4 with the field pH usually 5 to 6.

Salinity and Sodicity. The salt bulge at 0.5 to 0.6 m (EC 0.28 dS/m at 0.2–0.3 m, 0.61 dS/m at 0.5–0.6 m) corresponds to the soil becoming strongly sodic in the upper B horizon (ESP 16 at 0.2–0.3 m, 31 at 0.5–0.6 m).

Soil nutrients. The medium levels of nutrients in the surface corresponds to surface accumulation of organic matter (Table 8). This soil tends to have higher nutrient status than equivalent soils on the deeply weathered sedimentary rocks (for example, the *Avondale* soil) reflecting past leaching environments.

Table 8. 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	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Kolan	0-0.1	0.22 (M)	2.2 (H)	--	2 (VL)	1.9 (M)	0.1 (M)	0.18 (L)	0.77 (M)
	0.5-0.6	0.15 (L)	0.11 (VL)						

VL – very low; L – low; m – medium; H – high

Plant available water capacity (PAWC). The shallow rooting depth due to the strongly sodic, saline upper B Horizon results in a low PAWC. A predicted rooting depth of 0.3–0.6 m corresponds to a PAWC 63–75 mm. The low nutrient status particularly very low calcium, below the surface may further reduce rooting depth and PAWC.

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).

A sodic B horizon may be indicated in the field by the presence of one or more of the following: a bleached A2 horizon abruptly changing to a clay B2 horizon with columnar or coarse angular blocky or prismatic structure; a high pH (>8.5); the soapy nature of the clay when wet; dispersion of the clay.

Five sodosols have been recognized (Table 9) with soils developed on deeply weathered sedimentary rocks (*Turpin, Avondale*), moderately weathered sedimentary rocks (*Tirroan*) and alluvial plains (*Peep, Butcher*). They occur extensively throughout the study area, occupying 17 241 ha or 23%

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

Mapping Unit	**Major Attributes of Dominant Soil**	**Australian Classification**	**Area (ha)**
HILLSLOPES ON MODERATELY WEATHERED SEDIMENTARY ROCKS			
Tirroan	Black or grey sandy loam to fine sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5 m) over an acid, mottled, grey sandy medium clay (0.45 to 1.2 m) over weathered rock.	Grey Sodosol	195
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Avondale	Grey or black fine sandy loam to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.35 m) with ferruginous nodules over an acid, mottled, grey or occasionally brown medium clay to heavy clay (0.35 to 1.5 m) over weathered rock.	Grey Sodosol Grey Kurosol Brown Kurosol Brown Sodosol Redoxic Hydrosol	12698
Avondale Rocky phase	As above with >20% rock fragments throughout the profile or rock within 0.3 m of the surface.	Grey Sodosol	114
Turpin	Grey or occasionally black loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.25 to 0.5 m) with ferruginous nodules over an acid, mottled, grey or brown medium clay to heavy clay (0.4 to 1.5 m) over weathered rock.	Grey Sodosol Grey Kurosol Brown Sodosol Brown Kurosol Redoxic Hydrosol	3065

Table 9 (continued)

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
ALLUVIAL PLAINS OF THE MARY RIVER			
Butcher	Black or grey loam fine sandy to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.3 m) over an acid to alkaline, mottled, grey or brown light medium clay to heavy clay.	Grey Sodosol Brown Sodosol	897
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
Peep	Grey or black fine sandy loam to clay loam fine sandy and silty clay loam surface over a conspicuously bleached A2 horizon (0.15 to 0.45 m) over an acid to alkaline, mottled, grey or brown medium clay.	Grey Sodosol Grey Kurosol Brown Sodosol	272

Landscape

The *Turpin*, *Avondale* and *Tirroan* soils occur on hillslopes of rises on sedimentary rocks. The *Avondale Rocky phase* frequently occurs on the edges of breakaways where slopes are steep (>15%) and soils are shallow often with rock outcrops. The *Butcher* soil occurs on alluvial plains and terraces along the Mary River where slopes are generally less than 1%. The *Peep* soil occurs on narrow alluvial plains of streams draining the local geology.

Vegetation

Dominated tree vegetation is related to soil type. The *Turpin*, *Avondale* and *Tirroan* soils have similar vegetation with trees dominated by stringy bark (*Eucalyptus umbra*) and rusty gum (*Angophora costata*) with scattered grey ironbark (*E. drepanophylla*), brown bloodwood (*Corymbia trackyphloia*), pink bloodwood (*C. intermedia*) and paperbarks (*Melaleuca* spp.).

The *Butcher* and *Peep* soils on the alluvial plains are dominated by forest red gums (*E. tereticornis*), but are mostly cleared for pastures and sugarcane.

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 usually with coarse angular blocky or prismatic structure.

Avondale always occurs in association with *Woco* (Dermosol) and frequently downslope of *Kepnock* (Dermosol). *Turpin* occurs downslope of the contact between coarse grained (upslope) and fine grained (downslope) deeply weathered sedimentary rocks, and therefore adjoins a variety of sandy surfaced Dermosols, Kandosols, Hydrosols and Sodosols on upper slopes.

The *Turpin* and *Avondale* Sodosols on deeply weathered sedimentary rocks have been separated on surface attributes. *Turpin* has a medium to thick (0.25–0.5 m) sandy surface while *Avondale* has a medium (0.15–0.3 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. *Tirroan* which has developed on moderately weathered sedimentary rocks has similar morphology to *Turpin* but has no maghemite nodules. *Tirroan* frequently occurs upslope of the *Kolan* soil (Kurosol).

Butcher and *Peep* soils on alluvial have been separated by the sediments the soils were formed from. Both soils have a medium to thick (0.15–0.45 m) loamy surface over a frequently mottled, brown or grey clay subsoil. Manganiferous nodules usually occur in alkaline subsoils and lime nodules may occur. *Butcher* usually grades into *Granville* (Dermosol) on backplains due to alluvium becoming finer further from the river and may adjoin *Aldershot* (Dermosol) where drainage improves on elevated edges of terraces. *Pee*p frequently adjoins sandy levee soils (*Littabella* **-** Kandosol).

Soil chemistry

Soil pH. Profile pH generally reflects geology and geomorphology. The *Turpin* and *Avondale* soils developed on deeply weathered sedimentary rocks consistently have lower pH than other soils in the Sodosols groups. Field pH of the subsoil range from 5 to 6 with laboratory pH for the limited number of soils in the analysed profiles ranging 5–5.5.

The Sodosols on alluvium (*Butcher, Peep*) have variable pH reflecting the variability in parent material and deposition. Subsoil field pH ranging from 6 to 8.5 with neutral to alkaline pH (pH >7) predominating.

Salinity. There is a marked increase in salt levels in the subsoil (surface EC 0.01–0.07 dS/m, Cl 0.001–0.007%; clay subsoils EC 0.04–0.4 dS/m, Cl 0.004–0.072%) which correspond to the abrupt texture change and strongly sodic clays. These elevated salt levels indicate impermeable subsoils. Clearing of vegetation on soils originating from deeply weathered sedimentary rocks always results in surface salinisation of the *Turpin* and *Avondale* soils on lower slopes.

Sodicity. All Sodosols are sodic to strongly sodic (ESP 15–51, average 30) in the upper B horizon. The high sodicity levels contribute to the slow permeability and salt accumulation in the profile.

Soil nutrients. Variability reflects geology, geomorphology and vegetation.

The low to very low nutrient levels in the *Turpin* and *Avondale* soils reflects the low levels of nutrients in the highly leached deeply weathered sedimentary rocks. The sparse vegetation reflects the lower organic carbon and total nitrogen compared to other soils (Table 10).

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

Table 10. 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	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Avondale	0-0.1	0.09 (L)	0.7 (L)	7 (VL)	3 (VL)	1.1 (L)	0.05 (L)	0.2 (L)	0.3 (L)
	0.5-0.6	0.11 (L)	0.4 (VL)						
Peep	0-0.1	0.1 (L)	0.8 (L)	7 (VL)	3 (VL)	1.5 (L)	0.07 (L)	0.15 (L)	0.33 (L)
	0.5-0.6	0.05 (L)	0.22 (L)						
Turpin	0-0.1	0.08 (L)	0.55 (L)	4 (VL)	2 (VL)	0.88 (L)	0.03 (VL)	0.12 (L)	0.34 (L)
	0.5-0.6	0.1 (L)	0.16 (VL)						

VL –very low; L – low

Plant available water capacity (PAWC). PAWC (Table 11) reflects mainly surface texture, depth of surface horizons and rooting depth. The sandy surfaced Sodosols, such *Turpin* and *Tirroan,* have lower PAWC. The rooting depth is indicated by a salt bulge and strongly sodic subsoils. The very low nutrient status below the surface in the *Avondale* and *Turpin* soils may further reduce root distribution and PAWC.

No analysis profiles, and therefore estimated PAWC, are available for the *Butcher* soils. Based on profile morphology, rooting depth should be 0.4–0.8 m with a PAWC of 50–85 mm.

Table 11. Estimated PAWC (mm) and rooting depth (m) for the soils of the Sodosols

Soil	Rooting depth (m)	PAWC (mm)
Avondale	0.4–0.6	43–55
Peep	0.4–0.8	42–62
Turpin	0.4–0.6	37–53

Chromosols

Chromosols are soils with strong texture contrast between A horizon and B horizon. The B horizon is not strongly acid and is not sodic.

One Chromosol has been mapped (Table 12). Although, *Isis* is dominantly a Chromosol, it has a high proportion of Dermosol. Other soils *(Gooburrum, Kepnock)* have a minor Chromosol component. The *Isis* soil occurs on 1962 ha or 2.7% of the area.

Table 12. Major attributes, classification and area for soil of the Chromosols

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
HILLSLOPES AND PLAINS ON DEEPLY WEATHERED SEDIMENTARY ROCKS			
Isis	Grey or occasionally black sandy loam surface over a conspicuously bleached A2 horizon (0.3 to 0.7 m) over an acid, mottled, yellow or brown light clay to medium clay.	Yellow Chromosol Brown Chromosol Yellow Dermosol Brown Dermosol	1962

Landscape

The *Isis* soil occurs on hill crests on rises and low hills or slightly elevated areas on level plains.

Vegetation

The *Isis* has predominantly been cleared for sugarcane. In uncleared areas, the tree vegetation is dominated by pink bloodwood (*Corymbia intermedia*) and brown bloodwood (*C. tractyphloia*).

Soil profile

Generally well drained Dermosols (*Gooburrum*) occur upslope while poorly drained Hydrosols (*Alloway*, *Robur*) occur downslope.

The *Isis* soil has a grey or occasionally black sandy surface over a conspicuously bleached A2 horizon up to 0.7 m with clear to diffuse change to a mottled yellow clay subsoil. The B horizon has a moderate to strong friable structure.

Soil chemistry

Soil pH. The *Isis* is typically medium to strongly acid (field pH 5.5 to 6.5) reflecting other soils on the deeply weathered geology.

Salinity. The *Isis* soil has very low salt levels (EC <0.03 dS/m, Cl <0.002%) throughout the profile which can be attributed to good profile drainage.

Sodicity. The *Isis* soil is generally sodic (ESP 10) at depth. However, the low ECEC (4 meq/100 g), low clay activity (11 meq/100 g clay) indicating kaolin clays, and low dispersion (0.01) in the clay subsoil indicates that the effects of sodicity are not expressed.

Soil nutrients. The *Isis* soil is developed on deeply weathered sedimentary rocks which typically have low to very low levels of all nutrients (Table 13).

Table 13. Profile soil nutrients for the Isis soil of the Chromosols

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Isis	0-0.1	0.05 (L)	1.4 (L)	8 (VL)	2 (VL)	1.3 (L)	0.05 (L)	0.1 (L)	0.2 (L)
	0.5-0.6	0.02 (L)	0.73 (L)						

VL – very low; L - low

Plant available water capacity (PAWC). The *Isis* soil has a rooting depth >1 m, sandy surface textures and therefore has a lower PAWC (57–61 mm) compared to the similar soil with a loamy surface textures (*Kepnock*).

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 thirteen soils are included in this soil order (Table 14). They include soils formed on basalt, deeply weathered sedimentary rocks, and alluvium associated with the Mary River.

This group of soils occupy 9548 ha or 13% of the study area and represent the main group of soils under cultivation for sugarcane and horticulture.

Table 14. Major attributes, classification and areas for soils of the Dermosols

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
HILLSLOPES ON BASALTS			
Berren	Black or brown light clay surface over a neutral, brown light clay to medium clay (0.3 to 0.65 m) over weathered basalt, >20% basalt fragments throughout the profile.	Brown Dermosol	138
Dundowran	Black light medium clay surface over a neutral to alkaline, mottled, grey or black medium clay to heavy clay (0.7 +m) with manganese nodules over weathered basalt.	Grey Dermosol Black Dermosol	30

Table 14 (continued)

Mapping Unit	**Major Attributes of Dominant Soil**	**Australian Classification**	**Area (ha)**
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 Red Chromosol	239
Meadowvale	Grey loamy sand to sandy loam surface over a conspicuously bleached A2 horizon (0.25–0.7 m) gradually changing to a mottled, massive, yellow or brown sandy clay loam to sandy light clay gradually changing to an acid, mottled, structured, yellow or brown light clay to medium clay.	Yellow Dermosol Brown Dermosol	195
PLAINS AND HILLSLOPES ON DEEPLY WEATHERED FINE GRAINED SEDIMENTARY ROCKS			
Avondale Yellow variant	Grey fine sandy loam to clay loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.3 m) with ferruginous nodules over an acid, mottled, yellow light clay to light medium clay (0.4 to 0.6 m) over an acid, mottled, grey medium clay to heavy clay.	Yellow Dermosols	48
Bungadoo	Black or grey clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.55 m) over a strongly acid, mottled, brown, grey or yellow medium clay (0.75 to 0.9 m) over weathered silicified rock. >20% silicified rock fragments throughout the profile.	Brown Dermosol Grey Dermosol Yellow Dermosol	2333
Craignish	Black or grey loam fine sandy to light clay surface over a conspicuously or sporadically grey bleached A2 (0.1 to 0.35 m) over a neutral to alkaline, grey or brown medium clay to heavy clay over weathered rock at depth.	Grey Dermosol Brown Dermosol	546

Table 14 (continued)

Mapping Unit	Major Attributes of Dominant Soil	Australian Classification	Area (ha)
Kepnock	Grey or black loam fine sandy to clay loam surface over a bleached A2 horizon (0.3 to 0.45 m) over an acid, mottled, yellow or brown light clay to medium clay with ferruginous nodules.	Yellow Dermosol Brown Dermosol Yellow Chromosol Brown Chromosol	1999
Woco	Grey or black loam fine sandy to clay loam surface over a conspicuously bleached A2 horizon (0.2 to 0.4 m) 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 Redoxic Hydrosol	1771
Woolmer	Grey fine sandy loam to loam fine sandy surface over a conspicuously bleached A2 horizon (0.15 to 0.35 m) 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	17
Watalgan	Black or brown clay loam surface over an acid, red light clay to medium clay with ferruginous nodules.	Red Dermosol	371
ALLUVIAL PLAINS OF THE MARY RIVER			
Aldershot	Grey, black or brown fine sandy loam to fine sandy clay loam surface (0.1 to 0.35 m) over a neutral, red light clay to light medium clay frequently with manganiferous nodules.	Red Dermosol	76
Granville	Black or grey light clay to light medium clay over a sporadically bleached A2 horizon (0.1 to 0.25 m) over an acid, mottled, grey to brown medium clay to heavy clay.	Grey Dermosol Brown Dermosol	1569
Mary	Black or brown silty clay loam to silty clay surface (0.1 to 0.25 m) over an acid to neutral, brown, light clay to medium clay.	Brown Dermosol	216

Landscape

The *Berren* and *Dundowran* Dermosols on the Dundowran basalt occur as hillslopes on rises, low hills and hills with slopes up to 30%.

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 *Bungadoo*, generally occur as hillslopes on gently undulating rises with slopes generally <8% or level plains. *Bungadoo* only occurs on the crests and hillslopes of the silicified Maryborough Formation ridge running north west - south east through the study area. Slopes are up to 20%.

The *Granville* soil occurs on the elevated alluvial plains or older terraces of the Mary River. *Aldershot* occurs on the elevated edges of the older terraces while the *Mary* soil occurs on channel benches, scrolls and floodplains of the Mary River.

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 *Woco* and *Bungadoo* soils which remain largely uncleared. The very rocky soils of *Bungadoo* generally have tall lemon scented gum/spotted gum (*Corymbia citriodora*) with other scattered eucalypts and a dense understory of brushbox (*Lophostemon conferta*). The *Woco* soil is of limited extent with stringy bark (*Eucalyptus umbra*) and scattered bloodwood (*C. intermedia*) and tea tree *(Melaleuca viridiflora*). Soils found on the alluvial plains of the Mary River have been cleared.

Soil profile

The Dermosols formed on basaltic rocks generally have a black or brown light clay surface gradually changing to a brown clay subsoil (*Berren*). The darker subsoils generally indicate a predominance of swelling type clays (montmorillonite clays) and usually have sub-angular blocky structure. The *Dundowran* soil has a black light medium clay surface which gradually changes to a black or grey mottled light medium clay to heavy clay subsoil with lenticular structure.

The Dermosols on the deeply weathered sedimentary rocks give rise to the most diverse range of soils with subsoil colors ranging from red to yellow to grey. The well drained red *Watalgan* soils grade into the moderately well drained yellow *Woolmer* soils which grade into the imperfectly drained yellow *Kepnock* soil. This latter soil usually grade into the *Woco* soil or *Avondale* soil (Hydrosols, Kurosols or Sodosols) on lower slopes. The increase in soil wetness corresponds to paler subsoil colors, bleached A2 horizons and greater numbers of ferruginous nodules. A similar sequence occurs on the coarse grained sedimentary rocks with *Gooburrum* grading into *Meadowvale* which grades into *Isis* (Chromosol) which grades into the *Alloway* and *Robor* Hydrosols. The rocky *Bungadoo* Dermosol has a clay loam surface over a conspicuously bleached A2 horizon gradually changing to a mottled, brown, yellow or grey clay subsoil.

The *Mary* soil on the alluvial plains of the Mary River is a moderately well drained brown clay loam to clay soil and grades into the poorly drained *Walker* soil (Hydrosols) on lower channel benches. The *Granville* soil has a sodic grey heavy clay subsoil with vertic properties but does not crack at the surface. The *Aldershot* soil on elevated edges of terraces has a well drained red or brown clay subsoil.

Granville grades into *Beaver* (Hydrosol) in swamps and *Butcher* (Sodosol) closer to the river.

Soil chemistry

Soil pH. Soil pH is strongly related to parent material and leaching environment.

The soils developed on basalt (*Berren*, *Dundowran)* have neutral to alkaline field pH (pH 6.8–9) in the profile. The *Dundowran* subsoil has a laboratory pH 9.2 corresponding to the occurrence of soft lime.

The soils developed on deeply weathered sedimentary rocks (*Gooburrum*, *Kepnock*, *Meadowvale*, *Watalgan*, *Woolmer*, *Woco*) are typically slightly acid to very strongly acid in the surface (field pH 5–6.3, laboratory pH 4.6–6.5) and neutral to very strongly acid in the subsoil (field pH 5–7, laboratory pH 4.6–6). The well drained *Gooburrum* soil occasionally has a subsoil pH up to 7.

The pH of the soils of alluvial origin reflects the age of the soils and possibly parent material. The *Granville* soil on older alluvial plains has a strongly acid to slightly acid pH (pH 5.0–6.5), whilst *Aldershot* and *Mar*y soils have a strongly acid to mildly alkaline pH (field pH 5.5–7.5).

Salinity. All the analysed profiles of the Dermosols on sedimentary rocks (*Bungadoo*, *Gooburrum*, *Kepnock*, *Meadowvale*, *Woolmer*), except *Woco* and *Craignish*, have very low salt levels (EC <0.1 dS/m, Cl <0.012%) throughout the profile. *Woco* has a salt accumulation (EC 0.18–0.64 dS/m) in the strongly sodic clay subsoils, and salts increase to medium to high levels at 1 m (EC 0.42–1.4 dS/m, Cl 0.039–0.212%) in the *Craignish* soil. *Granville* on the alluvial plains has very high salinity (>1.3 dS/m) in the subsoil corresponding to impermeable, strongly sodic subsoils. The other Dermosols with no EC information (*Berren*, *Watalgan*, *Mary*, *Aldershot*) have good profile drainage and occur in elevated positions and would be expected to also have very low salts in the profile.

The *Dundowran* soil on basalt has a non saline surface (EC <0.06 dS/m) increasing to medium levels at 0.5 m (EC 0.34–0.6 dS/m, Cl 0.012–0.05%)

Sodicity. The deep Dermosol derived from basalts (*Dundowran*) is sodic from 0.5+ m corresponding to medium salt levels and strongly alkaline pH (pH >8.5).

The red and yellow Dermosols developed on deeply weathered sedimentary rocks (*Watalgan*, *Gooburrum*, *Bungadoo*, *Kepnock*, *Meadowvale*, *Woolmer)* are non sodic to sodic (ESP 3–16) at depth with the *Woco* soil being strongly sodic (ESP 24–36) in the upper B horizons. B horizons of *Kepnock*, *Meadowvale*, *Woco* and *Woolmer* are also frequently magnesic (Ca/Mg <0.1). However, these soils are frequently strongly acid (pH <5.5) with an effective cation exchange capacity of <5 meq/100 g, and low clay activity (<15 meq/100 g clay) indicating kaolin clays, and have moderate to strong, fine, stable structure which does not disperse (dispersion ratio 0.06–0.08) on wetting. These factors suggest that sodicity is not expressed at low ECEC and clay activity.

On the other hand, the *Craignish* soil developed from a mixing of basalt and deeply weathered sediments is strongly sodic (ESP >23) and magnesic (Ca/Mg <0.1) in the clay B horizon at 0.5+ m. This soil may also be strongly acid (laboratory pH 4.9) at 0.5–0.6 m. However, this clay subsoil has a high CEC (>31 meq/100 g) and clay activity ratio (56 meq/100 g clay) indicating montmorillinite type clays, and a dispersion ration of 0.92 indicating that sodium does influence dispersion in this soil.

The *Granville* soil on the Mary River alluvium is strongly sodic (ESP >27) at 0.5+ m. The *Mary* and *Aldershot* soils have no analysed information.

Soil nutrients. Nutrient status (Table 15) of the Dermosols reflects the parent material, leaching environment and relative age of the soils.

The soils developed on the deeply weathered sedimentary rocks (*Watalgan, Gooburrum, Bungadoo, Kepnock, Meadowvale, 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 unanalysed *Avondale Yellow variant* soil would be expected to show similar trends. The poorer drained soils such as *Woco*, have lower Ca levels particularly in the subsoil corresponding to the low nutrient levels in the Hydrosols developed on deeply weathered sedimentary rocks.

The *Craignish* soil developed from mixed basalt and deeply weathered sediments surrounding the Dundowran basalt, is medium to low in all nutrient but significantly higher in calcium, compared to the soils on deeply weathered sediments.

The *Aldershot* and *Mary* soils on the alluvial plain have not been analysed. The *Granville* soil has low to medium nutrient level, and a strong surface accumulation of calcium.

Table 15. Mean profile soil nutrients for soil of the Dermosols

	Depth (m)	**K meq/100g**	**Ca meq/100g**	**Acid P mg/kg**	**Bicarb P mg/kg**	**Organic C %**	**Total N %**	**Cu mg/kg**	**Zn mg/kg**
Bungadoo	0-0.1	0.41 (M)	2.8 (M)	8 (VL)	7 (VL)	6 (VH)	0.27 (H)	0.05 (VL)	0.72 (M)
	0.5-0.6	0.15 (L)	0.02 (VL)						
Craignish	0-0.1	0.29 (M)	3.2 (M)	5 (VL)	8 (VL)	1.7 (M)	0.12 (L)	0.43 (M)	0.96 (M)
	0.5-0.6	0.07 (L)	4.7 (M)						
Dundowran	0-0.1	0.34 (M)	10 (H)	6 (VL)	10 (VL)	2.3 (M)	0.16 (M)	1.5 (M)	0.85 (M)
	0.5-0.6	0.13 (L)	15 (H)						
Gooburrum	0-0.1	0.1 (L)	2.3 (M)	<5 (VL)	--	2 (M)	0.07 (L)	--	--
	0.5-0.6	0.1 (L)	0.7 (L)						
Granville	0-0.1	0.19 (L)	5.4 (H)	5 (VL)	6 (VL)	2.8 (H)	0.17 (M)	1.4 (M)	0.82 (M)
	0.5-0.6	0.2 (L)	0.23 (VL)						
Kepnock	0-0.1	0.21 (M)	1.1 (L)	--	2 (VL)	1.2 (L)	0.06 (L)	0.11 (L)	0.4 (L)
	0.5-0.6	0.03 (L)	0.56 (L)						

Table 15 (continued)

	Depth (m)	K meq/100g	Ca meq/100g	Acid P mg/kg	Bicarb P mg/kg	Organic C %	Total N %	Cu mg/kg	Zn mg/kg
Meadow-vale	0-0.1	0.1 (L)	1.1 (L)	6 (VL)	6 (VL)	1.4 (L)	0.06 (L)	0.21 (L)	0.36 (L)
	0.5-0.6	0.05 (L)	0.09 (VL)						
Woco	0-0.1	0.09 (L)	1.4 (L)	--	1 (VL)	1.5 (L)	0.06 (L)	0.1 (L)	0.3 (L)
	0.5-0.6	0.05 (L)	0.12 (VL)						
Woolmer	0-0.1	0.12 (L)	0.92 (L)	3 (VL)	1 (VL)	0.6 (L)	0.03 (VL)	0.3 (L)	0.2 (L)
	0.5-0.6	0.03 (L)	0.14 (VL)						

VL – very low; L – low; M – medium; H – high; VH – very high

Plant available water capacity (PAWC). The Dermosols with sandy surface textures (*Gooburrum, Meadowvale*) have lower PAWC compared to similar soils with loamy surface textures (*Watalgan, Kepnock, Woolmer*). The soils with a high proportion of rock fragments in the profile (*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.

The basaltic soils (*Berren, Dundowran*) with a proportion of swelling clays (montmorillonite) and a high cation exchange capacity have a high PAWC per unit value of soil. However, *Berren* is an extremely rocky soil and expected to have low PAWC. The *Granville* soil on alluvium has a medium PAWC (73–101) due to shallow rooting depth from a strongly sodic subsoil and a salt bulge. No analysed profiles, and therefore estimated PAWC, are available for *Aldershot* and *Mary* soils. Based on profile morphology, rooting depth should be >1 m with a PAWC of >75 mm.

Table 16. Estimated PAWC (mm) and rooting depth (m) for soils of the Dermosols

Soil	Rooting depth (m)	PAWC (mm)
Berren	0.4–0.7	<50
Bungadoo	0.4–0.6	<50
Craignish	0.6–1	79–85
Dundowran	0.5–1	90–148
Gooburrum	>1	63
Granville	0.4–0.6	73–101
Kepnock	>1	74–105
Meadowvale	>1	68
Woco	0.4–0.8	65–76
Woolmer	>1	73–90

Kandosols

Kandosols are soils which lack strong texture contrast, have massive or only weakly structured B horizons, and are not calcareous throughout.

Only three Kandosols have been recognised (Table 17) with *Farnsfield* (unmapped soil) occurring in association with the dominant *Quart* soil. They occupy 218 ha or 0.3% of the study area.

Table 17. 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 sandy clay loam surface over an acid to neutral, red sandy clay loam to light clay.	Red Kandosol	Unmapped soil
Quart	Grey loamy sand to sandy loam surface over an acid, mottled, yellow sandy clay loam to clay loam.	Yellow Kandosol	147
ALLUVIAL PLAINS OF THE LOCAL CREEKS AND RIVERS			
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	71

Landscape

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

The remaining Kandosol (*Littabella*) on alluvia plains of the local creeks may have channel microlief.

Vegetation

The vegetation on the soils has been mostly cleared with only minor remnants remaining in state forests. The dominant tree vegetation is pink bloodwood (*Corymbia intermedia)* and brown bloodwood *(C. trachyphloia).*

Soil profile

Structure is typically single grain or massive at the surface and massive to weak polyhedral or subangular blocky in the subsoil.

The Kandosol formed on sandstone (*Quart*) typically has a sandy surface over a sandy clay loam to clay loam subsoil. As subsoil colour changes from red (*Farnsfield*) to yellow (*Quart*) to grey (*Mahogany*) in a typical toposequence, surface colours become paler, A2 horizons become paler and bleached, mottles increase and ferruginous nodules generally increase reflecting increased wetness in the profile.

The Kandosol on creek alluvium (*Littabella*) has variable profile attributes reflecting deposition changes over short distances. *Littabella* is generally confined to levees along larger creeks and adjoins *Peep* (Sodosol) on the back slopes of the levees.

Soil chemistry

Soil pH. Soil pH for the Kandosols is typically strongly acid to medium acid (laboratory surface pH 5.2–6.3, subsoil pH 4.7–6.3). Lower subsoil pH is associated with lower calcium levels.

Salinity. The *Quart* and *Farnsfield* soils have very low salt levels (EC <0.07 dS/m, Cl <0.11%) throughout the profile which can be attributed to a sandy permeable profile. *Littabella* has not been analysed but would be expected to also have low salts.

Sodicity. The *Quart* and *Farnsfield* soils are predominantly non sodic (ESP ≤6) at depth but occasionally sodic (ESP 8). Due to low ECEC (<5 meq/100 g) and low clay activity (10 meq/100 g clay), the effects of sodicity on dispersion are not expressed.

Soil nutrients. The *Quart* and *Farnsfield* soils developed on deeply weathered sedimentary rocks typically have low to very low levels of all nutrients except in the surface due to organic matter accumulation (Table 18). *Littabella* would be expected to be low in all nutrients. The better drained *Farnsfield* soil has on average, higher nutrients that the imperfectly drained *Quart* which, on average has higher nutrients that poorly drained *Mahogany* (Hydrosol-Kandosol) soil.

Table 18. 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**	**Organic C %**	**Total N %**	**Cu mg/kg**	**Zn mg/kg**
Farnsfield	0-0.1	0.34 (M)	2 (L)	--	--	1.1 (L)	0.05 (L)	0.7 (M)	0.4 (L)
	0.5-0.6	0.08 (L)	1.4 (L)						
Quart	0-0.1	0.2 (M)	1.2 (L)	3 (VL)	2 (VL)	0.8 (L)	0.04 (VL)	0.17 (L)	0.23 (L)
	0.5-0.6	0.04 (L)	0.78 (L)						

VL – very low; L – low; M - medium

Plant available water capacity (PAWC). The sandy surface *Quart* and *Farnsfield* give rise to a low to medium PAWC (Table 19).

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

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

Tenosols

Tenosols are soils with only weak pedalogical organisation apart from the A horizons. The Tenosols in the study area are confined to soils with conspicuously bleached A2 horizons over rock, and a sand on discontinuous beach ridges adjacent to Great Sandy Strait (Table 20).

Table 20. 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 0.55 m) over weathered silicified rock. >20% silicified rock fragments throughout the profile.	Bleached Tenosol	Unmapped soil
BEACH RIDGES			
Diamond	Black sand to loamy sand over a frequently conspicuously bleached A2 horizon (0.5 to 1.0 m) over an acid, brown, yellow or occasionally red sand to loamy sand with ferruginous nodules.	Bleached Tenosol Orthic Tenosol	244

Landscape

The *Takoko* soil is an unmapped soil which occurs on crests and hillslopes with slopes of 0–20% in association with the *Bungadoo* Dermosols. The *Diamond* soils occur on low discontinuous Holocene beach ridges along Great Sandy Strait, usually overlying old Pleistocene marine plains.

Vegetation

The vegetation on the *Takoko* soil and associated *Bungadoo* soil (Dermosol) is dominated by tall (18–20 m) lemon scented gums/spotted gum (*Eucalyptus citiodora*) with other eucalypts such as stringybark (*E. umbra*, *E. acmenoides*) and brown bloodwood (*Corymbia trackyphloia*). A dense understory of brush box (*Lophostemon confertus*) is usually present. The *Diamond* soil usually has pink bloodwood (*C. intermedia*), usually with scribbly gum (*E. signata*) being conspicuous.

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 *Diamond* soil has a uniform sandy profile with a massive subsoil. The subsoil is frequently mottled and varies in colour (brown, yellow or red) depending on local drainage.

The *Avondale Tenic Variant* (unmapped soil) 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.

Soil chemistry

No analysed profiles for the Tenosols are available in the Maryborough-Hervey Bay area.

Field pH in the *Diamond* and *Takoko* soils are typically acid (pH 5.0–6.5) with the beach ridge *Diamond* subsoil pH (6.0–6.5) consistently higher than the *Takoko* soil pH (5.0–5.5) developed on deeply weathered sedimentary rocks.

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 degradation 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 Maryborough-Hervey Bay area are spray irrigation of a range of crops and trickle irrigation of horticultural crops and tree crops. Crops include asparagus, avocado, beans, citrus, crucifers (cabbage, cauliflowers, etc.), cucurbits (melons, pumpkins), grape, lucerne, lychee, improved pasture, macadamia, maize, mango, navybean, peanut, pineapple, *Pinus*, potato, sorghum, soybean, stonefruit, sugarcane, sweetcorn, sweet potato, vegetables (capsicum, tomato, zucchini). Furrow irrigation of sugarcane and other crops have also been assessed as separate land uses. The land use requirements and limitations that have been identified as important for successfully irrigating crops in the Maryborough-Hervey Bay area are listed in Table 21.

Table 21. Land use requirements and limitations for irrigated farming systems in the Maryborough-Hervey Bay area (from Land Resources Branch Staff, 1990)

Land use requirements	**Limitations**
Frost free	climate (c)
Adequate rainfall (rainfed crops only)	climate (c)
Adequate water supply	water availability (m)
Adequate nutrient supply	nutrient deficiency (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)
Efficient furrow infiltration	furrow infiltration (if)
Efficient water recharge of the soil profile	soil profile recharge (ir)
Minimum drainage from acid sulfate soil	drainage water hazard (da)

All the limitations listed do not necessarily apply to each land use or to all soils but are still assessed as part of the process. Some limitations are more important for some soils. The limitations appropriate to the Maryborough-Hervey Bay 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 for the incidence of frosts. Rainfall for the supply of adequate moisture for irrigated and rainfed crops (*Pinus*) decrease gradually from east to west. Maryborough has an average annual rainfall of 1166 mm. Local experience on the frequency and severity of frosts, and landscape position were used to determine the limitation classes for the various crops (Appendix V). Seasonal adaptation 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 frost sensitive crops such as avocados and mangoes. The low lying channel benches and depressions in the terraces along the rivers mainly to the west of the survey area can receive a large number (>20) of severe frosts per year. These severely affected areas limit the choice of crops to deciduous plants such as low-chill stone fruits, grapes, and tolerant small crops and field crops.

Water availability (m)

All plants require an adequate water supply for optimum growth. Crop yield is directly related to the amount of water stored in the soil available for plant growth. Plant available water capacity (PAWC) is a measure of the amount of soil water (mm) between field capacity and wilting point (-1500 kPa) over the effective rooting depth. Gardner and Coughlan (1982) concluded that sodic subsoils offer resistance to plant roots and water entry caused by unfavourable structure, high ESP or high bulk density. Generally, they suggest that the start of this restriction may be similar to the rooting depth. For most soils, PAWC tends to decrease with depth due to increasing bulk densities and lower root densities (Littleboy 1997).

Effective rooting depth was taken to be 1.0 m or the depth to rock, hardpans, high salt levels or where a rapid increase in profile electrical conductivity indicates the depth of regular wetting if <1.0 m. Restriction to root growth caused by nutrient deficiencies below the layers of fertiliser placements (eg. the plough layer) was not assessed but is recognised as a possible limitation to rooting depth.

Under irrigation, a reduced PAWC means more frequent irrigations to attain optimum yield. For example, in the Maryborough-Bundaberg area, evaporation rates are 6 mm/day during summer. Evapotranspiration rates for mature crops are approximately the same as evaporation rates. For a soil with a PAWC of 100 mm, 100 mm irrigation could be applied every 15 days, whereas a soil with a PAWC of 50 m would require irrigation every 8 days. Any excess application would be lost to deep drainage or runoff. The ability to recharging the soil water deficit completely within the irrigation period is also important. Incomplete profile recharging will reduce the amount of water available for crop growth and therefore, require more frequent irrigation (see soil profile recharge limitation).

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 and is important for irrigation scheduling to optimise yields.

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).

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 type, planting date and stage of growth (Doorenbos and Pruitt, 1977).

BSES staff have developed a chart which outlines how to use pan evaporation figures to determine sugarcane water use. The chart and Daily Class A pan evaporation for Bundaberg are available on request from BSES.

Estimated PAWC (Shaw and Yule, 1978) is largely determined by predicted rooting depth, the amount of hard segregations or rock in the profile and soil textures. The model developed by Littleboy (1997) from the model of Shaw and Yule (1978) was used to estimate PAWC. Estimated PAWC for the various soils is discussed in Chapter 3.

In general, the sandy soils (*Kinkuna, Theodolite, Wallum, Berren, Toogum, Winfield*), sandy surfaced sodic texture contrast soils (*Kolbore, Robur, Turpin, Tirroan*) and shallow rocky soils (*Kolan rocky phase, Avondale rocky phase, Bungadoo, Berren*) have very low estimated PAWC (<50 mm). Some sodic texture contrast soils (some *Avondale, Kolan*) with very shallow rooting depth (<0.4 m) also have very low PAWC. Deep (>1 m), loamy surfaced, structured soils *(Beaver, Walker, Fairydale, Fairymead, Jaro, Tandara, Kepnock, Watalgan, Mary*) generally have high PAWC (>100 mm). Natural rooting depth of crops (eg. shallow rotted root crops) and irrigation methods (eg. microirrigation) have been taken into account to determine suitability (Appendix V).

Very low soil water availability to crops (<50 mm PAWC) is a major limitation in the survey area occurring over 31 255 ha or 42.3% of the area.

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 to improve soil fertility and crop yield requires large initial fertiliser application. Phosphorus and nitrogen will need to be applied to all unfertilised soils in the study area.

Soils on the deeply weathered sedimentary rocks except the red soils *(Kinkuna, Theodolite, Wallum, Alloway, Mahogany, Robur, Clayton, Kolan, Kolbore, Avondale, Turpin, Isis, Meadowvale, Bungadoo, Kepnock, Woco, Woolmer, Quart, Winfield)* are typically low to very low in all nutrients, particularly potassium and calcium in the subsoils. Calcium deficiency in subsoils is difficult to correct due to calcium strongly absorbing to the soils cation exchange sites on clay and organic matter, and therefore, does not move readily from the placement area. Calcium leaching into the subsoil from surface applications or slotting of calcium into subsoils requires investigation, especially the effects of calcium on other cations (Mg, K, Na, Al, trace elements) in the highly weathered low cation exchange capacity (<5 meq/100 g) soils dominant in the study area.

The basaltic soils (*Dundowran, Berren*) would be expected to have relatively good soil nutrition in the natural state (based on similar soils in Childers-Bundaberg area) while other soils are variable with nutrient levels generally related to relative age of the soils, lithology and weathering environment (see soil chemistry sections).

Limitation classes (Appendix V) are based on critical levels of phosphorus and potassium. Trace elements are not considered as they represent a minor cost to production.

Soils with very low phosphorus (<10 ppm) occupy 59 129 ha or 80.1% of the area and low potassium (<0.2 meq/100 g) occupy 53 611 ha or 72.6% of the area.

Nutrient leaching (nl)

Nutrients leaching out of the root zone occurs on well drained or highly permeable soils, usually associated with light (sandy) subsoil textures and a low subsoil cation exchange capacity (especially <5 meq/100 g). Nitrates are readily leached on permeable soils while cations (Ca, K, trace elements) are leached relatively slower on permeable low cation exchange capacity soils. The light textured uniform soils (*Kinkuna, Winfield, Burrum, Toogum, Wallum, Diamond*) well drained soils (*Farnsfield*), and low effective cation exchange capacity soils (*Alloway, Mahogany, Clayton, Isis, Gooburrum, Meadowvale, Kepnock, Woolmer, Quart)* have these features. Split fertiliser applications or slow release fertilisers may be beneficial to limit nutrient loss below the root zone and possible watertable contamination.

Nutrient leaching on highly permeable soils at 1.5 m depth is a limitation occurring on 229 ha or 0.3% of the area.

Nutrient fixation (nf)

Where nutrients are bonded or fixed to soil minerals and become unavailable for plant growth, additional management is required. Humic or organic soils and soils high in iron-aluminium oxides fix phosphorous. Soils with these attributes include *Jaro, Tandora, Fairydale* and *Beaver*. Limitation classes are shown in Appendix V.

Humic soils occupy 7754 ha or 10.5% of the area.

Element toxicity (nt)

Plant growth may be inhibited by either high levels or a high proportion of specific cations (eg. aluminium) 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 and highly leached Hydrosols frequently have strongly acid pH. The acid sulfate soils (*Jaro, Fairydale)* require special management to over come the extremely acid (pH <4) soil conditions.

Limitation classes (Appendix V) are based in soil pH in the top 0.3 m.
Strongly acid soils (pH <5.5) occupy 8270 ha or 11.2% of the area.

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

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

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

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 *(Theodolite, Walker, Alloway, Mahogany, Robur, Clayton, Kalah, Kolbore, Avondale, Turpin, Woco)*. Soils on upper slope positions are generally imperfectly to well drained (*Kinkuna, Alloway, Mahogany, Robur, Avondale, Turpin, Gooburrum, Meadowvale, Bungadoo, Craignish, Kepnock, Woco, Woolmer, Watalgan, Quart, Winfield, Farnsfield).*

Wetness in the soils on the alluvial plains is influenced by slight changes in elevation. The soils which are very strongly sodic (ESP >15) at depth (*Woober, Granville, Butcher, Peep)* have high salt levels (EC >0.7 dS/m) in the subsoil. The soil bulge at depth indicates the depth of regular wetting which suggests that surface water does not regularly penetrate to depth and most of any excess surface water is lost by surface flow to drainage lines or evaporation. 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. Special management is required on the acid sulfate and potential acid sulfate soils (*Jaro, Fairydale*) to avoid disturbance, drainage or exposure of subsoil horizons high in oxidisable sulfur which release sulfuric acid upon exposure to air (see drainage water hazard limitations).

Limitation classes are shown in Appendix V.

Wetness is a major limitation in the survey area. A total of 13 soils covering 46% of the area are classified as Hydrosols, which typically occur on lower slopes, depressions and on the flat coastal marine plains. A number of other soils have Hydrosols as minor components. A total of 43 793 ha or 59.3% of the areas has been assessed as having a poorly drained horizon to 1 m.

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 water availability limitation). Limitation classes (Appendix V) have been determined through consultation with crop specialists and local producers. Soils <0.3 m are extremely minor in the study area.

Flooding (f)

Flooding is defined for the study area as over-flow from natural watercourses and does not include 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.

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 are costs associated with flooding which must be considered against the agricultural benefits of farming on the flood plain.

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 prone lands. Land management should aim at stabilising the flood plain in high risk areas. This includes not clearing existing vegetation 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 Mary River, and local creeks. Sand and silt deposition, bank erosion and scouring is most severe where water velocities are high. The lower channel benches are the most severely and most regularly affected.

The channel benches have a flooding limitation 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 are assessed similarly.

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. Sugarcane is moderately tolerant of inundation but the level of crop damage will vary depending upon variety. 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.

One in ten year floods or more frequent affect 10 318 ha or 14% of the area.

Rockiness (r)

Rock fragments of any size 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 (sugarcane, navybeans, soybeans) have a low tolerance to rock. Root crops (potato, peanuts) are very sensitive due to harvesting requirements. 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 limitation classes (Appendix V). Rock fragments are consistently a problem on the *Bungadoo*, *Avondale rocky phase*, *Kolan rocky phase* and *Berren* soils.

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 restricts 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 suitable soil in a UMA is not a minimum production area (see Appendix V), 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%) but where the component soils have different suitability classes, the highest suitability class is downgraded when the area of each soil is less than the minimum production area size. For example, if a UMA contains two subdominant soils with a sugarcane 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.

Landscape complexity due to gullies or stream channels dissecting land into small areas is a minor limitation in the study area.

Microrelief (tm)

Microrelief 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 laser levelling is necessary to enable efficient irrigation to occur. The extent of laser levelling depends 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.

Soils with weakly developed gilgai (*Granville*) which have not been cultivated, cover a minor part of study area. 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 infiltration 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.

Slopes >15% are minor occupying 506 ha or 0.7% of the area.

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. Limitation classes are determined by the severity of hardsetting and crusting or size o coarse structure (Appendix V).

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 cloddiness and varying soil moisture in the seedbed are the major factors involved. These factors would be expected in the sodic texture contrast soils with shallow loamy (fine sandy loam to clay loam) A horizons (*Avondale, Kolan, Butcher*, *Peep*). 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 crusting and cloddiness when sodic clay is exposed.

Surface soils with a high proportion of fine sand and silt, and with low organic matter content (*Clayton, Kalah, Kepnock, Kolan, Kolbore, Woco, Avondale, Kalah, Butcher, Peep, Woober*) 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 and crop residue retention (eg. sugarcane trash) and minimum tillage is recommended to improve structure and decrease the severity of crusting and improve infiltration. Controlled traffic and a permanent bed farming system may also be useful on these soils.

Strongly hardsetting soils associated with fine sandy loam to clay loam fine sandy textures are very common and affect 39 415 ha or 53.4% of the area.

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 when they are 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.

Braunack and McPhee (1985) 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, and may cause compaction problems.

The clay soils *(Granville)* have a narrow moisture range for tillage, while the hardsetting fine sandy loam to clay loam fine sandy surface soils *(Clayton, Kalah, Kepnock, Kolan, Kolbore, Woco, Avondale, Butcher, Peep, Woober)* have a moderate moisture range for tillage. Limitation classes are based on texture and structure stability, and on local opinion of the severity of the problem (Appendix V).

Soils with a narrow moisture range (some clay soils) are relatively minor occupying 2298 ha or 3% of the area.

Soil adhesiveness (pa)

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. Limitation classes are based on texture consistence and structure (Appendix V)

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 erodibility and management. Slope limits for the soils and crops 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 steeper slope limits than other uses because of the reduced cultivation and increased plant cover.
Stable soils with <8% slopes occupy 3940 ha or 5.3% while unstable soils with <5% slope occupy 25 458 ha or 43.5% of the area.

For furrow irrigation of sugarcane and other crops, 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 is available 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. Raine *et al.* (1998) investigated this issue and used a computer model (SIRMOD) to measure irrigation efficiency through field design and irrigation management practices.

On more steeply sloping land (greater than 1%) the furrow gradient can be reduced by aligning furrows across the slope. The maximum slope on stable soils is 4–5% and 2–3% on unstable soils (Appendix V).

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. High salt levels are associated with fine grained sedimentary rocks while sandstones have low salt levels.

In the Maryborough-Bundaberg areas, salinisation occurs from long term evaporation and capillary rise of salts from non saline watertables close to the surface.

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 the Maryborough-Bundaberg area, all soils on upper slopes appear to act as intake areas (Appendix V).

In discharge (seepage) area, there is an upward component to groundwater flow near the soil surface which may result in secondary salinisation. Discharge areas frequently occur at breaks of slope, in flat or incised areas or in regions of concave slope. Seepage salting is the main form of salinisation in the Maryborough-Bundaberg area and is mainly associated with the deeply weathered geology.

Salinisation is consistently evident on the sodic duplex soils developed on deeply weathered fine grained sedimentary rocks and drainage depressions found on discharge areas (*Kalah, Kolbore, Turpin, Avondale, Woco, Woober*) and occasionally on poorly drained soils on deeply weathered sandstones (*Robur, Theodolite, Mahogany, Alloway, Clayton*) and occasionally on moderately weathered sedimentary rocks (*Tirroan, Kolan*). Soils developed on marine plains (*Jaro, Tandora, Fairydale, Maroom*) typically have salty watertables and are subject to surface salting if inadequately drained and/or over irrigated.

Losses to groundwater must be reduced in the recharge areas to avoid salinisation of the discharge areas. Furrow irrigation is not recommended on soils of the recharge areas because of the difficulty in controlling water application rates and amounts. 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. Soils in the study area with similar properties include *Kalah, Kolbore, Turpin, Avondale, Woco, Woolmer Robur, Theodolite, Tirroan, Kolan*. Any area with existing natural salinisation is considered unsuitable for development.

Soil profile recharge (ir)

Recharging the soil water deficit completely within an irrigation period (the period over which water is applied) is important in irrigation scheduling to maximise crop growth and water use efficiency. Irrigation application rates must match infiltration rates over the irrigation period to avoid incomplete recharge of the rooting zone and runoff. If incomplete profile recharge occurs, irrigation will be required more frequently or for longer periods. For on-farm irrigation cycles using spray or furrow irrigation methods, high volumes (eg. 50 mm) are often applied over short periods (eg. 2 to 3 hours). These application rates often exceed surface infiltration and subsoil permeability rates.

Local experience indicates that the fine sandy loam to clay loam fine sandy surface soils *(Clayton, Kalah, Kolbore, Woober, Kolan, Avondale, Butcher, Peep, Bungadoo, Craignish, Kepnock, Woco, Woolmer, Watalgan, Aldershot)* slake and surface seal under irrigation, particularly spray irrigation. Soils with a high sodicity in the upper profile *(Theodolite, Duingal, Robur, Kalah, Kolbore, Woolmer, Maroom, Tandora, Kolan, Tirroan, Avondale, Turpin, Butcher, Peep, Craignish, Woco, Granville)* have low subsoil permeability and therefore reduced ability to recharge the soil profile.

Furrow infiltration (if) (deep drainage)

For furrow irrigation, water application rates and amount of water applied is difficult to control and monitor for any site. The water application rate must match the permeability of the soil to avoid deep drainage (Loveday, 1981) and rising watertables. Also, furrow gradient and length should be designed to meet water application rates and soil permeability to avoid waterlogging of sensitive crops in the upper end. Management try to make furrows as long as possible because additional management effort is required if furrow are short.

The effect of deep drainage on groundwater levels is related to landscape and the ability to control groundwater levels.

Because furrow irrigation management has difficulty in regulating water application amounts, deep drainage in recharge areas or undulating landscapes can contribute significantly to watertables in lower landscape positions and is therefore, not suitable (Appendix V). On level plains where there is no inflow of groundwater from adjacent areas, deep drainage on very slowly permeable to slowly permeable soils can be managed effectively to avoid watertable rises. This is particularly effective on incised or elevated alluvial plains where any deep drainage water can flow into incised drainage lines. The sodic soils on alluvial plains (*Butcher, Granville*) can generally be managed effectively.

Within declared groundwater areas, pumping of groundwater is an effective means of controlling watertable rises. However, no declared groundwater areas exist in the study area.

Drainage water hazard (da)

Drainage water from acid sulfate soils creates an environmental and soil degradation hazard, When acid sulfate soils (including potential acid sulfate soils) are disturbed or drained, existing acidity and potential acidity from the oxidation of pyrite (FeS_2) allows toxic quantities of acid, aluminium, iron and heavy metals to leach from soils to contaminate waterways. Such contamination can injure and destroy aquatic flora and fauna, affect or kill vegetation and crops, and accelerate structural failure of pipes, foundations, bridges and road surfaces.

Two of the indicators of actual acid sulfate soil (AASS) are a pH <4 and the presence of jarosite (an iron-potassium-sulfate compound) in the profile. Some AASS have very low pH (<4) where nearly all acid has been leached from the soil and acid drainage is not a problem. On the other hand, ASSS can contain significant volumes of acid which can be a hazard, however, pH only measures the concentration of acid and does not measure the volume of acid or potential acid in the soil. For this reason, the depth to which low pH (pH <4) occurs has been recorded as an attribute in the UMA files to indicate that existing acidity may be a problem.

Potential acid sulfate soils (PASS) contain inoxidised pyrite (FeS_2). PASS may also have elevated pH (pH 4 to >7) and no jarosite. Field testing for pyrite involves reaction of a small sample of soil with peroxide (30% H_2O_2) to rapidly oxidise pyrite to acid. The strength of reaction and the change in pH are noted. A pH change of at least one unit below the pH of the peroxide (pH adjusted 4.5–5.5) and field pH of the original sample (which ever is the lowest pH) may indicate PASS. A strong reaction together with a pH change to <3 indicates PASS.

Quantitative assessment of the hazard posed by AASS and PASS is based on the depth and quantity of oxidisable sulfur for particular texture categories. Because clay content tends to influence the soils natural pH buffering capacity, the critical (indicator) quantities of oxidisable sulfur is based on soil texture and has been grouped into three broad texture groups (Appendix V). Quantities of oxidisable sulfur below the indicator quantities are deemed to not cause a hazard.

The depth to oxidisable sulfur (pyrite) is recorded and combined with the indicator quantities of oxidisable sulfur to determine limitation classes. For example, a S1 code in the UMA data corresponds to a sand to loamy sand texture (code S) with an oxidisable sulfur content >0.03% (indicator quantity) at <0.5 m (code 1).

The depth to pyrite corresponds to the level of management required to control and monitor acid drainage water when these waterlogged soils are cultivated and drained for agricultural purposes. For example, if pyrite occurs above the indicator quantities at <0.5 m, any cultivation and shallow drains will initiate oxidation of the pyrite and acid drainage and is therefore, unsuitable for development.

Any drainage works or disturbance (eg. cultivation) should be shallower than the depth of pyrite to avoid acid drainage. Moderately deep drains (1 m) are adequate for moderately deep (≤1 m) rooting crops (eg. sugarcane). Therefore, AASS and PASS are suitable for cropping when pyrite occurs at >1 m (Appendix V). However, strict control on drain depth is essential together with regular monitoring to ensure any acid drainage water or soil acidification can be corrected. Pyrite at greater depths allows greater flexibility in management of AASS and PASS soils.

5. Land suitability

Land resource information collected during the soil survey was used to determine the suitability of the land for 25 land uses based on soil and land attributes in the existing state. Using procedures 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 sugarcane, horticultural crops, grain crops and pastures under irrigation, and the growing of *Pinus* (exotic pine trees) under rainfed conditions.

The significant limitations to agricultural production were identified for each of the 1318 unique map areas (UMA's) delineated in the study. The severity of each limitation was assessed on a 1 to 5 scale as follows:

Class 1 Suitable land with negligible limitations
Class 2 Suitable land with minor limitations
Class 3 Suitable land with moderate limitations
Class 4 Marginal land which is presently considered unsuitable due to severe limitations
Class 5 Unsuitable land

The overall suitability class of a UMA for a land use is usually determined by the most severe limitation class, however, a combination of limitations may lead to a downgrading of the suitability class.

An assessment of the limitations and suitability ratings for each UMA and each of the different land uses is recorded on computer files. Table 22 shows the areas of various land suitability classes for the 25 land uses.

Table 22. Irrigated land suitability ratings and areas (ha) for different land uses

Land use	**Irrigated land suitability rating**				
	Suitable (ha)			**Marginal (ha)**	**Unsuitable (ha)***
	Class 1	**Class 2**	**Class 3**	**Class 4**	**Class 5**
Asparagus	--	1809	7588	11971	64029
Avocado	--	--	259	654	84483
Beans	--	421	3334	7159	74481
Citrus	--	247	652	3309	81188
Cruciferae	--	3032	6365	11971	64029
Cucurbits	--	1808	7588	11971	64029
Grapes	--	696	2328	3507	78864
Lucerne	--	284	1816	4634	78662
Lychee	168	3706	9148	22759	49615
Macadamia	--	248	652	3309	81188
Maize	--	1379	3790	11806	68420
Mango	--	727	4010	12786	67872
Navybean	--	323	3374	7207	74491
Pasture	--	3821	11799	26132	43643

Table 22 (continued)

Land use	Irrigated land suitability rating				
	Suitable (ha)			Marginal (ha)	Unsuitable (ha)*
	Class 1	Class 2	Class 3	Class 4	Class 5
Peanut	--	323	2033	8548	74491
Pineapple	--	1568	4602	15800	63426
Pinus (rainfed)	218	4952	3959	25304	50963
Potato	--	1625	6844	11059	65867
Sorghum (forage)	--	1379	3790	11806	68420
Soybean	--	1241	3613	10050	70492
Stonefruit	--	679	2340	3512	78864
Sugarcane (spray irr.)	216	563	11659	26953	46004
Sugarcane (furrow irr.)	--	--	3086	28531	53777
Sweet corn	--	1379	5042	10613	68361
Sweet potato	--	1625	7649	12063	64058
Vegetable	--	3032	6365	11971	64029

* Unsuitable (class 5) – includes miscellaneous units such as urban, marine wetlands, dams and stream channels, quarries.

Sugarcane is the main crop grown in the Maryborough-Hervey Bay area. From Table 22, 12 438 ha are suitable (classes 1–3) for sugarcane using travelling irrigators or other overhead irrigation systems.

Other crops such as lychees and small crops also have relatively large areas suitable for production. However, the main limitation to improved yields on suitable lands, is the highly variable low rainfall typical of the study area, and the lack of adequate irrigation water.

The development of the Eli Creek sewerage effluent reuse scheme where effluent water is applied to sugarcane is a boost to sugarcane yields and environmentally desirable compared to effluent disposal into Hervey Bay.

For furrow irrigation suitability, the limitations for determining irrigation suitability using travelling irrigators (or other overhead irrigation) is combined with the furrow infiltration limitation and modified by the slope limitation (if applicable). Sugarcane is the only crop likely to be furrow irrigated on 3086 ha or 3.6% of the area.

The Department of Natural Resources land resource geographic information system provides an effective and rapid means of assessing attribute and limitation information for each UMA. Thematic maps can be generated to depict spatially land suitability and limitation information. Enquiries for any recorded information for a particular UMA or for the whole coverage is available from the Department of Natural Resources, Maryborough, Bundaberg and Indooroopilly.

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Appendix I

Soil profile classes

Conventions used in the descriptions of the morphology, landscape and vegetation of the soil profile classes

A soil profile class is a three dimensional soil body or group or soil bodies, such that any profile within the body(s) has a similar number and arrangement of major horizons whose attributes primarily morphological, are within a defined range. All profiles within the units have similar parent materials. The soil profile class may be at varying levels of generalisation depending primarily on the scale of the survey and density of ground observations.

A **soil variant** is a soil with profile attributes clearly outside the range of defined soil types but not extensive enough to warrant defining a new type.

A **soil phase** is a subdivision of a soil profile class based on attributes that have particular significance in the use of the soil, for example, rocky phase.

Australian Classification as described by Isbell (1996) are listed in order of frequency of occurrence.

Great Soil Group as described by Stace *et al.* (1968) are listed in order of frequency of occurrence.

Principle Profile Form (PPF) as defined by Northcote (1979) are listed in order of frequency of occurrence.

Geology as defined on the Maryborough 1:250 000 geology series map, 1992.

Surface characteristics as in McDonald *et al.* (1990).

Landform as in McDonald *et al.* (1990).

Vegetation structural formation as in McDonald *et al.* ((1990)

Vegetation species listed in order of frequency of occurrence. "/" means with or without.

The **pH profiles** are based on field determination for each horizon.

Horizons as in McDonald *et al.* (1990).

Textures are field textures as in McDonald *et al.* (1990)

Structure as in McDonald *et al.* (1990).

Segregation as in McDonald *et al*. (1990).

Boundary type as in McDonald *et al.* (1990).
Frequency of occurrence
Frequently = >30% of occasions
Occasionally = <30% of occasions

Colour codes (moist) are those of Munsel soil colour charts (1994) while colour nomenclature is based on the colour class limits of Isbell (1996).

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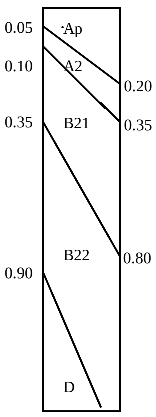
ALDERSHOT (Ad)

Concept:	Massive loamy surface over a non-sodic, red, structured clay subsoil on aluvium of the Mary River.
Australian Classification:	Red Dermosol.
Great Soil Group:	Red brown earth.
Principle Profile Form:	Dr2.21, Gn3.22, Gn3.72.
Surface characteristics:	Hardsetting.
Geology:	Quaternary alluvium (Qa).
Landform:	Alluvial plains.
Vegetation:	Cleared.

Depth(m)



Ap: Grey, black or brown (7.5 YR 3/2, 10 YR 4/1, 4/2, 4/3); fine sandy loam to fine sandy clay loam; massive; pH 5.5 to 6.5. Clear to gradual change to

A2: Occurs in undisturbed soils. Sandy clay loam to silty clay loam; massive; pH 6.0 to 6.5. Abrupt to clear change to

B21: Occasionally mottled; red or brown (5 YR 4/3, 4/4, 10 YR 5/3); clay loam sandy to light medium clay; weak to moderate 5 to 10 mm subangular blocky; <2% manganiferous nodules <2 mm; pH 6.3 to 7.0. Clear to gradual change to

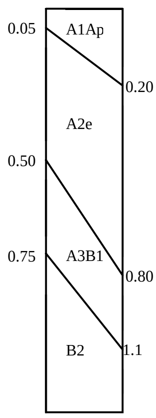
B22: Red (2.5 YR 4/6, 5 YR 4/4, 5/6); light clay to light medium clay; moderate to strong 5 to 20 mm angular blocky or subangular blocky; <2% manganiferous nodules <2 mm; pH 6.5 to 7.5. Clear to gradual change to

D: Occasionally occurs. Brown (7.5 YR 4/6); clay loam sandy, massive; pH 7.0 to 7.5.

ALLOWAY (Al)

Concept:	Bleached sandy surface over a mottled, non-sodic, structured, gleyed subsoil on deeply weathered coarse grained sedimentary rocks.
Australian Classification:	Redoxic Hydrosol , Grey Dermosol.
Great Soil Group:	Gleyed podzolic soil.
Principle Profile Form:	Gn3.04, Dg2.41, Dg4.41, Dy3.41.
Surface characteristics:	Hardsetting or loose.
Geology:	Elliott Formation (Te).
Landform:	Level plains to hillslopes on gently undulating rises. Slopes 0 to 2%.
Vegetation:	15 to 18 m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Corymbia trachyphloia / Corymbia intermedia.*

Depth(m)



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

A2e: Conspicuously bleached. Occasionally mottled; loamy sand to sandy loam; massive; pH 5.5 to 6.0. Clear to diffuse change to

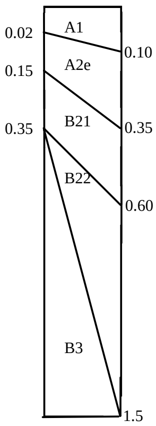
A3, B1: Mottled; grey or yellow (10 YR 6/3, 6/4, 6/5, 7/2, 7/3, 7/4, 8/3); sandy clay loam or occasionally clay loam sandy increasing to light clay in the B1; massive in A3 or weak 2 to 10 mm polyhedral or subangular blocky in the B1; frequently 2 to 50% ferruginous nodules 2 to 20 mm; pH 5.5 to 6.5. Clear to diffuse change to

B2: Mottled; grey or occasionally yellow (10 YR 6/2, 6/3, 7/1, 7/2, 7/3, 7/4, 8/1, 8/2); moderate or strong 2 to 10 mm polyhedral or subangular blocky; light clay to medium clay; frequently 2 to 50% ferruginous nodules 2 to <60 mm; pH 5.5 to 6.5.

AVONDALE (Av)

Concept:	Sodic texture contrast soil with a shallow (<0.35m) loamy surface containing ferruginous (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
Surface characteristics:	Hardsetting.
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 18 m mid-dense *Eucalyptus umbra, Angophora costata with scattered Eucalyptus drepanophylla / Corymbia trachyphloia, Corymbia intermedia / Melaleuca viridiflora*.

Depth(m)



A1: Grey or black (5 YR 4/2, 7.5 YR 3/2, 4/2, 4/3, 10 YR 3/2, 4/2); fine sandy loam to clay loam fine sandy; massive; frequently <2 to 50% ferruginous (maghemite)nodules <6 mm; 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 <6 mm; pH 5.5 to 6.0. Abrupt to sharp change to

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

B22: Frequently occurs in deeper profiles. Mottled; grey (7.5 YR, 5/2, 6/2, 7/2, 10 YR 5/2, 6/1, 6/2); medium heavy clay to heavy clay; strong 5 to 20 mm angular blocky, strong 20 to 50 mm prismatic or strong <5 mm lenticular frequently with slickensides; pH 5.0 to 5.8. Clear to diffuse change to

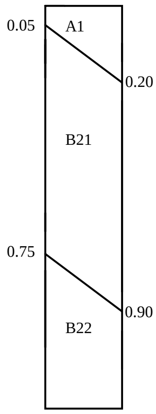
B3: Mottled; grey (7.5 YR 5/1, 5/2, 6/2, 7/1, 10 YR 5/2, 6/2, 7/1, 7/2) medium clay to heavy clay; strong 5 to 20 mm angular blocky or occasional strong <5 mm lenticular; rock fragments; pH 5 to 5.5.

Avondale Rocky Phase AvRp: as above with >20% rock fragments or rock at 0.3 m.
Avondale Tenic Variant AvTv: Bleached Tenosol. A1 and A2 horizons as above over weathered rock.
Avondale Yellow Variant AvYv: Yellow Dermosols. A1 and A2 horizons as above over an acid, mottled, yellow light clay to light medium clay B21 heavy on 0.4 to 0.6 m) over a B22 heavy on as above.

BEAVER (Bv)

Concept:	Humic loamy surface over a strongly mottled grey clay subsoil on alluvial plains of the Mary River.
Australian Classification:	Redoxic Hydrosol.
Great Soil Group:	Humic gley.
Principle Profile Form:	Dd4.11, Dy5.11
Surface characteristics:	Soft.
Geology:	Quaternary alluvium (Qa).
Landform:	Swamps.
Vegetation:	12-18 m mid-dense *Melaleuca quinquenervia*.

Depth(m)



A1: Mottled; black (7.5 YR 2/2, 3/2); loam to clay loam; strong <2 mm granular; pH 5.8. Abrupt to clear change to

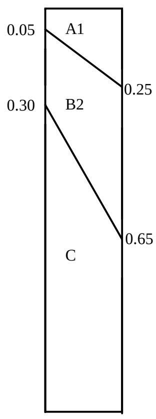
B21: Mottled; black or grey (7.5 YR 2/2, 10 YR 3/2, 4/1); light medium clay to medium clay; strong 2 to 5 mm subangular blocky; pH 5.3 to 5.8. Diffuse change to

B22: Mottled; grey (10 YR 5/2, 6/2); medium clay to heavy clay; strong 2 to 5 mm lenticular; pH 5.5.

BERREN (Be)

Concept:	Very gravelly brown clay soil on basalt.
Australian Classification:	Brown Dermosol.
Great Soil Group:	Prairie Soil.
Principle Profile Form:	Uf6.31.
Surface Characteristics:	Hardsetting or firm with coarse fragments.
Geology:	Tertiary Dundowran Basalt (Tmb).
Landform:	Hillslopes on undulating hills to rolling low hills. Slopes 8 to 30%.
Vegetation:	Cleared.

Depth(m)



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 200 mm; strong 2 to 5m granular; pH 7.0. Clear change to

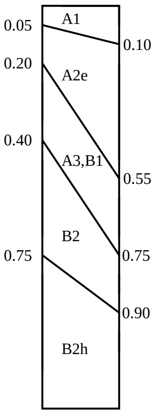
B2: Brown (7.5 YR 3/3, 4/3, 10 YR 3/4); light medium clay to medium clay with 20 to 50% basalt fragments 60 to 200 mm; strong 5 to 10m subangular blocky; pH 6.8 to 7.0. Clear to diffuse change to

C: Rock.

BUNGADOO (Bg)

Concept:	Very stony soil with bleached loamy surface on silicified Maryborough Formation.
Australian Classification:	Brown Dermosol, Grey Dermosol, Yellow Dermosol.
Great Soil Group:	No suitable group, affinities with soloth.
Principle Profile Form:	Gn3.04, Gn3.84.
Surface Characteristics:	Hardsetting with >20% coarse fragments, 20 to 60 mm.
Geology:	Silicified mudstones, siltstones of the Maryborough Formation (Km).
Landform:	Hillslopes on rises and low hills. Slopes 0 to 20%.
Vegetation:	18 to 20 m mid-dense *Corymbia citriodora / Corymbia trachyphloia/ Eucalyptus umbra / Lophostemon confertus*.

Depth(m)



A1: Black or grey (7.5 YR 3/2, 4/2, 10 YR 3/2, 4/2); clay loam; massive or weak <5 mm granular; >20% rock fragments 20 to 60 mm; pH 5.5 to 6.0. Clear change to

A2e: Conspicuously bleached. Clay loam; massive; >20% rock fragments 20 to 60 mm; pH 5 to 5.5. Clear to diffuse change to

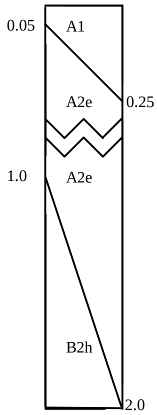
A3, B1: Mottled; grey or brown (7.5 YR 4/4, 5/4, 6/4, 10 YR 4/2, 5/3, 6/3, 6/4, 6/3); light clay; moderate 2 to 5 mm subangular blocky; >20% rock fragments 20 to 60 mm; pH 5 to 5.5. Diffuse change to

B2: Mottled; brown, grey or occasionally yellow (7.5 YR 4/4, 4/6, 5/2, 5/3 10 YR 4/2, 5/3, 6/3, 6/4) frequently becoming paler at depth; medium clay; strong 2 to 10 mm polyhedral or subangular blocky; >20% rock fragments 20 to 60 mm; pH 5 to 5.5. Clear to diffuse change to

C: Silicified sedimentary rock.

BURRUM (Br)

Concept:	Conspicuously bleached sandy surface 1-2m over an acid, black coffee rock pan on old beach ridges.
Australian Classification:	Aquic Podosol.
Great Soil Group:	Podzol.
Principle Profile Form:	Uc2.33.
Surface Characteristics:	Loose.
Geology:	Quaternary coastal beach sands (QPcb).
Landform:	Beach ridge.
Vegetation:	Heath with scattered *Eucalyptus umbra*.



A1: Black (7.5 YR 2/1, 10 YR 2/1, 3/1,); sand; single grain; pH 4 to 6. Clear change to

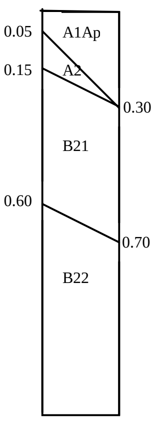
A2e: Conspicuously bleached. Sand; single grain; pH 4 to 7. Clear to diffuse change to

B2h: Black (7.5 YR, 10 YR, 3/1, 3/2, 2/2); sand; massive; coffee rock pan; pH 5.5 to 7.

BUTCHER (Bt)

Concept:	Fine loamy surfaced texture contrast soils with mottled, grey or brown sodic subsoil on alluvial plains.
Australian Classification:	Grey Sodosols, Brown Sodosols.
Great Soil Group:	Soloth, solodic soil.
Principle Profile Form:	Dy3.41, Dy3.42, Dy3.43.
Surface characteristics:	Hardsetting.
Geology:	Quaternary alluvium (Qa).
Landform:	Alluvial plain.
Vegetation:	Cleared.

Depth(m)



A1, Ap: Black or grey (7.5 YR 3/2, 4/2, 10 YR 4/1, 4/2, 5/2); loam fine sandy, clay loam fine sandy or silty clay loam; massive to weak 2 to 5 mm cast; pH 5.5 to 6.5. Clear to abrupt change to

A2e: Conspicuously bleached; mottled; loam fine sandy, clay loam fine sandy or silty clay loam; massive; frequently <2 to 50% manganiferous nodules <6 mm; pH 5.5 to 6.5. Sharp to abrupt change to

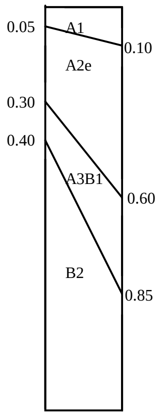
B21: Mottled, grey or brown (7.5 YR 4/2, 5/2, 5/3, 10 YR 4/2, 5/2, 5/3, 5/4, 6/3); light medium clay to medium clay; strong 5 to 20 mm subangular or angular blocky; frequently <2 to 50% manganiferous nodules <6 mm; pH 5.5 to 6.5. Diffuse change to

B22: Mottled; grey or brown (10 YR 4/4, 5/4, 6/1, 6/2, 6/3, 2.5 Y 5/2, 6/3); light medium clay to heavy clay, strong 10 to 20 mm angular blocky or 20 to 50 mm prismatic; pH 5.8 to 8.5.

CLAYTON (Cl)

Concept:	Loamy surface over a acid or neutral, mottled, fine polyhedral structured grey 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.
Surface characteristics:	Hardsetting.
Geology:	Elliott Formation (Te).
Landform:	Level plains.
Vegetation:	12 to 18 m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Corymbia intermedia / Corymbia trachyphloia /Eucalyptus exserta.*

Depth(m)



A1: Grey or occasionally black (7.5 YR 3/2, 4/1, 4/2, 10 YR 5/2, 6/3); 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 6.0. Clear to gradual change to

A3 or B1: Mottled; grey or occasionally yellow (10 YR 6/2, 6/3, 6/4, 7/2,7/3, 7/4, 2.5 Y 6/4, 7/2, 7/4); massive A3 or weak or moderate 2 to 5 mm subangular or polyhedral B1; <2 to 50% ferruginous nodules 2 to 20 mm; pH 5.5 to 6. Clear to gradual change to

B2: Mottled; grey or occasionally yellow (10 YR 6/1, 6/2, 6/3, 6/4, 7/2, 7/4, 2.5 Y 6/4, 7/2, 7/4); light clay to medium heavy clay; strong 2 to 5 mm polyhedral; <2 to 50% ferruginous nodules 2 to 20 mm; pH 5.0 to 8.

CRAGNISH (Cg)

Concept: Bleached surface over a mottled, alkaline, grey or brown clay subsoil on moderately weathered fine grained sedimentary rocks influenced by adjacent basalt.

Australian Classification: Grey Dermosol, Brown Dermosol.

Great Soil Group: Solodic, No Suitable Group.

Principle Profile Form: Dy3.33, Dy3.32, Uf3, Gn3.06, Gn3.03.

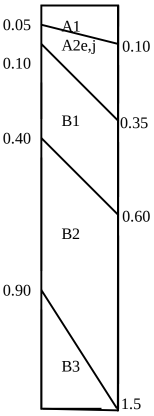
Surface characteristics: Hardsetting.

Geology: Mudstones, siltstones of the Maryborough Formation (Km) adjacent to the Dundowran Basalt (Tmb).

Landform: Level plains to hillslopes on gentle rises.

Vegetation: 15 to 20 m sparse to dense *Eucalyptus tereticornis / Eucalyptus umbra / Eucalyptus moluccana / Lophostemon suaveolens / Corymbia tessellaris / Melaleuca quinquenervia.*

Depth(m)



A1: Black or grey (10 YR 3/2, 4/1, 4/2, 5/2); loam fine sandy, clay loam or light clay, moderate 2 to 5 mm granular to subangular blocky; frequently <2% ferromanganiferious nodules <2 mm; pH 6 to 7. Clear to gradual change to

A2e,j: Conspicuously or sporadically bleached. Loam fine sandy, clay loam or light clay; massive; <2 to 20 % ferromangiferous nodules <6 mm; pH 6 to 8. Clear to gradual change to

B1: Mottled; brown or grey (10 YR 4/3, 4/4, 5/2, 6/2, 2.5 Y 4/2, 4/4, 5/2, 6/2); light clay to medium clay; strong 5 to 20 mm prismatic parting to 2 to 10 mm subangular blocky; pH 6 to 9. Clear to gradual change to

B2: Mottled; grey or brown (10 YR 5/3, 6/3, 2.5 Y 5/2, 5/4, 6/2); medium clay to heavy clay; strong 5 to 50 mm prismatic or strong 2 to 5 mm lenticular; frequently slickensides; occasional rock fragments; pH 6.8 to 9.

B3: Mottled; grey (2.5 YR 5/2, 6/1); medium clay to heavy clay with rock fragments; strong prismatic.

DUINGAL (Dg)

Concept: Sporadically 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.

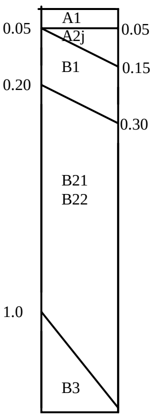
Surface characteristics: Hardsetting.

Geology: Mudstones, siltstones of Maryborough Formation (Km).

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

Vegetation: Cleared.

Depth(m)



Ap: Black (7.5 YR 3/2); light clay to light medium clay, moderate 2 to 10 mm granular or cast; pH 5.0 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 10 mm granular or subangular blocky; pH 5.5 to 6. Abrupt to clear change to

B1: Mottled; grey (7.5 YR 4/2, 5/1, 5/2, 5/3, 10 YR 4/2, 5/3); light medium clay to medium heavy clay; strong 2 to 10 mm subangular blocky; pH 5 to 6. Gradual change to

B21, B22: Mottled; grey or occasionally brown (5 YR 6/2, 7.5 YR 5/2, 5/3, 6/3, 10 YR 5/2, 5/3, 6/2, 6/3, 2.5 Y 5/2, 5/3) usually paler at depth; medium clay to heavy clay; moderate or strong 2 to 5 mm lenticular; frequently slickensides; pH 4.5 to 6. Gradual to diffuse change to

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

DIAMOND (Dm)

Concept: Sands on younger beach ridges.

Australian Classification: Bleached Tenosol, Orthic Tenosol, minor semiaquic Podosol.

Great Soil Group: Earthy sand, minor Podzol.

Principle Profile Form: Uc2.22, Uc2.21, Uc4.21, Uc4.24.

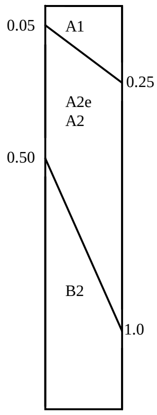
Surface characteristics: Loose with occasional shell fragments.

Geology: Quarternary coastal beach sands (Qhcb).

Landform: Beach ridges.

Vegetation: 12 to 20 m mid-dense *Corymbia intermedia / Angophora costata / Eucalyptus signata / Lophostemon suaveolens.*

Depth(m)



A1: Black or occasionally grey (5 YR, 7.5 YR 2/2, 3/2, 10Y R 4/2); sand to loamy sand; single grain or weak 2 to 5 mm cast; pH 5.5 to 6.5. Clear to gradual change to

A2e; A2: Conspicuously bleached or grey; sand to loamy sand; single grain or massive; pH 5.5 to 6.5. Diffuse change to

B2: Frequently mottled; brown, yellow or occasionally red (5 YR 6/6, 7.5 YR 5/3, 6/8, 10 YR 7/4, 6/6); sand to loamy sand; massive; 20 to 90% ferruginous nodules 6 to 20 mm; pH 6.0 to 6.5.

DUNDOWRAN (Dr)

Concept: Black clay on basalt.

Australian Classification: Grey Dermosol, occasionally Black Dermosol.

Great Soil Group: Prairie soil, Chernozem.

Principle Profile Form: Uf6.41, Uf6.42.

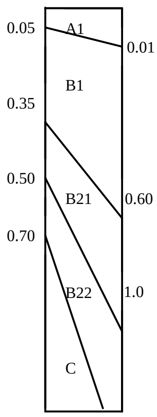
Surface Characteristics: Self mulching, firm.

Geology: Tertiary Dundowran Basalt (Tmb).

Landform: Hillslopes on gentle to undulating rises. Slopes 1 to 8%.

Vegetation: Cleared.

Depth(m)



A1: Black (7.5 YR 2/1, 10 YR 2/1, 3/2); light medium clay to heavy clay; strong <2 to 5 mm granular; pH 6 to 7. Abrupt to gradual change to

B1: Black or occasionally brown or grey (7.5 YR 3/1, 10 YR 2/1, 3/1, 4/1, 2.5 Y 3/1); light medium clay to heavy clay; strong 2 to 10 mm subangular blocky; frequently <10% manganiferous nodules <6 mm; pH 6.5 to 8.5. Clear to gradual change to

B21: Mottled; grey or black (2.5 Y 3/1, 4/2); light medium clay to heavy clay; strong 5 to 10 mm subangular blocky; occasional slickensides; frequently <10% manganiferous nodules <6 mm; pH 7.5 to 9. Gradual to diffuse change to

B22: Mottled; black or grey (2.5 Y 3/1, 4/2); light medium clay to heavy clay; strong <5 mm lenticular; frequently <10% manganiferous nodules <6 mm and occasionally <2% soft carbonate; pH 8 to 9. Clear to diffuse change to

B3: Grey (10 YR 6/2); medium clay with angular basalt fragments; frequently <2% manganiferous nodules <6 mm: pH 8.0 to 9.0.

C: Weathered rock.

FAIRYDALE (Fd)

Concept: Black clay loam surface over a mottled, grey clay over a sandy horizon with pyrite at depth.

Australian Classification: Redoxic hydrosol.

Great Soil Group: Humic gley.

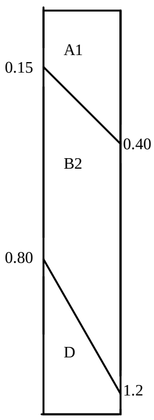
Principle Profile Form: Uf6.41, Gn3.21.

Geology: Quaternary alluvium (Qa), Quaternary coastal sediments (Qc).

Landform: Swamps on marine plains and extratidal flats.

Vegetation: 12 to 20 m mid-dense *Melaleuca quinquenervia* with scattered *Eucalyptus tereticornis* in swamps and *Sporobolis virginicus /Casuarina glauca* on extratidal flats.

Depth(m)



A1: Black (7 YR, 10 YR 2/1, 3/2); clay loam to light clay; strong 2 to 10 mm subangular blocky; pH 4.5 to 7.0. Clear change to

B2: Mottled; grey (7.5 YR, 10 YR 4/1, 4/2, 5/2, 6/1, 6/2); light clay to medium clay; strong 5 to 20 mm subangular blocky to 20 to 50 mm prismatic; frequently <10% sulfurous soft segregation <6 mm; pH 4.5 to 6.0. Gradual change

D: Frequently mottled in the upper horizon; grey or occasionally brown in upper horizon (10 YR 5/3, 8/2, 2.5 Y 5/1, 6/2, 7/2, 7/3); coarse sand to sandy clay loam; pH 4.5 to 6.8

FARNSFIELD (Ff)

Concept: Red, brown or black massive surface over a red, massive clay loam to clay 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.

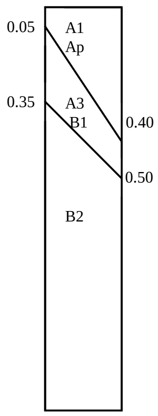
Surface characteristics: Firm to loose.

Geology: Sandstones of the Elliott Formation (Te).

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

Vegetation: Cleared.

Depth(m)



A1,Ap: Red, brown or black (2.5 YR 3/3, 4/2, 4/3, 5 YR 3/2, 4/2, 4/3, 7.5 YR 3/3, 4/3); loamy sand to sandy loam; 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 sandy clay loam; 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 10 mm subangular blocky or polyhedral; pH 5.5 to 7.

GOOBURRUM (Gb)

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

Australian Classification: Red Dermosol, Red Chromosol.

Great Soil Group: Red podzolic soil.

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

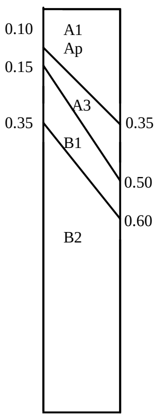
Surface characteristics: Hardsetting to loose.

Geology: Elliott Formatiion (Te).

Landform: Plains and hillslopes on rises.

Vegetation: Mostly cleared.

Depth(m)



A1, Ap: Brown, black or occasionally grey (5 YR 3/2, 4/2, 4/3, 7.5 YR 3/2, 3/3, 4/1, 4/2, 4/3, 10 YR 3/2, 4/1); loamy sand to sandy clay loam; massive; pH 5.5 to 6.5. Clear change to

A2: Occurs in undisturbed soils (minor). Loamy sand to sandy loam; pH 5.5 to 6.5. Abrupt to diffuse change to

A3, B1: Red or brown (2.5 YR 4/3, 4/4, 4/6, 5/6, 5 YR 3/3, 4/3, 4/4, 4/6, 5/6, 7.5 YR 5/4, 5/6, 5/8, 6/4); sandy clay loam to clay loam sandy; massive; pH 5.5 to 6.5. Clear to gradual change to

B2: Red (10 Y 3/6, 4/6, 4/8, 2.5 YR 3/6, 4/6, 4/8, 5 YR 5/6); clay loam sandy, clay loam, sandy light clay, light clay; moderate or strong 2 to 5 polyhedral; pH 5.8 to 7.

GRANVILLE (Gr)

Concept: Sporadically bleached grey clay on alluvial plains of the Mary River.

Australian Classification: Grey Dermosol, Brown Dermosols.

Great Soil Group: No suitable group.

Principle Profile Form: Uf3.

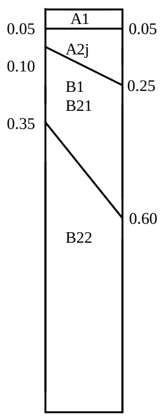
Surface characteristics: Hardsetting, usually with normal gilgai.

Geology: Quaternary alluvium (Qa).

Landform: Alluvial plains.

Vegetation: Cleared.

Depth(m)



A1: Grey (10 YR 4/1, 4/2, 5/2, 6/2); light clay to light medium clay; moderate to strong 2 to 5 mm granular; pH 5.5 to 6.0. Clear change to

A2j: Sporadically bleached; mottled; light clay to light medium clay; moderate to weak 2 to 10 mm subangular blocky; pH 5.5 to 6.0. Clear change to

B1,B2: Mottled; grey or brown (7.5 YR, 10 YR 4/2, 5/2, 5/3); light medium clay to medium clay; strong 2 to 10 mm subangular blocky; pH 5.0 to 6.0. Gradual to diffuse change to

B22: Mottled; grey (7.5 YR 5/1, 5/2, 10 YR 5/2, 6/2, 2.5 Y 6/1, 6/2); medium heavy to heavy clay; strong 2 to 5 mm lenticular; pH 5.0 to 6.5.

ISIS (Is)

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

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

Great Soil Group: Yellow podzolic soil.

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

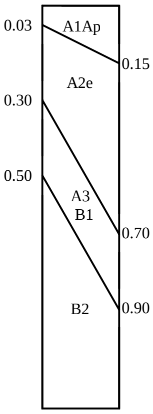
Surface characteristics: Hardsetting or loose.

Geology: Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating rises.

Vegetation: Mostly cleared.

Depth(m)



A1, Ap: Grey or occasionally black (7.5 YR 4/1, 4/2, 5/1, 5/2, 10 YR 3/1, 4/1 4/2, 5/1, 5/2, 5/3, 2.5 Y 5/2, 5/3); sandy loam to fine sandy loam; massive; pH 5.5 to 6. 5. Clear to diffuse change to

A2e: Conspicuously bleached. Sandy loam to fine sandy loam; massive; pH 5.5 to 6.5. Clear to gradual 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 light clay, light clay in the B1; massive or weak 2 to 5 mm polyhedral; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 6.5. Clear to diffuse change to

B2: Mottled; yellow or occasionally brown (5 YR 6/6, 7/5, 10 YR 5/6, 6/4, 6/5, 6/6, 6/8, 7/5, 7/6); light clay to medium clay; moderate or strong 2 to 5 mm polydedral or subangular blocky; frequently ferruginous nodules 2 to 60 mm; pH 5.5 to 6.5.

KALAH (Kh)

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

Australian Classification: Redoxic Hydrosol.

Great Soil Group: Soloth, solodic soil.

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

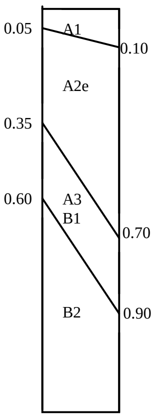
Surface characteristics: Hardsetting.

Geology: Elliott Formation (Te).

Landform: Level plains.

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

Depth(m)



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

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

A3, B1: Frequently occurs. Mottled; grey, brown or occasionally yellow (7.5 YR 4/2, 5/4, 6/2, 6/3, 7/3, 10 YR 4/2, 5/3, 6/3, 7/2, 7/3, 7/4); sandy clay loam, clay loam sandy, sandy clay, light clay; massive or moderate 10 to 20 mm subangular blocky in B1; pH 5.5 to 6. Abrupt to gradual change to

B2: Mottled; grey or occasionally brown (7.5 YR 5/2, 5/3, 6/2, 7/1, 7/2, 10 YR 5/1, 5/2, 5/3, 6/2, 7/2, 2.5 Y 6/2); usually paler at depth; light medium clay to heavy clay; strong 10 to 20 mm angular blocky or 20 to 50 mm prismatic parting to angular blocky; pH 5.5 to 8.

JARO (Jr)

Concept: Black loam to light clay surface over an acid, mottled, grey clay subsoil with sulfurous inclusions (jarosite) on marine plains.

Australian Classification: Redoxic Hydrosol, Extratidal Hydrosol.

Great Soil Group: Humic gley.

Principle Profile Form: Uf6.42, Dy5.11, Uf6.41, Gn3.90.

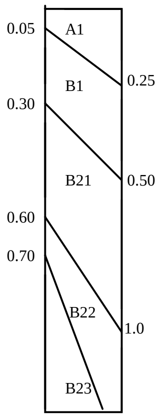
Surface characteristics: Firm or soft.

Geology: Quaternary alluvial (Qa), Quaternary coastal sediments (Qc).

Landform: Swamps on marine plains, extratidal flats.

Vegetation: 12 to 20 m mid-dense *Melaleuca quinquenervia* with scattered *Eucalyptus tereticornis* in swamps and *Sporobolus virginicus / Casuarina glauca* on extratidal flats.

Depth(m)



A1: Mottled; black (5 YR 2/1, 7.5 YR 2/1, 2/2, 2/3, 10 YR 2/1, 3/1, 3/2); loam, clay loam, light clay; moderate to strong 2 to 5 mm granular or subangular blocky; pH 4.5 to 7. Abrupt to clear change to

B1: Mottled; black or grey (7.5 YR 2/1, 2/2, 3/2, 10 YR 2/1, 4/2, 5/2); light clay to medium clay; strong 5 to 10 mm subangular blocky; pH 4.5 to 6. Clear change to

B21: Mottled; grey or occasionally black (7.5 YR 3/2, 4/1, 5/1, 10 YR 4/1, 5/1, 2.5 Y 5/1); light medium clay to heavy clay; strong 5 to 10 mm subangular blocky or occasionally strong 2 to 5 mm lenticular, frequently slickensides; pH 4.5 to 5.0. Clear to diffuse change to

B22: Mottled; grey (7.5 YR 5/1, 10 YR 4/1, 5/1, 2.5 Y 5/1, 6/1); medium clay to heavy clay; strong 2 to 5 mm lenticular or 20 to 50 mm prismatic; frequently slickensides, frequently <10% sulfurous soft segregations <6 mm increasing with depth; pH 4 to 5.5. Gradual to diffuse change to

B23: Grey (10 YR 51, 6/1, 2.5 Y 5/1, 6/1); light clay to heavy clay; strong 10 to 50 mm angular blocky or frequently structureless (wet); pH 3.4 to 6.

KEPNOCK (Kp)

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

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

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

Principle Profile Form: Gn3.84, Gn3.81, Dy3.41.

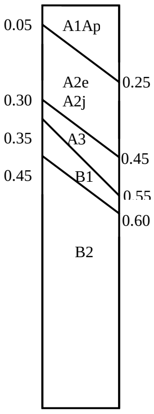
Surface characteristics: Hardsetting.

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.

Depth(m)



A1, Ap: Grey or black (7.5 YR 3/2, 4/1, 4/2, 10 YR 3/2, 4/2, 5/2, 5/3); loam fine sandy, sandy clay loam, clay loam, clay loam fine sandy; massive; pH 5.5 to 6.5. Clear change to

A2e,j: Conspicuously or sporadically bleached. Loam fine sandy, sandy clay loam, clay loam fine sandy; massive; frequently 2 to 50% ferruginous nodules <6 mm; pH 5.5 to 6. Clear to gradual change to

A3: Frequently occurs. Mottled; yellow or brown (10 YR 5/4, 6/4, 6/6); clay loam, clay loam fine sandy; massive or weak 2 to5 mm polyhedral; frequently 2 to 50% ferruginous or ferromanganiferous nodules <20 mm; pH 5.5 to 6.5. Gradual to diffuse change to

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

B2: Mottled; yellow or brown (7.5 YR 6/5, 6/6, 7/6, 10 YR 5/5, 6/5, 6/6, 6/8); light clay to medium clay; moderate or strong 2 to 5 mm polyhedral or subangular blocky; 10 to 50% ferruginous or ferromanganiferous nodules <20 mm; pH5.5 to 6.5.

KOLBORE (Kl)

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

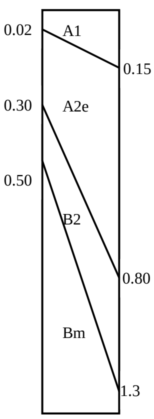
Surface characteristics: Hardsetting.

Geology: Elliott Formation (Te).

Landform: Drainage depressions in level plains, and level plains.

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

Depth(m)



A1: Grey (7.5 YR 4/1, 5/1, 5/2, 5/3 10 YR 4/1 5/2 6/2); 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. Sharp to abrupt 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 light clay to sandy medium clay; strong 10 to 20 mm angular blocky or 20 to 50 mm prismatic or columnar; pH 5.5 to 9. Sharp to clear change to

Bm: Mottled; grey or brown (7.5 YR 6/2, 10 YR 4/3, 5/3, 5/4, 6/2, 6/3, 7/1,7/2, 8/1); very hard, brittle duripan.

KINKUNA (Kn)

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

Australian Classification: Semiaquic Podosol, Aquic Podosol (minor).

Great Soil Group: Podzol.

Principle Profile Form: Uc2.32, Uc 2.33.

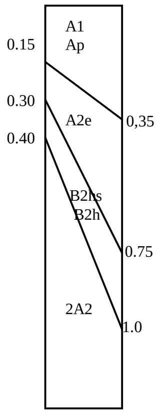
Surface characteristics: Loose.

Geology: Elliott Formation (Te).

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

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

Depth(m)



A1: Black or grey (7.5 YR 2/1, 10 YR 2/1, 3/1, 4/1, 5/1, 5/2, 6/1); sand to loamy sand; single grain; pH 4.0 to 6.0. Clear to diffuse change to

A2e: Conspicuously bleached. Sand; single grain; pH 4.5 to 6. Abrupt to clear change to

B2 hs/h: Brown or black (5 YR, 7.5 YR 3/2, 3/3, 4/3, 4/4, 10 YR 3/3, 4/2); sand to loamy sand; ortstein pan or coffee rock pan; pH 4.5 to 6. Clear to diffuse change to

2A2: 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.

Variant: Colour B2 (no pan).

KOLAN (Ko)

Concept: Strongly acid 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, minor Grey Sodosol.

Great Soil Group: Soloth.

Principle Profile Form: Dy3.41.

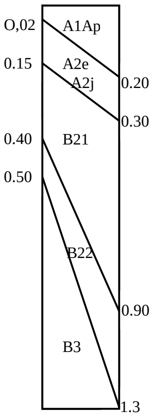
Surface characteristic: Hardsetting.

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

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

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

Depth(m)



A1: Black or grey (7.5 YR 2/2, 3/2, 4/2, 10 YR 3/1,3/2, 4/2); loam fine sandy to clay loam fine sandy; massive to moderate 2 to 5 mm granular; pH 5.0 to 6. Abrupt to clear change to

A2e, j: Occurs in undisturbed soils. Conspicuously or sporadically bleached. Loam fine sandy to clay loam fine sandy, massive; frequently <2 to 50% ferruginous nodules <6 mm; pH 5.5 to 6. Sharp to abrupt change to

B21: Mottled; grey or brown (7.5 YR 4/2, 4/3, 5/2, 5/3, 10 YR 4/2, 5/2, 5/3, 6/2, 6/3); medium clay to heavy clay; strong 2 to 10 mm angular to subangular blocky; frequently 2 to 10% ferruginous nodules <20 mm; pH 4.5 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, 6/1, 6/2); medium clay to heavy clay; strong 5 to 20 mm angular blocky or strong 2 to 5 mm lenticular; occasional 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); medium clay to heavy clay; moderate to strong 5 to 20 mm angular blocky; fragments of mudstone or siltstone; pH 4.5 to 5.5.

Kolan Red Variant KoRv: Red B2 with 20 to 50% grey mottles.
Kolan Rocky Phase KoRp: As above with >20% coarse fragments in the surface.

MAHOGANY (Mh)

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.

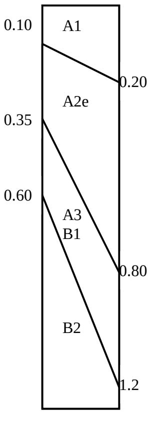
Surface characteristics: Loose or hardsetting.

Geology: Elliott Formation (Te).

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

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

Depth(m)



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 6.5. Diffuse change to

A3, B1: Mottled; grey or yellow (10 YR 6/3, 6/4, 7/3, 7/4, 8/3, 2.5 Y 7/3, 7/4); sandy loam to sandy clay loam; massive; occasionally ferruginous nodules 2 to 20 mm; pH 5 to 7. 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 light clay; massive; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 6.5.

LITTABELLA (Lt)

Concept: Massive, yellow, grey or red sandy loam to sandy clay loam soil on local alluvium.

Australian Classification: Yellow Kandosol, Grey Kandosol, Red Kandosol, Orthic Tenosol, Semi-aquic Podosol.

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

Principle Profile Form: Um5.52, Um4.23, Gn2.71, Gn2.94, Uc5.22, Uc2.3

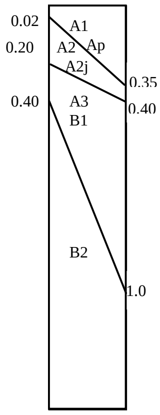
Surface characteristics: Firm or loose.

Geology: Quaternary alluvium (Qa)

Landform: Levees and scrolls on alluvial plains.

Vegetation: Mostly cleared, minor dense scrub.

Depth(m)



A1, Ap: Black or grey (7.5 YR 3/2, 4/2, 10 YR 4/1); sandy loam, fine sandy loam, loam, loam fine sandy; massive or weak 2 to 5 mm cast or granular; pH 5.5 to 6.0.

A2e,j: Occasionally occurs as a colour, sporadically or conspicuously bleached A2. Sandy loam, fine sandy loam, loam fine sandy; massive; pH 5.5 to 6.5. Gradual to diffuse change to

A3, B1: Brown, grey or red (5 YR 5/3, 5/4, 7.5 YR 4/3, 5/4, 10 YR 6/3, 7/5); sandy loam to loam fine sandy; massive; pH 6 to 8. Diffuse change to

B2: Occasionally mottled; yellow, grey or red (5 YR 5/6, 7.5 YR 6/3, 10 YR 6/2, 6/6, 7/1); sandy loam, loam fine sandy, sandy clay loam, clay loam sandy; massive; pH 6 to 8.

MAROOM (Mm)

Concept: Sandy loam to sandy clay loam surfaced texture contrast soil with strongly mottled clay subsoil on marine plains.

Australian Classification: Redoxic Hydrosol.

Great Soil Group: Soloth, solodic soil.

Principle Profile Form: Dy3.41, Dy3.42, Dd2.31.

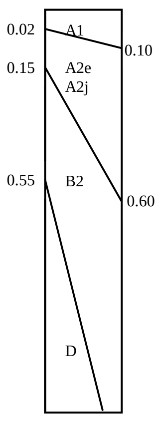
Surface Characteristics: Hardsetting.

Geology: Quaternary coastal deposits (Qhcb).

Landform: Marine plains.

Vegetation: 12 to 20 m mid-dense *Corymbia intermedia / Eucalyptus exserta / Angophora costata / Lophostemon suaveolens / Melaleuca quinquenervia.*

Depth(m)



A1: Black or grey (5 YR 4/1, 7.5 YR 3/1, 3/2, 4/2); sandy loam to sandy clay loam; massive to moderate 2 to 5 mm granular; pH 5.5 to 6.5. Abrupt to clear change to

A2e,j: Conspicuously bleached, occasionally sporadically bleached; Mottled; sandy loam to sandy clay loam; massive; pH 5.5 to 6.5. Abrupt to sharp change to

B2: Mottled (strongly mottled in lower B2); grey or brown or occasionally black, becoming paler in lower B2; (7.5 YR 3/2, 3/3, 4/3, 5/1, 5/3, 6/1, 6/3, 7/1, 8/1, 10 YR 5/2, 5/3, 6/1, 6/2); sandy light clay to sandy medium heavy clay; moderate to strong 10 to 20 mm angular blocky or strong >20 mm prismatic; pH 5.5 to 7.0.

D: Occasionally occurs at depth >0.55 m. Sand or sandy clay loam.

MARY (My)

Concept: Non-sodic brown structured clay on alluvium of the Mary River.

Australian Classification: Brown Dermosol.

Great Soil Group: Brown earth, prairie soil.

Principle Profile Form: Gn3.21, Uf6.33.

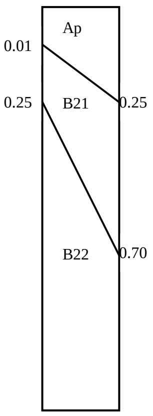
Surface Characteristics: Hardsetting.

Geology: Quaternary alluvium (Qa).

Landform: Alluvial plains.

Vegetation: Cleared.

Depth(m)



Ap: Black or brown (10 YR 3/1, 3/2, 4/3); silty clay loam to silty clay; weak to moderate 2 to 5 mm granular; pH 5.5 to 7. Abrupt to clear change to

B21: Brown (10 YR 4/3, 5/4); light clay to medium clay; moderate to strong 5 to 10 mm subangular blocky or angular blocky; pH 5.5 to 7. Gradual to diffuse change to

B22: Brown (10 YR 4/3, 5/4); medium clay to heavy clay; strong 5 to 10 mm subangular blocky or angular blocky; pH 5.5 to 7.5.

MEADOWVALE (Md)

Concept: Bleached sandy surface over a yellow massive subsoil over a mottled, yellow 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.

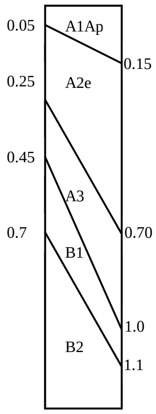
Surface characteristics: Hardsetting or loose.

Geology: Elliott Formation (Te).

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

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

Depth(m)



A1, Ap: Grey (7.5 YR 4/1, 4/2, 5/2, 10 YR 4/1, 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 light clay; massive or weak 2 to 10 mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 6. Clear to diffuse change to

B2: Mottled; yellow or brown (10 YR 5/5, 5/6, 6/4, 6/5, 6/6, 6/8, 7/4, 7/5, 7/6); sandy light clay to medium clay; moderate or strong 2 to 10 mm subangular blocky or polyhedral; frequently ferruginous nodules 2 to 20 mm; pH 5.5 to 5.8.

PEEP (Pp)

Concept: Sodic texture contrast soil on local alluvium.

Australian Classification: Grey Sodosol, Brown Sodosol.

Great Soil Group: Solodic soil, soloth.

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

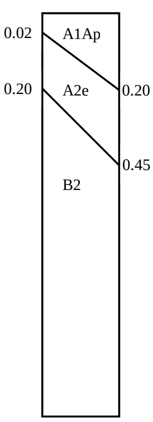
Surface Characteristics: Hardsetting.

Geology: Quarternary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: 15 to 20 m sparse to mid-dense, variable, *Eucalyptus umbra, Angophora costata / Eucalyptus exserta / Melaleuca* species or *Eucalyptus moluccana / Eucalyptus tereticornis.*

Depth(m)



A1, Ap: Grey or black (7.5 YR 3/2, 4/2, 5/1, 5/2, 5/3 10 YR 3/2, 4/2,5/2,5/3, 6/3); 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 6. Abrupt to clear change to

B21: Mottled; grey or brown (7.5 YR 4/2, 5/2, 5/3, 6/2, 6/3, 10 YR 4/2, 5/1, 5/2, 5/3, 6/2, 6/3, 7/1, 7/2); light medium clay to medium heavy clay; moderate or strong 5 to 20 mm angular blocky or 20 to 50 mm prismatic parting to angular blocky; pH 5.5 to 8.

QUART (Qr)

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.

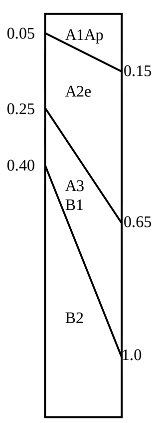
Surface Characteristics: Loose.

Geology: Sandstones of the Elliott Formation (Te).

Landform: Level plains to hillslopes on gently undulating rises. Slopes 0 to 4%.

Vegetation: Mostly cleared.

Depth(m)



A1, Ap: Grey or occasionally black (7.5 YR, 10 YR 2/1, 4/1, 4/2, 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 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, 2.5 Y 7/6); sandy loam, light sandy clay loam, sandy clay loam, clay loam sandy; massive; pH 5.5 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, 8/4, 8/6. 2.5 Y 7/4, 7/5); sandy clay loam, clay loam sandy, clay loam; massive; frequently ferruginous nodules 2 to 20 mm; pH 5.5

ROBUR (Rb)

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, Grey Sodosol.

Great Soil Group: Soloth, minor solodic soil.

Principle Profile Form: Dy3.41, Dg2.41, Dg2.42, Dy5.41, Dg 4.41.

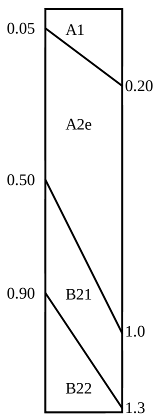
Surface Characteristics: Hardsetting or Loose.

Geology: Elliott Formation (Te).

Landform: Level plains and hillslopes on gently undulating rises. Slopes 0 to 8%.

Vegetation: 10 to 18 m sparse to mid-dense *Eucalyptus umbra, Melaleuca viridiflora / Corymbia trachyphloia,* frequently with an understory of *Banksia oblongifolia / Banksia robur.*

Depth(m)



A1: Grey (7.5 YR 4/1, 4/2, 5/1, 5/2, 10 YR 4/1, 4/2, 5/1, 5/2, 5/4, 6/2); loamy sand to sandy loam, massive; pH 5.5 to 6.0. 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 6/1,6/2, 6/3, 7/2,7/1,7/3); sandy light clay to medium heavy clay; moderate or strong 10 to 50 mm angular blocky or prismatic; frequently <2 to 20% ferruginous nodules 2 to 20 mm; 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, 8/1, 2.5 Y 7/1); sandy light medium clay to heavy clay; strong 10 to 20 mm angular blocky or 20 to 50 mm prismatic parting to 10 to 20 mm angular blocky; occasional slickensides; frequently 2 to 50% ferruginous nodules 2 to 20 mm; pH 4.7 to 7.5.

TANDORA (Tn)

Concept: Black clay loam to clay surface over a strongly acid to neutral, mottled, grey medium to heavy clay on old marine plains.

Australian Classification: Redoxic Hydrosol.

Great Soil Group: Humic gley.

Principle Profile Form: Uf6.41, Dy5.11, Dy3.11, Gn3.91.

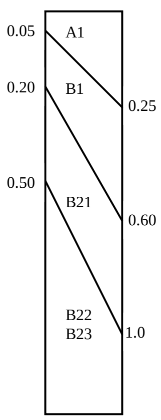
Surface characteristics: Hardsetting or firm.

Geology: Quaternary coastal sediments (Qc).

Landform: Marine plains.

Vegetation: 12 to 20 m mid-dense *Melaleuca quinquenervia / Eucalyptus tereticornis / Lophostemon suaveolens / Corymbia intermedia.*

Depth(m)



A1: Mottled; black (7.5 YR 2/1, 3/2, 10 YR 2/1, 2/2, 3/1); clay loam to light medium clay; moderate to strong 2 to 5 mm subangular blocky or granular; pH 4.5 to 7. Abrupt to clear change to

B1: Mottled; grey or occasionally black or brown (7.5YR 3/2, 4/2, 5/1, 10YR 3/1, 4/2, 5/2, 5/3); light clay to medium clay; strong 5 to 10 mm subangular blocky or 20 to 50 mm prismatic; occasional slickensides; pH 5 to 7. Clear to gradual change to

B21: Mottled; grey (10 YR 4/2, 5/2, 2.5 Y 5/2); medium clay to heavy clay; 5 to 10 mm subangular blocky or strong 20 to 50 mm prismatic parting to angular blocky; occasional slickensides; pH 4.5 to 7. Diffuse change to

B22, B23: Mottled; grey (7.5 YR 5/1, 10 YR 4/1, 5/1, 5/2, 2.5 Y 5/2, 6/1); medium heavy clay to heavy clay; strong 2 to 5 mm lenticular or 20 to 50 mm prismatic; frequently slickensides; pH 4.5 to 7.

TAKOKO (Tk)

Concept: Bleached clay loam on Silicified Maryborough formation.

Australian Classification: Bleached Tenosol.

Great Soil Group: No suitable group, affinities with (bleached) lithosol.

Principle Profile Form: No provision.

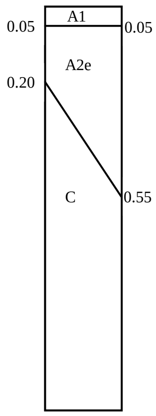
Surface Characteristics: Hardsetting with >20% coarse fragments 60 to 600 mm.

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

Landform: Hillslopes and hillcrests on rises and low hills. Slopes 0 to 10%.

Vegetation: 18 to 20 m mid-dense *Corymbia citriodora / Corymbia trachyphloia / Eucalyptus umbia / Lophostemon confertus*

Depth(m)



A1: Black or grey (7.5 YR 3/2, 4/2, 5/3); clay loam; massive or weak 2 to 5 mm 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 5.0 to 5.5. Clear to gradual change to

C: Silicified rocks.

THEODOLITE (Th)

Concept: Bleached sand over a brown sand B2 horizon over a sodic structured clay on sandstones.

Australian Classification: Aquic Podosol over a Redoxic Hydrosol.

Great Soil Group: Podzol.

Principle Profile Form: Uc2.21, Uc2.23, Uc2.32, Uc2.34.

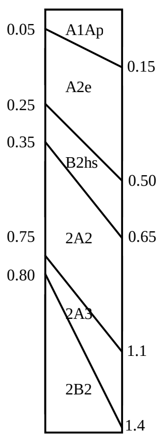
Surface Characteristics: Loose.

Geology: Elliott Formation (Te)

Landform: Level plains.

Vegetation: 3 to 6 m very sparse to sparse *Eucalyptus umbra* with an understory of heath or 1 to 3 m mid-dense to dense *Melaleuca nodosa* mixed with heath species.

Depth(m)



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

A2e: Conspicuously bleached. Sand to loamy sand; single grain; pH 4.5 to 5.5. Clear change to

B2 hs/h: Brown or occasionally grey with brown or yellow mottle (7.5 YR 4/3, 5/3, 5/4, 10 YR 4/2, 4/3, 5/3, 6/3, 7/1); sand to loamy sand; single grain; occasionally ortstein pan; pH 5 to 6. Clear to gradual change to

2A2: Conspicuously bleached; sand to sandy loam; massive or occasionally single grain; pH 4.8 to 6. Clear to diffuse change to

2A3: Mottled; grey or occasionally yellow (7.5 YR 7/3, 10 YR 6/4, 7/1, 7/2, 7/4, 8/2, 2.5 Y 7/2, 8/2); sandy loam to sandy clay loam; massive; pH 5 to 6.2. 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 8/2); sandy light clay to sandy medium clay; moderate >20 mm angular blocky or prismatic; pH 5 to 6.

TIRROAN (Tr)

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.

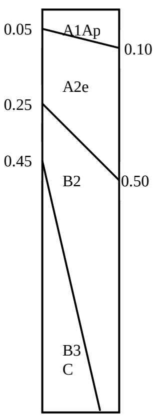
Surface Characteristics: Hardsetting.

Geology: Sandstones of the Elliott Formation (Te).

Landform: Hillslopes on undulating rises and low hills.

Vegetation: 18 to 22 m mid-dense, variable, *Eucalyptus acmenoides, Corymbia trachyphloia / Eucalyptus umbra / Eucalyptus exserta / Corymbia intermedia/ Corymbia citriodora / Angophora costata.*

Depth(m)



A1, Ap: Black or grey (7.5 YR 3/2, 4/2, 10 YR 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 (7.5 YR 4/2, 5/2, 6/1, 6/2 10 YR 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 50 mm prismatic or angular blocky; pH 5.5 to 6.0 rarely up to 8.0. Abrupt to gradual to change to

B3 or C: Mottled; grey (7.5 YR 5/1, 5/2, 5/3, 6/1, 6/3, 2.5 Y 6/2); sandy light medium clay to medium clay with sandstone fragments, strong 10 to 20 mm angular blocky; pH 5.5 to 6.0; or weathered rock.

TOOGUM (To)

Concept: Bleached sand over an acid to neutral brown sand on younger beach ridges.

Australian Classification: Aquic Podosol.

Great Soil Group: Podozol.

Principle Profile Form: Uc2.21, Uc2.22.

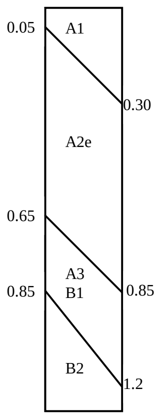
Surface Chartacteristics: Loose.

Geology: Quaternary coastal beach sands (Qhcb).

Landform: Beach ridges.

Vegetation: 12 to 20 m mid-dense *Eucalyptus exserta / Eucalyptus robusta / Meleluca quinquenervia.*

Depth(m)



A1: Grey or black (7.5 YR 3/1, 4/1, 10 YR 2/1, 3/3, 4/1); sand; massive or single grain; pH 4.5 to 7. Clear change to

A2e: Conspicuously bleached. Sand; single grain; pH 5.5 to 7. Gradual to diffuse change to

A3, B1: Grey or occasionally brown (7.5 YR 6/2, 10 YR 5/3, 6/1, 7/2); sand; single grain; pH 4.0 to 6.0. Clear to gradual change to

B2h: Brown or brown mottled grey (7.5 YR 5/4, 10 YR 3/3, 5/3, 6/2, 6/4, 2.5 Y 5/6); sand; single grain; pH 5.5 to 8.0.

TURPIN (Tp)

Concept: Sodic texture contrast soil with a thick (0.25 to 0.5 m) sandy surface containing ferruginous (maghemite) nodules over a grey clay 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.

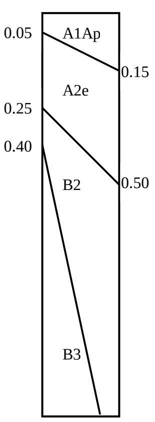
Surface Characteristics: Hardsetting frequently with >10% ferruginous nodules 2 to 6 mm.

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: Hillslopes on gently undulating to undulating rises. Slopes 2 to 12%.

Vegetation: 12 to 18 m mid-dense *Eucalyptus umbra, Angophora cosata /Corymbia trachyphloia / Corymbia intermedia / Eucalyptus exserta/ Melaleuca viridiflora.*

Depth(m)



A1, Ap: Grey or occasionally black (7.5 YR 3/2, 4/2 10 YR 4/1, 4/2, 5/2, 6/3); loamy sand to sandy loam; massive; pH 5.5 to 6.0. Clear to gradual change to

A2e: Conspicuously bleached. Mottled; loamy sand to sandy loam; massive; frequently <2 to 50% ferruginous (maghemite) nodules in lower A2, <20 mm. 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 10 mm angular blocky or strong 20 to 50 mm prismatic; frequently <2 to 50% ferruginous (maghemite) nodules <20 mm, 2 to 20% nodules usually in upper B; pH 5.3 to 6.0. Clear to diffuse change to

B3: Mottled; grey (7.5 YR 5/2, 6/1, 6/2, 10 YR 6/1, 6/2, 7/1, 7/2, 8/1, 8/2); clay with rock fragments.

WALKER (Wk)

Concept: Black clay loam to clay surface over a mottled, grey clay subsoil on alluvium of the Mary River.

Australian Classification: Redoxic Hydrosol, Black Dermosol.

Great Soil Group: Humic gley.

Principle Profile Form: Gn3.91, Gn3.92, Uf6.41

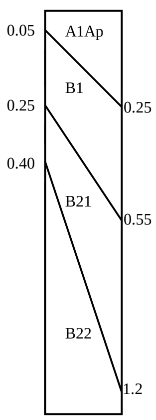
Surface Characteristics: Hardsetting.

Geology: Quaternary alluvium (Qa).

Landform: Alluvial plains.

Vegetation: Cleared.

Depth(m)



A1, Ap: Black or occasionally grey (7.5 YR 2/2, 3/2, 4/2, 10 YR 3/2); silty clay loam to light medium clay; moderate to strong 2 to 5 mm granular or subangular blocky; pH 6 to 6.5. Clear to abrupt change to

B1: Brown mottled, black or occasionally grey (7.5 YR 2/2, 3/1, 3/2, 10 YR 3/2, 2.5 Y 4/1); light medium clay to medium clay; strong 2 to 10 mm subangular blocky; pH 5.7 to 7. Gradual to diffuse change to

B21: Brown mottled; grey or occasionally black (7.5 YR 2/2, 4/2 10 YR 3/2, 4/1, 4/2); light medium clay to heavy clay; strong 2 to 10 mm subangular blocky; pH 5.7 to 7. Gradual to diffuse change to

B22: Brown mottled; grey (10 YR 5/1, 5/2, 6/2, 2.5 Y 4/1, 5/1); medium clay to heavy clay; strong 2 to 5 mm subangular blocky or lenticular; pH 5.5 to 7.

WALLUM (Wm)

Concept: Bleached sand over a brown sand B2 horizon (occasionally a ortstein pan) over a massive sandy clay loam to sandy clay on sandstones.

Australian Classification: Aquic Podosol over a Redoxic Hydrosol.

Great Soil Group: (Rudimentary) podzol, podzol.

Principle Profile Form: Uc2.21, Uc2.23, Uc2.22, Uc2.32.

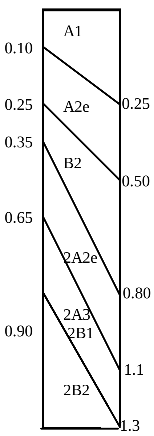
Surface Characteristics: Loose.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 3 to 12 m mid-dense to isolated *Eucalyptus umbra* with an understory of heath or 12 to 20 m sparse to mid-dense *Eucalyptus acmenoides / Eucalyptus umbra / Corymbia intermedia.*

Depth(m)



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 gradual change

A2e: Conspicuously bleach. 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

2A2: 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 light clay; massive; pH 5 to 6.

WINFIELD (Wf)

Concept: Bleached, massive grey sand on deeply weathered coarse grained sedimentary rocks.

Australian Classification: Redoxic Hydrosol.

Great Soil Group: (Bleached) earthy sand.

Principle Profile Form: Uc2.23, Uc2.22.

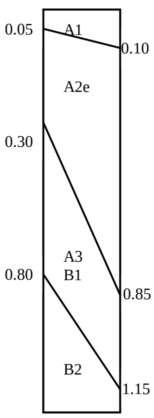
Surface Characteristics: Loose.

Geology: Elliott Formation (Te).

Landform: Level plains.

Vegetation: 10 to 18 m mid-dense *Eucalyptus umbra / Corymbia trachyphloia / Corymbia 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 (7.5 YR 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 (7.5 YR 6/3, 10 YR 7/2, 8/3); loamy sand to sandy loam; massive; frequently <50% ferromanganiferous nodules 2 to 20 mm; pH 5.5 to 6.

Winfield Yellow Variant: Yellow B2 (10 YR 7/4, 7/6).
Winfield Red Variant: Pale A2, red B2 (5 YR 4/6).

WATALGAN (Wt)

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, Gn3.11p, Dr2.21.

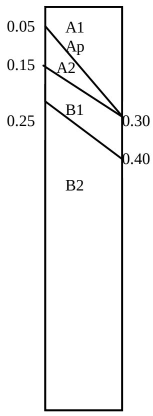
Surface Characteristics: Hardsetting frequently with >10% ferruginous nodules 2 to 6 mm.

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

Landform: Level plains to hillcrests of rises and low hills.

Vegetation: Mostly cleared. Minor 8 to 25 m mid-dense *Corymbia 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, 10 YR 2/2, 2/3, 4/3, 4/4); clay loam; weak to strong 1 to 6 mm granular or cast; <2% to >50% ferruginous nodules <20 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, 10 YR 4/3, 4/4); clay loam, weak or moderate 2 to 5 mm granular or subangular blocky; <2% to >50% ferruginous nodules <20 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, 5/4, 6/3); light clay; moderate or strong 2 to 6 mm subangular blocky or polyhedral; <2% to >50% ferruginous nodules <20 mm; pH 5.5 to 6. Gradual to diffuse change to

B2: Red (10 R 3/6, 4/4, 4/6, 2.5 YR 3/4, 3/6, 4/4, 4/6, 4/8, 5 YR 4/6, 4/8); light clay to medium clay; strong 2 to 5 mm polyhedral; <2% to 50% ferruginous nodules <20 mm; pH 5.5 to 6.3.

WOCO (Wo)

Concept: Bleached 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.

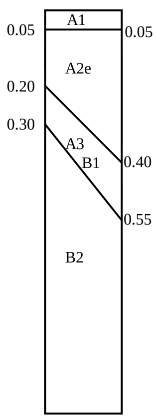
Surface Characteristics: Hardsetting.

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 18 m mid-dense *Eucalyptus umbra / Melaleuca viridiflora / Corymbia intermedia / Lophostemon suaveolens.*

Depth(m)



A1: Grey or black (7.5 YR 3/2, 4/2, 10 YR 3/2, 4/2, 5/3); loam fine sandy to clay loam; 2 to 5 mm 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 5 mm granular; pH 5.5 to 6.0. Clear to gradual change to

A3, B1: Mottled; brown, grey or yellow (7.5 YR 4/3, 5/3, 6/4, 10 YR 5/4, 6/4, 7/3); clay loam to light clay; 2 to 50% ferruginous (maghemite) nodules <2 to 6 mm; weak or moderate 2 to 5 mm subangular blocky or polyhedral; pH 5.0 to 6.0. Clear to diffuse change to

B2: Mottled; grey or brown (10 YR 4/2, 4/3, 5/2, 5/4 6/3, 7/1, 7/3); light clay to medium clay; strong to 2 to 5 mm polyhedral or subangular blocky; 10 to 50% ferruginous (maghemite) nodules <2 to 6 mm; pH 5 to 5.5.

WOOBER (Wb)

Concept: Bleached non-cracking clay on local alluvial plains.

Australian Classification: Redoxic Hydrosol.

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

Principle Profile Form: Uf2, Uf3, Gn3.04, Gn3.05.

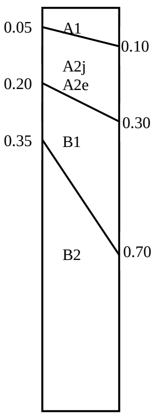
Surface Characteristics: Hardsetting.

Geology: Quartnary alluvium (Qa).

Landform: Alluvial plain.

Vegetation: 12 to 20 m mid-dense to dense *Eucalyptus tereticornis / Melaleuca quinquenervia / Eucalyptus umbra / Lophostemon suaveolens.*

Depth(m)



A1: Black or grey (7.5 YR 2/1, 3/2, 4/2, 10 YR 2/1,3/2, 4/2, 5/2); silty loam, clay loam, silty clay to light medium clay; massive or weak 2 to 5 mm cast or granular; pH 5.0 to 6.5. Clear change to

A2 j,e: Sporadically or conspicuously bleached; Mottled; silty loam, clay loam, silty clay, light medium clay; massive; pH 5.5 to 6.0. Clear change to

B1: Mottled; grey (7.5 YR, 10 YR 5/2, 6/1, 6/2); light clay to light medium clay; moderate 10 to 20 mm angular blocky; pH 5.0 to 6.0. Clear to gradual change to

B2: Mottled; grey (7.5 YR 5/1, 5/2, 6/2, 10 YR 5/1, 6/2); light medium clay to medium heavy clay; strong 10 to 50 mm angular blocky or prismatic; occasional slickensides; pH 5.5 to 7.0.

WOOLMER (Wr)

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.

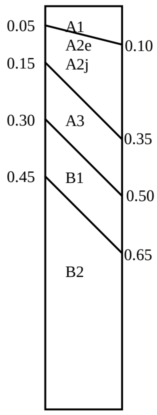
Surface Characteristics: Hardsetting.

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 18 m mid-dense *Eucalyptus umbra, Corymbia trachyphloia / Corymbia intermedia.*

Depth(m)



A1: Grey (7.5 YR 4/1, 4/2, 10 YR 4/2, 4/3); 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 clay loam fine sandy; massive; <2 to 20% ferruginous (maghemite) nodules <20 mm; 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 6 mm polyhedral on subangular blocky; 2 to 50% ferruginous (maghemite) nodules <20 mm; 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 5 mm polyhedral; 10 to 50% ferruginous nodules <20 mm; pH 5 to 5.8.

Appendix II

A key to the soils of the Maryborough - Hervey Bay study area.

In classifying the soil profile, it is necessary to identify various horizons and materials. All terms used in the key are consistent with those defined in the Australian Soil and Land Survey Field Handbook (Mcdonald *et. al.*, 1990) or else as defined in the glossary at end of key (indicated by *).

To identify a soil at any site, the following procedure should be adopted:

1. Work successively through the key stepwise and select the first Australian classification order (uppercase, bold, eg. **PODOSOL**) that apparently includes the soil being studied, checking out definition in the Glossary as needed.
2. Then select the appropriate geomorphology/geology unit.
3. Then select the horizon attributes that best describes the soil.

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

⇒ **PODOSOLS**

••• Soils on beach ridges………….........	•• Sandy A horizon <1m over a brown sand (no pan)..................	• **Toogum** (To)
	•• A horizon >1 m over a black Bh pan horizon …...........	• **Burrum** (Br)
••• Soils on deeply weathered sedimentary rocks……………..…..	•• A Bhs, Bh horizon over sand…..	• **Kinkuna** (Kn)
	•• A Bhs, Bh horizon over yellow sand..............................…	• **Wallum** (Wm)
	•• A Bhs, Bh horizon over a 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 moderately weathered sedimentary rocks	•• Acid grey or brown B horizon……………………..	• **Duingal** (Dg)

****

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....................	• Massive sandy clay loam to sandy light clay B horizon......................	• **Mahogany** (Mh)
		• Structured, non sodic clay B horizon..............	• **Alloway** (Al)
		• Structured, sodic clay B horizon - Clay > 0.5m	• **Robur** (Rb)
		- Clay < 0.5m with iron (maghemite) nodules.....	• **Turpin** (Tp)
	•• Loamy* surface....................	• Structured, non sodic clay B horizon..............	• **Clayton** (Cl)
		• Structured, sodic clay B horizon - no pan in profile..........	• **Kalah** (Kh)
		- duripan at <1.2m.........	• **Kolbore** (Kl)
	•• Loamy* surface with iron (maghemite) nodules.................	• Coarse structured (>5 mm) very firm to strong consistence (≥4) sodic clay B horizon..............	• **Avondale** (Av)
		• Fine structured (<5 mm) friable (consistence <3) sodic clay B horizon..	• **Woco** (Wo)
••• Soils on alluvium...	•• Along the Mary River……..	•Black loamy to clay surface over an acid, yellow and red mottled, grey clay........................	• **Beaver** (Bv)
		• Black or grey loam to clay surface over a acid to neutral, brown mottled, grey clay........	• **Walker** (Wk)
	•• Along local creeks................	• Loamy or clayey bleached surface gradually changing to mottled grey sodic clay at depth........................	• **Woober** (Wb)
••• Soils on marine plains………………....	•• Jarosite or pyrite* present..	• Sandy subsoil................	• **Fairydale** (Fd)
		• Clay subsoil..................	• **Jaro** (Jr)

	•• No jarosite* or pyrite*..............	• Sandy surface over clay subsoil..........................	• **Maroom** (Mm)
		• Loam to clay surface over clay subsoil...........	• **Tandora** (Tn)

****

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

⇒ KUROSOLS

••• Soils on moderately weathered sedimentary rocks…...	•• Red mottled grey or brown clay B horizon............................	• No rock at <0.3 m.........	• **Kolan** (Ko)
		• Rock at <0.3m..............	• **Kolan rocky phase** (KoRp)
	•• 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 (5-20 mm) very firm to strong consistence (≥4) clay B horizon.............	• **Avondale** (Av)
		• Fine structured (<5 m) friable (consistence ≥3) clay B horizon.............	• **Woco** (Wo)

****

E. Soils with a clear* or abrupt* textural B horizon in which the pH is $\geq$ 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 on moderately weathered sedimentary rocks..….	•• Sandy* A horizons…….........		• **Tirroan** (Tr)
••• Soils on deeply weathered sedimentary rocks..............….........	•• Sandy* A horizon..........….	• A horizon >0.5 m..........	• **Robur** (Rb)
		• A horizon <0.5 m with iron (maghemite) nodules........................	• **Turpin** (Tp)

••• Soils on deeply weathered sedimentary rocks............................	•• Loamy* A horizon with iron (maghemite) nodules..................	• Rock at >0.3m..............	• **Avondale** (Av)
		• Rock at <0.3m..............	• **Avondale rocky phase** (AvRp)
••• Soils on alluvium	•• Along Mary River…....…….	• Mottled grey or brown B horizon....................	• **Butcher** (Bt)
	•• 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 ≥ 5.5 in the major part of the upper 0.2 m of the B2 horizon.

⇒ CHROMOSOLS

••• Soils on deeply weathered sedimentary rocks………………….	•• Sandy* A horizon.................	• Red B horizon..............	• **Gooburrum** (Gb)
		• Mottled, yellow or brown B horizon…...…	• **Isis** (Is)
	•• Loamy* A horizon................	• Mottled, yellow or brown B horizon...........	• **Kepnock** (Kp)

****

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

⇒ DERMOSOLS

••• Soils on basalt.…...	•• Neutral brown B horizon with basalt fragments.................		• B**erren** (Be)
	•• Neutral to alkaline mottled black or grey B horizon..............		• **Dundowran** (Dr)
••• Soils on deeply weathered sedimentary rocks............................	•• Sandy* surface.........……….	• Red, B horizon.............	• **Gooburrum** (Gb)
		• Mottled, yellow or brown B horizon...........	• **Isis** (Is)
		• Yellow massive thick A3 horizon >0.3m over mottled. yellow B horizon.........................	• **Meadowvale** (Md)
		• Mottled, grey, non sodic clay B horizon......	• **Alloway** (Al)

	•• Loamy* surface ………..	• Red B horizon..............	• **Watalgan** (Wt)
		• Yellow massive A3 horizon >0.3m thick over mottled, yellow or brown B horizon..........	• **Woolmer** (Wr)
		• Mottled, yellow non sodic clay upper B horizon over sodic lower B........................	• **Avondale Yellow Variant** (AvYv)
		• Mottled, yellow or brown B horizon..........	• **Kepnock** (Kp)
		• Strongly acidic (pH<5.5) fine structured (<5 mm) friable, (consistence ≤3) mottled, grey or brown sodic B horizon............	• **Woco** (Wo)
		• Mottled, neutral to alkaline grey or brown sodic B horizons...........	• **Craignish (Cg)**
		• Mottled, brown, grey or yellow B horizon with silicified rock from Maryborough Formation	• **Bungadoo** (Bg)
••• Soils on alluvium...	•• Along Mary River ………..	• Red clay B horizon........	• **Aldershot** (Ad)
		• Brown B horizon..........	• **Mary** (My)
		• Black or grey loam to clay surface over a acid to neutral, brown mottled, grey clay.........	• **Walker** (Wk)
		• Sporadically bleached, mottled, grey or brown clay...............................	• **Granville** (Gr)

****

H. 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………………….	•• Grey B horizon……….........		• **Mahogany** (Mh)
	•• Yellow B horizon……….….....		• **Quart** (Qr)
••• Soils on local alluvium………	•• Yellow, grey or red B horizon		• **Littabella** (Lt)

I. Other soils with only weak* pelodological organization apart from the A horizons

⇒ TENOSOLS

••• Soils on deeply weathered sedimentary rocks…………………	•• Loamy* surface with a bleached A2 horizon………	• Silicified rock from Maryborough Formation throughout profile...........................	• **Takoko** (Tk)
		• A2 over other rocks.......	• **Avondale tenic variant** (AvTv)
••• Soils on beach ridges..........................	•• Brown, yellow or red sand B horizon......................................		• **Diamond** (Dm)
••• Soils on local alluvium....................... .	•• Yellow, grey or red B horizon......................................		• **Littabella** (Lt)

****

Glossary

Bh horizons. Organic-aluminum compounds are strongly dominant with little or no evidence of iron compounds.

Bhs horizons. Iron and organic compounds are both present.

Clear or abrupt textural B horizons. The boundary between the horizon and the overlying horizon is clear, abrupt or sharp and is followed by a clay increase (usually 20% increase) giving a strong texture contrast.

ESP. Exchangeable sodium percentage (exch Na/CEC x 100%)

Jarosite. A sulfurous segregation.

Lenticular peds. Lense shaped peds.

Loamy. Soil textures of fine sandy loam to clay loam fine sandy.

Massive. A soil appears as a coherent or solid mass which is largely devoid of peds.

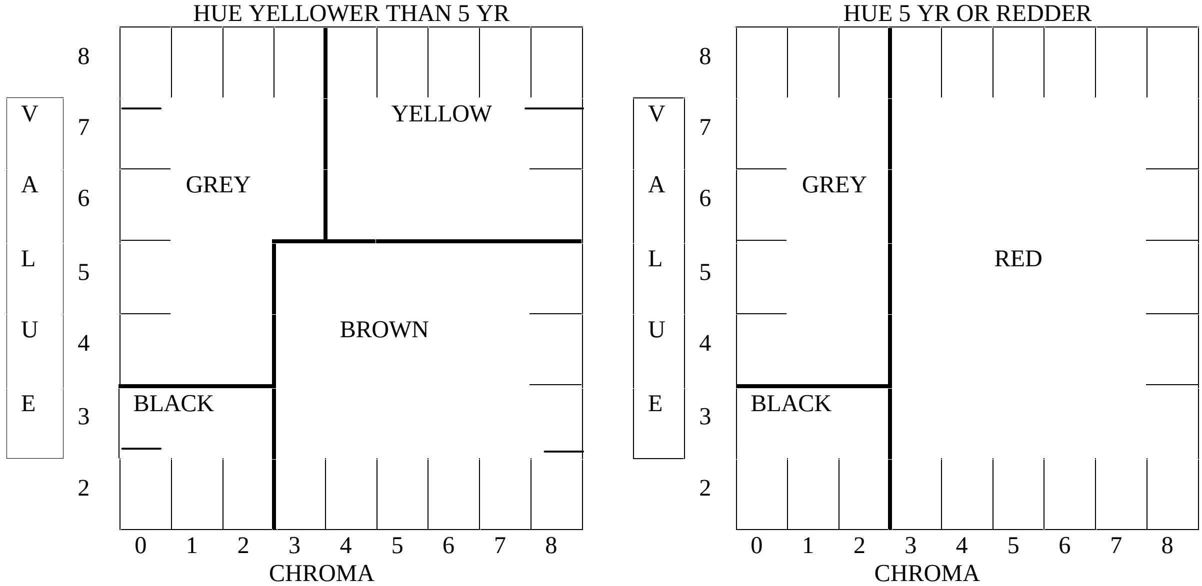
Pyrite. Iron sulfide material (FeS_2)

Sandy. Soil textures of sand, loamy sand to sandy loam.

Slickensides. Polished and grooved surfaces that are produced by one mass sliding past another.

Weak grade of structure. Peds are indistinct and when disturbed less than one-third of the soil material is found to consist of peds.

Soil colour class limits.



Appendix III

Morphological and analytical data

Soil Type: Toogum (Tg)
Site No: 43
A.M.G. Reference: 469 483 mE 7 205 798 mN Zone 56
Great Soil Group: Podzol
Principal Profile Form: Uc2.21
Type of microrelief: No microrelief
Profile morphology:
Condition of surface soil when dry: Loose

Slope: 2 %
Landform Element Type: Beach ridge
Landform Pattern Type: Level plain
Vegetation: Cleared

Horizon	**Depth**	**Description**
AP	0 to 0.20 m	Black (7 YR 3/1); no mottles; single grain; moderately moist; very weak. Abrupt to
A1	0.20 to 0.30 m	Grey (10 YR 4/1); no mottles; single grain; moderately moist; very weak. Abrupt to
A21	0.30 to 0.75 m	Grey (10 YR 6/4); few faint yellow mottles; single grain; moist; very weak. Clear to
A22	0.75 to 0.85 m	Yellowish (10 YR 6/3); no mottles; single grain; moderately moist; very weak. Clear to
A3	0.85 to 1.05 m	Grey (10 YR 7/2); common faint yellow mottles; single grain; moist; very weak. Clear to
B1	1.05 to 1.15 m	Grey (10 YR 7/2); common faint brown mottles, yellow mottles; single grain; moist; very weak. Gradual to
B2	1.15 to 1.50 m	Yellowish (10 YR 6/4); many faint brown mottles, yellow mottles; single grain; wet; very weak.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
		mS/cm	%	%	%	%	%	%			meq%					%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5	0.01	BQ						1	0.57	0.2	0.03	0.05	0.1	0.3						3.8
0-0.10	5.4	0.01	BQ	0.1	7	90	1	4	1	0.61	0.71	0.01	0.06	0.1	0.1	1	0.1	0.01	0.067	0.012	4.1
0.10-0.20	5.1	0.01	BQ						1	0.45	0.52	BQ	0.06	0.1	0.2						3.9
0.20-0.30	5	0.01	BQ	0.1	6	92	BQ	4	1	0.28	0.32	BQ	0.05	0.2	0.3	1	0.1	0	0.065	0.01	3.8
0.30-0.40	5.7	0.01	BQ						1	0.15	0.13	BQ	0.03	0.1	0.2						3.9
0.40-0.50	5	0.01	BQ						BQ	0.06	0.19	BQ	0.02	0.2	0.2						4.1
0.50-0.60	5.1	0	BQ	0.01	4	95	1	1	1	0.08	0.12	0.02	0.02	0.2	0.3	BQ	0.1	0	0.061	0.007	4.2
0.60-0.70	5.1	0.01	BQ						1	0.06	0.6	BQ	0.02	0.3	0.4						4.2
0.70-0.80	5.1	0.01	BQ						1	0.04	0.47	BQ	0.03	0.4	0.4						4.2
0.80-0.90	5.2	0.01	BQ	0.15	11	88	BQ	3	1	0.03	0.21	BQ	0.03	0.3	0.3	BQ	0.1	0	0.067	0.008	4.3
0.90-1.00	5.3	0.01	BQ						1	0.04	0.07	BQ	0.03	0.3	0.4						4.3
1.00-1.10	5.4	0.01	BQ						1	0.03	0.31	BQ	0.03	0.3	0.3						4.4
1.10-1.20	5.4	0.01	BQ	0.01	16	83	1	1	1	0.02	0.26	BQ	0.02	0.2	0.2			0	0.03	0.007	4.5
1.20-1.30	5.6	0.01	BQ						BQ	0.03	0.07	BQ	0.02	0.2	0.2						4.6

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	0.50	0.01	4	7	0.09	34	5.8	0.47	0.82	1.0

Soil Type: Bungadoo (Bg)
Site No: 56
A.M.G. Reference: 466 942 mE 7 203 718 mN Zone 56
Great Soil Group: No suitable group
Principal Profile Form: Um2.21
Type of Microrelief: No microrelief
Surface Coarse Fragments: Abundant coarse pebbles, angular
Profile Morphology:
Condition of surface soil when dry: Firm

Slope: 12 %
Landform Element Type: Hillslope
Landform Pattern Type: Undulating plains
Vegetation
Structural form: very tall open forest
Dominant species: *Corymbia citriodora, Eucalytus drepanophylla, Angophora costata, Acacia aulacocarpa*

Horizon	**Depth**	**Description**
A11	0 to 0.05 m	Black (7.5 YR 2/1); clay loam; fragments, abundant angular platy pebbles; moderate <2 mm granular; dry; very weak
A12	0.05 to 0.20 m	Black (10 YR 3/1); clay loam; fragments, abundant angular platy pebbles; moderate <2 mm granular; dry
A22	0.20 to 0.30 m	Black (10 YR 3/2); clay loam; fragments, abundant angular platy pebbles; massive; dry; very weak
A22e	0.30 to 0.50 m	Grey (10 YR 4/2) dry; clay loam; fragments, abundant angular platy pebbles; massive; dry; very weak

						Particle size					Exchangeable					BAR	Dispersion		Total element		
	mS/cm		%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	PH
0B0-0.10	5.5	0.06	0.002						18	11	5.6	0.34	0.65	0.2	0.3						4.7
0.10-0.20	5.3	0.06	0.002						11	5.7	3.7	0.26	0.46	0.5	0.7						4.5

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	9.2	0.37	15	15	0.68	135	36	0.17	1.8	7.0

Soil Type: Bungadoo (Bg)
Site No: 57
A.M.G. Reference: 466 942 mE 7 203 577 mN Zone 56
Great Soil Group: No suitable group
Principal Profile Form: Uf3
Type of Microrelief: No microrelief
Surface Coarse Fragments: Many cobbles, angular platy strong
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 12 %
Landform Element Type: Hillslope
Landform Pattern Type: Rolling hills
Vegetation
Structural form: Tall open forest
Dominant species: *Eucalyptis tereticornis, Corymbia citriodora, Angophora costata, Acacis leuoicalyx*

Horizon	**Depth**	**Description**
A21e	0 to 0.08 m	Brown (7.5 YR 5/4), dull yellowish orange (10 YR 6/3) dry; few medium faint orange mottles; light clay; abundant cobbles, subrounded platy; massive; dry; moderately firm. Clear to
A22e	0.08 to 0.15 m	Brown (7.5 YR 4/6), dull yellowish orange (10 YR 7/3); few medium distinct orange mottles; light clay; abundant cobbles, subrounded platy; massive 2-5 mm subangular blocky; dry; moderately firm. Clear to
B1	0.15 to 0.30 m	Brown (7.5 YR 4/4); few fine faint brown mottles; medium clay; abundant cobbles, subrounded platy; moderate 2-5 mm polyhedral; dry; very firm. Diffuse to
B2	0.30 to 0.50 m	Red (5 YR 4/4); few medium distinct brown mottles; heavy clay; abundant cobbles, subrounded platy; strong 2-5 mm polyhedral; moderately moist; very firm.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%	meq%							%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	PH
B0-0.10	5	0.08	0.005						9	2.8	3	0.48	0.41	1.8	2.6						4.3
0-0.10	5.2	0.09	0.005	1.6	15	14	23	44	9	2.6	3	0.52	0.5	1.4	2	14	IS	0.02	0.165	0.028	4
0.10-0.20	5.4	0.06	0.003						5	0.32	1.8	0.4	0.3	1.4	1.8						4.1
0.20-0.30	5.6	0.04	0.003	0.8	4	10	19	64	5	0.19	2	0.39	0.26	1.4	1.8	13	0.72	0.01	0.146	0.012	4.2
0.30-0.40	5.7	0.04	0.003						5	0.14	2.3	0.43	0.22	1.7	2.2						4.2
0.40-0.50	5.6	0.05	0.005						7	0.15	3	0.54	0.2	2.4	3.2						4.1
0.50-0.60	5.6	0.04	0.003	3.5	6	5	14	72	10	0.02	3	0.68	0.15	5	5.8	20	0.57	0.01	0.183	0.014	4.1
0.60-0.70	5.3	0.06	0.006						11	0.04	3	0.58	0.15	6.3	7.2						4
0.70-0.80	5.1	0.07	0.006						12	0.08	2.3	0.56	0.14	7.7	8.9						3.9
0.80-0.90	5	0.07	0.006	4.2	1	2	10	83	13	0.13	2	0.56	0.14	7.9	9.7	20	0.32	0.01	0.271	0.026	3.9
0.90-1.00	4.8	0.07	0.007						13	0.11	1.6	0.48	0.15	9.2	10.9						3.8
1.00-1.10	4.7	0.09	0.01						13	0.1	1.4	0.53	0.18	9.4	11.2						3.7
1.10-1.20	4.6	0.1	0.012	3	1	4	20	73	14	0.06	2	0.59	0.18	9.7	11.6			0.02	0.399	0.031	3.7

			Extract P		**Repl**		**DTPA Extractable**			
	%	**%**	**mg/kg**		**meq%**		**mg/kg**			**mg/kg**
Depth	**Org C**	**Tot N**	**Acid**	**Bic**	**K**	**Fe**	**Mn**	**Cu**	**Zn**	**SO4-S**
B0-0.10	6.0	0.27	8	7	0.43	146	6.3	0.05	0.72	12

Soil Type: Jaro (Jr)
Site No: 386
A.M.G. Reference: 480 860 mE 7 190 133 mN Zone 56
Great Soil Group: Humic gley
Principal Profile Form: Dy3.41
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform Element Type: Drainage depression
Landform Pattern Type: Level plain
Vegetation
Structural form: Tall woodland
Dominant species: *Eucalyptus tereticornis, Melaleuca quinquenervia, Casuarina littoralis*

Horizon	**Depth**	**Description**
A1	0 to 0.30 m	Black (5 YR 2/1); common fine distinct brown mottles; loam; strong <2 mm subangular blocky; moist; very weak; few medium organic tubules. Gradual to
B21	0.30 to 0.60 m	Grey (2.5 Y 5/1); common medium prominent orange mottles, brown mottles; medium heavy clay; strong 5-10 mm prismatic parting to 2-5mm angular blocky; moist; moderately weak; few medium sulphurous soft segregations. Diffuse to
B22	0.60 to 1.20 m	Grey (2.5 Y 5/1); medium clay; strong 2-5 mm prismatic; moist; very weak; many medium soft segregations. Diffuse to
B23	1.20 to 1.70 m	Grey (2.5 Y 4/1); light medium clay; moist; moderately firm; few medium soft segregations.

						Particle size						Exchangeable				BAR	Dispersion		Total element		
	mS/cm		%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	3.9	2	0.265						19	0.91	3.1	6.8	0.76	6	7						3.7
0-00.10	3.9	2.3	0.335	3.9	IS	IS	IS	IS	22	0.73	3.1	8.7	0.94	7.4	8.7	27	0.25	0.1	0.804	0.284	3.8
0.10-0.20	3.7	1.5	0.206						18	0.48	2.2	5.5	0.83	8.2	9.3						3.8
0.20-0.30	3.6	1.1	0.138	2.5	14	15	24	46	16	0.44	2.6	4	0.61	7	8.6	23	0.6	0.04	1.11	0.2	3.5
0.30-0.40	3.5	1.2	0.143						18	0.59	3.1	4.5	0.58	7.7	9.7						3.4
0.40-0.50	3.5	1.2	0.15						20	0.72	3.6	5.4	0.59	8.4	10						3.3
0.50-0.60	3.5	1.2	0.158	2.7	6	10	29	55	20	0.82	3.9	5.7	0.57	7.2	9.2	23	0.7	0.03	1.86	1.14	3.3
0.60-0.70	3.5	1.2	0.156						20	0.83	4.5	5.7	0.57	6.5	8.6						3.3
0.70-0.80	3.5	1.3	0.175						20	0.84	4	6.2	0.61	6.1	8.2						3.3
0.80-0.90	3.5	1.5	0.209	5.6	3	13	26	56	IS	0.99	4.9	7.7	0.72	IS	IS	24	0.74	0.02	1.57	0.617	3.3
0.90-1.00	3.5	1.8	0.24						23	0.99	5	10	0.67	3.3	6.2						3.2
1.00-1.10	3.6	1.9	0.245						22	1.1	4.7	8.8	0.7	5.1	6.3						3.3
1.10-1.20	3.6	1.6	0.215	5.6	IS	IS	IS	IS	20	1.1	4.8	8.3	0.66	3.9	5.5			0.02	2.41	2.08	3.3

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	8.4	0.38	19	32	0.55	122	0.97	0.06	0.28	620

Soil Type: Craignish (Cr)
Site No: 444
A.M.G. Reference: 472 653 mE 7 199 180 mN Zone 56
Great Soil Group: Solodic soil
Principal Profile Form: Dy3.11p
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 1%
Landform Element Type: Hillslope
Landform Pattern Type: Gently undulating plains
Vegetation
Structural form: Tall isolated trees
Dominant species: *Eucalyptus tereticornis*

Horizon	**Depth**	**Description**
A1	0 to 0.30 m	Black (5 YR 2/1); common fine distinct brown mottles; loam; strong <2 mm subangular blocky; moist; very weak; few medium organic tubules. Gradual to
B21	0.30 to 0.60 m	Grey (2.5 Y 5/1); common medium prominent orange mottles, brown mottles; medium heavy clay; strong 5-10 mm prismatic parting to 2-5mm angular blocky; moist; moderately weak; few medium sulphurous soft segregations. Diffuse to
B22	0.60 to 1.20 m	Grey (2.5 Y 5/1); medium clay; strong 2-5 mm prismatic; moist; very weak; many medium soft segregations. Diffuse to
B23	1.20 to 1.70 m	Grey (2.5 Y 4/1); light medium clay; moist; moderately firm; few medium soft segregations.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
		mS/cm	%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	CEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5.8	0.08	0.007						9	3.7	4.5	0.49	0.24	0.1	0.1						3.4
0-00.10	5.9	0.06	0.004	1.7	8	43	23	23	9	3.6	4.5	0.4	0.2	0.1	0.1	9	0.69	0.02	0.118	0.063	3.4
0.10-0.20	6.2	0.04	0.002						7	1.8	4.7	0.62	0.08	NA	NA						4.8
0.20-0.30	5.8	0.09	0.006	1.7	17	32	17	34	14	1.7	9.6	1.6	0.07	0.4	0.6	15	0.96	0.02	0.138	0.095	4.8
0.30-0.40	5.4	0.19	0.019						18	1.4	13	2.8	0.08	0.6	1.2						4.6
0.40-0.50	5.1	0.44	0.05						24	1.1	17	4.7	0.08	0.7	1.5						4.4
0.50-0.60	4.9	0.67	0.089	3.2	6	25	15	55	31	1.3	21	7.1	0.08	0.4	1.1	24	0.92	0.01	0.059	0.037	4.3
0.60-0.70	4.8	1.1	0.162						35	1.3	24	8.9	0.1	0.2	0.7						4.4
0.70-0.80	4.7	1.3	0.197						41	1.4	28	11	0.1	0.2	0.6						4.4
0.80-0.90	4.8	1.4	0.21	5.1	1	15	14	70	42	1.5	28	12	0.1	0.2	0.5	32	IS	0.01	0.066	0.025	4.4
0.90-1.00	4.8	1.4	0.212						43	1.5	28	13	0.09	0.2	0.5						4.5
1.00-1.10	4.8	0.54	0.06						40	1.5	27	11	0.1	0.2	0.5						4.4
1.10-1.20	4.9	1.4	0.208	6.5	1	15	16	68	44	1.5	29	13	0.11	0.2	0.4			0.01	0.062	0.019	4.6
1.20-1.30	5.1	1.3	0.199						46	1.7	30	14	0.1	0.2	0.3						4.7
1.30-1.40	5	1.4	0.205						45	1.7	29	14	0.08	0.1	0.3						4.7
1.40-1.50	5.2	1.3	0.192						43	1.6	28	13	0.1	0.1	0.3						4.8

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	2.0	0.15	5	9	0.23	128	86	0.71	1.5	22

Soil Type: Dundowran (Dr)
Site No: 445
A.M.G. Reference: 472 575 mE 7 199 390 mN Zone 56
Great Soil Group: Prairie Soil
Principal Profile Form: Uf6.41p
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 8%
Landform Element Type: Hillslope
Landform Pattern Type: Undulating plains
Vegetation: Cleared

Horizon	**Depth**	**Description**
AP	0 to 0.3 m	Black (7.5 YR 3/1); few fine faint brown mottles; light clay; strong <2 mm subangular blocky; moderately moist; moderately firm; very few fine manganiferous nodules. Sharp to
B1	0.03 to 0.22 m	Black (2.5 Y 3/1); few medium faint brown mottles; light medium clay; strong 5-10 mm angular blocky; moderately moist; moderately firm; few fine manganiferous nodules. Clear to
B21	0.22 to 0.52 m	Black (2.5 Y 3/1); few fine distinct brown mottles; medium clay; strong 5-10 mm prismatic parting to strong <2 mm angular blocky; moist; moderately weak; few fine manganiferous nodules. Diffuse to
B22	0.52 to 0.95 m	Grey (2.5 Y 4/2); common fine distinct brown mottles; medium heavy clay; strong 20-50 mm prismatic; moist; moderately firm; common fine manganiferous nodules, very few fine ferruginous nodules. Diffuse to
2B2	0.95 to 1.40 m	Yellow (2.5 Y 6/6); common fine distinct grey mottles; heavy clay; strong 20-50 mm prismatic; moist; moderately strong; few fine manganiferous nodules, very few medium ferruginous nodules

					Particle size					Exchangeable				BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%		meq%				%	Ratio	%	%	%	CaCl2
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	CEC	Ca	Mg	Na	K	15	R1	P	K	S	PH
B0-0.10	6.3	0.05	0.003						33	10	9.5	0.47	0.34						5.1
0-0.10	6.4	0.04	0.001	5.2	5	21	24	49	IS	IS	IS	IS	IS	23	0.55	0.05	0.358	0.035	5.1
0.10-0.20	6.6	0.06	0.001						40	12	11	0.63	0.31						5.4
0.20-0.30	7.6	0.29	0.002	3.6	3	17	23	60	42	19	16	1.0	0.19	29	IS	0.03	0.312	0.028	7
0.30-0.40	8.1	0.27	0.004						42	20	19	1.5	0.15						7.4
0.40-0.50	8.4	0.16	0.009						45	18	33	2.3	0.17						7.4
0.50-0.60	8.7	0.34	0.012	4	6	15	21	59	43	15	33	2.7	0.13	28	IS	0.01	0.297	0.021	7.9
0.60-0.70	8.9	0.37	0.017						48	14	34	3.7	0.14						8
0.70-0.80	8.9	0.42	0.022						43	13	37	4.3	0.25						8
0.80-0.90	9.1	0.48	0.027	5.3	4	14	20	63	44	12	28	4.8	0.12	29	0.7	0.02	0.403	0.013	8
0.90-1.00	9.2	0.48	0.031						40	9.2	24	4.4	0.09						8.1
1.00-1.10	9.2	0.51	0.035						36	7.8	22	4.2	0.09						8.1
1.10-1.20	9.2	0.53	0.038	4.4	5	16	16	63	35	7.5	24	4.4	0.09			0.01	0.598	0.019	8.1
1.20-1.30	9.2	0.58	0.045						39	7.7	23	4.8	0.11						8.1
1.30-1.40	9.2	0.6	0.047						37	7.6	22	4.8	0.11						8.1
1.40-1.50	8.9	0.54	0.05						41	7.3	25	5.4	0.13						8

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	2.3	0.16	6	10	0.39	85	83	1.5	0.85	9.0

Soil Type: Craignish (Cr)
Site No: 446
A.M.G. Reference: 4723 535 mE 7 199 620 mN Zone 56
Great Soil Group: Solodic soil
Principal Profile Form: Dy3.43
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 1%
Landform Element Type: Drainage depression
Landform Pattern Type: Level plain
Vegetation:
Structural form: Tall open forest
Dominant species: *Corymbia intermedia, Eucalyptus umbra, Lophstemon suaveolens, Melaleuca quinquenervia*

Horizon	**Depth**	**Description**
A1	0 to 0.20 m	Black (10 YR 3/2); very few fine faint brown mottles; light sandy clay loam; massive; dry; moderately weak; very few fine ferruginous nodules. Clear to
A2e	0.20 to 0.30 m	Grey (10 YR 4/2); few fine faint brown mottles; light sandy clay loam; massive; dry; moderately weak; common medium ferruginous nodules. Abrupt to
B1	0.30 to 0.42 m	Grey (10 YR 5/2); common fine distinct brown mottles; light medium clay; weak 2-5 mm prismatic; moderately moist; very firm; many medium ferruginous nodules. Clear to
B21	0.42 to 0.65 m	Grey (2.5 Y 5/2); many fine distinct orange mottles; medium clay; moderate 5-10 mm angular blocky; moderately moist; moderately strong; few medium ferruginous nodules, few medium manganiferous nodules. Gradual to
B22	0.65 to 0.98 m	Yellow (2.5 Y 5/3); common fine distinct brown mottles; medium clay; strong 20-50 mm prismatic; moist; moderately strong; many medium manganiferous nodules, few medium manganiferous nodules. Diffuse to
2B2	0.98 to 1.40 m	Yellow (2.5 Y 7/4), few fine distinct orange mottles; medium heavy clay; prismatic; moist; very firm; few medium manganiferous nodules, many medium carbonate soft segregations. Clear to
3B2	1.40 to 1.50 m	Yellow (2.5 Y 6/4); common medium prominent orange mottles; medium heavy clay; prismatic; moist; very firm; few medium manganiferous nodules, very few medium carbonate soft segregations.

						Particle size					Exchangeable				BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%			meq%				%	Ratio	%	%	%	CaCl$_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	CEC	Ca	Mg	Na	K	15	R1	P	K	S	pH
B0-0.10	6.6	0.04	0.001						8	2.6	1.5	0.14	0.09						5.3
0-0.10	6.4	0.03	BQ	0.5	9	64	18	10	8	1.9	1.3	0.13	0.05	5	0.78	0.01	0.03	0.017	5.1
0.10-0.20	6.6	0.02	0.001						10	1.8	1.5	0.21	0.03						5
0.20-0.30	6.9	0.02	BQ	1	28	47	15	13	10	2.5	2.1	0.28	0.04	7	0.78	0.01	0.027	0.017	5.3
0.30-0.40	7.1	0.03	0.001						IS	IS	IS	IS	IS						5.6
0.40-0.50	7.2	0.04	0.002						15	5.8	4.8	0.54	0.04						5.7
0.50-0.60	7.1	0.07	0.007	2.2	13	38	19	34	19	8.0	6.6	0.70	0.05	17	0.59	0.01	0.031	0.014	6
0.60-0.70	7.5	0.11	0.011						22	10	8.1	0.87	0.05						6.4
0.70-0.80	7.6	0.15	0.017						25	11	8.9	0.98	0.05						6.6
0.80-0.90	8.5	0.36	0.029	3.6	5	39	18	41	31	16	13	1.3	0.05	19	0.6	0.01	0.047	0.014	7.5
0.90-1.00	8.6	0.42	0.039						32	15	12	1.3	0.05						7.7
1.00-1.10	8.6	0.48	0.05						26	12	10	1.0	0.04						7.7
1.10-1.20	8.6	0.55	0.059	3.4	3	51	20	30	24	12	10	1.1	0.05			0.01	0.047	0.012	7.9
1.20-1.30	8.6	0.57	0.063						22	10	9.0	0.94	0.05						7.9
1.30-1.40	8.5	0.68	0.079						23	11	9.7	0.97	0.05						7.9
1.40-1.50	8.4	0.8	0.108						28	13	11	1.1	0.06						7.9

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
0-0.10	1.3	0.09	4	6	0.09	68	25	0.14	0.42	4.0

Soil Type: Burrum (Br)
Site No: 447
A.M.G. Reference: 469 610 mE 7 204 610 mN Zone 56
Great Soil Group: Podsol
Principal Profile Form: Uc1.21
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform Element Type: Beach ridge
Landform Pattern Type: Level plain
Vegetation:
Structural form: Low isolated trees
Dominant species: *Eucalyptus umbra*, *Banksia oblongifolia*

Horizon	**Depth**	**Description**
A11	0.10 to 0.20 m	Black (10 YR 3/2); sand; massive; dry; loose. Clear to
A12	0.20 to 0.40 m	Grey (10 YR 4/1); sand; massive; dry; loose. Gradual to
A21e	0.40 to 0.70 m	Grey (10 YR 6/1); few fine distinct brown mottles, orange mottles; sand; massive; moist; very weak. Diffuse to
A22e	0.70 to 1.20 m	Grey (10 YR 6/2); common fine distinct brown mottles; sand; massive; moist; very weak. Diffuse to
A23e	1.20 to 1.40 m	Grey (10 YR 6/2); common fine distinct brown mottles; sand; massive; wet; very weak. Clear to
A24e	1.40 to 1.50 m	Grey (10 YR 6/2); sand; massive; wet; loose.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	PH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5.2	0.02	0.002						3	0.16	1.1	0.19	0.06	0.2	1.3						3.3
0-0.10	4.6	0.04	0.001	0.3	IS	IS	IS	IS	4	0.24	1.3	0.33	0.05	0.3	2	6	0.1	0	0.007	0.021	2.8
0.10-0.20	4.5	0.03	0.001						2	0.11	0.4	0.15	0.02	0.1	0.9						3
0.20-0.30	4.8	0.01	BQ	0.2	20	77	BQ	3	1	0.1	0.21	0.07	0.02	0.1	0.4	1	0.1	0	0.006	0.008	3.1
0.30-0.40	4.9	0.01	BQ						1	0.07	0.65	0.02	BQ	0.1	0.3						3.4
0.40-0.50	5.3	0.01	BQ						1	0.12	0.16	0.05	BQ	0.1	0.2						3.6
0.50-0.60	4.8	0.02	BQ	0.1	17	82	BQ	2	1	0.06	0.54	0.03	BQ	0.1	0.2	1	0.1	0	0.008	0.007	3.6
0.60-0.70	4.7	0.02	BQ						BQ	0.12	0.13	0.04	BQ	BQ	0.1						3.7
0.70-0.80	4.7	0.02	BQ						1	0.08	0.49	0.03	BQ	BQ	0.1						3.8
0.80-0.90	4.7	0.02	BQ	0.05	12	87	2	BQ	1	BQ	0.32	0.05	BQ	BQ	0.2	1	0.1	BQ	0.004	0.006	3.7
0.90-1.00	4.7	0.02	BQ						1	0.06	0.57	0.05	BQ	BQ	0.1						3.8
1.00-1.10	4.5	0.04	0.001						1	0.12	0.14	0.11	BQ	BQ	0.2						3.8
1.10-1.20	4.7	0.03	0.001	0.01	9	89	2	BQ	1	0.1	0.41	0.06	BQ	BQ	0.2			0	0.003	0.009	3.7
1.20-1.30	4.8	0.02	BQ						1	0.07	0.61	0.05	BQ	BQ	0.1						3.7
1.30-1.40	4.8	0.02	0						BQ	0.11	0.14	0.08	BQ	BQ	0.1						3.8
1.40-1.50	5	0.01	BQ						BQ	0.1	0.13	0.06	BQ	BQ	0.1						4

			Extract P		Repl	DTPA Extractable				
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	3.1	0.06	3	5	0.04	37	0.8	0.02	0.17	2.0

Soil Type: Granville (Gr)
Site No: 448
A.M.G. Reference: 480 525 mE 7 178 545 mN Zone 56
Great Soil Group: No suitable group. Affected with grey clay
Principal Profile Form: Uf3.
Type of Microrelief: No microrelief
Surface Coarse Fragments: No coarse fragments
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform Element Type: Plain
Landform Pattern Type: Level plain
Vegetation:
Structural form: Tall open forest
Dominant species: *Eucalyptus tereticornis, Melaleuca quinquenervia*

Horizon	**Depth**	**Description**
A1	0 to 0.10 m	Black (10 YR 3/2); common fine distinct brown mottles; light medium clay; moderate 2-5 mm subangular blocky; dry; very firm; few fine manganiferous nodules. Clear to
B1	0.10 to 0.30 m -	Black (10 YR 3/2); common fine distinct brown mottles; medium clay; strong 2-5mm angular blocky; dry; very firm; few medium manganiferous nodules. Clear to
B21	0.30 to 0.65 m	Grey (2.5 Y 5/2); few fine distinct orange mottles; medium heavy clay; strong 2-5mm lenticular; moderately moist; moderately strong; very few medium manganiferous nodules. Gradual to
B22	0.65 to 1.20 m	Grey (2.5 Y 5/2); few fine distinct orange mottles; heavy clay; strong 2-5mm lenticular; moderately moist; moderately strong; very many fine manganiferous veins. Diffuse to
B23	1.20 to 1.60 m	Grey (2.5 YR 5/2); common fine distinct orange mottles; heavy clay; moderate 2-5 mm lenticular; moderately moist; moderately strong; few fine manganiferous veins.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
		mS/cm	%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	6.4	0.09	0.005						11	5.4	4.8	0.72	0.19	NA	NA						5.5
0-0.10	6	0.09	0.006	1.6	5	25	36	31	10	3.9	5	0.58	0.32	NA	NA	15	0.53	0.02	0.304	0.032	4.9
0.10-0.20	5.9	0.08	0.005						9	1.8	5.9	0.83	0.16	0.3	0.3						4.6
0.20-0.30	5.5	0.24	0.025	3.5	3	14	23	62	15	1.4	10	2.1	0.17	0.6	1.1	24	0.46	0.02	0.426	0.037	4.5
0.30-0.40	5.1	0.48	0.066						19	0.88	13	3.7	0.2	0.7	1.4						4.4
0.40-0.50	5.1	0.66	0.113						20	0.41	13	4.9	0.18	0.5	1.1						4.5
0.50-0.60	5.1	0.82	0.126	3.4	2	12	23	65	22	0.23	15	6.1	0.2	0.4	0.8	24	0.62	0.01	0.481	0.041	4.5
0.60-0.70	5.1	1.1	0.174						27	0.12	18	8.3	0.21	0.2	0.4						4.7
0.70-0.80	5.1	0.96	0.154						25	0.14	17	7.4	0.22	0.3	0.6						4.7
0.80-0.90	5.2	1.1	0.174	4.3	2	11	27	63	28	0.2	18	8.8	0.22	0.2	0.3	24	0.99	0.01	0.534	0.04	4.8
0.90-1.00	5.3	1.1	0.177						23	0.11	15	7.3	0.22	0.2	0.2						4.9
1.00-1.10	5.6	1.1	0.185						30	0.17	20	9.9	0.24	0.1	0.1						5.1
1.10-1.20	5.8	1.1	0.176	5.1	3	12	27	59	31	0.28	20	9.9	0.23	0.1	0.1			0.01	0.609	0.026	5.2
1.20-1.30	6.1	1.2	0.186						33	0.31	21	11	0.26	NA	NA						5.5
1.30-1.40	6.2	1.3	0.198						33	0.46	22	10	0.35	NA	NA						5.7
1.40-1.50	6.3	1.3	0.198						33	0.48	22	10	0.35	NA	NA						5.7
1.50-1.60	6.4	1.2	0.189						34	0.5	22	11	0.32	NA	NA						5.8

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	2.8	0.17	5	6	0.17	82	80	1.4	0.82	15

Soil Type: Tandora (Tn)
Site No: 449
A.M.G. Reference: 485 104 mE 7 183 990 Zone 56
Great Soil Group: Humic gley
Principal Profile Form: Uf6.41
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform Element Type: Plain
Landform Pattern Type: Level plain
Vegetation:
Structural form: Tall open forest
Dominant species: *Eucalyptus tereticornis, Melaleuca quinquenervia*

Horizon	**Depth**	**Description**
A11	0 to 0.10 m	Black (7.5 YR 2/1); few fine faint brown mottles; light clay; moderate 2-5 mm subangular blocky; dry; very firm. Abrupt to
A12	0.10 to 0.30 m	Black (10 YR 3/2); common fine faint brown mottles, orange mottles; light clay; weak 2-5 mm subangular blocky; moderately moist; very firm. Clear to
B21	0.30 to 1.00 m	Grey (10 YR 5/2); common fine distinct orange mottles; medium heavy clay; 5-10 mm lenticular; moist; moderately firm. Diffuse to
B22	1.00 to 1.70 m	Grey (2.5 Y 5/2); many fine distinct orange mottles, red mottles; medium heavy clay; strong 2-5 mm lenticular; moist; moderately strong.

				Particle size					Exchangeable							BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%				meq%				%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	PH
B0-0.10	5.5	0.44	0.047						18	6.9	7.1	2.7	1.2	0.1	0.1						4.9
0-0.10	5.8	0.29	0.029	2.6	12	38	20	27	17	6.4	6.6	2.2	1.3	0.1	0.1	19	0.48	0.04	0.615	0.073	4.9
0.10-0.20	5.3	0.37	0.038						11	2	4.6	2.6	0.84	0.7	1						4.4
0.20-0.30	4.9	0.52	0.052	2	5	35	19	43	12	1.5	4.8	3.5	0.66	0.9	1.7	18	0.73	0.01	0.624	0.085	4.1
0.30-0.40	4.8	0.59	0.059						13	1.4	5.1	4.1	0.56	1	1.8						4
0.40-0.50	4.7	0.72	0.077						16	1.5	6.4	5.6	0.52	0.9	1.7						4.1
0.50-0.60	4.7	0.92	0.115	2.1	3	31	20	47	18	1.5	7.3	7.3	0.56	0.7	1.5	18	0.99	0.01	0.531	0.055	4.1
0.60-0.70	4.6	1	0.134						19	1.5	7.6	8.2	0.57	0.5	1.3						4
0.70-0.80	4.6	1	0.142						20	1.6	7.7	8.5	0.56	0.5	1.2						4.1
0.80-0.90	4.5	1.2	0.156	2.4	3	31	20	47	20	1.4	7.9	9.2	0.59	0.4	1	19	0.99	0.01	0.554	0.062	4
0.90-1.00	4.5	1.2	0.159						20	1.2	7.8	9.3	0.59	0.3	0.8						4
1.00-1.10	4.5	1.1	0.161						18	1.1	6.9	8.5	0.54	0.3	0.7						4.1
1.10-1.20	4.5	1.2	0.162	1.2	5	40	18	37	18	1.1	6.9	8.6	0.55	0.3	0.6			0.01	0.695	0.053	4.1
1.20-1.30	4.7	1.2	0.164						19	1.1	7.3	9.1	0.59	0.2	0.6						4.2
1.30-1.40	4.7	1.3	0.178						20	1.1	7.6	9.8	0.62	0.3	0.5						4.3
1.40-1.50	4.7	1.2	0.166						18	1.1	7.1	9.2	0.6	0.2	0.4						4.3
1.50-1.60	4.8	1.2	0.167						18	1.1	6.7	9	0.57	0.2	0.3						4.4

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	6.2	0.37	3	16	0.98	432	20	1.1	1.7	108

Soil Type: Woober (Wb)
Site No: 450
A.M.G. Reference: 475 620 mE 7 187 690 mN Zone 56
Great Soil Group: No suitable group
Principal Profile Form: Uf2.
Type of Microrelief: No microrelief
Profile Morphology:
Condition of surface soil when dry: Hard setting

Slope: 0%
Landform Element Type: Plain
Landform Pattern Type: Level plain
Vegetation:
Structural form: Tall woodland
Dominant species: *Eucalyptus umbra, Angophora costata, Melaleuca quinquenervia*

Horizon	**Depth**	**Description**
A2j	0 to 0.02 m	Grey (10 YR 4/2); common fine faint grey mottles; silty clay; weak 2-5 mm blocky; dry; moderately weak. Abrupt to
A2e	0.02 to 0.20 m	Grey (10 YR 5/2); few fine distinct orange mottles; silty clay; massive; moderately moist; moderately firm. Clear to
B21	0.20 to 0.60 m	Grey (10 YR 5/2); common fine distinct orange mottles; light medium clay; moderate 2-5 mm lenticular; moderately moist; moderately firm. Diffuse to
B22	0.60 to 0.90 m	Grey (10 YR 6/2); few medium distinct orange mottles; medium clay; moderate 10-20 mm prismatic parting to lenticular; moderately moist; moderately strong. Gradual to
B3	0.90 to 1.55 m	Grey (2.5 Y 6/1); very few medium prominent orange mottles, red mottles; medium heavy clay; strong 5-10 mm lenticular; moist; very firm; common medium ferruginous soft segregations

						Particle size						Exchangeable					BAR	Dispersion		Total element		
	mS/cm		%	%	%	%	%	%				meq%					%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5.2	0.13	0.017						3	0.46	1.6	0.62	0.06	0.4	0.6						4.2
0-0.10	5.1	0.28	0.037	0.7	5	32	45	16	5	1.1	2	1.1	0.1	0.2	0.3	6	0.85	0.01	0.041	0.039	4.4
0.10-0.20	5	0.25	0.031						4	0.29	1.7	1.1	0.06	0.3	0.5						4.4
0.20-0.30	5	0.26	0.032	0.6	4	32	45	20	4	0.25	1.7	1.4	0.05	0.3	0.5	6	0.87	0.01	0.038	0.032	4.1
0.30-0.40	4.9	0.28	0.032						5	0.3	2.3	1.5	0.06	0.4	0.6						4.1
0.40-0.50	5	0.26	0.029						5	0.18	2.7	1.7	0.21	0.4	0.6						4.1
0.50-0.60	4.9	0.31	0.034	1.2	5	28	39	30	6	0.14	3	2.3	0.06	0.6	0.9	11	0.26	0.01	0.037	0.047	4
0.60-0.70	4.9	0.33	0.036						7	0.13	3.1	2.7	0.06	0.6	1.1						4
0.70-0.80	5.1	0.36	0.039						9	0.16	4.2	3.5	0.07	0.7	1.3						4
0.80-0.90	4.9	0.39	0.043	1.5	7	24	38	31	11	0.24	5.5	4.1	0.07	0.8	1.4	14	0.84	0.01	0.046	0.042	4
0.90-1.00	4.9	0.5	0.056						13	0.31	6.6	5.1	0.06	0.6	1.4						4
1.00-1.10	4.8	0.55	0.062						15	0.43	7.1	6	0.09	0.8	1.5						3.9
1.10-1.20	4.7	0.58	0.065	2.7	11	20	29	38	17	0.43	7.9	6.6	0.1	0.8	1.5			0.01	0.083	0.053	3.9
1.20-1.30	4.8	0.66	0.079						17	0.46	8.2	7.2	0.1	0.7	1.5						3.9
1.30-1.40	4.7	0.7	0.084						19	0.55	9.1	8	0.13	0.9	1.6						4
1.40-1.50	4.7	0.77	0.097						20	0.58	9.3	8.3	0.14	0.9	1.6						4

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	1.6	0.06	3	4	0.05	239	1	0.07	0.21	8.0

Soil Type: Robur (Rb)
Site No: 451
A.M.G. Reference: 476 865 mE 7 200 570 mN Zone 56
Great Soil Group: Soloth
Principal Profile Form: Dy3.41
Type of Microrelief: No microrelief

Slope: 0%
Landform Element Type: Plain
Landform Pattern Type: Level plain
Vegetation:
Structural form: Mid-high woodland
Dominant species: *Eucalyptus umbra, Banksia oblongifolia*

Profile Morphology:
Condition of surface soil when dry: Hard setting

Horizon	**Depth**	**Description**
A1	0 to 0.04 m	Black (10 YR 3/2); very few fine faint pale mottles; sandy loam; massive; dry; very weak. Abrupt to
A21j	0.04 to 0.20 m	Grey (10 YR 4/2); very few fine faint yellow mottles; sandy loam; massive; dry; moderately weak. Abrupt to
A22e	0.20 to 0.30 m	Brown (10 YR 5/4); many fine faint yellow mottles; fine sandy loam; massive; dry moderately firm. Gradual to
A31	0.30 to 0.55 m	Brown (10 YR 5/6); many fine distinct orange mottles; massive; moderately moist; moderately weak; very few medium ferruginous nodules. Clear to
B21	0.55 to 0.90 m	Grey (10 YR 6/1); common fine prominent red mottles, orange mottles; light medium clay moderate 2-5 mm lenticular; moist; moderately firm. Clear to
B22	0.90 to 1.10 m	Grey (10 YR 7/1); few fine prominent orange mottles, red mottles; medium clay; moderate 10-20mm prismatic parting to 2-5 mm lenticular; moist; very firm. Diffuse to
B3	1.10 to 1.20 m	Grey (10 YR 7/1); very few fine prominent red mottles; medium heavy clay; many fragments angular mudstone; strong 2-5 mm angular blocky; moderately moist; moderately strong; few ferruginous nodules.

						Particle size						Exchangeable					BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%				meq%					%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5.7	0.01	0.002						1	0.16	0.58	0.06	0.03	0.3	0.3						4.2
0-0.10	5.3	0.02	0.001	0.2	20	71	2	5	1	0.19	0.33	0.06	0.05	0.3	0.4	2	0.84	0	0.014	0.013	4.2
0.10-0.20	5.4	0.01	0						1	0.06	0.64	0.08	0.03	0.5	0.5						4.3
0.20-0.30	5.4	0.01	0	0.4	19	67	5	10	2	0.04	1.2	0.09	0.03	0.6	0.7	3	0.68	0	0.021	0.016	4.2
0.30-0.40	5.6	0.02	0						3	0.06	1.7	0.09	0.03	0.9	1						4.2
0.40-0.50	5.5	0.02	BQ						4	0.07	2	0.19	0.04	1.6	1.9						4.2
0.50-0.60	5.4	0.04	0.001	1.4	16	42	5	37	8	0.07	3.2	0.37	0.06	3.3	4	13	0.13	0.01	0.053	0.035	4
0.60-0.70	5.4	0.04	0.001						9	0.15	2.8	0.52	0.07	4.9	5.4						3.9
0.70-0.80	5.2	0.05	0.002						10	0.05	3.2	0.54	0.07	5.3	5.9						3.9
0.80-0.90	5.2	0.05	0.002	1.4	12	35	7	47	11	0.06	3.6	0.7	0.09	6.2	6.9	16	0.1	0.01	0.086	0.035	3.8
0.90-1.00	5.3	0.05	0.002						12	0.08	3.5	0.86	0.1	6.6	7.8						3.7
1.00-1.10	5.4	0.07	0.003						19	BQ	4.9	1.3	0.15	10.5	12.6						3.8
1.10-1.20	5.3	0.07	0.003	2.1	10	24	10	55	18	0.12	5	1.4	1.8	9.4	11.4	0.17		0	0.331	0.025	3.7
1.20-1.30	5.2	0.06	0.004						20	0.03	6.5	1.8	0.2	9.9	11.5	0.2					3.7

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	0.65	0.01	7	3	0.02	72	0.18	0.02	0.09	3.0

Soil Type: Jaro (Jr)
Site No: 558
A.M.G. Reference: 476 130 mE 7 178 940 mN Zone 56
Great Soil Group: Humic gley
Principal Profile Form: Uf6.41
Type of Microrelief: No microrelief

Slope: 0%
Landform Element Type: Plain
Landform Pattern Type: Level plain
Vegetation: Cleared

Profile Morphology:
Condition of surface soil when dry: Firm

Horizon	**Depth**	**Description**
A1	0 to 0.8 m	Black (7.5 YR 2/3); many fine distinct brown mottles; light medium clay; no coarse fragments; strong 2-5 mm granular; moderately moist; very firm; no segregations. Clear to
B1	0.08 to 0.30 m	Black (7.5 YR 2/2); common fine distinct brown mottles; medium heavy clay; strong 20-50 mm prismatic; moderately moist; very firm. Clear to
B21	0.30 to 0.40 m	Black (7.5 YR 3/1); common fine distinct brown mottles; heavy clay; strong 5-10 mm subangular blocky; moderately moist; moderately firm. Gradual to
B22	0.40 to 0.80 m	Grey (10 YR 5/1); many medium distinct yellow mottles; heavy clay; strong 2-5 mm lenticular; moist; moderately firm. Gradual to
B23	0.80 to 1.00 m	Grey (2.5 Y 4/1); many coarse distinct brown mottles; heavy clay; strong 2-5 mm lenticular; moist; moderately firm. Diffuse to
B24	1.00 to 1.35 m	Black (10 YR 3/1); no mottles; heavy clay; strong 2-5 mm lenticular; moist; moderately firm.

					Particle size						Exchangeable					BAR	Dispersion	Total element			
	mS/cm		%	%	%	%	%	%			meq%					%	Ratio	%	%	%	$CaCl_2$
Depth	pH	EC	Cl	ADMC	CS	FS	SI	CLA	ECEC	Ca	Mg	Na	K	Al	Acid	15	R1	P	K	S	pH
B0-0.10	5	0.44	0.034						17	3.7	8.3	3	1.5	0.5	0.6						4.4
0-0.10	5.2	0.32	0.024	2.8	IS	IS	IS	IS	IS	3.6	7.6	2.3	1.3	IS	IS	22	0.4	0.08	1.36	0.128	4.4
0.10-0.20	5.5	0.43	0.038						19	3.2	9.6	4.2	1.2	0.3	0.4						4.7
0.20-0.30	5.7	0.6	0.059	3.1	IS	IS	IS	IS	IS	3.5	11	6.2	1.4	IS	IS	24	0.8	0.05	1.46	0.092	4.9
0.30-0.40	5.8	1	0.128						27	3.6	12	9.2	1.6	0.1	0.1						5.2
0.40-0.50	5.8	1.5	0.197						31	3.5	13	13	1.8	0.1	0.1						5.4
0.50-0.60	5.8	1.9	0.249	4.2	1	18	20	63	IS	IS	IS	IS	IS	IS	IS	28	0.96	0.08	1.41	0.066	5.4
0.60-0.70	6	2.5	0.339						34	3.3	12	17	1.7	NA	NA						5.7
0.70-0.80	6.4	2.8	0.379						38	3.8	13	19	1.9	NA	NA						6.1
0.80-0.90	6.7	3.1	0.411	5.6	BQ	17	20	64	IS	IS	IS	IS	IS	NA	NA	IS	0.98	0.04	1.48	0.097	6.4
0.90-1.00	6.7	3.7	0.487						44	4.5	15	23	1.9	NA	NA						6.4
1.00-1.10	6.5	3.9	0.503						46	5	14	24	1.9	NA	NA						6.2
1.10-1.20	6.2	4.4	0.56	3	1	21	20	59	44	4.2	14	24	1.9	NA	NA			0.02	1.46	0.142	5.9
1.20-1.30	5.8	5	0.658						46	4.5	15	25	1.8	BQ	BQ						5.6
1.30-1.40	5.5	5.5	0.741						IS	4.7	16	28	1.8	IS	IS						5.4
1.40-1.50	5	6.1	0.849						51	4.7	16	28	1.9	0.1	0.1						4.9

			Extract P		Repl		DTPA Extractable			
	%	%	mg/kg		meq%		mg/kg			mg/kg
Depth	Org C	Tot N	Acid	Bic	K	Fe	Mn	Cu	Zn	SO4-S
B0-0.10	6.1	0.44	54	147	1.3	466	8.7	0.29	1.3	169

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 Crops

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 III. 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. Pinus are rainfed. Patures are not listed under the wetness and flooding limitations where species selection enables adaption to a wide range of conditions.

The agricultural land uses listed are:

Asparagus
Avocado
Beans
Citrus
Crucifers (cabbage, cauliflowers, etc)
Cucurbits (melons, pumpkins)
Furrow irrigation (other than sugarcane)
Grape
Lucerne
Lychee
Improved pasture
Macadamia
Maize
Mango
Navybean
Peanut
Pineapple
Pinus
Potato
Sorghum
Soybean
Stonefruit (peaches, nectarines)
Sugarcane (spray irrigation)
Sugarcane (furrow irrigation)
Sweet corn
Sweet potato
Vegetables (capsicum, 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	*Pinus*	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	1
Regular frosts Code: C2	5	3	3	2	1
Severe frosts (channel benches, depressions in lower terraces) Code: C3	5	4	4	3	1
Rainfall > 1000 mm <1000 mm			0** 4		

* All other crops refers to crops listed in this appendix. Seasonal adaptation is not considered, for example, summer crops are not grown in winter.

** '0' (zero) = suitable. Insufficient information to separate into classes 1, 2 or 3.

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 (Littleboy 1997, 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 (6 mm/day in summer) 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	*Pinus* (rainfed)
Soil PAWC (to 1.0 m)					
>150 mm Code M1	1	2	1	1	1
150-125 mm Code: M2	1	2	1	1	1
125-100 mm Code: M3	1	2	1	1	1
75-100 mm Code: M4	1	2	1	2	1
50-75 mm Code: M5	1	2	2	3	2
<50 mm Code: M6	1	3	3-4	4	3

[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 1.0 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 (Ks >500 mm/day)
M Moderately permeable (Ks 50-500 mm/day)
S Slowly permeable (Ks 5-50 mm/day)
V Very slowly permeable (Ks <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)		
	Avocado	Citrus, Macadamia	Mango	Lychees	Lucerne Stone-fruit, Grape	Maize, Sorghum (forage), Sweet corn, Soybean	*Pinus*	Sugar cane	Navybean, Peanuts, Beans	Veges, Cruciferae, Cucurbits, Asparagus, Potato, Pineapple, Sweet potato
6H	1	1	1	1	1	1	1	1	1	1
5H	2	1	1	1	1	1	1	1	1	1
5M	3	2	1	1	2	1	1	1	2	1
4H	3	2	1	1	2	1	1	1	2	1
4M	4	3	2	1	3	2	1	1	3	2
4S	5	4	3	2	4	3	2	2	4	3
4V	5	4	3	2	4	3	2	2	4	3
3H	4	3	2	2	3	2	2	2	3	2
3M	5	4	3	2	4	3	2	2	4	3
3S	5	5	4	3	5	4	3	3	5	4
3V	5	5	4	3	5	4	4	3	5	4
2H	5	5	5	3	5	5	3	3	5	5
2M	5	5	5	3	5	5	3	3	5	5
2S	5	5	5	4	5	5	4	4	5	5
2V	5	5	5	4	5	5	5	4	5	5
1H	5	5	5	5	5	5	5	4	5	5
1M	5	5	5	5	5	5	5	4	5	5
1S	5	5	5	5	5	5	5	5	5	5
1V	5	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 rooting depth: Depth to decomposing rock, pan, high salts or impermeable layer.

Limitation class determination

Consultation.

Soil/land attribute level	Limitation classes for various crops			
Effective soil depth	Tree crops	Sugar cane	*Pinus*	All other crops
> 1 m Code: D1	1	1	1	1
0.6 to 1 m Code: D2	2	1	2	1
0.4 to 0.6 m Code: D3	3	1	4	1
0.3 to 0.4 m Code: D4	4	2	5	1
< 0.3 m Code: D5	5	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	
	Pinus	Other crops
Standard fertiliser rates and practices. Code: NO	1	1
Nutrient levels		
P>40 ppm Code: P1	1	1
P 20-40 ppm Code: P2	1	1
P 10-20 ppm Code: P3	1	2
P <10 ppm Code: P4	2	2
K >0.6 meq Code: K1	1	1
K 0.2 meq Code: K1	1	1
K <0.2 meq Code: K3	2	2
Highly permeable soils with water table fluctuations deeper than 1.5 m. Code: 6H to 3H (see wetness limitations)	2	2
Humic/organic soils. Code: N1	2	2
Soil pH to 0.3 m:		
pH >6.5 Code: H5	1	1
pH 6.0-6.5 Code: H4	1	1
pH 5.5-6.0 Code: H3	1	1
pH 5.0-5.5 Code: H2	1	2
pH <5.0 Code: H1	1	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 *Pinus*	Sugarcane, Maize, Sorghum (forage), Sweet corn	Soybean, Veges, Cucurbits, Lucerne, 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 the amount of levelling required.

Limitation class determination

Local opinion and consultation.

Soil/land attribute level	Limitation classes for various crops
Vertical interval	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			
	Sugarcane, Soybean, Maize, Sorghum (forage), Asparagus, Sweet corn	Avocado, Macadamias, Citrus, Pineapple, Mango, Lychee, Stone fruits, Grapes	Lucerne, Navybean, Beans, Peanuts, *Pinus*	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. The real effects of flooding 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	*Pinus*	Pastures
>10 Code: X0	1	1	1	1	1	1	1
5-10 Code: X1	1	1	1	4	1	1	1
2.5-5 Code: X2	1	1	3	5	2	4	1
1.5-2.5 Code: X3	1	2	4	5	2-3	5	1
<1.5 Code: X4	4	3	5	5	4	5	1

[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, *Pinus*	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, *Pinus*	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 fine sandy loam 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	
	All crops	*Pinus* (rainfed)	Other crops	All crops	*Pinus* (rainfed)	Other crops
6H	0 *	0	0	-	1	1
5H	0	0	0	-	1	1
5M	0	0	0	-	1	1
4H	0	1	2	-	1	1
4M	0	1	2	-	1	1
4S	0	1	3	-	1	2
4V	0	2	3	-	1	2
3H	0	1	2	5	1	1
3M	0	2	3	5	1	2
3S	0	3	4	5	2	3
3V	0	4	5	5	3	3
2H	0	2	3	5	1	2
2M	0	3	4	5	2	3
2S	0	4	5	5	3	4
2V	0	5	5	5	4	4
1H	-	3	4	5	2	3
1M	-	3	4	5	2	3
1S	-	3	4	5	2	3
1V	-	3	4	5	2	3
existing salinisation	5	5	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, *Pinus*	Sugar cane (spray) Lucerne	Maize, Sorghum, Veges, Cruciferae, Cucurbits, Asparagus, Sweet corn, Pineapple, Sweet potato	Navybean, Peanuts, Potato, Soybean, Beans	Furrow irrigated Sugarcane	Furrow irrigated other crops
Very stable soils: Ferrosols							
	Code:						
0	E0	1	1	1	1	1	2
0 - 2	E1	1	1	1	1	2	3
2 - 5	E2	1	2	2	3	3	4
5 - 8	E3	1	2	3	4	4	5
8 - 12	E4	2	3	4	5	5	5
12 - 15	E5	2	4	5	5	5	5
15 - 20	E6	3	5	5	5	5	5
20 - 30	E7	4	5	5	5	5	5
>30	E8	5	5	5	5	5	5
Stable soils: Vertosols, clayey surfaced Dermosols, coarse surfaced well drained Dermosols, Chromosols, Rudosols and Kandosols							
	Code:						
0	A0	1	1	1	1	1	2
0 - 2	A1	1	1	2	2	2	3
2 - 5	A2	1	2	3	3	3	4
5 - 8	A3	2	3	4	4	5	5
8 - 12	A4	3	4	5	5	5	5
12 - 15	A5	3	5	5	5	5	5
15 - 20	A6	4	5	5	5	5	5
>20	A7	5	5	5	5	5	5
Unstable soils: Sodosols, Hydrosols, Podosols, Kurosols, loamy surfaced Dermosols and Tenosols							
	Code:						
0	B0	1	1	1	1	2	3
0 - 1	B1	1	1	2	3	2	3
1 - 3	B2	1	2	3	4	3	4
3 - 5	B3	2	3	4	5	4	5
5 - 8	B4	3	4	5	5	5	5
8 - 12	B5	4	5	5	5	5	5
>12	B6	5	5	5	5	5	5

FURROW INFILTRATION (if) (Deep drainage)

Effect

The amount of water applied and the rate of application as furrow irrigation must match the permeability of the soil to minimise deep drainage and to determine more suitable furrow length. Additional management requirements are associated with short furrows and waterlogging in the upper end of the furrows if furrow lengths are too long. The most suitable furrow lengths for flood irrigation needs to be determined.

Deep drainage in recharge areas or undulating landscapes can contribute significantly to watertables in lower landscape positions. The effect of deep drainage on groundwater levels can be managed on very slowly to moderately permeable soils within areas where groundwater is used for irrigation and on level plains with very slowly to slowly permeable soils where there is minimal contribution to groundwater levels from the surrounding landscape.

Pinus are rainfed, therefore, furrow infiltration is not assessed.

Assessment

Subsoil permeability (see w limitation) and landscape position. Indicator attributes for soil permeability include texture, grade and type of structure, sodicity, pH, salt bulge.

Limitation class determination

Consultation

Limitation classes relate directly to soil permeability, landscape and whether the site is located within a groundwater area. Hydraulic conductivity (permeability) measurements are required.

Soil/land attribute level	Limitation classes for various landscapes		
Subsoil permeability to 1m	Undulating landscape	Level plains	Areas within a groundwater area
	All crops	All crops	All crops
V- very slowly permeable	0	0	0
S- slowly permeable	4	0	0
M - moderately permeable	5	4	3
H - highly permeable	5	5	4

‘0’ (zero) = suitable, insufficient information to separate into classes 1, 2 or 3

SOIL PROFILE RECHARGE (ir)

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) and to minimise runoff.

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, and any salt bulge.

Limitation class determination

Consultation.

Surface infiltration and soil permeability are considered in relation to slow soil profile recharge or additional management requirements. Surface infiltration (disc permeameter) and hydraulic conductivity measurements are required.

Soil/land attribute level	Limitation classes for all land uses
Surface condition (Codes: see p limitation)	
Slow surface infiltration - hardsetting massive soils with surface textures of fine sandy loam to clay loam fine sandy and very firm consistency when dry. Code: S2	2
Other soils. Codes : S1, S3, S4	1
Soil permeability to 0.5 m	
(Codes: see w limitation)	
Very slowly permeable. Code: V	2
Slowly permeable. Code: S	2
Moderately permeable. Code: M	1
Highly permeable. Code: H	1
Surface condition and soil permeability Combined	
Hardsetting massive soils with surface textures of fine sandy loam to clay loam fine sandy (Code: S2) and slow to very slow subsoil permeability at 0.5 m (Code: V or S)	3

DRAINAGE WATER HAZARD (da)

Effect

Toxic quantities of acid, aluminium, iron and heavy metals may contaminate land and adjacent waterways when acid sulfate soils are disturbed or drained. Such contamination can injure and destroy aquatic flora and fauna, affect or kill vegetation and crops, and accelerate structural failure of pipes, foundations, bridges and road surfaces.

Assessment

A soil pH of 4 or less and the presence of jarosite are usually indicators of actual acid sulfate soils (AASS) but pH does not measure the volume of acid or potential acid. However, existing acidity can present a significant hazard, therefore, depth to pH <4 is recorded as a UMA attribute only.

Potential acid sulfate soils (PASS) which contain unoxidised pyrite (FeS_2) may have elevated pH (pH 4.0 to >7.0) and no jarosite. Field testing involves reaction with peroxide (H_20_2) to rapidly oxidise pyrite to acid and comparing any pH change with the field pH of an unreacted sample. A pH change in the reacted sample of at least 1 unit below the peroxide pH (pH adjusted 4.5-5.5) and field pH (which ever is the lower), may indicate the presence of pyrite. PASS is indicated by a pH <3 after reaction with peroxide and the presence of a visible reaction.

Quantative assessment of the hazard posed by acid sulfate soils is based on the depth and quantity of oxidisable sulfur (from unoxidised pyrite) for particular texture categories.

Acid sulfate soils are usually variable in pyrite (FeS_2) distribution within the landscape, within the soil profile and from point to point within pyritic layers. Elevation (<5 m), geomorphology (coastal marine plains, swamps) and hydrology (poorly drained horizons) may indicate the spatial extent of the hazard.

Limitation class determination

Indicator quantities of oxidisable sulfur agree with national guidelines. Because clay content tends to influence the soils natural pH buffering capacity, the indicator quantity of oxidisable sulfur are grouped into three broad texture categories. Quantities of oxidisable sulfur below the indicator quantities are deemed to not cause a hazard. The depths to oxidisable sulfur correspond to the level of management required to control and monitor acid drainage water when these waterlogged soils are cultivated and drained for agricultural production. For example, cultivation and very shallow surface drains will instigate acid drainage when pyrite is <0.5 m. Drainage works should be shallower than depth to oxidisable sulfur. Therefore, moderate deep drains (1 m) are generally adequate for crops with ≤1 m rooting depths when pyrite occurs at >1m.

Texture category McDonald *et al.*, (1990)		Approx. clay %	Indicator quantities percent oxidisable sulfur (%S)
Sands to loamy sands	Code: S (sand)*	≤5	0.03
Sandy loam to light clay.	Code: L (loam)	5-40	0.06
Light medium to heavy clay.	Code: C (clay)	≥40	0.1

Soil/land attribute level Depth (m) to oxidisable sulfur		Limitation class for various crops
		All crops
<0.5	Code: 1*	5
0.5 - 1	Code: 2	4
1 - 2	Code: 3	3
2 - 4	Code: 4	2
>4	Code: 5	1

* Texture categories code is combined with depth to oxidisable sulfur code, and recorded in the UMA data, for example, S1 = sand textures with oxidisable sulfur >0.03% at <0.5 m.